



Module 16

Livestock: Slaughter and Killing Animals for Disease Control Purposes

Lecture Notes

Slide 1:

This lecture was first developed for World Animal Protection by Dr David Main (University of Bristol) in 2003. It was revised by World Animal Protection scientific advisors in 2012 using updates provided by Dr Caroline Hewson.

Slide 2:

This lecture considers the common welfare problems that can arise in farmed ruminants, pigs and poultry at slaughter. The slaughter of fish is covered separately in the modules on fish welfare (modules 23 and 24).

Slaughter is a huge topic and this lecture cannot teach you everything you need to know. What we will do today is focus on the main areas of concern at abattoirs and show you how you can use audits to help both your farm-based clients and local slaughter plants to address these problems.

Slide 3:

Slaughter is the killing of animals for food. The term can also be used when large numbers of animals are killed to control an outbreak of disease. In this lecture we are mainly concerned with killing for food.

The consumption of meat is a part of many peoples' dietary culture. In some cultures animals are only killed after they have had a considerable period of life, but in most production systems animals are killed as soon as they reach full or adequate size – for example lambs, beef cattle, pigs and poultry are usually killed for meat before they reach maturity.

To supply meat to urban populations the centralised commercial slaughter of farmed animals is now common. This means that huge numbers of animals are transported from farm or production units to the place of slaughter. The transport of farm animals is discussed in Module 25.

Despite the industrialisation of slaughter, huge numbers of farmed animals are killed locally

by farmers themselves for their communities. The welfare aspects of this are outlined on the next slide.

Slide 4:

The advantage of killing animals on the farms where they are reared is that they do not have the stress of transport to market or the slaughter plant.

On family farms and in isolated areas slaughter methods may not have changed for thousands of years:

- Smaller animals (lambs, poultry) are usually killed by exsanguination or by decapitation
- Larger species are sometimes shot in the head and then bled out. Alternatively a knife (known as a 'puntilla') may be used to sever the spinal cord; this procedure immobilises the animal who will collapse immediately ensuring the operators have easy access to cut the throat. However, the animals remain conscious until bleeding is complete. This practice is not humane and should be discontinued.

During these types of slaughter animals may be restrained to facilitate the operator and to protect their safety. Restraint is typically achieved with hobbles, ropes and rings in the floor, or by tying the animal to posts or trees. All these methods can be very stressful for the animal.

All traditional approaches to slaughter have the potential for poor welfare as often there is little or no external oversight or formal training. Consequently the farmers cannot take advantage of improvements in techniques, some of which may greatly improve the welfare of the animals in their care, as well as making it easier and safer for the slaughter personnel to do their work.

Slide 5:

Commercial slaughter at abattoirs involves a chain of events as shown on the slide.

The animal experiences:

- collection on farm
- loading onto a vehicle
- transport to the slaughter plant, sometimes with rest breaks
- unloading at the plant
- lairage, sometimes overnight
- movement from the holding pen to the restrainer
- restraint
- stunning (in secular slaughter and some halal slaughter) and killing.

The animal's experience at each point in the chain depends on how the brain processes the stimuli concerned. That processing is, in turn, affected by the animal's existing emotional state, past experience and genetics. The next slide reviews this.

Slide 6:

Starting on the left, we see that sensory input at each stage of the experience is created by internal and external cues. Examples of these cues in the context of slaughter are: external conditions such as noises from equipment or from handlers shouting; internal cues include lack of gut fill because of food being withheld.

Nerves transmit all this sensory information to the animal's brain which evaluates it. At the top right you see that memory is involved in the evaluation.

Also, the emotion that the animal was feeling as he or she evaluates the sensory information may affect that evaluation by a process called cognitive bias.

The end result of the brain's evaluation is the generation of emotions and the urge to perform a particular behaviour, i.e. motivation.

All this gives rise to physiological responses such as the stress response, which you see at the bottom, and to behavioural responses which you see at the bottom on the far right.

Finally, these behavioural and physiological responses create further sensory input as you see by the arrows going across to our starting point on the left.

This diagram shows that the animal's brain is constantly evaluating ongoing sensory input. In the case of slaughter, that input can make the animal's experience more or less stressful and this can affect the subsequent quality of their meat. Therefore, reducing stress at slaughter is both humane and good for meat quality.

Slide 7:

The sensory input that animals receive during the chain of events leading to slaughter includes:

- handling and increased human contact
- unfamiliar environments
- lack of food and water
- varying climatic conditions
- changes in social structure, e.g. separation from original social group and mixing on the truck and at lairage.

If those inputs are managed well most animals may feel minimal fear at slaughter. However, if those inputs are not managed well they can result in negative experiences such as:

- fear
- dehydration and hunger
- fatigue
- pain.

The animal's physiological responses to those experiences can affect meat quality, as the next slide outlines.

Slide 8:

Stress can affect the acidity and water-holding capacity of the muscle, and therefore the value of it as a meat product.

In beef, lamb and poultry 'dark firm dry' (DFD) meat results from pre-slaughter stress, e.g. from extreme cold or rough handling. This stress depletes muscle glycogen stores. As a result there is little lactic acid in the muscle at slaughter so the pH of the meat is higher than normal.

This higher pH means:

- The normal post-mortem setting of meat does not occur and the meat looks dark, and is firm and dry. Also, the meat is generally tough and unpalatable.
- The meat is more susceptible to bacterial spoilage.
- DFD meat indicates that the animals experienced stress, injury, disease or fatigue before slaughter. It points to shortcomings in animal care by some or all of the following: farmer; haulier; abattoir.
- Reduced profit for the abattoir because the meat may be unusable.

A different effect of stress on meat quality is Pale Soft Exudative (PSE) pork.

- Here, glycogen is not depleted in the pig during pre-slaughter stress, but stressors including fatigue and handling predispose the muscle to rapid glycolysis post-mortem.
- Following slaughter there is therefore a rapid drop in pH. The meat is pale and exudes fluid; this makes it look unpalatable, and it is also unsuitable for processing.
- There is a genetic predisposition towards PSE meat and it may be made worse by high voltage electrical stunning.

DFD and PSE meat illustrate how reduced welfare translates into reduced profit. However, note that the absence of these conditions (i.e. a normal pH) does not guarantee palatability. Studies show that consumers dislike meat from animals that have been stressed even when the pH is normal. For example, the use of electric goads immediately before slaughter resulted in drier beef and lamb and reduced consumer acceptance compared to meat from animals that had not been goaded. So although the use of goads did not significantly affect the final pH of the meat, it was still less palatable than the meat from animals that had not been goaded.

Slide 9:

This slide illustrates the appearance of meat that is DFD. The photo is of dark, firm, dry beef on the right, compared to normal beef on the left.

We shall now leave the consumer aspect of slaughter (i.e. meat quality) and focus on main areas of welfare concern in the animals.

Slide 10:

Module 25 describes the welfare issues that may arise when animals are collected on the farm, loaded onto the vehicle, transported to the slaughter plant and unloaded.

This slide briefly reviews some of the main issues. For example:

- educating the stockperson and driver about handling and loading animals (e.g. appreciating the animal's flight distance)
- design factors such as non-slip flooring and the ramp design and angle can facilitate loading for handlers and animals.

During transport factors that may reduce or increase welfare include:

- whether the animals are fit for transport
- environmental conditions including driving style, road conditions, vehicle design and operation, space allowance, etc.
- long transport times: these may be acceptable if the animals are fit and all environmental conditions are good. However, if there is widespread non-compliance with regulations or industry standards and inadequate enforcement or supervision to provide optimal conditions, the argument for limiting journey times is strengthened.

Slide 11:

On arrival at the slaughter plant unloading may adversely affect welfare, just as loading can, if for example the vehicles are not adapted for animals or the handlers are not trained.

A further stressor at unloading is that animals may be immediately restrained so that personnel can check their identification (e.g. ear tags) which enables tracing of the animals after death for public health reasons.

Note that, despite these general points, each country needs their own research on the welfare of animals during loading, transport and unloading, so as to understand particular areas of weakness and then target time and money effectively. For example, recent reviews from different regions of the world indicated that:

- Extremely cold winter weather in parts of the US and Canada are associated with mortality during transport or before slaughter. This means it was a mistake to rely only on transport research generated in Europe, where the climate is very different in many places.

- In Namibia, high levels of carcass bruising in beef cattle were associated in part with stocking density in the vehicle, gravel roads, and cattle running after they got off the truck. Part of the latter problem was that, often, the truck floor did not fit closely to the off-loading ramp.

Note that in some other countries, road surfaces are very smooth and do not significantly affect welfare during transport. However, local research can generate data that may prompt governments to improve infrastructure. In Brazil, Chile and Uruguay, handling, vehicle design and road conditions are proven to affect carcass quality. However, as elsewhere, the introduction of legal standards together with monitoring is markedly reducing the percentages of animals affected.

Slide 12:

Once animals are unloaded at the abattoir they are held in pens close to the slaughterhouse; this is termed 'lairage'. In some countries animals are slaughtered on the day they arrive at the plant and are only held in lairage for a few hours. In other countries they are held overnight.

Lairage offers the possibility of resting the animals after sometimes long journeys. However, lairage itself may be very stressful because animals may:

- be mixed with other unfamiliar animals, resulting in fighting
- be washed to remove faeces and dirt; high pressure spraying with water can be stressful
- have food withheld
- be hit or goaded with electric prods to move them within the lairage
- not be provided with water or shade
- not have the opportunity to carry out 'coping' behaviours such as escape, hiding, etc. to enable them to deal with bullying or high stocking densities in the lairage.

These stressors may interact and negate any potential benefit of a long lairage time. For example animals may not rest or drink enough water during their lairage time.

A randomised controlled study in Chile investigated whether the legally required minimum of 12 hours' pre-slaughter lairage for cattle had a positive effect on animal welfare. The authors measured physiological variables such as plasma glucose and packed cell volume in animals that underwent three-hour or 16 hour journeys, followed by lairage for 3, 6, 12 and 24 hours.

Statistical comparison of the data from these different combinations of journey and lairage times suggested that lairage time of 12 hours and longer depleted energy reserves, especially when the preceding journey had been long. Also, animals did not consume sufficient water during lairage. In summary, the study suggested that the legal requirement for 12 hours of lairage seemed to adversely affect welfare, not to protect it.

Slide 13:

Moving animals from the lairage area to the restraint pen prior to slaughter should be done while applying basic animal behaviour knowledge. In the case of farm mammals, this includes:

- knowledge of their 'personal space' or flight distance which is a function of how accustomed the animals are to being handled, as well as their species
- knowledge of the point of balance (the point at which a person will come into the animal's line of sight and potentially stop it moving forward. This is usually the shoulder for cattle)
- understanding that most farmed animals are gregarious and therefore better handled in groups
- understanding their sensory behaviour (visual, audible and olfactory) and what they perceive as distractions that prevent them from moving ahead smoothly.
- Designs that are problematic for their sensory behaviour include:
 - too many sudden changes in floor structure
 - sharp bends in the raceway as they are always perceived as dead ends
 - too many contrasting light areas as they are perceived often as physical objects
- understanding the differences in behaviour between those animals kept outdoors with little interactions with humans and those animals with daily interactions with stockmen
- Understanding that behaviour will differ according to the sex, age and breed as well as their previous experience with different types of handlers

Slide 14:

Mechanical restraint is much preferred to ropes and casting (the use of a rope or a special harness to make an animal fall to the ground) because the latter cause considerable distress (with exemption of animals who are accustomed to casting, such as local cattle breeds in many Asian countries).

For pigs and ruminants, a mechanical restraint may hold the animal slightly above the floor or support him/her on the floor. A good mechanical restraint should:

- allow for a comfortable, upright position (fully supported by a sling if above the floor)
- use non-slip flooring
- ensure that if there is any pressure on the animal's sides, back or belly it is evenly distributed
- try to ensure there are no pressure points (total pressure should not be so tight that it causes struggling or vocalising or other signs of distress)

- minimise the animal's view of shadows or sudden movements, which can be frightening
- block any vision from the restraining box using solid walls.

In addition, personnel and devices should move slowly and smoothly – sudden or jerky movements will cause the animals distress and make the slaughter process more difficult.

If restraining cattle prior to mechanical captive bolt stunning, boxes should be equipped with head restraints.

Slide 15:

The commercial slaughter of poultry involves different restraint and handling equipment and techniques.

Many systems for slaughtering poultry are automated: birds are suspended upside down by the legs (“shackled”) and moved along an automated line prior to stunning (as shown in the image).

While shackling may improve the efficiency of killing and, in some cases, reduce the time the animal may be subjected to the intense stimuli associated with the period just before slaughter, suspension by the legs can cause great distress.

While some birds may struggle and vocalise when they are shackled, others cope by going into a state of tonic immobility whereby they are completely still. This immobility, and the birds' small size compared to mammals may be some of the reasons why shackling of conscious poultry has been widely accepted.

Stressors in shackling include the physical experience of being restrained upside down: gravity causes abdominal organs to increase pressure on the heart and respiratory system (because poultry do not have a diaphragm) which increases the work that the heart and respiratory system do. This will feel increasingly more uncomfortable over time.

Another stressor for shackled birds is, almost certainly, the psychological experience of being unable to right themselves. However, there has been relatively little research on the extent to which birds are distressed by shackling. In one example researchers evaluated stress in three groups of broilers who were shackled, respectively, for 30 seconds, 60 seconds or 120 seconds. Based on behavioural measures and measurements of corticosterone and lactate, the authors concluded that shackling those birds for more than 60 seconds caused excessive stress (Badanova et al 2007).

THE OIE guidelines are that the interval between shackling and stunning should not exceed 60 seconds (OIE, 2009). Note that the birds in the experiment were in a research facility and had not undergone the stresses of transport, crating, and holding at the abattoir that commercial poultry typically have before being slaughtered.

Other reasons why shackling conscious poultry at the abattoir can be a welfare concern are that:

- a significant minority (~5%+) of broiler chickens suffer from tendonitis and joint problems; shackling is likely to increase the associated pain
- end-of-lay hens have brittle bones due to osteoporosis: one survey indicated that ~30% of hens had at least one broken bone at the point of slaughter. Some of these fractures occurred during collection and transport to slaughter, however shackling and the associated wing-flapping and struggling contributed to these injuries

The period for which poultry can be legally suspended before slaughter is regulated in many countries. In other countries however, birds may be suspended for very long periods including during transport when, for example, the birds may be transported by bicycle and suspended by their legs.

As a result of the numerous welfare concerns, gas stunning before slaughter is increasingly being used to avoid shackling.

Slide 16:

In the slaughter process, once an animal has been restrained, he or she is killed. This usually involves making the animal unconscious by stunning before killing.

However, traditionally, Jewish and Islamic religious slaughter has not permitted stunning. In many countries such as China, stunning has not been typical at commercial plants either, although not for particular religious reasons. In these cases animals are killed by exsanguination. In Bolivia and Vietnam it is also uncommon to stun animals before commercial slaughter. Instead, the puntilla is commonly used to sever the spinal cord (and disable the animal) prior to cutting their throat (Limon et al., 2012). However, as we noted at the start of this lecture, this method is inhumane and, as we shall see later on, it is prohibited by under the OIE guidelines for slaughter.

We will now consider slaughter with stunning; we will address slaughter without stunning later in the lecture.

With stunning

The animal should be made unconscious before being able to register that he or she has been struck or stunned. In many species neuro-electrical measurements indicate that it takes about 200ms (1/5 of a second) for the nervous system to register and interpret nociceptive stimuli resulting from the stunning method, meaning the ideal stunning method must be effective within 200 milliseconds.

The slide shows the most common methods of stunning which are:

- electrical stunning
- captive bolt stunning
- percussive stunning
- gas stunning.

Both electrical and captive bolt and percussive stunning can achieve instantaneous insensibility in almost all animals (i.e. within 200 milliseconds).

However, animals stunned with electricity regain consciousness within 20 to 60 seconds depending on the species; therefore they must be killed very quickly.

In contrast, penetrative captive bolt stunning can typically achieve long-lasting or permanent insensibility, so there is less time pressure to kill them as quickly. However, monitoring is essential here.

The killing itself usually involves exsanguination. In ruminants and pigs, this method of killing is sometimes called 'sticking' or 'bleeding'. Typically, the carotid arteries and jugular veins are severed by a cut or 'stick' into the upper chest area of the unconscious animal just above the heart. This method is called 'chest sticking'.

Exsanguination causes the circulating blood volume to collapse, with associated loss of brain function. In general, for meat to be palatable, much of the blood needs to be removed from the carcass, and exsanguination serves this purpose as it typically allows 50 per cent of blood to be lost.

Other methods of killing are cardiac arrest by electrocution and killing by gas.

- Electrocution is always used immediately after an animal is stunned by electrical current, meaning the animal dies in a short time while fully unconscious. Follow up bleeding is necessary for hygiene reasons. This method is used for killing pigs, small ruminants and birds but rarely for cattle.
- Killing by gas causes anoxia (animals inhale blends of gases that cause loss of consciousness due to lack of oxygen in the blood stream and central nervous system). This method is used for killing pigs and birds only and is always followed by bleeding.

Slide 17:

Now we will look a little more at the main welfare points of stunning.

First, electrical stunning. This method renders animals unconscious by delivering electrical energy to the brain and causing a 'grand mal' seizure, i.e. uncoordinated electrical activity (epileptiform activity).

The picture shows electrical tongs. The electrodes must span the animal's brain: they are placed on each side of the head and the current passes through the brain from one probe to the other.

The amount of electrical energy supplied to the brain (the current) depends on the voltage; this is influenced by the electrical resistance of the tissues in the head.

To overcome the resistance there must be enough voltage and good electrical contact between the stunning tongs and the skin. Therefore accurate positioning is essential.

However, as we noted earlier, electrical stunning is reversible, which means the animal will eventually recover. It takes on average about 200 milliseconds to take effect; if a lower voltage is used it may take longer and this would result in the animal feeling pain for a short time before losing consciousness.

Electrical stunning is associated with haemorrhaging in the muscles known as 'blood splash', caused partly by increased venous pressure following muscle contraction. This results in reduced meat quality.

Slide 18:

In the case of poultry, many systems use automated 'water bath' electrical stunning. In the image on the slide the birds on the right have their heads in an electrified water bath. This system has several potential hazards to poultry welfare.

- Pre-stun shocks: birds may receive shocks from wet surfaces before the water bath. These shocks will not stun the bird but will be very painful. Close attention to the design of systems is important and new designs should always include an electrically insulated ramp that prevents animals from receiving electric shocks.
- Ineffective and inadequate stunning: this can be caused by small birds not making good contact with the water, poorly designed water baths, or poor regulation of voltage/current.
- Poor bleed-out: inadequate severing of the blood vessels can be a problem when automated neck cutters are used.

Slide 19:

We have seen that although electrical stunning has the potential to be very effective in most animals, it is not perfect. No stunning method is, but captive bolt stunning is preferred for some species.

In this method, a bolt is released when the pistol is fired at the skull. This transmits a wave of energy through the nervous tissue of the brain and the first part of the spinal cord, causing the intracranial pressure to rise.

As the bolt penetrates the skull it causes irreversible damage to the frontal cortex and midbrain which helps to ensure the animal cannot recover. As a result, the nervous tissue is severely damaged and animal becomes insensible typically within 15 milliseconds. The pistol is shown on the left.

Some stunners are non-penetrating. With these, the head of the stunning pistol transfers energy through the bones of the skull causing depolarisation of the nerves without penetrating

the bone. This is called concussive stunning and an example is shown on the right.

Small birds up to the size of a turkey, rabbits, fish (salmon) and small lambs and kids can be killed by concussive stunner.

This method has been used in religious slaughter, where stunning with penetration is perceived as being contrary to the requirement for the animal to be 'intact' at the time of exsanguination.

If producer recommendations are followed, concussive stunners used in the religious slaughter of cattle do not cause the death of the animal.

Slide 20:

As with electrical stunning, positioning of the stunning (captive bolt) gun is important. This differs according to the species, the presence of horns and the animal's age.

For example:

- Cattle are best stunned with the weapon against the front of the face. The optimum shooting position is at the intersection of two imaginary lines drawn from the rear of the eyes to the opposite horn buds (illustrated on the left of the slide). The gun must be positioned towards skull at a 90 degrees angle.
- For pigs, the optimum shooting position is along the midline of the skull, approximately 2.5 cm above the imaginary line connecting the eyes. In mature sows and boars preferably 1 cm either side of the midline.
- In water buffalo the skull is thick at the front and stunning is more effective if they are stunned at the back of the head. High-velocity bolt pistols are necessary; the exact direction of the stun depends on the age of the animal.
- In sheep and goats without horns the position is on the top of the head, at the highest point of the skull. In horned sheep and goats the stunning gun is positioned just behind the ridge connecting the horns while the gun is aimed towards the angle of the jaw.

You will need much more detail and practical training to enable you to stun an animal yourself.

Slide 21:

We have already mentioned that gas may be used to stun or kill animals. The correct concentration of gas initially stuns the animal and subsequently causes irreversible pathological changes that kill the animal.

Gas stunning is used for poultry and pigs: the animals are placed in chambers with high concentrations of CO₂ (carbon dioxide) or argon gas. These induce a stunned state followed rapidly by death from anoxia.

Argon is an inert gas that displaces oxygen; it is not sensed by the animal. At high concentrations, CO₂ acts as an anaesthetic gas; however, there is a period of time before the

induction of a stunned state during which the animal may find the sensory aspects of the gas (acidic, cold) aversive and pungent while causing respiratory distress.

Welfare concerns with gas stunning depend on the exact mixture of gases; they include:

- breathlessness before birds lose consciousness due to anoxia
- convulsions if oxygen concentrations are very low.

The aversive effects of CO₂ and the relatively high cost of argon mean research into optimal methods is ongoing. From a practical point of view, issues of ventilation and draughts can affect the efficacy of a gas mixture, and is one of the issues you would consider if you were auditing a plant and found a high percentage of unstunned animals.

Slide 22:

With the various methods of stunning unconsciousness is not always permanent and, in the case of electrical stunning, it is very brief. Therefore, killing must be carried out without delay to avoid any potential return of sensibility. However, it is important not to kill the animal without first being sure that the stunning has been effective.

Depending on the method, some of the signs that stunning has been effective include:

- lack of corneal reflexes and blinking
- head hangs straight down
- tongue may hang out
- body hangs straight down – no arching of the back or struggling (although the legs may move)
- gasping and gagging reflexes, but no rhythmic breathing or vocalisations
- no peripheral body reflexes, i.e. when pricking nose.

Slide 23:

Following stunning, exsanguination is achieved by cutting the major blood vessels in the neck (carotid arteries and jugular veins).

We will now look at the particular welfare concerns with slaughter by cutting the neck without stunning.

Keep in mind that these concerns equally apply where stunning has been attempted but has been ineffective. In both situations, the animals are conscious when their necks are cut.

Slide 24:

Module 27 looks more closely at the role of animals in different religions and how their welfare may be affected by religious belief.

Briefly, the Jewish method of slaughter is called *schechita* and it produces kosher meat. Stunning is not permitted.

The Muslim method is called *dhabh* or *zabiha* and it produces halal meat. (*Kosher* and *halal* both mean 'permitted'). Some Muslim authorities allow stunning before the bleeding, some afterwards.

The methods used in religious slaughter were considered to be best practice when they were introduced more than 1,000 years ago, so both Jewish and Muslim slaughter requirements include gentle handling of animals and rules about having a smooth and very sharp knife.

However, modern advances in understanding of animal suffering and welfare raise questions over slaughter without stunning.

Slide 25:

The slide lists the particular welfare concerns of slaughter without stunning, including the following:

- If animals are conscious when their throat is cut they may experience pain, fear, anxiety and distress from the method of restraint and from the cut itself.
- If it takes the animals a long time to lose consciousness they may feel further distress due to hypotension caused by blood loss.
- Cutting the throat may cause aspiration of blood into the upper and lower respiratory tracts and alveolar haemorrhage during agonal breathing. If animals have not lost consciousness while these changes occur this presence of blood may cause pain and distress.

Research is ongoing to investigate these concerns scientifically. As you will see, some of the issues are biologically complex.

Slide 26:

We'll begin looking at some of these concerns by considering methods of restraint for slaughter without stunning.

The animal needs to be restrained in such a way that the slaughterer can cut the throat effectively with one cut (this need is the same as the need for appropriate restraint to allow stunning).

For slaughter without stunning, restraining animals on their backs is very stressful and causes many or all of them to vocalise. Auditing the percentage of animals vocalising during restraint is a useful way to assess welfare pre-slaughter in secular and religious slaughter alike.

The most comfortable way to restrain animals for slaughter is upright. A study of the electroencephalograms of 31 veal calves that were killed without stunning indicated increased brain activity when they were held upside down in the rotated position and the authors concluded that the animals found this rotated position distressing. In religious slaughter, the restraint box may be slowly rotated to facilitate cutting. If the cut is made within seconds of rotation animals do not vocalise any more than if they are kept upright.

A second concern with religious slaughter is that animals experience distress and pain when their necks are cut.

Observational data suggest that when religious guidelines are followed, animals do not show any behavioural reactions to the cut. However, the electroencephalogram data in the above study of calves indicated that the knife did cause pain. This was a concern because it took approximately 80 seconds for the animals to lose consciousness.

This finding is not surprising from our knowledge of nociception as skin, muscle, nerves and other soft tissue are all cut. However, the lack of observable physical reaction in ~95 per cent of cases may indicate that the pain is not severe.

In either case, however, the question of how long it takes for animals to lose consciousness is very important. We will look at this next.

Slide 27:

We have seen that with well-conducted stunning in secular slaughter animals lose consciousness in less than a second. We also noted that if animals are not unconscious within 200 milliseconds they may feel the effect of the stunning.

With religious slaughter anecdotal data suggest that 90 per cent of cattle collapse and lose consciousness within 17 seconds of being slaughtered by knife. For sheep it is quicker, typically in 14 seconds.

However, studies of halal and shechita slaughter of cattle and water buffalo, and of cattle that are stunned and then cut, all indicate that some animals may undergo protracted perfusion of the brain which delays the onset of unconsciousness.

This is because the haemorrhage is impeded by the formation of false aneurysms at the cephalic ends of the severed carotid arteries that prevents fast bleeding. In addition, in cattle the brain is supplied by vertebral arteries that cannot be severed by neck cut. This can cause prolonged slow bleeding and delayed loss of consciousness.

The aneurysms can form within seven seconds of the cut and, where animals are not stunned this may cause some to remain conscious for more than 60 seconds.

Larger studies are needed, from a greater number of abattoirs. However, studies involving samples of 100 to 200 cattle have been conducted in Indonesia, Belgium and the UK. They suggest that 5–14 per cent of cattle that are killed without stunning may suffer prolonged consciousness due to early formation of false aneurysms.

That research also suggests that false aneurysms seem much less likely to form early on if

the animals are cut at the level of the first cervical vertebrae, instead of the traditional position between the second, third, fourth or perhaps fifth cervical vertebrae.

Slide 28:

The fourth concern about slaughter without stunning is that the conscious animal aspirates blood into the trachea and lungs, which may cause pain.

This is being studied as it is known that cutting the neck causes blood to flow onto the animal's glottis and to enter the windpipe and alveoli in some cases. It was thought that animals could not feel this because the cut was made at the level of the third to fifth cervical vertebrae, which severs the recurrent laryngeal nerve. It is important that animals do not feel it because the cut also means that they would be unable to cough in response, owing to the vagus nerve being cut.

More recently, however, there has been evidence that some sensation could be retained from afferent branches of the cranial laryngeal nerve which is anterior to the level of the cut.

A 2012 study on the formation of false aneurysms (Gregory, et al., 2012) concluded that making the cut at the level of the first cervical vertebra in order to prevent the aneurysms from forming rapidly could also help to minimise the likelihood of the animal feeling blood in the airways while not being able to cough.

Slide 29:

We have now outlined the chain of events that take an animal from the farm to commercial slaughter.

We have noted the main welfare concerns in pre-slaughter handling and restraint, the effectiveness and duration of the stun under different methods, and the concerns about slaughter without stunning.

Another concern (common to all types of slaughter) is whether animals are distressed if they see another animal being stunned or killed. We will look at this next.

Slide 30:

Many countries have made it unlawful for living animals to be in the same area as animals who are being killed or butchered. This is also a stipulation of halal slaughter.

But other countries do not specify this, and in many slaughter plants both dead and living animals mix in the same space. The picture illustrates this: at the top right you can see an eviscerated carcass. There is also a lot of blood on the floor and walls.

Many animals do not seem to sense death because they don't try to move away from recently killed animals. However, it may be prudent to assume that animals' well-developed senses of smell, taste and social awareness may be influenced by the slaughter environment.

For example, seeing or smelling blood is not thought to cause distress unless the animal whose blood is present had been distressed during slaughter (e.g. he or she struggled and vocalised).

Studies of empathy in animals are investigating whether animals have an emotional reaction to the emotion and experience of another animal. It is a very new field but studies of ewes with their young following castration and studies of corvids (crows and related birds) suggest that animals may feel empathy.

In the case of slaughter, empathy has not been studied well and it is very challenging to design effective research. For example, it is hard to distinguish a general response to feelings of distress in the observer animal from feelings of empathy that the animal may have in response to what the other animal is feeling.

Slide 31:

Now that we have looked at areas of welfare concern during stunning and killing, we will outline how you can use audits to monitor their occurrence.

Audits are a simple way to raise awareness amongst slaughter personnel and to help them improve standards of care. They have been shown to be very effective in several countries including the US, Brazil, Chile and Uruguay.

Once you have audited a slaughter plant you can discuss the economic aspects of improving conditions: while some changes require major investment, many do not (as in the case of animal handling). Implementing better practice may also increase profits because meat quality will improve.

Slide 32:

There are two main methods of auditing slaughter plants. Both have been shown to be feasible, valid and reliable.

One is a numerical scoring system developed by Professor Temple Grandin. This system assesses the percentage of animals showing very specific signs at different points during the slaughter process. The system measures welfare outputs (i.e. animal-based measures) in 100 animals for each point of concern. Measurements are based on clear 'Yes/No' questions, so you can calculate the percentage of 'Yes' vs. 'No' for the presence of each welfare concern.

There are cut-off points beyond which a plant fails the audit if more than a stated percentage of animals show the signs of concern.

This system has been applied very successfully in the US and several Asian and South American countries.

The other method is of auditing stems from the Welfare Quality® project (discussed in several other modules).

The Project was a joint venture between the European Union and four Latin American countries: Uruguay, Mexico, Chile and Brazil. It uses a 12-point framework to assess farm animal's experience during life and slaughter.

At slaughter plants it is applied to differing numbers of animals depending on the species and the welfare point concerned.

It includes some welfare inputs as well as welfare outputs. Like the first method, it is based on 'Yes/No' questions, but also grades some issues as 0, 1 or 2. For example: in lairage, if the drinkers and the water itself are clean, the score is '0'; if the drinkers are dirty but the water is clean, the score is '1'; if both the water and drinkers are dirty, the score is '2'.

These methods are examined in more detail in the following slides.

Slide 33:

The numerical scoring method of auditing welfare at slaughter is based on the OIE standards of transport and slaughter. It specifies five variables when auditing animal welfare at slaughter.

1. The percentage of animals that are effectively stunned at the first attempt: at least 95 per cent of cattle must be stunned effectively on the first attempt.
2. The percentage of animals that show signs of regaining consciousness before slaughter is complete: if any animals show signs of regaining consciousness before being hung on the rail, the slaughterhouse fails the audit.
3. The percentage of animals that vocalise during handling and stunning: less than 5 per cent of pigs should vocalise when in the restrainer box or stunning pen.
4. The percentage of animals that fall during handling: handling practices or flooring need to be improved if more than 1 per cent of the animals fall during handling
5. The percentage of animals that are moved with an electric goad: this should be fewer than 25 per cent (depending on the species) and the goad should only be picked up when an animal refuses to move.

These standards are easy to assess: for each animal the criterion of care is either met or it is not met. Then you calculate the total number of animals where the criterion is not met and estimate the overall percentage of animals affected; that percentage tells you if the standard of care concerned has been met overall or not.

Slide 34:

Following the OIE, the practices shown on the slide are absolutely prohibited.

Note that the numerical scoring approach to welfare assessment does not mean that other aspects of animal handling during the slaughter process are not important. For example, welfare problems that occurred on the farm and during transport can also be assessed in a slaughterhouse welfare audit, as shown on the next slide.

Slide 35:

Welfare problems that occurred on the farm and during transport can be assessed in a slaughterhouse welfare audit, using similar numerical scoring for the percentages of:

- lame animals
- thin animals
- dirty animals
- animals with sores, bruises or lesions
- animals that are dead on arrival or die before slaughter takes place
- animals with disease or injuries
- birds with broken wings and broken legs.

Slide 36:

An alternative system for auditing an abattoir is the framework provided by the Welfare Quality® project.

This slide shows which of the 12 welfare criteria are applied when auditing the welfare of pigs and of beef cattle at slaughter, including unloading and lairage.

Note that not all the criteria are used in both species; this is because trials indicated that obtaining the information was either not feasible or did not generate reliable data. For example the two criteria under 'Appropriate behaviour' are not assessed for pigs or beef cattle.

This auditing framework is more complex than the numerical scoring one. If you are a vet who works for an abattoir and the plant is not part of an external monitoring scheme, you will probably find it easier to use the numerical scoring system.

We shall now look briefly at how you might apply the results of an audit.

Slide 37:

If you found that 45 per cent of animals received prods from an electrical goad as they were moved into the restraining box, you might then look for inter-related causes such as:

- slippery floors in the walkway or in the box
- shadows falling on the floor of the walkway or the box
- noise from the equipment or from people shouting
- gusts of air blowing through the area
- whether the goads were all done by one particular member of staff and what training staff were given.

In another example, you might find that 15 per cent of cattle were not stunned at the first attempt. In the case of captive bolt stunning you might need to look at factors such as:

- how fast the animals were being put through
- whether the pistol was being cleaned and oiled regularly and properly (e.g. if the trigger was dirty, causing it to misfire)
- how the cartridges were stored (e.g. if they were damp)
- the experience of the operator (i.e. shooting cattle too high on the forehead)
- whether the pistol was powerful enough to stun cattle with thick, heavy skulls.

In both these examples, you might also enquire about the meat quality – whether there was also a lot of bruising or PSE/DFD meat. You could then use that information to help the plant's owner to quantify how much the high percentages of goading/non-stunning was costing him/her.

Slide 38:

We have seen that auditing can improve welfare problems within individual plants. Legislation can also help.

In countries without much legislation the minimum standards defined by the World Organisation for Animal Health (OIE) provide a useful starting point. However, note that legislation also requires enforcement.

In many countries legislation may not be effective because of factors such as:

- Limited resources – the slaughter plant may not have the manpower or knowledge to provide adequately skilled and professional personnel to oversee slaughter. Alternatively, the local authority or policing organisation may not have the manpower, time or will to monitor this area of animal use.
- Limited training of slaughterhouse personnel – the techniques for best practice of slaughter are widely described and may be laid down in local legislation. However, if staff are not trained in these techniques, they will be unaware of the ways in which they could show improved levels of professional skill.
- A lack of willingness by local authorities to consider slaughter as an area where animal welfare is of concern as the animals have only a 'short time to live'.
- Local or regional differences in accepted practices – this could mean that producers know that it is possible to 'get away' with something in one region that would be prevented in another.
- The enforcement body may share interests with those policed, or the industry is policed 'internally' – e.g. the body responsible for the protection of welfare at slaughter plants is also responsible for carcass inspection, or management of other parts of the process and is

not impartial in its link with the processor or slaughterhouse.

- The legislation may be poorly designed and therefore difficult for the courts to interpret if a prosecution is made.

Slide 39:

You now have an understanding of how reducing animals' stress at slaughter can result in better meat quality and therefore more income for the farmer and the abattoir owner.

You also know that humane slaughter minimises animals' stress and improves their welfare using simple techniques such as gentle handling and the use of methods that allow rapid loss of consciousness.

You have also seen that scientific research is the basis of improvements in welfare at slaughter because it gives us an understanding of the animal's experience based on their physiology.

Finally, you also now have a basic background in how to audit plants, which will help your clients maximise their income while safeguarding animal welfare.

There are lots of issues that we have not covered, such as the low economic value of culled animals (causing them to be handled very roughly and slaughtered inhumanely). However, by applying the principles that we have covered today, you are in a position to be aware of and help to address those problems too.