

HEARING CONSERVATION ON THE FARM

Compiled by:

Lisa M. Kluge, M.S., CCC-A

Licensed Audiologist

Rural Wisconsin Health Cooperative

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Definition of the Problem

Farmers and farm employees are at high risk for noise-induced hearing loss. Noise is a common part of their daily work, that is generated from tractors, combines, grinders, choppers, elevators, power tools, barn fans, etc. Even sounds from animals in enclosed spaces can reach hazardous levels. As a result of frequent exposure to loud noise levels, farmers have a higher incidence of hearing loss than people in other occupations. A clinic in Iowa found that 70% of farmers who were given a hearing test had poorer than normal hearing for their age. ¹

Noise induced hearing loss is permanent but preventable. It has occurred in adults and also in youth who are exposed to farm related noise. Studies of high school and college students with farm backgrounds have found that a significant percentage have less auditory sensitivity than their peers.² Symptoms most commonly appear between the ages of 30-40 years and become more severe with time.¹ Many of these individuals are unaware of the degree of their hearing loss, but report symptoms of tinnitus (ringing in the ears) and difficulty hearing especially when in groups of people. The amount of hearing loss that occurs as the result of noise exposure is dependant on the decibel level of the noise and the duration of exposure.

Pathophysiology

Defining noise in terms of sound pressure level, frequency and duration

Sound pressure waves are generated from sources of noise such as a farm tractor. Loud sounds are caused by large pressure waves. The size or amplitude of these waves is the intensity or sound pressure level which is measured in decibels (dB). The unit dB(A) is used to indicate the loudness of sound as received by the ear. The letter "A" indicates A-weighted, and is the scale used to measure the sound on a sound level meter. The decibel scale is setup such that the sound level doubles for each increase of 6 dB on the scale (i.e., 106 dB is twice as loud as 100 dB!)

Frequency is the number of pressure waves occurring per second. More waves produced per second, will represent a sound of higher frequency or pitch. Frequency is measured in cycles per second also known as hertz (Hz). The human voice, for example, ranges from approximately 200-4,000 Hz.



Duration, of course, is the amount of time you are exposed to a noise source. The Occupational Safety and Health Association (OSHA) has adopted a standard for permissible noise exposure based on hours per day of exposure and the decibel level of the noise. Table 1, indicates the number of hours per day that an individual can safely be exposed to given noise levels.

Table 1. Allowable Exposure Duration/ dBA of Noise Intensity

8 hrs.	90 dBA
6 hrs.	92 dBA
4 hrs.	95 dBA
3 hrs.	97 dBA
2 hrs.	100 dBA
1.5 hrs.	102 dBA
1 hrs.	105 dBA
0.5 hrs.	110 dBA
0.25hrs. or less	115 dBA

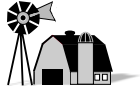
Source: U.S. Department of Labor, Bureau of Labor Standards. (1983).
Occupational Noise Exposure: OSHA Standard 1910.95 Federal Register, 48

This table of allowable noise exposure was determined after years of research on noise-induced hearing loss and is accepted as the standard. The decibel levels indicated are considered to be non-damaging to the unprotected auditory system, for the duration indicated. As you can see from the table, every 5 dB increase above 90 dBA cuts the allowable exposure time in half. For example, a tractor cab with a rating of 95 dBA would allow four hours of safe exposure, however if the tractor had a 90 dBA rating, the tractor could safely be driven for eight hours before reaching a damaging duration of noise exposure.

Understanding the effects of noise on the auditory system

The inner ear, cochlea, is susceptible to damage from exposure to high levels of noise. The cochlea houses the Organ of Corti. Within this organ are thousands of hair cells that respond to pressure waves passed over them by the hydraulic, fluid force caused by the movement of the stapes, which is driven by the vibrations of the tympanic membrane. The vibration produces a wave motion in the basilar membrane. If the vibrations are fast (high frequency sound), the wave will have its greatest amplitude at the base or “doorway” of the cochlea. If the vibrations are slow (low frequency sound) the greatest amplitude will peak near the apex.

Hair cells in a particular region of the cochlea are damaged, or even destroyed by continued exposure to high levels of noise. Once these hair cells are damaged they cannot be repaired to restore hearing in that frequency region. Only a few hair cells may be damaged at a time, but with repeated exposure over time, the cumulative effect can be substantial.



The warning signs of impending noise induced hearing loss

Our hearing provides two warning signs for overexposure:

- Tinnitus
- Temporary Threshold Shift (TTS)

After being exposed to noise, people commonly experience both of these symptoms. Tinnitus, or ringing in the ears, tends to be the most noticeable symptom. Temporary threshold shift, or a temporary loss of hearing sensitivity, generally, also occurs, but is less noticeable. In many instances, a TTS can only be identified through a hearing test. Sometimes a TTS is described as a feeling of fullness or a slightly muffled sound perception. Because hair cells can recover from infrequent, brief exposures to intense noise, these symptoms will diminish or even disappear after a period of up to 12-14 hours if there is no further noise exposure during this time. This recovery period varies, depending upon the individual, the severity and length of exposure.⁴

Noise induced hearing loss

If the noise exposure continues on a frequent basis the hair cells lose the ability to recover, and permanent sensorineural hearing loss will result. Damaging noises first impair the function of the hair cells near the base of the cochlea. This results in hearing loss in the 4,000 Hz. frequency range. As noise exposure continues the hearing loss spreads into the adjacent frequencies, which will create a hearing handicap that results in speech perception difficulties. The susceptibility to noise induced hearing loss varies among individuals.

Farmers who have damaged their ears permanently from overexposure to noise typically, also have a constant tinnitus, which can be a very bothersome symptom. It is most often described by the sufferer as ringing, whistling, buzzing, roaring, or hissing. The physiologic mechanism that produces tinnitus is still not fully understood. One theory by Davis⁵ is that mild tinnitus corresponds to spontaneous discharge of auditory nerve fibers and is essentially “normal.” More hyperexcitability drives the nerve fiber(s) to a faster rate of spontaneous discharge and more severe tinnitus. The discharges of the more sensitive auditory nerve fibers are accelerated by even minute mechanical disturbances.⁶ In other words, damaged hair cells will cause the attached nerve fibers to send an electrical signal to the brain, resulting in a perceived sound that is not actually present in the environment.

**Physical and psychological effects of noise induced hearing loss and it's associated tinnitus**

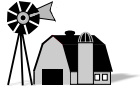
Most people that suffer from a noise induced hearing loss, have greater loss in the high frequencies. This type of loss creates several problems:

- Some of the sounds in our speech are high pitched, (i.e., /s/, /sh/, /ch/, /t/, /k/, /f/). These speech sounds range in frequency from approximately 1,500 Hz.-5,500 Hz.

Noise induced hearing loss affects the ability to hear these crucial sounds in our speech. When these sounds are not clearly perceived, the affected individual will complain that they can hear but they cannot understand. As a result speech is often not intelligible or it is misunderstood. This further impacts the affected individual because the speaker begins to lose patience with the listener, and may choose to “drop” the conversation. This leaves the listener isolated and frustrated.

- The ability to identify the location of the sound is greatly reduced, particularly if the hearing loss is not symmetrical. This can make the listener seem inattentive.
- In the presence of background noise, the listener with a high frequency hearing loss has difficulty separating the voice of the intended speaker from the voices of others in the area. In other words it becomes difficult to focus on the talker that should be heard, because their voice becomes lost amongst the speech of others in the room. The person with a hearing loss will often withdraw and avoid these types of occasions.
- Individuals with noise induced hearing loss often have a reduced tolerance for loud sounds. This is sometimes referred to as recruitment, which is described as an abnormally rapid growth of loudness perception with an increase in intensity.

Workplace noise is also known to contribute to stress that can manifest as headaches, irritability, insomnia, digestive disorders and psychological disorders. Studies have been done on workers in Europe who are exposed to noise. Noise has been found to contribute to a number of illnesses including: general morbidity, neuropsychological disturbances including headaches and insomnia as mentioned above, cardiovascular disturbances, digestive disorders including ulcers and colitis, and endocrine disorders.⁷



Agricultural Factors

There are many sources of noise in the agriculture industry. These include, but are not limited to the following: tractors, combines, barn cleaners, conveyors, elevators, compressors, pneumatic wrench, lawn mower, squealing sows, power tools, chain saws firearms, etc. These sources of farm noise, as well as other sources of noise are listed in Table 2. The typical decibel level of these noises are also indicated in the table. OSHA defines any noise level of 85dB or greater to be dangerous. You may wish to refer back to Table 1, for the allowable exposure duration per dBA of noise intensity. A simple way to determine if a noise is loud enough to be damaging to the auditory system is to determine if conversation at a normal level can be heard over the noise. **If a person has to raise their voice to be heard above the noise then the level of the noise is likely to be at a damaging level.**

Most sources of noise on a farm generate decibel levels near or above a level that is potentially damaging to the auditory system. The Nebraska Tractor Test Center has measured sound levels, at the operator's ear, of a representative number of tractors.

Although a few models are within the 85 dB(A) range, most tractors being tested today, especially those without cabs, still are at or over 91 dB (A). These sound levels likely increase with the age of the tractor. Other machines such as self-propelled combines, corn pickers, hammermills, and dryers produce sound levels exceeding 100 dB(A).⁸

Agricultural noise has an effect on farmers of all ages, including youth. A National Farm Medicine Center (NFMC) study published in the American Journal of Public Health (1989) compared hearing test results of Wisconsin high school students who lived or worked on farms with the results of non-farm students. The study found that teenagers actively involved in farm work had a higher prevalence of mild and early noise-induced hearing loss than teens who are not exposed to farm noise. This loss may not be readily noticed by the teen, but is already discernable on a hearing evaluation.⁹

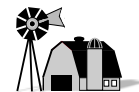
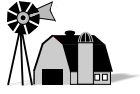


Table 2. Typical Decibel Levels of Agricultural Noise Sources

Noise level (Decibel)	Common Sounds
0	Lowest audible sound
50	Quiet empty barn, babbling trout stream, gentle breeze
60	Normal conversation
70	Chicken coop, farrowing area
85	Tractor or combine idling, barn cleaner, conveyor, elevator: At this decibel level, noise may begin to affect your hearing if you are exposed to it for more than 8 hours per day.
90	Blower compressor, pneumatic wrench, chopping silage (no cab), full throttle lawn mower: As noise gets louder, the “safe” time decreases; damage can occur if you’re exposed to it for more than 4 hours per day.
100	Tractor at 80% load, squealing sows, power tools, hand-held metal grinder: 1 hour of exposure per day is the limit at this decibel level.
110	Average walkman set above the halfway mark, full-throttle combine, 10-HP vane-axial barn fan: Anything over 15 minutes exposure per day can cause damage.
120	Thunderclap (near), sandblasting, bad muffler, old chain saw: The danger is immediate.
140	Gunshot, engine backfire, dynamite blast, jet engine: Any length of exposure time is dangerous, and may actually cause ear pain.



Management Issues

Prevention

Early awareness and protective action are important for reducing or eliminating noise as an agricultural hearing hazard. Increased awareness of the hazards of noise exposure is essential in the early stages of exposure to farm noise. **Farm families need to be educated about the potential harm that can be caused by farm related noise and the importance of taking protective action against noise exposure.** The protective action that is taken can be a combination of:

- 1) reducing the duration of exposure to damaging noise levels.
- 2) reducing the amount of noise that is produced.
- 3) isolating the farmer from the hazardous noise levels.
- 4) reducing the noise at the level of the ear by using hearing protection devices.

Reducing the length of time exposed to noise will help prevent the potential damage to hearing. Refer back to Table 1 for the allowable exposure duration for given decibel levels. When it is practical to do so, work schedules can be arranged so that farm workers do not exceed the allowable exposure limit.

Reducing the amount of noise can result from good maintenance practices such as:

- replacing worn, loose or unbalanced machine parts to cut down on the amount of vibration generated.
- lubricating machine parts to cut down on friction.
- installing good quality mufflers on engine powered equipment.¹⁰

Farmers may wish to partially isolate themselves from the noise with an acoustically sound insulated tractor cab to reduce the noise level. Tractor dealers should have information about the sound insulating characteristics of their tractor cabs. This information can also be obtained for various tractor models by contacting Nebraska Tractor Test Data, Department of Agricultural Engineering, University of Nebraska-Lincoln, college of Agriculture, NE 68583. Ask for publication MP37.¹¹ In addition, existing cabs can have insulation, wall liners and acoustical foam added to increase their sound insulating characteristics. Companies such as Fehr Cab Interiors provide custom made kits for insulating the cabs of existing agriculture equipment. (For more information go to www.freezonerb276.com/Fehrcabkits.htm.)

Hearing protection devices (HPDs) are one of the most effective and inexpensive ways for farmers to protect their hearing. There are essentially four types of hearing protection devices:

- pre-formed earplugs
- custom made earplugs
- earmuffs
- earmuffs with amplified communication devices



Pre-formed earplugs are the least expensive and can be purchased at most drugstores. Some of the most effective pre-formed plugs are those made of slow recovery foam. These are compressed by rolling them with a couple fingers before they are inserted and then they slowly expand to fit the shape of the ear canal. When properly inserted they provide a noise reduction rating of approximately 24 dB. The noise reduction rating (NRR) is an approximate value indicating the reduction in noise that the HPD provided in an ideal laboratory setting. The actual reduction value obtained through the use of earplugs is dependent, in large part, on being fully inserted, and held in place as they expand so they are fully occluding the diameter of the ear canal. The NRR will vary by manufacturer and style of earplug, and should be indicated on the package. A larger number equates to greater protection, which again, is dependent on proper use. If a farmer is operating a tractor that produces 100 decibels and earplugs with a NRR of 26 are worn, this reduces the noise exposure to below 80 decibels which is well below the level that is considered safe for the duration of the work day.

It is worthy to note here that cotton does not serve as an effective earplug. It cannot block out high frequency sound and does not provide protection from high sound levels.

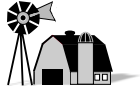
Custom made earplugs are cast from a silicone impression of each ear. These are considerably more expensive, but are also considerably more comfortable than pre-formed earplugs because they are made specifically for the person wearing them. These can be obtained through any licensed audiologist. They provide an NRR rating similar to a preformed earplug. Custom earplugs can also be made with an internal valve that closes when a sudden loud noise occurs. These are generally used for hunting or shooting. The earplugs offer little to no reduction in sound until a sound wave with a large amplitude enters the earplug and closes the valve, providing a level of noise reduction. This allows the wearer to hear environmental sounds while waiting for the right shot. These provide less protection than other earplugs but are a good consideration for hunters. Expect the cost of hunters plugs to be greater than other standard earplugs.

Earmuffs are another option for hearing protection. They afford a NRR ranging from 18-33 dB depending on the make and model. Their effectiveness depends on a snug fit, the tension of the headband and the seal of the ear cups. These can be purchased at most retail hunting, woodworking and home improvement stores.

If communicating with others while working around noise is an issue, then the use of an earmuff with a built in communication radio might be the answer. These devices provide hearing protection while making it possible to communicate with others by way of a built-in radio. The range of communication is more than 1,000 ft.¹² Using this type of earmuff provides the wearer with good hearing protection while allowing the added safety of effective communication while working around loud, and potentially, physically dangerous equipment.

“But I can’t hear the tractor noises if I wear earplugs”...

Some farm workers are reluctant to wear hearing protection because they are concerned that this will prohibit their ability to hear key sounds that are important for the proper operation of equipment. However, properly fitted hearing protection reduces the noise to a safe level and still permits sound to



reach the ears for informational and safety purposes. In fact, sounds that might indicate trouble in the machinery can be heard just as well with hearing protection as without protection.¹³ Machinery does sound different when hearing protection is worn, but with continuous use, the wearer can learn the new sounds and still be able to determine whether the machinery is operating properly.¹⁴ For some people whose hearing is already damaged, earplugs or muffs do slightly reduce the ability to understand normal speech. However, all noise is reduced, so sounds still can be compared to one another. According to a Kansas farmer who is over age 60 and has a hearing loss, “I’ve heard folks say they won’t wear ear protection because they need to hear the tractor noise. Well, I hear it every bit as well now, (with hearing protection) and I’m still using the same old tractor.¹⁵ Hearing protection allows the wearer to monitor a machine better, since the brain is not being overwhelmed by all the excess noise.¹⁶

Diagnosis

Noise induced hearing loss is the second most common form of sensorineural hearing loss. Presbycusis or age related hearing loss is the most common. Farmers who have been exposed to excessive noise should have an early hearing evaluation. This should include a physical examination (including otoscopic examination), a thorough history, and a full audiologic evaluation.¹⁷ The U.S. Preventive Services Task Force recommends periodic screening of older adults for hearing loss. Other authorities have advocated similar screening for all patients who report significant noise exposure.¹⁸

Physicians can ask patients who have a history of farm related noise exposure, if they have difficulty understanding speech, especially in noisy situations, if they need to turn the TV louder or have increasing difficulty hearing on the phone, or if they frequently have to ask people to repeat words when they are in one-to-one or group conversation.

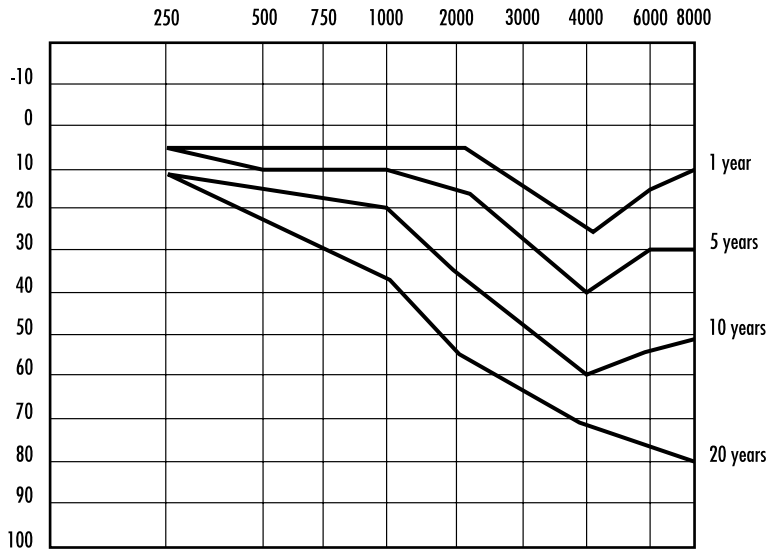
Some patients may be reluctant to admit they are having hearing difficulty. Family members often are the first to report a problem. If a hearing problem is suspected a referral should be made to a licensed audiologist. The audiologist should also obtain a complete history, including, noise exposure history, family history of hearing loss, ear health history, history of head trauma, previous hearing test results, history of symptoms including hearing loss, discharge, pressure or fullness in the ears, tinnitus and vertigo. An otoscopic exam should be completed to determine the presence of cerumen impaction or evidence of possible middle ear disease. A full hearing evaluation should be done to measure air and bone conduction to determine if the hearing loss is sensorineural, conductive or mixed. Speech reception thresholds, word recognition and uncomfortable loudness levels should be assessed. Tympanometry and acoustic reflexes are useful in some cases to provide more information regarding the middle and inner ear status.¹⁹

Noise induced hearing loss will be revealed on an audiogram as a sensorineural loss that begins in the higher frequencies. An audiogram, puretone threshold level greater than 25 dB is considered abnormal. If the loss is sensorineural, etiologies other than noise should be excluded.



In the earliest stages of a noise induced hearing loss the audiogram configuration will typically show a “notch”, or poorest hearing thresholds, centered around the 4,000 Hz. test frequency as shown in Table 3. This will develop gradually as the result of continued noise exposure.

Table 3. Typical progression in hearing loss as a function of years of exposure to industrial noise of high intensity.*



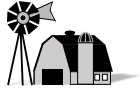
Source: Newby & Popelka. *Audiology* 5th ed., Englewood Cliffs, NJ: Prentice-Hall, 1985, p.297.

*Both ears would be affected similarly.

As you can see from the above audiograms, a noise induced hearing loss will typically begin in the higher frequencies and with years of continued noise exposure, will progressively worsen in the high frequencies, eventually also affecting the mid-frequency range as well.

A hearing loss may develop more suddenly from short term impulsive noise such as gunfire, or explosives. Sudden hearing loss is referred to as acoustic trauma. It is worthy to note that patients with sudden sensorineural hearing loss (hearing loss developing in minutes or hours) should be referred immediately to an otolaryngologist, because treatment initiated within the first 24 hours can improve outcomes.²⁰

Noise induced hearing loss is most often symmetrical, however asymmetry is sometimes present from noise sources such as firearms or farm tractors. Asymmetrical hearing loss can result from driving tractors when the driver spends a good portion of time looking over one shoulder to monitor the activity behind the tractor, resulting in more noise exposure to one ear. However, if a unilateral or asymmetric sensorineural loss, tinnitus (especially unilateral tinnitus), vertigo or other significant ear pathology is found, a referral to an otolaryngologist is warranted.²¹



Treatment

Currently, the treatment of noise induced hearing loss is limited to the selection and fitting of hearing aids and providing counseling. There have been many advances in hearing aid technology including digital circuitry, programmability, and directional microphone technology. These advancements help to make speech more intelligible even in groups of people, however, normal hearing does a far better job of processing speech than a hearing loss that is aided.

The family physician can encourage a patient with a significant hearing loss to seek treatment, as many patients with hearing loss are reluctant to consider trying hearing aids. Hearing aids should be carefully matched to the person's hearing deficit and lifestyle by a qualified audiologist.²² This should only be done after the results of a comprehensive hearing evaluation have been obtained. When dispensing hearing aids in the state of Wisconsin, these results need to be current within the last six months. The audiologist should also obtain a signed medical clearance from the patient's primary care physician or otolaryngologist, to insure that there are no medical contradictions to the use of amplification.

The patient should also be counseled by the audiologist regarding the use, care, expectations and maintenance of their hearing aids. They should also be counseled regarding the causes and coping strategies of tinnitus if they suffer from this symptom.

Information should be provided regarding noise induced hearing loss, and its prevention, including the various types of hearing protection, proper use of HPDs by all farming family members and the importance of periodic routine hearing evaluations. A study published in the *Journal of School Health*, October 1998, found that providing teenagers, who live or work on farms, with an abundant supply of free earplugs that can be placed somewhere in close proximity of noisy equipment significantly increased their likelihood of using hearing protection. Members of families who live or work on the farm should have their hearing tested annually if hearing loss is present. Even individuals who do not suspect, or have known hearing loss, but are exposed to a daily dose of excessive noise should be advised to have a hearing evaluation periodically as part of their routine physical, in an effort to identify and prevent noise induced hearing loss before it becomes a hearing handicap.

Regulations

Wisconsin family farms are not under any regulatory agency that mandates the monitoring of noise levels, the use of hearing protection or assessment of hearing in farmers. The Occupational Safety and Health Act (OSHA), Standard 1910.95 does have information and requirements that owners and managers of corporate agriculture businesses or family farms with 10 employees or more, should follow. This standard should be considered a good guide for the family farmer, as well, who is concerned about the conservation of hearing in the members of the family and of the hired help. Highlights of the OSHA Standard 1910.95 will be summarized here. This is not meant to be comprehensive or all inclusive. For full information, refer to OSHA's website at www.osha.gov.

According to the OSHA Standard, action must be taken when noise levels reach an eight-hour time weighted average of 85 dB. The permissible duration of exposure at various decibel levels is indicated



in Table 1, as previously discussed. Employers must provide hearing protection when the sound levels are at or above those indicated in the table and when those noises cannot be reduced through engineering controls.

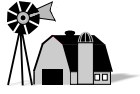
The employer is also required to institute an effective hearing conservation program. This includes regularly monitoring noise levels and notifying employees who are exposed to noises that are at or above the 85 dB level. These employees then need to be included in an annual hearing screening program to monitor their hearing for any potential signs of noise induced hearing loss. A baseline audiogram should be measured within six months of an employee's date of hire. The employee should then be tested annually, thereafter, and these results are compared to the baseline audiogram. If this comparison indicates a change in hearing, or standard threshold shift (STS), of an average of 10 decibels or more at 2000, 3000 and 4000 Hz in either ear, the employee must be notified of the STS in writing within 21 days of the determination. Employees with an STS should be fitted or re-fitted with adequate hearing protection, shown the proper way to use and care for them and their use should be made mandatory. The hearing protection is provided by the employer to those employees who are working in the excessive noise areas. The employer must also have a training program in place for the employees who are exposed to noise at or above the action level, and should appropriately update and repeat the training annually.

All employee hearing screening records, and noise monitoring records should be kept and maintained by the employer. These records also need to be available to employees as well as to OSHA for their review, if requested.

This information on OSHA Standard 1910.95 was derived from the U.S. Department of Labor, Bureau of Labor Standards. (1983) Occupational Noise Exposure. Federal Register, 48.

Conclusion

The primary care physician must be instrumental in increasing awareness among farmers and their families of the effects of farm related noise, and the work practices and products that are available to prevent noise induced hearing loss. Farm families need to be informed that their work is very damaging to their hearing, causing hearing loss that is permanent, but very preventable, if protection measures are taken early in the exposure to noise. Family physicians can also help to motivate patients to seek treatment for an existing hearing deficit.



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