
The Last Day of a Hen's Life: Depopulation and Transport

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Once egg laying hens reach the end-of-lay period (when they are referred to as 'spent hens'), they are removed from layer farms in a process known as depopulation. Every year billions of laying hens are depopulated and either shipped to slaughterhouses or disposed of in other ways. As we explore in this chapter, the depopulation of laying hens and their care until they are killed remains one of the most serious welfare problems in the poultry industry.

One amplifier of the poor welfare outcomes endured by spent hens is their low commercial value [1]. Compared to other poultry species bred for meat production, laying hens are characterized by a much lower proportion of edible meat, which tends to have a more rigid texture (their meat is perceived by consumers as being too 'tough'). End-of-lay hens also have extremely fragile bones (Chapter 3 [2]), which may lead to the presence of residual bone fragments in the meat after deboning [3]. The poor health, plumage condition and skeletal strength that is typical of many end-of-lay flocks also make them less apt to withstand the challenges associated with transport and traditional slaughter [4]. The proportion of hens found dead on arrival at the slaughter plant is often higher than for broilers and other poultry species [5]. Not surprisingly, few slaughter plants are able or willing to accept end-of-lay hens, so long distance road journeys of several hours are often required to reach the small number of facilities to where they are shipped [6]. In other cases, producers do not get enough income from the birds to pay for the transport costs, so birds are killed within the farms or sold live for local markets at a very low price [7]. In the United States, for example, approximately 65% of spent hens are sold for slaughter, and 35% are rendered, destroyed or disappear (Figure 7.1). In general, the low commercial value of these birds means there is little financial incentive to encourage their careful handling once they are no longer efficient at egg production [8].

The poor handling of spent hens is further exacerbated by lack of proper training and the existence of incentives for high throughput under pressure to complete the work quickly. There is little systematic information on the catching industry of spent hens, but information available for the catching of broilers provide a general idea of the challenges imposed by the procedure. For example, in Brazil, catching and loading of broilers is often conducted by small outsourced teams of about 10 workers, most young and uneducated, some without formal contracts. Not uncommonly, they catch over 50 thousand chickens per shift [9]. This pattern does not seem atypical, with reports in the United States indicating the use of crews of seven to ten men to catch and crate 7,000 to 10,000 birds per hour during eight-hour shifts [10]. Given the much lower number of laying hen facilities compared to broilers, and the more occasional nature of this job, it has been suggested that staff is even less specialized for the catching of spent hens. In the United Kingdom, typical catching rates are of approximately 5,000 hens caught and loaded per hour per team of 8 catchers [11], or about 10 hens

per minute per catcher. To make matters worse, independent welfare auditing during depopulation and transport is nearly non-existing.

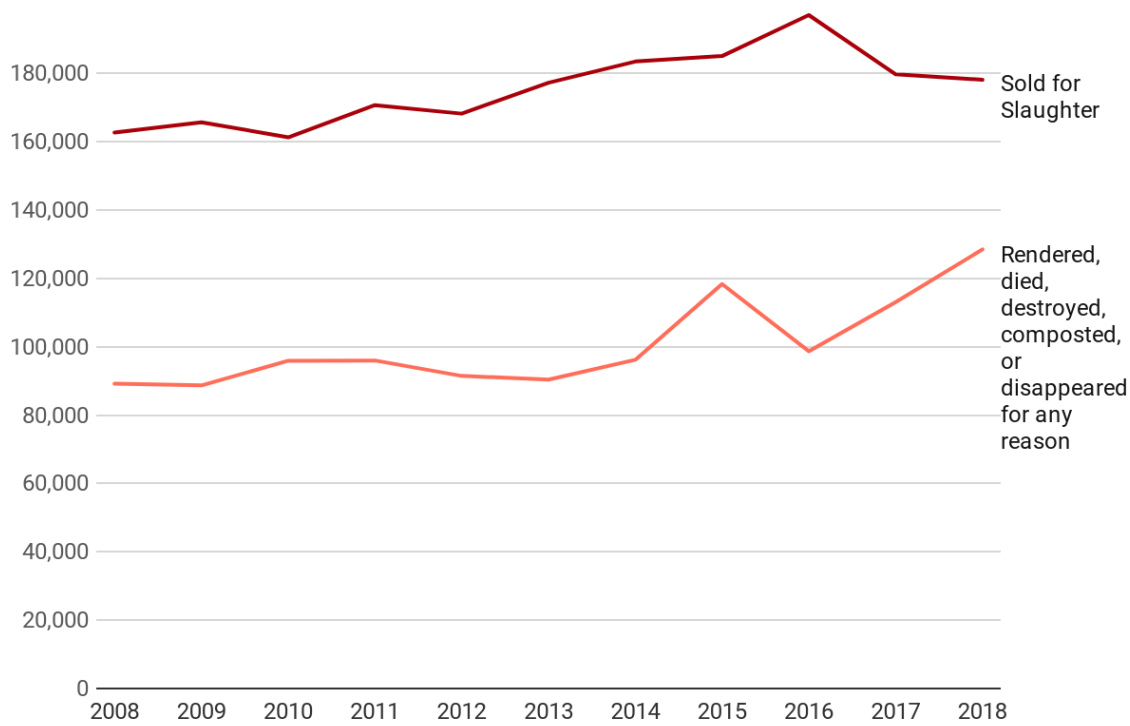


Figure 7.1. Number of laying hens (in thousands) sold for slaughter, or with alternative fates, in the United States, from 2008 to 2018. Source: NASS - [National Agricultural Statistics Service](#) (USA)

In this chapter, we review existing evidence on the welfare challenges endured by laying hens during and after depopulation and propose a tentative scheme for the classification of the intensity and duration of the multiple harms to which they are exposed in the last day of their lives. We start by briefly reviewing the procedures, and durations, typical of the depopulation and handling of hens until their arrival in the slaughterhouses.

Common Practices

Before depopulation food is withdrawn from hens to reduce defecation (and soiling of the birds) during transport, as well as fecal contamination of the carcasses during processing. Water is also removed at the beginning of the catching process. From then on, spent hens will not have access to either water or food. In the European Community, legislation suggests that adult birds should not be deprived of feed and water for more than 12 hours (Council Regulation EC No 1/2005). In Australia, the Land Transport of Poultry code does not allow for greater than 24 hours crating of birds. However, as we'll see, practiced times often exceed this limit.

Although the depopulation process can be performed mechanically, most hens are removed from their cages manually. In this process, often performed in semi-darkness, each hen is pulled out by one leg and then held upside-down by the catcher (although most codes of practice recommend holding the hens by both legs, compliance is not always observed). During removal, they may be struck against the cage furnishings, such as the food trough or the cage small doors [12]. In furnished cages the process is more difficult, as their higher depth makes access to the birds more difficult. In these cages, hens may also collide against the perches. Catchers usually hold three to five birds in each hand before passing them on to another person, who will carry them out of the house to be loaded onto crates of about 5 to 15 birds each, or about 50 to 60 Kg per square meter [7,13]. In larger facilities, hens may be passed along three to four times from person to person, in a human chain, before being crated. Here, too, they may also hit house structures as they are carried [12]. The larger the house, the longer the hens will be suspended by their legs. A study in the United Kingdom found that, on average, hens spend about a minute in contact with humans before being crated [14]. The inverted position places an extraordinary strain on the joints, in many cases leading to traumatic dislocation [15]. Wing flapping and struggling while inverted is not uncommon, increasing the likelihood of injury. Placement into the crates often involves pushing the hen through a relatively small opening, during which their wings may be broken. In those crates with a lid or where a drawer must slide into a module, birds may also get trapped and injured [16]. Steps are similar for cage-free flocks, although cage-free houses can pose more challenges to catch the birds. For example, hens may pile up at the extremities of aisles (which may cause suffocation of some individuals), or move to the back of the tiers, where they are not reachable. To make the process easier, some teams drive the hens to a restricted area (e.g. a pen) before depopulation is initiated.

Once the last hen is loaded, transportation journeys begin. In a study of transport practices in Brazil, the average time laying hens spent in crates, from the moment they were loaded until they were unloaded at the slaughter plant, was of approximately 18 to 20 hours [7]. In Ontario, Canada, transportation times within the province lasted 18 hours on average and 26 hours in interprovincial journeys [17]. In Australia, transport journeys have been reported to last up to 32 hours [18]. When arriving at the slaughter plants, most end-of-lay hens are reported to be manually removed from containers [12].

Impact of Welfare Challenges

Hens are exposed to several concurrent stressors during depopulation and transportation. In addition to a high prevalence of new fractures and lesions, they are also affected by thermal stress (either cold or heat stress, depending on the environmental conditions), metabolic exhaustion, thirst and dehydration, and the psychological distress associated with exposure to multiple stressors (noise, vibration, social disturbance, physical pain) and the transportation in crowded conditions.

Here we analyse the main welfare challenges associated with this process, represented in Pain-Tracks 7.1 to 7.4. Because heat stress, dehydration and metabolic exhaustion are closely intertwined in terms of symptoms (symptoms greatly overlap), we chose to treat them as a single welfare offense, but distinguish those cases where heat stress is fatal (heat stress is the primary cause of mortality during transport). In addition, we also propose a **Pain-tTrack** for bone fractures endured during depopulation and transport.

All four **Pain-Tracks** are divided into ten time segments, each with a duration depicted by an uncertainty interval shown below each segment. The first five segments represent the period from initiation of the depopulation process until the last hen is loaded onto trucks. This process may last anything from 2 to 8 hours (from initiation until the beginning of the journey to the slaughterhouse) depending on the capacity of the house and the number of catchers involved when depopulation is manual. Naturally, most hens will not be immediately removed from their cages once the process begins. We estimate that hens will, on average, spend half of this period (1-4 hours) in their cages (or pens) before being caught ('initiation' phase in the **Pain-Tracks**). During this time, they only witness the catching of other layers and the presence of catching teams in the house. The transportation journey is split into two time segments (vi and vii, corresponding to the first and second half of the journey) due to the long duration typical of the transportation of laying hens, and the possibility of aggravation of many conditions. Based on the reported statistics on journey times discussed in the previous section, we estimate that transportation journeys may last anything from 6 to 30 hours in total. The next sections address each welfare challenge.

New Bone Fractures

The capture and handling of laying hens during depopulation results in a high incidence of new fractures in all housing systems. Commonly broken bones include hip and leg bones (humerus, ischium and pubis), along with the keel and wings, which may be broken when the birds are placed into the crates [19].

Previous research has shown that better handling during depopulation can substantially reduce injury rates (e.g. from 14% to 5% in broilers [20]). Thus, we assume that fractures occur predominantly during the process of catching, carrying and placement in the crates. Evidence on the intensity and temporal evolution of the pain associated with bone fractures has been extensively discussed in Chapter 3 [2]. However, different from fractures endured over the laying cycle, the pain and discomfort resulting from pre-transport fractures is likely exacerbated by many factors, including the existence of previous fractures, the older age of the hen, the traumatic mode of fracture, the vibrations, accelerations, braking and other environmental stressors in the journey to the slaughter plants [6,8]. It has been previously shown that motion and moderate vibration are aversive to poultry even in the absence of any traumatic injury [21,22]. In injured birds, these physical forces should amplify the pain associated with a new fracture, especially if periosteal nociceptors become hyperalgesic due to inflammation [23]. In longer journeys, birds are expected to suffer progressively more [24]. It has been even suggested that the ability of injured birds to withstand the stressful transport conditions is greatly impaired, leading to higher mortality rates during transport [23]. For this reason, in many countries legislation dictates that birds with fresh or unhealed fractures are "unfit for transport" due to the inevitably greater potential for pain and suffering [6], although in practice this requirement is not fulfilled. In light of these factors, in **Pain-Track 7.1** we propose that the intensity of the pain associated with a new fracture, from catching until the end of the transport journey, fits the definition of the disabling category (see Box 1.2 in Chapter [25] 1 for a definition of intensity categories). However, the possibility of a greater intensity (compatible with the excruciating category) in a small fraction of the animals (or for a small fraction of the time) in the moments immediately following the fracture (when the hen is intensely manipulated) cannot be ruled out.

Pain-Track 7.1. Hypotheses proposed for the temporal evolution of the pain endured as a result of fractures suffered by laying hens during depopulation (see Box 1.2, Chapter 1 [25], for the definition of each intensity category).

	i. initiation	ii. Catching	iii. Carrying	iv. Crating	v. Waiting	vi. Transport (1)	Vii. Transport (2)	viii. Unloading of Truck	ix. Crate removal	x. Lairage
Excruciating		5%	5%	5%					5%	
Disabling		95%	95%	95%	100%	100%	100%	100%	95%	100%
Hurtful										
Annoying										
	1-4 hrs	1-2 min	0.5-3 min	5-30 sec	1-4 hrs	3-15 hrs	3-15 hrs	10-30 min	15-60 sec	0.5-3 hrs

Heat Stress, Dehydration and Metabolic Exhaustion (Non-Fatal)

Heat stress (hyperthermia) represents a major source of poor welfare during transportation. Although birds are homeotherms (they are able to maintain their body temperature within an appropriate range under normal circumstances), multiple factors severely compromise their ability to thermoregulate during road journeys. Poor ventilation, high temperatures and humidity all contribute to heat stress, with high stocking densities, water deprivation and the metabolic exhaustion that is typical of these journeys aggravating the problem. The possibility to lose body heat by adjusting posture or behavior (e.g., by lifting their wings away from the body or moving away from other birds) is also compromised in the crowded crating conditions.

Unfortunately, most vehicles used to transport spent hens do not provide controlled environmental conditions. Extremes of thermal conditions are possible within the same load [16], with either too little or too much air movement in different parts of the truck [26]. Often, side curtains are used as protection against precipitation, wind and solar radiation, and to hide the birds from public view [12]. However, by restricting ventilation, they cause heat and moisture to build up around the birds [12].

One of the first visible signs of heat stress is panting. Since birds do not have sweat glands, they evolved other mechanisms to keep their temperature from rising. Panting is one important means whereby excessive heat is dissipated through evaporation of the air from the respiratory tract. Although panting can be sustained for long periods of time, when air moisture levels are high, expelling out the air becomes harder. To compensate, breathing rates can increase by as much as 10 times the resting rate [27]. Rapid breathing, which consumes a lot of energy, can tire the animals, further reducing their ability to cope with extended periods of heat stress [27].

Heat stress is also aversive to poultry in other ways. Birds subjected to heat stress have been shown to reduce feeding and movement in general, up to the point of irreversible lethargy, as discussed in the next section. Stress hormones, such as elevated plasma corticosterone concentrations also appear in the blood [28]. The immunosuppressive effects of heat stress are similarly well established, and

include higher heterophil:lymphocyte ratios, reduced thymus, spleen, bursa, liver and lymphoid organ weights, as well as lower levels of total circulating antibodies, and lower specific IgM and IgG levels during primary and secondary humoral responses [28].

Heat stress also compromises the welfare of hens by exacerbating feelings of thirst, as suggested for other species [29], and other symptoms of dehydration. Although under normal environmental conditions hens can sustain extended periods of time without water, dehydration is substantially increased by heat stress. Because the pathophysiology and symptoms of cellular and extracellular dehydration seem to be comparable in birds and humans (Box 7.1), we start by describing them for the latter case, for which extensive literature exists. Dehydration often becomes noticeable after 1-2% of loss of water volume. With mild dehydration (<5% body mass loss), subjects experience thirst and discomfort, an adaptive mechanism to ensure that animals seek and consume water [30] (indeed, the demand for water is inelastic in most species [31]). Other symptoms at this stage can include loss of appetite, elevated body temperatures and fatigue. Symptoms become increasingly severe with greater water loss, with heart and respiration rates increasing to compensate for the lower plasma volume and blood pressure [32]. With around 5% to 6% water loss, individuals may become sleepy, experience nausea, and may feel tingling in their limbs. With about 10% to 15% of fluid loss, muscle cramps may be experienced, vision may dim and urination will be reduced and may become painful.

Box 7.1. Pathophysiology of Severe Dehydration

At the initial stages of water deprivation, plasma Na^+ concentration (osmolality) is kept constant at the expense of blood volume. If deprivation lasts longer, osmolality increases since the decrease in blood volume is blunted to protect the heart against the increased blood viscosity. The reduction in blood volume eventually leads to arterial hypotension. Compensatory mechanisms promote peripheral vasoconstriction, increased cardiac contractility and tachycardia, which in turn increases myocardial oxygen demand which, together with reduced tissue perfusion, may lead to myocardial failure. Finally, the anaerobic metabolism triggered in response to reduced perfusion may produce acidosis and, together with myocardial dysfunction, contribute to multiorgan failure [33].

These observations find parallels in many bird and mammal species. In laying hens, two hours of water deprivation has been shown to induce frustration-induced aggression towards a subordinate hen [34]. In white leghorn hens, six hours of water deprivation under normal environmental conditions were associated with an increase of about 4% in osmolality [35]. Body mass, in turn, typically drops over 5% after 24 hours of water deprivation [36,37], a loss typical of moderate levels of dehydration in humans. Most birds would require veterinary care when reaching 10% weight loss due to dehydration [38]. Symptoms of fatigue are likely magnified by the progressive depletion of liver glycogen (which provides a ready source of metabolic fuel in the form of glucose) with journey time [12], as suggested by observations that many birds arrive at the slaughterhouse in an apparently exhausted state [12].

In light of existing evidence, we propose a tentative scheme for the time course of the negative sensations associated with heat stress, dehydration and physiological fatigue, represented in

Pain-Track 7.2 ¹. We estimate that in the period of 1 to 4 hours while waiting on the crates to be loaded onto trucks (phase *v*), hens only experience mild thermal discomfort and thirst, at the annoying level, with a small percentage of birds (10%) experiencing distress at the hurtful (more disruptive) level in those cases of longer waiting times. As the journey progresses, the degree of unpleasantness associated with these feelings is increased, with a proportionally greater number of hens experiencing higher pain intensity as the journey progresses (phases *vi* to *x*). The distribution of probabilities in the Pain-Track can be understood as the likelihood of pain at each intensity category, or the fraction of hens experiencing discomfort at each category.

Pain-Track 7.2. Hypotheses proposed for the temporal evolution of the pain endured as a result of heat stress during the journey to the slaughterhouse (see Box 1.2, Chapter 1, for the definition of each intensity category).

	i. initiation	ii. Catching	iii. Carrying	iv. Crating	v. Waiting	vi. Transport (1)	Vii. Transport (2)	viii. Unloading of Truck	ix. Crate removal	x. Lairage
Excruciating										
Disabling						20%	40%	40%	40%	50%
Hurtful					10%	50%	50%	50%	50%	50%
Annoying					90%	30%	10%	10%	10%	
	1-4 hrs	1-2 min	0.5-3 min	5-30 sec	1-4 hrs	3-15 hrs	3-15 hrs	10-30 min	5-30 sec	0.5-3 hrs

Heat Stress, Dehydration and Metabolic Exhaustion (Fatal)

Not all laying hens reach the slaughter plants alive. Those that perish on the way are often referred to as ‘dead on arrivals’ (DOA). As with other welfare harms discussed in this book, global estimates of DOA for laying hens have not been systematically collated. Where investigated, they have been reported to range from 0.27% in the UK [5] to 1.01 and 1.22% in the Czech Republic and Italy [39,40] and 1.73% in Brazil [7]. Even in those countries with lower mortality rates, such as the United Kingdom, 93% of the loads are reported to have DOAs [5]. Death rates may, however, increase significantly along with changes in ambient temperature and transport duration. In the USA and Canada, an increase in hen mortality, from 0.7% to 2.3%, have been reported as the time between loading and unloading increased from under 12 hours to over 24 hours [17].

Death from hyperthermia is preceded by the symptoms discussed in the previous section, including rapid breathing rate, tachycardia, fatigue, nausea and the concurrent metabolic changes described. As the loss of water and electrolytes progressively disturbs their chemical balance, multiorgan failure occurs and the bird dies (Box 7.1). Here, we adapt Pain-Track 7.2 to describe the time course of pain at each intensity level of an individual hen that died of heat stress during transportation. To this end, we

¹ Although these negative experiences are not typically referred to as pain, the definition of pain (*‘an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage’*) can also be applied to describe affective states emerging from unmet physiological needs (e.g. thirst, hunger) and perceived as unpleasant (see Box 1.1 of Chapter 1 [25]).

assume that the hen dies on the second half of the transportation journey. The hypothesis is represented in Pain-Track 7.3.

In terms of intensity, when a bird is severely dehydrated, there may be symptoms of disorientation and seizures. In humans, neurological signs, consisting of lethargy, weakness and confusion appear with great losses (>10%) of body water [41]. Interestingly, there is evidence in mice to suggest that neurological disturbances at this level may compromise the body's ability to perceive pain. Mice exposed to prolonged osmotic stress due to dehydration showed a significant decrease in pain perception, probably as a consequence of changes in the metabolism of dopamine and serotonin [42]. In these animals, concurrently subjected to food deprivation, pain and discomfort are moderated by the accumulation of ketones in the body, a by-product of the use of fat (instead of carbohydrates) to meet their energy needs. This process generates a form of self-sedation, the causes of which are still unknown but may be related to the metabolism of central neurotransmitters. Therefore, in its final stages, death from dehydration may be associated with less pain and discomfort [43]. Accordingly, we reduce the likelihood of pain at higher intensity categories (relative to Pain-Track 7.2) in the second half of the transportation journey, when the bird dies.

Pain-Track 7.3. Hypotheses proposed for the temporal evolution of the pain endured as a result of a fatal episode of heat stress during the journey to the slaughterhouse (see Box 1.2, Chapter 1 [25], for the definition of each intensity category).

	I. initiation	ii. Catching	iii. Carrying	iv. Crating	v. Waiting	vi. Transport (1)	Vii. Transport (2)	viii. Unloading of Truck	ix. Crate removal	x. Lairage
Excruciating										
Disabling						80%	20%			
Hurtful					20%	20%	20%			
Annoying					80%					
	1-4 hrs	1-2 min	0.5-3 min	5-30 sec	1-4 hrs	3-15 hrs	3-15 hrs			

Psychological Pain: Fear

The process of depopulation and transport has been shown to be very distressing for the birds, even in the absence of physical injuries or thermal discomfort. Physical contact with a human is known to elicit fear in laying hens [14], particularly the rough type of handling practiced during catching, carrying and crating [44]. Indeed, laying hens show substantial adrenal responses when caught [24]. High fear levels seem to persist following transportation, as assessed by measurement of tonic immobility responses [8], a classic measure of fearfulness. In general, birds do not appear to habituate to transport stress on journeys lasting several hours. In fact, evidence in broilers point to the contrary: positive associations between the duration of the journey and subsequent immobility reactions have been found, with longer journeys eliciting more extreme fear responses [45]. The hypotheses proposed in Pain-Track 7.4 reflect these findings. Acute fear, of a disabling nature (i.e. when all attention is engaged in the threat), is assumed during the process of catching, crating, unloading and crate removal. However, although unlikely in light of the evidence discussed, the possibility of

habituation during the long transportation and waiting times (phases *v-vii* and *x*) cannot be completely ruled out, hence the attribution of a 30% probability to the hurtful category at these phases. Because these probabilities effectively translate into the proportion of time spent at each category of pain intensity, they may also be interpreted as the fraction of the time spent at each category of psychological pain (or as the fraction of the population experiencing fear at each category of intensity).

Pain-Track 7.4. Hypotheses proposed for the temporal evolution of the psychological pain endured as a result of fear during depopulation and the journey to the slaughterhouse (see Box 1.2, Chapter 1 [25], for the definition of each intensity category).

	i. initiation	ii. Catching	iii. Carrying	iv. Crating	v. Waiting	vi. Transport (1)	Vii. Transport (2)	viii. Unloading of Truck	ix. Crate removal	x. Lairage
Excruciating										
Disabling		100%	100%	100%	70%	70%	70%	100%	100%	70%
Hurtful					30%	30%	30%			30%
Annoying										
	1-4 hrs	1-2 min	0.5-3 min	5-30 sec	1-4 hrs	3-15 hrs	3-15 hrs	10-30 min	5-30 sec	0.5-3 hrs

Burden of Pain in Affected Individuals

Figure 7.2 shows the time that end-of-lay hens spend in pain in their last day of life (during depopulation and transport) as a result of the concurrent stressors analyzed here. The estimates are based on the hypotheses proposed in Pain-Tracks 7.1 to 7.4, encompassing the moment from initiation of the depopulation procedure until the end of the lairage time, at the slaughter plant.

The time spent in pain due to new bone fractures is analyzed separately, disaggregated by the housing system. This is because the expected number of fractures endured during depopulation differs for hens raised in different systems, given the differences in bone strength in each case. Existing evidence indicates that, on average, 1-3 fractures ‘per fractured bird’ are sustained in conventional cages, 1-2 in furnished cages, and 1 in aviary systems (Chapter 8 [46]).

As is clear in the Figure, stressors that alone would lead to long moments of disabling pain are concurrently present in the experience of depopulation and transport. Most of the time in disabling pain is attributed to bone fractures (19, 29 and 39 hours on average in conventional cages, furnished cages and aviaries, respectively), as they are assumed to occur during the catching and crating process, at the beginning of the time period considered. Where more than one fracture is likely (furnished and conventional cages), the resulting time in pain adds to the time in pain due to previous fractures (depopulation fractures can occur in different bones, representing a source of pain at different anatomical locations). These estimates assume that the aversive experience of one harm is not affected by the other, but future refinements (including synergistic effects) are possible.

Overall, the total time in disabling pain as a result of all non-fatal welfare challenges (except fatal cases of heat stress) adds to 62 hours, 52 hours and 42 hours for hens raised in conventional cages, furnished cages and aviaries, respectively. These times are longer than the total burden of disabling pain endured as a result of other conditions, such as pecking injuries (Chapter 4 [47]) and egg peritonitis syndrome (Chapter 5 [48]), confirming the expectation that the process of depopulation and transport represents a major hotspot of suffering in commercial layers.

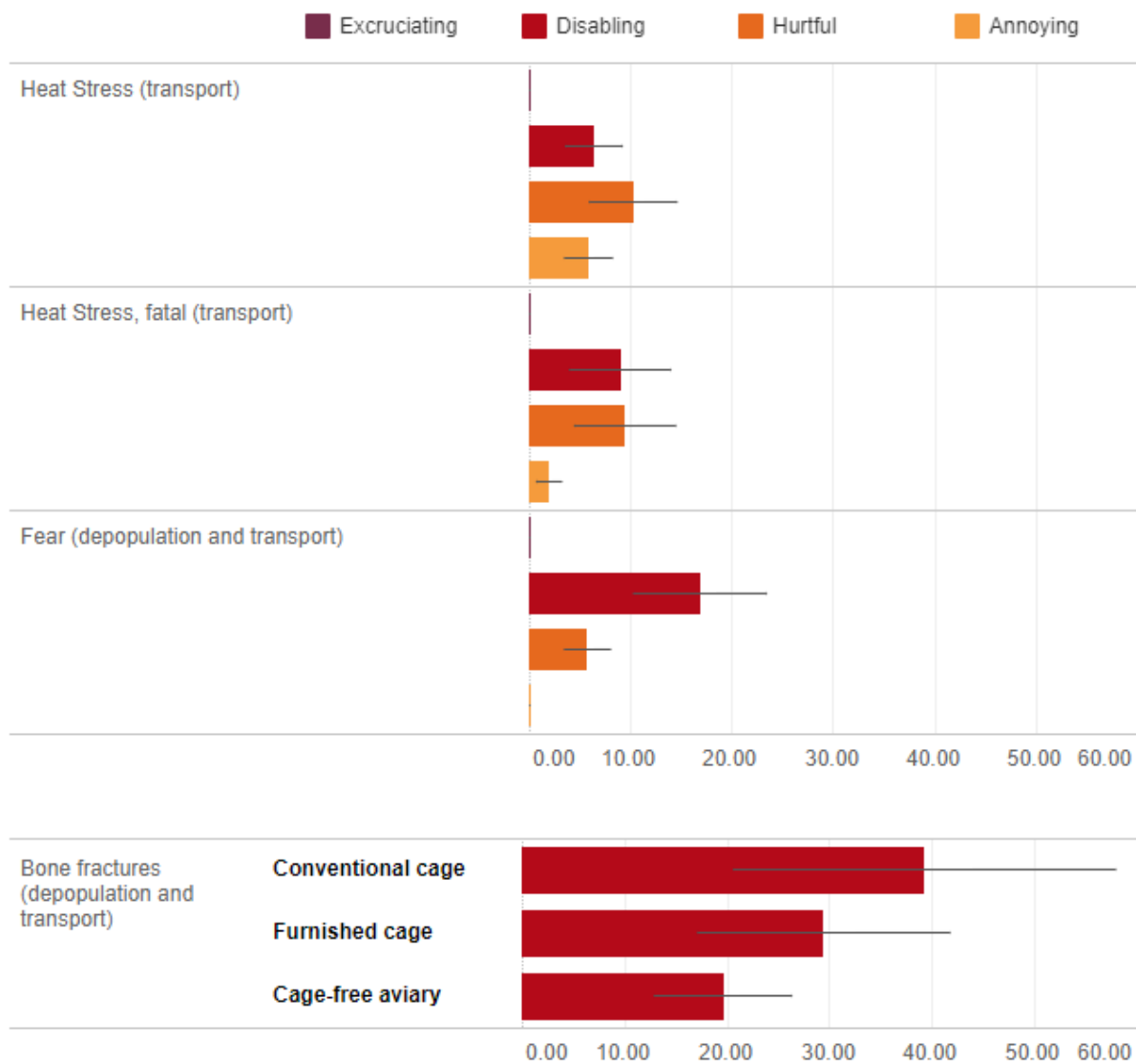


Figure 7.2. Time endured at each level of pain intensity (hours) as a result of the concurrent stressors to which end-of-lay hens sent to slaughter plants are exposed in their last day of life (during depopulation and transport). For fractures, the chart depicts the pain endured by hens that are fractured (not all hens suffer a fracture at depopulation). Error bars represent 95% confidence intervals.

Research Gaps

- ❑ Although the depopulation of laying hens and their care until they are killed remains one of the most serious welfare problems in the poultry industry, there is very little information on the catching industry of spent hens.
- ❑ Of the 7.5 estimated billion commercial layers alive every year, a substantial proportion (approximately one third in the United States) are not sent to the slaughterhouse, but instead destroyed in other ways. There is currently no published information on the fate of these birds or methods of slaughter applied in these cases.
- ❑ Of those layers sent to slaughterhouses, not all reach the slaughter plants alive. Those that perish on the way are often referred to as 'dead on arrivals' (DOA). Global estimates of DOA for laying hens have not been systematically collated.
- ❑ Similarly, statistics on journey times (longer for end-of-lay hens than for other poultry species) are unavailable for most countries.

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