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The reasons for and practice of on-farm emergency slaughter

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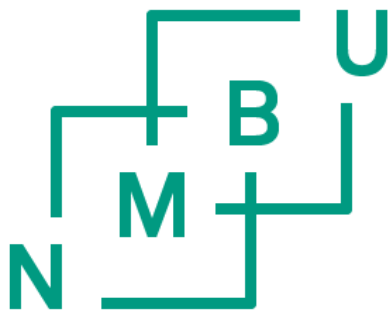
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Contents

Acknowledgements	3
List of publications.....	3
Sammendrag Norsk.....	3
Summary in English.....	4
Introduction	6
Background.....	6
The practice of OFES in Norway	6
Legal background and international comparison.....	7
Knowledge gaps	7
Aims.....	8
Materials and Methods	8
Overview of the practices of OFES of cattle in the Nordic countries (Article I).....	8
Occurrence and reasons for OFES of cattle in Norway (Article II).....	8
Results	10
Overview of the practices of OFES of cattle in the Nordic countries (Article I).....	10
Occurrence and reasons for OFES of cattle in Norway (Article II).....	10
Discussion	14
Project management and conflicts	14
Scientific discussion of the results.....	15
Conclusion.....	16
Future work	16
References	17

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List of publications

Skúladóttir G, Phythian CJ, Holmoy IH, Myhre G, Alvåsen K, Martin AD. Overview of the practices of on-farm emergency slaughter of cattle in the Nordic countries. *Acta Vet Scand.* 2022;64(1):9

Skúladóttir G, Holmoy IH, Phythian CJ, Myhre G, Martin AD. Occurance and reasons for on-farm emergency slaughter of cattle in Norway. *Unpublished manuscript, sent to Frontiers in Veterinary Science, October 2022.*

Sammendrag Norsk

«Årsaker og praksis av nødslakt»

Nødslakt er en ordning som gir mulighet til å slakte akutt skadde dyr til humant konsum som ellers ikke ville vært transport-dyktige til den grad at det ikke er dyrevelferdsmessig forsvarlig å transportere de til slakteri. Grunnet manglende data om årsakene til nødslakt av

storfe i Europa, samt at det ikke foreligger noen informasjon eller forskning på forskjeller mellom de Nordiske landene var målet til dette prosjektet å beskrive årsaken til og utførelsen av nødslakt. Dødelighet utenfor slakteri er et viktig tema sett i sammenheng med bærekraft i storfeproduksjon, og da nødslakt er en underkategori for dødelighet kan data fra nødslakt være et viktig tema i diskusjonen som omfatter både bærekraft og velferd i storfehold- og produksjon. Veiledere for nødslakt samt praksis og rutiner i 5 nordiske land (Danmark, Finland, Island, Norge, og Sverige) ble kartlagt, sammenliknet og beskrevet. Videre ble nødslakt attester fra januar, april, juli og oktober 2018 fra fire ulike slakterier i Norge samlet inn til en database og satt i sammenheng med data hentet fra Ku-kontrollen og Storfe-Kjøttkontrollen. Resultatene fra dette forskerlinje prosjektet viste at nødslakt av storfe er praktisert vesentlig mer i Norge enn i de øvrige nordiske nabolandene, noe som vil si at det er en større andel av storfepopulasjonen i Norge som blir benyttet til humant konsum sammenliknet med de andre Nordiske landene undersøkt. Videre viser resultatene at tilnærmet halvpart av studiens storfe ble nødslaktet på grunn av tilstander i bevegelsessystemet. Halthet, en underkategori til bevegelsessystemårsaker, var grunnen til nødslakt i en av 5 kasus, og denne prevalensen var enda høyere blant eldre dyr. Resultatene av studien avdekker rom for forbedringspotensialet knyttet til praksisen rundt nødslakt av storfe i Norge, særlig i forhold til digitalisering samt at regelverket bør håndheves og følges nøyer. Dessuten er det stort potensiale til å bruke de kartlagte årsakene til nødslakt for å forbedre management, veiledere og protokoller til utsjalting av dyr i besetningene.

[Summary in English](#)

On-farm emergency slaughter (OFES), known as “nødslakt” in Norwegian, is an option to slaughter compromised animals for human consumption, that for one reason or another are ineligible for transport. In the absence of data for OFES of cattle in Europe, and lack of information on the difference between the Nordic countries, the aim of this project was to describe the practice in the Nordic countries and reasons for OFES in Norway. On-farm mortality is an important topic in the context of sustainable cattle production and as a subcategory to on-farm mortality, OFES can contribute to the discussion. Guidelines and practice of OFES in the different Nordic countries were described and compared. Further, veterinary certificates for OFES from January, April, July, and October 2018, from 4 slaughterhouses in Norway were transcribed to a database and merged with supplementary registry data. The results of this research track project showed that OFES is practiced more in Norway than in its neighbouring countries, and thus contributes a bigger proportion of its

cattle production to the meat market than the other Nordic countries. Further, the project showed that nearly half of the OFES of cattle in the study were slaughtered for locomotory related reasons. Lameness was a subcategory to locomotory reasons and accounted for around one-fifth of the whole study, even more in older animals. The results showed that some improvement can be done in the practice of OFES, both in digitalisation and in following the legislation better, but furthermore, there is a possibility of using the reasons for OFES to make better management guidelines and protocols.

Introduction

Background

On-farm emergency slaughter (OFES), known as “nødslakt” in Norwegian, is an option to slaughter compromised animals for human consumption, that for one reason or another are ineligible for transport. According to data from Animalia, 4.2% of all cattle slaughter in Norway in 2018 were OFES (1). This has not changed in the following years; the reported percentage was 4.1% in 2021. Published international research on OFES of cattle is lacking, and the questions surrounding concerns of animal welfare, public health, management, and reasons for OFES, go unanswered.

Sustainability has become an important topic both within the research community and the public, in an effort to decrease the environmental impact of animal agriculture. Efficiency of meat and dairy production is essential when discussing the sustainability of cattle production (2). Reducing on-farm mortality, especially in younger animals, and animals in peak productivity, is vital to improving efficiency, by needing fewer animals to produce the same amount or more. On-farm emergency slaughter is a subcategory of on-farm mortality. However, the practice of OFES itself can also play an important part in increasing efficiency, by increasing the use and salvaging of the meat produced by the animals, that if euthanised or died-on-farm, would likely not have been used for human consumption. The only other alternative is domestic slaughter/home slaughter, which according to the legislation, can only be for the consumption of the direct family of the farmer (3). Investigating and describing the reasons for on-farm mortality, and within OFES can help discover areas of improvement in cattle production.

Public health concerns regarding slaughter hygiene are important (4). As the European Union (EU) introduces control of the cleanliness of live animals coming to the slaughterhouse, with *antemortem* consideration and scoring of the cleanliness, OFES poses a question of risk. Concerns such as increased dirt on the animal after long periods of lying down and therefore compromised slaughter hygiene give cause to describe the reasons for OFES of cattle in Norway (5).

The practice of OFES in Norway

OFES is a possibility when an accident or an unforeseen incident has happened, while the animal is not otherwise sick, and it must be suitable for human consumption. To evaluate these criteria, and to fulfil the legal requirements for meat produced for the market, a

veterinarian must do an *antemortem* inspection on-farm (6). A farmer discovers the animal, compromised, and calls the veterinarian to evaluate what are the options and prognosis after an *antemortem* inspection, a veterinary certificate is filled out, by farmer and veterinarian. The farmer must then call the slaughterhouse that sends out a slaughterman on a truck made to transport the carcass back to the slaughterhouse for the rest of the slaughter process. Stunning and exsanguination are performed on the farm, and the transport happens with the carcass lying on the floor of the truck, sometimes with a few together. There are requirements for a cooling system in the truck if weather conditions do not help keep the carcass cool (3). The veterinary certificate includes a section for the slaughterman to write comments on the stunning and exsanguination, as well as time at killing. After the finished slaughter process at the slaughterhouse, an official veterinarian performs a *postmortem* inspection, after which, if approved, the meat can be sold in all the same markets as usual. The veterinary certificate is a form from the Norwegian Food Safety Authority (NFSA) which is completed in handwriting by farmer, field veterinarian, slaughterman, and official veterinarian (7).

Legal background and international comparison

All countries within the EU share legislation on food safety and animal health and welfare, which also sets the minimum standard for countries within the European Economic Area (EEA). Under this, stands legislation on OFES, described in Chapter VI of Annex III of Regulation (EC) 853/2004 (6). Despite harmonised legislation, the practice is not the same in all European countries, as the published data from Europe depicts a different picture than the data from Norway. The proportion of OFES of cattle, of total cattle slaughter in the Republic of Ireland, Northern Ireland and the Netherlands has been reported as 0.01%, 0.10%, and 0.90%, respectively (8).

Knowledge gaps

No published data were available to compare OFES within the Nordic countries. Of the few articles on OFES internationally, only one in Canada categorised and described the reasons for OFES (9). Other articles on OFES discussed OFES in tandem with casualty slaughter and focused on occurrence and animal types, as well as the opinion of the actors within the practice, and not the reasons for the slaughter (10, 11). As questions surrounding animal welfare and health, as well as public health and sustainability of meat production are often raised in discussions of OFES, both government and industry need to get good data on the practice (12).

Aims

The aims of this research project were to fill some of the knowledge gaps within the study of OFES. The first aim was to review if the Nordic countries, with a similar legal background, displayed similar practice of OFES. This would then inform if the percentage in Norway was an outlier or a norm within its neighbouring countries. The second aim was to describe the reasons for OFES in Norway.

Materials and Methods

The majority of the work performed in this project is included in the two articles written for it, and as such, only the highlights are included in this thesis. Further information can be found in the published review (Article I) or the manuscript in the appendix (Article II).

Overview of the practices of OFES of cattle in the Nordic countries (Article I)

First, a literature search was performed, searching for any published research into OFES within the Nordic countries. Information on the guidelines, forms and legal requirements for OFES in all 5 Nordic countries was collected from their respective food safety authority website, as well as reading the legislation in each country. This was performed by the research track student, Gíslína Skúladóttir, for the Danish, Icelandic, Norwegian and Swedish ones, but as the most detailed information from Finland was in Finnish, help was sought from a colleague, research track student Siiri Seppä to collect the needed information. For additional information on the practice of OFES, the research track student contacted the respective national food safety authorities directly by email. Thus, information was sought on legislation, recommendations, and practices in all five countries. Further, official numbers of cattle population and slaughter and on-farm mortality were taken from the European Commission's official statistics body – Eurostat (www.ec.europa.eu/eurostat).

As a review, not an original research article, this format allowed for collecting data and information that is normally not seen together in this context and put together, to make a better foundation of data for further research and discussion of OFES of cattle.

Occurrence and reasons for OFES of cattle in Norway (Article II)

Study design

It was decided to make a database from the information recorded on the veterinary certificate for OFES of cattle in Norway. The year 2018 was chosen as it made for easy access to both certificates and published information from both Tine and Animalia for supplementary data. To get enough data, but to limit time spent in the data collection stage, only four months of

the year were chosen. These were decided to be January, April, July, and October, or every 3rd month, one month in every season. Four slaughterhouses were chosen, the three with the highest annual cattle slaughter numbers, and one for its geographical placement.

Data collection

The OFES veterinary certificate is kept in the office of the official veterinarian at each respective slaughterhouse and with cooperation from NFSA, the student accessed these handwritten certificates for data collection, in each of the four chosen slaughterhouses. A form was made to digitalise all information from the certificate into a database. When information was not found on the certificate, the corresponding field was left empty in the digital form. This work was done by the research track student, Gíslína, but a few dozen illegible certificates were scanned with permission from the NFSA and reviewed by the supervisors to be able to categorise the reason for the OFES of those cattle.

Data analysis

The data were cleaned and then merged with secondary data from the voluntary national cattle recording systems in Norway, using Stata SE/15 (Stata Corp., College Station, TX, USA). The recording systems are the Norwegian Dairy Herd Recording System (NDHRS) and the Norwegian Beef Cattle Recording System (NBCRS). Secondary data of sex, date of birth, date of slaughter, parity, and last date of calving amongst others were extracted for the animals in the database, by using the 12-digit identification number that all cattle in Norway must carry in both ears. This was facilitated by supervisor Ingrid Hunter-Holmøy. Not all animals were matched in the national cattle recording systems.

Age was calculated and animal type groups were chosen, accounting for both sex and age; calf, heifer, young cow, cow, and bull. Calves were then all animals that are 300 days old or younger, heifers were 301-730 days old, and bulls were any male animals from 301 days old. Young cows were 731-1460 days old, while a cow was any female that was over 1460 days old. Production type was decided on account of the breed of the animal, where crossbreeds and common beef cattle breeds were categorized as the beef production system, while Norwegian Red and other common dairy cattle breeds in Norway were categorized as the dairy production system. The analysis was performed by the research track student, with guidance on coding from supervisor Ingrid Hunter-Holmøy, and support from all supervisors on what kind of data was needed for the final article. Only a part of the data from the finished database was used for this article. Variables such as condemnation and the time and date for

the writing of the certificate and the time and date for the killing of the animal, as well as data on the drugs given to the animals in the last 30 days before slaughter were removed. This data is intended to be used in later work.

Results

All results from this project have been included in the respective articles, found in the appendices, but a summary can be found below.

Overview of the practices of OFES of cattle in the Nordic countries (Article I)

Despite following the same basis of EU legislation, the practice, and guidelines for OFES of cattle differs within the Nordic countries. While OFES represents over 4% of all cattle slaughtered in Norway, it is barely practised in Finland and Sweden. It is more common practice with private slaughterhouses than others in Denmark, but still not near the proportion reported in Norway. Iceland does not practice OFES at all, despite the legislation allowing for it.

Occurrence and reasons for OFES of cattle in Norway (Article II)

The database built by the research track student, included information from 2229 veterinary certificates, with supplementary data for 1746 animals. The reasons for slaughter were categorised into 5 main categories; recumbency, mammary gland, obstetrics, locomotion and other, with 20 subcategories. The categories are listed, and subcategories are explained in Table 1. While the article in the appendix shows the results from only a few variables, the database has 53 variables, recorded from the veterinary certificates, extracted from the voluntary national recording databases, or even analysed variables, such as the age of the animal, or time difference between the time the veterinary certificate was written, and the animal was stunned. The database could therefore be used for further publications on the subject of OFES of cattle in Norway.

Table 1: Inclusion criteria for categories of reason for OFES, including the sorting of subcategories within main categories.

Category	Subcategory	Inclusion criteria for category
Recumbency	Unable to stand	Cases unable to stand, but unknown cause
	Milk fever	Cases of milk fever, not recovering
	Splits	Have done the splits, recumbent.
	Palsy	Cases of muscle, nerve or tendon damage, or unexplained palsy.
Mammary Gland	Mastitis	Cases of mastitis
	Udder Damage	Cases of trauma to the udder as well as risk to mastitis
Obstetrics	Prolapse	Cases with a current vaginal or uterine prolapse, sometimes in combination with a
	Dystocia	All reasons relating to the upcoming calving or just calved. Cases of calving
Locomotion	Lame	Cases of lame animals
	Damaged Legs	Cases of trauma to legs, minus fractures.
	Fracture	Cases of fractures or tentative factures
	Arthritis	Cases of arthritis
Other	Trauma	Cases of trauma (not to legs or udder)
	Internal	Cases of clinical signs of internal cause.
	Poor Appetite	Cases reported having poor appetite
	Wild	Including animals that can't be caught after being released outside, as well as
	Illegible	Cases where the reason for slaughter was illegible on the certificate to all authors of
	Management	Cases where no medical reason was stated, only that the farmer wished for OFES
	Empty	Cases where no reason included on the certificate
	Rectal Prolapse	Cases of rectal prolapse, not in combination with other prolapse

The results of this part of the project are explained and discussed more thoroughly in the article in the appendices, but can be summarised by Table 2 and Figure 1:

Figure 1: Bar graph showing the proportion of each reason for OFES for 3 animal types; Heifer, Young Cow and Cow. n=1405.

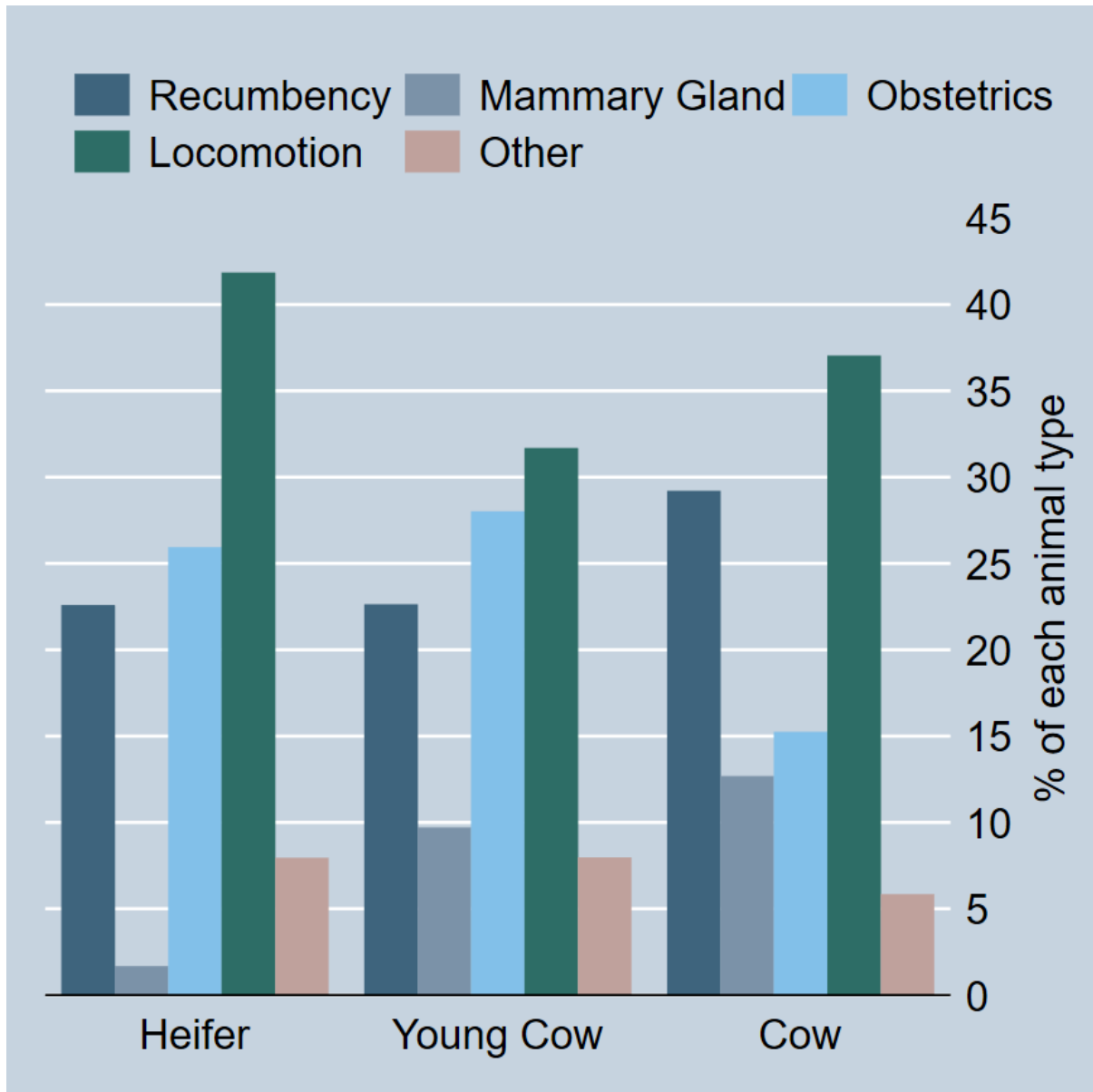


Table 2: Descriptive table showing number and percentage of total of each production system within each subcategory for OFES. Records missing data on production system are n=666 (29.9%) included in the total.

Causes	Production System		
	Dairy	Beef	Total
Recumbency			
Unable to Stand	29 (2.4%)	9 (2.4%)	55 (2.5%)
Milk Fever	25 (2.1%)	3 (0.8%)	38 (1.7%)
Splits	50 (4.2%)	18 (4.8%)	89 (4%)
Palsy	179 (15%)	47 (12.6%)	328 (14.7%)
Mammary Gland			
Mastitis	21 (1.7%)	0 (0%)	29 (1.3%)
Udder Damage	99 (8.3%)	6 (1.6%)	128 (5.7%)
Obstetrics			
Prolapse	56 (4.7%)	63 (17%)	201 (9%)
Dystocia	83 (7%)	41 (11%)	175 (7.8%)
Locomotion			
Lame	268 (22.5%)	62 (16.7%)	467 (21%)
Damaged Legs	227 (19.1%)	68 (18.3%)	418 (18.7%)
Fracture	72 (6%)	25 (6.7%)	139 (6.2%)
Arthritis	5 (0.4%)	1 (0.3%)	8 (0.4%)
Other			
Trauma	30 (2.5%)	12 (3.2%)	63 (2.8%)
Internal	25 (2.1%)	7 (1.9%)	42 (1.9%)
Poor Appetite	2 (0.2%)	0 (0%)	8 (0.4%)
Wild	8 (0.7%)	3 (0.8%)	16 (0.7%)
Illegible	1 (0.1%)	0 (0%)	4 (0.2%)
Management	8 (0.7%)	0 (0%)	10 (0.4%)
Empty	2 (0.2%)	0 (0%)	2 (0.1%)
Rectal Prolapse	1 (0.1%)	7 (1.9%)	9 (0.4%)
Total	1191 (53.4%)	372 (16.7%)	2229 (100%)

Discussion

Project management and conflicts

Collecting data from only 4 months of 2018 was a planning decision made before the start of data collection. While collecting from the whole year would've been viable timewise, within the research track year, it would've involved more cost, in accommodation and travel for the student. It was evaluated that the 4 months represented the year well. As the work of collecting the data from 2229 veterinary certificates took 5 weeks, collecting a whole year from each slaughterhouse would have meant less time for data cleaning, analysis, and writing in the study. Categorising three times more data would not have been feasible. Working with handwritten documents, with different spelling between different regions, because of dialect, proved troublesome. The integrity of the data could have been better confirmed if a double entry of data was performed, but this was not done in this case, for time and personnel constraints.

Although at the start of data collection the research track student and co-supervisor Clare Phythian considered marking the veterinary certificates in the database by their legibility. This proved to be hard to categorise, as a lot of work went into getting to read the ones that were more difficult to understand. When one could in the end write up the information, it felt strange to mark the certificate illegible. Regrettably, a standard was not established for this categorisation beforehand, as it would have been informative to have good numbers to present regarding the legibility of the certificates. On the other hand, after this collection, it is clear that a handwritten certificate offers too many possibilities of faults, whether to do with the identification number, birth date, or reason for OFES. These affect food-chain information security, the question of whether to screen for bovine spongiform encephalopathy (BSE), and the animal's eligibility for OFES, respectively, and thus are quite important to get right. This project thus concludes that a digital system, where the certificate is linked up to the Animal Health Portal (DHP); an animal registry for animal health, artificial insemination and food-chain information by Animalia (13).

Comparison with former on-farm mortality research in other countries, as well as of the practice and data between Nordic countries proved difficult. This is in large part because of the difference in how the input of data works in each country. It had to suffice to compare similar variables, but this of course leads to incomplete comparisons. Thus, comparing on-farm mortality data from Eurostat between countries might have led to biased results, however, the only way to verify that is to do more research on on-farm mortality itself in each

country. Most on-farm mortality research has not focused on reasons for mortality, which made for limited comparisons with the direct results of this project (14-16). Comparison of OFES practice between Norway and other countries that have published research on the topic, was also difficult, as the occurrence of OFES in Norway was higher than in other reported countries (8-10). One of the primary reasons for this was theorised to be the availability of the service from the slaughterhouses. On the other hand, that makes the contributions of this project to the field quite significant.

Scientific discussion of the results

This project found that OFES practice in Norway was exceptional when compared to the other Nordic countries, with 4.2% of all cattle slaughter in the country being OFES. Norway cannot look to neighbouring countries to see how the practice compares, because OFES of cattle is barely practiced in the other Nordic countries. This further confirmed our assumption that Norway needed to do its own research on OFES to inform on the practice. The practice of OFES might not be either good or bad, in any concern, but if done within the legislative framework, it can serve as a good way to salvage some value and product. This increases the efficiency and productivity of the cattle production in the country directly. At the same time, it offers the farmer an incentive to act quicker in cases of acute injury, when the prognosis for the animal is bad. The big proportion of OFES of cattle within on-farm mortality and all cattle slaughter in Norway can thus be a way to increase the sustainability of cattle production.

The most important result in the second article in this project was that young animals (here under 400 days old) were OFES for locomotory related reasons in 4 out of every 5 cases. This is a major problem, and if Norway managed to reduce the incidence of acute locomotory injury to young animals, this would also directly influence the sustainability of cattle production. Nonetheless, when an acute injury has happened, OFES is often the best option, for sustainability, and of economic interest for the farmer, as long as it does not compromise animal welfare. During the project, in 2021, the Norwegian guidelines for OFES were changed, but the proportion of OFES of cattle of all cattle slaughter in Norway remained unchanged (17-19). In 2021, McDermott et al. published an article analysing guidelines for the management of acutely injured animals (20). The results of the OFES project in Norway concluded that harmony of guidelines and practice throughout the country is vital in tidying up the practice of OFES. That includes not only guidelines on culling and management of acutely injured animals, but also more fundamental management. Further research and work

into using data from on-farm mortality and OFES is a worthwhile project to improve cattle production.

A concern floated when analysing the veterinary certificates, were the categories that were either ineligible for OFES, or on the border. These were the cases where the farmer had asked for OFES, without another reason stated, when the animal was reported to have a poor appetite, or when the animal showed clinical signs of internal illness. Additionally, certificates categorised as “milk fever” in this project, listed milk fever as a reason, which has been allowed by the Norwegian guidelines, as a recumbent cow that has had clinical signs of milk fever, been treated, and then does not get up, despite the disappearance of typical clinical signs of milk fever. Further, as displayed in the first article of the project, lameness was not eligible for OFES in the other countries that allowed for OFES of cattle. Even though Norway only allows for lameness within a certain frame, to avoid chronic cases, it is still a big part of the OFES of cattle in Norway, accounting for 21% of the cases in the study (19).

Conclusion

OFES of cattle was found to be practiced more in Norway than in neighbouring countries. Practising OFES of cattle instead of euthanasia and disposing of the carcass can increase the efficiency and thus the sustainability of a nation's cattle production. The results of this study indicate areas in cattle production needing improvement, concerning digitalisation of the certification process for OFES of cattle in Norway and guidelines for the management of cattle. For data on animal welfare within OFES of cattle in Norway, further research is needed.

Future work

The database constructed during this project certainly offers enough information to build future work and articles. Animal welfare concerning the different reasons for OFES of cattle in Norway was discussed in the second article of this project. However, the most immediate animal welfare concern linked to the practice of OFES is how long the animal must wait from injury to death. Despite the benefits of OFES to cattle production and sustainability, they cannot override good animal welfare. An aim in the future is therefore to describe and analyse the correlations between the waiting time and variables such as slaughterhouse, condemnation, reason for OFES and more.

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Appendices

1. **Appendix I** : Article I, Skúladóttir G, Phythian CJ, Holmoy IH, Myhre G, Alvasen K, Martin AD. Overview of the practices of on-farm emergency slaughter of cattle in the Nordic countries. *Acta Vet Scand.* 2022;64(1):9. doi: 10.1186/s13028-022-00627-0
2. **Appendix II**: Article II, Skúladóttir G, Holmoy IH, Phythian CJ, Myhre G, Martin AD. Occurrence and reasons for on-farm emergency slaughter of cattle in Norway. *Unpublished manuscript, sent to Frontiers in Veterinary Science, October 2022.*

REVIEW

Open Access



Overview of the practices of on-farm emergency slaughter of cattle in the Nordic countries

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Abstract

On farm mortality is an increasing problem in cattle production systems in the Nordic countries. It represents an economic loss to the farmer and raises questions of sustainability, food waste and animal welfare. On-farm emergency slaughter (OFES) represents, in some situations, an opportunity for a farmer to salvage some of the economic value from an animal that cannot be transported to a slaughterhouse. The basis of the regulation of OFES in the Nordic countries originates largely from legislation from the European Union. However, this review has found that the availability and practice of OFES in the Nordic countries differs considerably. For example, in Norway 4.2% of all cattle slaughter is OFES, whilst in Iceland OFES has never been recorded. National food safety authorities have issued differing regulations and guidelines regarding the suitability of sick and injured animals for OFES. This review shows there is a paucity of data regarding the incidence and reasons for the use of OFES of cattle in the Nordic countries and points out the need for more investigation into this area to improve veterinary education, consumer protection and animal welfare.

Keywords: Animal hygiene, Cattle, Mortality, On farm emergency slaughter, Slaughter

Background

On farm mortality encompasses all livestock death on farm including unassisted deaths, euthanasia, slaughter for home consumption, and on farm emergency slaughter (OFES) for commercial purposes. A definition of the terms used in this article to describe the death of an animal can be found in Table 1. Incidence of on farm mortality is an animal welfare indicator whereby high levels of mortality are associated with poor animal welfare [1, 2]. In addition to raising concerns about animal welfare, high levels of on farm mortality damage the reputation of the cattle industry with the public and raise significant

questions on the sustainability of cattle production systems [3, 4]. The death of animals on farm also leads to significant economic loss in the form of lost sales value, loss of production, cadaver disposal costs, and increased herd replacement costs [5, 6]. Despite advances in animal husbandry and veterinary medicine the incidence of bovine on farm mortality in the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden), and worldwide, has steadily increased over the past 30 years [2, 3, 7]. The reasons for the increase in incidence of on farm mortality are multifactorial and have yet to be fully elucidated [3, 5, 6, 8]. However, it has been postulated in Sweden [7] and Denmark [9] that part of the increases seen could be due, at least in part, to changes in legislation regarding the transport [10] and slaughter [11] of cattle in the European Economic Area (EEA).

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Table 1 Definitions of terms associated with mortality used in this article

Term	Definition
On-farm mortality	The death of an animal on farm, irrespective of the manner in which it died. Home slaughter, euthanasia, OFES as well as unassisted/uncontrolled death
Home slaughter	Animal is slaughtered on farm without a veterinary <i>ante-mortem</i> inspection. Meat may be used domestically—but sale is prohibited
On-farm emergency slaughter (OFES)	Animal is slaughtered on farm having passed an <i>ante-mortem</i> veterinary inspection. The carcass is transported to a slaughterhouse whereby it undergoes a <i>post-mortem</i> inspection. Sale of the meat allowed
Casualty slaughter	The slaughter of a sick or injured animal at a slaughterhouse. The animal undergoes normal <i>ante-mortem</i> and <i>post-mortem</i> controls. Sale of meat allowed
Euthanasia	The killing of an animal with no intention of human consumption

The minimum standards for food safety and animal health and welfare within the EEA are regulated by European legislation which is binding throughout the European Union (EU) and are adapted into national legislation by EEA countries that are outside of the EU. Of the Nordic countries, Denmark, Finland, and Sweden are members of the EU, whilst Iceland and Norway are members of the EEA. Home slaughter of animals for consumption, not sale, is allowed without any attestation throughout Europe. However, the slaughter of animals for sale is tightly regulated in the EEA. In 2004, the European Council decided that only healthy animals which have been slaughtered at a slaughterhouse are eligible for human consumption [11]. To ensure compliance all animals slaughtered for human consumption, and subsequent sale, must undergo an *ante-mortem* inspection by a veterinary surgeon in the 24 h preceding slaughter, as described in Section III of Annex II of Regulation (EC) 853/2004 [11] and legislated for in Regulation (EU) 2017/625 [12]. Usually, this is achieved by an Official Veterinarian examining the animals upon arrival to, or whilst being held in lairage at, a slaughterhouse. Guidelines for *ante-mortem* inspections have been developed [13].

Despite legislation prohibiting the slaughter of sick and injured animals for human consumption, provided strict criteria are met, animals which are injured or suffering from an ailment which does not endanger food safety can be slaughtered [11]. If the criteria are met the animal should be transported to a slaughterhouse for slaughter providing the transport will not cause additional suffering [10]. The slaughter of ill or injured animals at a slaughterhouse is termed casualty slaughter. However, ill or injured animals are generally considered unfit for transport [10]. In this situation the legislation allows for OFES if specific criteria are met as described in Chapter VI of Annex III of Regulation (EC) 853/2004 [11]. Clear definitions of 'slightly ill or injured' as well as 'additional suffering' are absent from the European regulations [14].

The OFES of ungulates is permitted provided the slaughtered animal is; *an otherwise healthy animal [that] must have suffered an accident that prevented its transport to the slaughterhouse for welfare reasons* [11]. In order to process animals killed on farm and intended for human consumption, slaughterhouses must have in place facilities to receive and process OFES [12]. An *ante-mortem* examination is still required for animals that undergo OFES. Specific exceptions from the requirement that *ante-mortem* inspection is performed in a slaughterhouse, Article 18 (2) (a) of Section II of Regulation (EU) 2017/625 [12], is made in Article 4 of Regulations (EU) 2017/625. Article 4 allows for an *ante-mortem* inspection by an official veterinarian to be performed outside of the slaughterhouse subject to compliance with the requirements for emergency slaughter laid down in points (1), (2) and (6) of Chapter VI of Section I of Annex III to Regulation (EC) No 853/2004 [11, 12].

There is evidence that there is within country variation regarding the practice of transport and slaughter regulations which increases stress on stakeholders [9, 15–17]. The lack of unequivocal definitions for key terms such as, 'slightly ill or injured', 'additional suffering', 'accident' in European legislation [10, 11, 14] means that practice in individual countries is likely to vary. There are considerable cultural and migratory ties between the Nordic countries, including veterinarians crossing borders to work and study. However, the extent of harmonisation of the practice of OFES between the Nordic countries is unknown. The aim of this article is to summarise the legislation and practice of OFES in the Nordic countries.

Material and methods

This article is an overview review article [18] and as such does not aim to provide an exhaustive review of research that has previously been carried out. The review of the legislation, recommendations, practices, and literature was initially performed in December 2020 and January 2021. A follow up review of the literature, legislation and

national guidelines occurred in the first week of January 2022 to account for any changes in practice and legislation introduced since the initial review.

Literature search

A PubMed search (<https://pubmed.ncbi.nlm.nih.gov/>) using the combined terms (((("On farm emergency slaughter") OR ("casualty slaughter") OR ("emergency slaughter")))) AND (cow OR cattle OR bovine)) NOT (spongiform) was used to gain an overview of published scientific work which linked with the focus area of this article. The term 'spongiform' was excluded from the literature search to remove articles dealing primarily with the control of transmissible spongiform encephalopathies (TSEs). This is because animals suffering from TSEs are not eligible for OFES in Europe.

Search for statistics on population and slaughter

Data on the cattle population and numbers of animals slaughtered annually were provided by searching the European Commission's official statistics body—Eurostat (www.ec.europa.eu/eurostat). Additional searches were performed to cross-check and complete missing data with national interest bodies (Landbrug & Fødevarer—the Danish Agriculture and Food Council, Luke—the National Resources Institute Finland, Bændasamtök Íslands—the Icelandic Farmers Association, Anima-lia—the Norwegian Meat Research Centre, Jordbruksverket—the Swedish Agricultural Board). Where data on the numbers of cattle which underwent OFES were not available from European and national statistics, the competent authority in each country was contacted by email to ascertain if records of the number of OFES were kept. The competent authorities for emergency slaughter in the Nordic countries are; the Danish Veterinary and Food Authority (www.foedevarestyrelsen.dk), the Finnish Food Authority (www.ruokavirasto.fi), the Icelandic Food and Veterinary Body (www.mast.is), the Norwegian Food Safety Authority (www.mattilsynet.no), and the Swedish Food Agency (www.livsmedelsverket.se).

Search for legislation and national guidelines

In addition to the literature reviewed the authors accessed the relevant European Council decisions pertaining to OFES in the EEA [10, 11, 19]. Further an internet search of the competent authorities for food safety in each of the Nordic countries was performed to ascertain the legislation, and the availability of guidelines for the OFES of cattle in each country, respectively. Further each competent authority was contacted by email and asked to describe their OFES regulations and the extent of the practice in their country. The practices in each country were summarised on a country-by-country basis before

being compared. Specific guidelines provided by the competent bodies regarding conditions in which OFES was/was not appropriate was summarised in a table (Table 3).

Results

Literature review

The described PubMed search identified 39 documents, 24 of which were from the year 2000 or later. Of these 24 documents 6 were from Canada and 18 from European countries. Seven of the documents originating from Europe were opinion letters written to the scientific journal *Veterinary Record*. Of the remaining 11 documents originating in Europe two are best characterised as case studies which resulted in emergency slaughter, one dealt with medicine residues, and one with animal welfare from birth until slaughter. Three articles from Ireland reported the investigation of the reasons for casualty slaughter, its certification and practice, two articles from Italy dealt with the reasons for on farm death and how culling can be managed, and a Spanish article dealt with culling in herds using robotic milking machines. No literature was found concerning OFES, or casualty slaughter, in the Nordic countries. Furthermore, no literature was found comparing practices between countries, which highlights the need for further knowledge in this area.

National cattle population and numbers slaughtered

Denmark and Sweden have the largest cattle populations of the Nordic countries with around 1.5 million head of cattle in each country. Finland and Norway both have a cattle population of around 850,000. Iceland has a smaller population, around 80,000. The numbers of cattle reported to be slaughtered annually in each country broadly correlates with the national cattle population, with each country slaughtering between 29 and 35% of its cattle population annually. More than 98% of cattle known to be slaughtered in Denmark, Finland and Sweden were slaughtered in slaughterhouses, compared to 95% in Norway, and 83% in Iceland. Domestic slaughter was highly prevalent in Iceland, whilst OFES was the predominant form of slaughter outside of a slaughterhouse in Norway. Table 2 summarizes the details of the cattle population, the number of animals slaughtered and location of slaughter for each of the Nordic countries.

General requirements for OFES in European Legislation

The OFES of ungulates for sale and human consumption is permitted provided the slaughtered animal is; *an otherwise healthy animal [that] must have suffered an accident that prevented its transport to the slaughterhouse for welfare reasons* [11]. This definition was first made in Chapter VI of Annex III of the Council

Table 2 Details of the cattle population and numbers of animals slaughtered in the Nordic countries in 2019

	Cattle population	Adult cows	Dairy cows	Beef Cows	Known number of cattle slaughtered	Number of cattle slaughtered in a slaughterhouse (% of known slaughtered)	Number of cattle slaughtered for domestic consumption (% of known slaughtered)	Number of OFES cattle (% of known slaughtered)
Denmark	1,500,000 ^a	645,800 ^a	563,000 ^a	83,000 ^a	468,000 ^{c,d}	464,000 (99.1%) ^c	4000 (0.9%) ^d	Unknown
Finland	840,420 ^a	318,360 ^a	258,940	59,420	247,000 ^{c,d}	242,940 (98.4%) ^c	4060 (1.6%) ^d	Unknown
Iceland	80,900 ^a	29,000 ^a	26,200 ^a	2900 ^a	27,130 ^{c,d}	22,730 (83.8%) ^c	4400 (16.2%) ^d	None
Norway	862,550 ^b	307,484 ^b	215,069 ^b	92,415 ^b	304,953 ^b	292,153 (95.8%) ^b	Unknown	12,800 (4.2%) ^b
Sweden	1,404,670 ^a	499,700 ^a	301,380 ^a	198,320 ^a	441,780 ^{c,d}	432,770 (98.0%) ^c	9010 (2.0%) ^d	Unknown

Data sources:

^a Anonymous. Bovine population—annual data 2019. European Commission's official statistics body—Eurostat. https://ec.europa.eu/eurostat/databrowser/view/APRO_MT_LSCATL__custom_697055/default/table?lang=en. Accessed 17 March 2022

^b Anonymous. The status of meat production 2019. *In Norwegian*. 2020. Animalia. <https://www.animalia.no/contentassets/3dce35cde68a47b091097fa8c6ec2dd5/kjotts-tilstand-2019.pdf>. Accessed 17 March 2022

^c Anonymous. Estimates of slaughtering, in slaughterhouses—annual data 2019. European Commission's official statistics body – Eurostat. https://ec.europa.eu/eurostat/databrowser/view/APRO_MT_PANN/default/table?lang=en&category=agr.apro.apro_anip.apro_mt.apro_mt_p. Accessed 17 March 2022

^d Anonymous. Estimates of slaughtering, other than in slaughterhouses—annual data 2019. European Commission's official statistics body – Eurostat. https://ec.europa.eu/eurostat/databrowser/view/apro_mt_slth/default/table?lang=en. Accessed 17 March 2022

Table 3 The guidelines provided by the competent authorities in Denmark, Finland and Norway regarding the acceptability of different clinical conditions for on-farm emergency slaughter

	Denmark	Finland	Norway
Trauma less than 24 h old, e.g. splits at calving, broken bone	✓	✓	✓
Mastitis	✗	✗	✗
Milk fever	✗	✗	✓*
Uterine prolapse	–	✗	✓
Displaced abomasum	–	✗	✗
Chronic lame	✗	✗	✗
Wild—dangerous to handle	✓	✗	✗

Key: '✓' acceptable for OFES, '✗' unacceptable for OFES, '–' condition not mentioned in guidelines

*Cows with clinical milk fever are not acceptable for OFES

removed must follow to the slaughterhouse, identified to the right carcass.

- 3) If transport takes over two hours, the carcass must be refrigerated, although not actively if climate conditions allow.
- 4) A declaration by the farmer of the identity of the animal and medication and withdrawal periods, must accompany the animal to the slaughterhouse.
- 5) A declaration issued by the veterinarian recording the favourable outcome of the *ante-mortem* inspection, the date and time of, and reason for the emergency slaughter, and details of any recent treatments, must accompany the slaughtered animal to the slaughterhouse.
- 6) That the carcass is deemed fit for human consumption after *post-mortem* inspection.
- 7) That the slaughterhouse follows the instructions given by the veterinarian of use of meat.

Regulation (EC) No 853/2004 [11], and is referred to in Regulation (EU) 2017/625 [19].

According to European regulations the following (paraphrased) criteria must be met for animals slaughtered on farm to be processed and passed as fit for human consumption [11, 19]:

- 1) A veterinarian must carry out an *ante-mortem* inspection of the animal.
- 2) The animal, killed and bled, must be transported hygienically to the slaughterhouse, without delay. Removal of stomach and intestines is allowed under veterinarian supervision, on-site, but all parts

Denmark

The competent body monitoring OFES in Denmark is the Danish Veterinary and Food Administration (DVFA). The Danish translation of the EU regulations states the first three requirements as in the EU regulation; namely that the animal is healthy and has suffered an accident, that an *ante-mortem* inspection must be performed and that the animal must be killed, bled and transported to a slaughterhouse as soon as possible [11]. A sick animal cannot be slaughtered and sold, but the owner can decide if he thinks it is fit for consumption and perform slaughter for home consumption. According to the DVFA all

slaughterhouses are equipped to receive OFES, although it is mostly the smaller slaughterhouses that do accept them (Jacob Gade, DVFA, personal communication).

The DVFA published a guide for farmers for OFES. The guide states that the animal owner must call a veterinarian for the *ante-mortem* inspection as a requisite for human consumption of the meat, and that it is the veterinarian's responsibility to decide if the animal is fit for human consumption. The second requirement is that the owner fills out a declaration including details on the animal to be slaughtered, the veterinary drugs the animal has received in the previous six months and a description of the accident that led to the OFES [20]. The DVFA provides a list of examples of what acceptable circumstances for OFES are. These examples include fractures and calving associated lesions, and a fresh wound in the hoof, e.g., puncture by a nail. The DVFA guidelines state that a cow with hypocalcaemia (milk fever) that could be treated, or an abscess in the hoof, should not be slaughtered as OFES [21]. Further DVFA guidelines state that cattle that can't be handled safely during transport due to their temperament are appropriate for OFES [21].

The veterinarian's role is to perform an *ante-mortem* inspection and confirm that the animal is fit for human consumption. The veterinarian also has a responsibility to describe clinical findings and the reason it may not be transported to a slaughterhouse. The veterinarian is also required to describe any treatment that has been given to the animal with the withdrawal period and comment on the 'accident' that resulted in OFES. The veterinarian can perform the slaughter, in which case they attest for this and the date and time of slaughter. Alternatively, the veterinarian can state the time in which the animal needs to be killed by a slaughterman before transportation. If the animal is killed after the deadline set by the veterinarian the animal will not be deemed fit for human consumption, even if seen by the veterinarian in the 24 h preceding slaughter.

Finland

The competent body monitoring OFES in Finland is the Finnish Food Authority (FFA). The FFA regards the practice of OFES in Finland as rare, stating that home slaughter is more frequent, as it is simpler. Many slaughterhouses (or farmers) do not have a proper hygienic vehicle for transporting a carcass to a slaughterhouse. Furthermore, there may be difficulties in finding a veterinarian fast enough to perform the *ante-mortem* inspection (R. McLean, personal communication). Despite this the FFA have produced a guide which is primarily aimed at veterinarians working with meat inspection frequently which describes well the legal framework and requirements for OFES, linking clearly to the relevant European

regulations [22]. In addition, guidelines are provided as to which animals may or may not be suitable for emergency slaughter [22].

The Finnish legislation follows the European legislation and the eight criteria that must be fulfilled in the European legislation to allow for OFES are all mentioned in the Finnish guidelines. The animal must have suffered an 'accident' to be eligible for OFES. The term accident is broadened to accept accidents, falls and ruptures in the 24 h preceding slaughter. The FFA gives examples of animals eligible for OFES. These include an animal; which has slipped and suffered a sprain in the past 24 h, or has a broken limb, a large wound, or a traumatised teat. The guidelines then specify several conditions that are not eligible for OFES because they do not result from an accident. These include animal's that have suffered from milk fever, dislocation of the abomasum, uterine prolapse, or acute mastitis. Furthermore, the guidelines state that animals which have been recumbent for more than 24 h, are ineligible for OFES.

Certification from the producer and veterinarian are required to accompany the carcass to the slaughterhouse. The producer must certify the animal's identity, the date, and details of any treatments (veterinary or otherwise) the animal has received, and any withdrawal periods for the medicinal treatments received. The veterinarian needs to certify the reason for the OFES, the result of the *ante-mortem* inspection, and the date and time of killing. According to the Finnish guidelines the veterinarian is required to confirm that slaughter was performed in an appropriate manner and confirm the time of slaughter. Consequently the veterinarian must be present during the stunning and exsanguination [22].

Iceland

The competent body for OFES in Iceland is Icelandic Food and Veterinary Body (IFVB). In 2012 Iceland included the regulations in Chapter 7 Article 15 of Council Regulation (EC) 853/2004 into Icelandic law [23]. However, no updates in this legislation have occurred since 2012. On-farm emergency slaughter is defined as; "*when an animal is killed outside a slaughterhouse, according to a veterinarian's decision, because of an accident or other reasons and the animal is then taken to slaughter in a slaughterhouse and its products used for human consumption*". The specified requirements of *ante-mortem* inspection, killing, bleeding and transport, mimic those in Council Regulation (EC) No 853/2004. A declaration by the veterinarian who performed the *ante-mortem* inspection is to follow the carcass to the slaughterhouse. It is to include the reason for OFES, and detail any medicines given to the animal in the last month of the animal's life. The slaughterhouse veterinarian is required

to perform a *post-mortem* examination, and ensure the viscera were removed within three hours after the stunning and exsanguination and perform a microbiological testing of the product [23].

Despite the regulations allowing OFES in Iceland the practice has yet to be performed. Currently there are no slaughterhouses equipped to receive OFES and as such the IFVB has not issued a form to be used in the case of OFES, or any guidelines on the practice.

Norway

The competent body monitoring OFES in Norway is the Norwegian Food Safety Authority (NFSA). The European legislation regarding OFES has been translated and accepted in Norwegian national legislation with one important difference; the term ‘accident’ has been translated to ‘unforeseen event’. Whilst it follows that the definition of accident in the English language is ‘an unforeseen incident, usually with negative effects’ [14], the term probably allows for a slightly wider interpretation than is available in the original European legislation. The NFSA has published guidelines on the application of the OFES regulations. These emphasize the requirement for an animal to have been subjected to an accident or unforeseen event which means that the animal is not allowed to be transported to a slaughterhouse, whilst the general condition of the animal is not affected in a way which prevents human consumption of the meat [24].

The NFSA guidelines for OFES specifically state that injuries sustained during calving, are eligible for OFES providing the animal to be slaughtered is not suffering from one or more of the of the following: infection, uterine torsion, mutation, or something similar to the three examples provided. The guidance further states that a prolapse is acceptable as a reason for OFES if the general condition of the animal is unaffected. The same applies for lame and recumbent cattle (providing under 24 h of recumbency when killed). Traumatic accidents, such as fractures and wounds, are also listed as an appropriate reason for OFES, and the guidelines point out the need for almost immediate slaughter in these cases. Post-partum first-calf cows which cannot be milked due to their temperament are eligible for OFES in the first week post-partum [24].

The NFSA guidelines specifically advise against the use of OFES in certain cases. These include mastitis, displacement of the abomasum, and cattle with a wild temperament. The guidelines emphasize that OFES should occur as soon as possible after the accident, with the only exception being grade 2–3 lameness on the 5-point scale, as described by Sprecher et al. [25]. Those cattle can be treated for up to a week after the first injury and undergo OFES if they have not sufficiently improved within seven

days. The guidelines also allow for OFES of cattle that have previously had milk fever, that at the time of the *ante-mortem* inspection show no clinical signs of the disorder apart from recumbency providing slaughter occurs within 24 h of the first sign of the disorder.

The NFSA has published a form which has to accompany carcasses to the slaughterhouse (<https://www.mattilsynet.no/skjema/nodslakteattest.1678/binary/N%C3%B8dslakteattest>). The form requires details on the holding the animal is from, as well as the animals signalment (including date of birth and ear-tag number). Further a description of the accident/unforeseen event which has resulted in the emergency slaughter as well as a statement about the animal’s general state of health is required. The farmer must also attest for the medicines the animal has been treated with in the preceding 30 days as well as treatment with any other medicine with a withdrawal period greater than 30 days. The veterinarian is required to sign the following declaration: ‘I have not found or been made aware of conditions that would make this animal unsuitable for human consumption (alternative euthanasia and destruction)’. The veterinarian then has a space in which he or she can make any comments they feel appropriate. The certificate is then signed, and the time and date of the signature recorded. A final box is for the slaughterman to complete which just states the time and date of death with space for any comments. Currently, the veterinarian performing the *ante-mortem* inspection needs no further training beyond their veterinary degree. However, the NFSA will soon require that veterinarians performing *ante-mortem* inspection have undertaken an additional training course to allow them to perform these OFES *ante-mortem* inspections as an ‘official veterinarian’. All the slaughterhouses in Norway which slaughter cattle offer OFES as a service.

Sweden

The competent body monitoring OFES in Sweden is the Swedish Food Agency (SFA). The practice of OFES is uncommon in Sweden, although around 30 small-scale slaughterhouses offer this service. Slaughter for home consumption of animals is possible, but these carcasses may only be consumed in the producers’ own household. Mobile slaughterhouses have been commercially available, but this practice was only used to a very small extent [8, 26]. Official written guidelines from the SFA on the practice of OFES are unavailable.

In order for OFES to occur in Sweden an official veterinarian must perform an *ante-mortem* examination and complete a form produced by the SFA (https://www.livsmedelsverket.se/globalassets/produktion-handel-kontroll/blanketter/livs_071_2013_01_veterinarintyg-vid-nodslakt.pdf). The form does not require the farmer

to complete or certify any information. The veterinarian must; (i) identify the animal and its location, (ii) identify the slaughterhouse to which the animal will be transported, (iii) describe the animal's condition, including the reason for OFES and any treatment the animal has received. The veterinarian is required to declare that an otherwise healthy animal suffered an accident that prevents its transport to the slaughterhouse and state the time and date of *ante-mortem* examination. Further the veterinarian needs to certify that the records and documents associated with the animal are legally correct and do not constitute an obstacle to slaughter. The last section of the form requires information on the time and date of stunning and exsanguination certified by an authorised slaughterman.

Specific guidelines relating to clinical conditions

Three of the five Nordic countries (Denmark, Finland and Norway) provide guidelines for how OFES should be practiced. These include examples of clinical conditions that are, and are not, acceptable for OFES which are summarized in Table 3.

Discussion

The practice of OFES varies throughout the Nordic countries. Iceland has no record of an animal been slaughtered in this way whilst in Norway 4.2% of all the cattle slaughtered in 2019 were OFES. Interestingly the inter-country differences in the number of cattle slaughtered on-farm for human consumption become greater when the estimates of cattle slaughtered on farm for home consumption and OFES are combined. In this situation the estimates for the proportion of animals slaughtered for human consumption become 0.9%, 1.6%, 16.2%, 4.2%, 2.0%, for Denmark, Finland, Iceland, Norway and Sweden, respectively. Whilst this article has highlighted some differences in the practice and guidelines surrounding OFES, the legislative framework for OFES is almost identical, meaning that other factors must account for these differences.

High levels of on farm mortality are not compatible with sustainable agricultural practices [2, 3, 8]. Despite this and the increased focus on animal's welfare on farm mortality in cattle production systems has been increasing [2, 3]. Whilst reducing the incidence of on farm mortality should be a priority for animal welfare and economic reasons there will always be deaths on farms. On farm emergency slaughter, and slaughter for home consumption, represent ways to mitigate food waste. In Norway 7% of dairy cows died on Norwegian dairy farms in 2019, almost half of these animals (44%) underwent OFES [27]. Similar on farm mortality statistics have been presented for the Danish and Swedish dairy industries

[7, 8, 28], and there is little reason to believe the figures would be hugely different in Finland. However, in contrast to Norway very few of the animals dying on farms in the EU Nordic countries (Denmark, Finland and Sweden) are salvaged for human consumption. The number of animals undergoing OFES in these three countries is virtually negligible and proportionally very few animals undergo home slaughter. Although in this regard a greater proportion of Swedish cattle are salvaged by home slaughter than is the case for Danish or Finnish cattle.

Studies have shown that a reasonable estimate for on farm mortality amongst dairy cows in Denmark, Finland, and Sweden is 6.5% [3, 6, 7, 27]. Using this estimate approximately 73,000 of the 1,123 million, dairy cows in these countries die on farm annually (Table 2). If 40% of these carcasses could be salvaged for human consumption (44% are salvaged in Norway) this would represent approximately 29,000 cows. In 2019, 17,160 animals in the EU Nordic countries were estimated to be home slaughtered (Table 2). If it is assumed all of these were dairy cows, so as to not overestimate, that would result in at least an estimated 12,000 dairy cows which were potentially fit for human consumption were destroyed in 2019. This unrefined estimate makes broad generalizations about the causes of on farm mortality between countries. For example, it is assumed that the reasons for on farm mortality, and the potential to salvage meat from the animals that died are the same between the Nordic countries. Further this estimate assumes that there is the possibility to harmonize the regulations throughout the Nordic countries and that there is equal access to OFES, which is not currently the case. Despite these limitations they illustrate a large potential to salvage meat from animals that died on-farm.

The legislation for OFES in the Nordic countries is virtually identical. Despite this the practice differs considerably. National guidelines regarding the eligibility of animals suffering from specific clinical conditions for OFES have been published by the competent authorities in Denmark, Finland and Norway and are summarized in Table 3. In Denmark the guidelines specifically allow for wild cattle to undergo OFES, whilst the guidelines in Norway specifically prohibit this, and whilst wild animals are not mentioned specifically in the Finnish guidelines, they fall outside of the guidelines. Interestingly cows suffering from a uterine prolapse are specifically mentioned as being eligible for OFES in Norway but are ineligible in Finland, where the Finnish guidelines specifically state that a uterine prolapse does not constitute an accident. Finnish guidelines state that a cow that has gotten milk fever, is not eligible for OFES, for the same reason as prolapse, while the

Norwegian one state that if the animal has been treated for milk fever, that arose in the last 24 h, is now without clinical signs of the disorder, but recumbent, they are eligible. Perhaps most importantly from an animal welfare perspective, lame animals are suitable for OFES in Norway according to the guidelines published by the NFSA. The same guidelines also dictate that one can try and treat low grade lameness for up to a week, before deciding on OFES. However, the same animal would fall outside of the guidelines in Denmark and Finland. As lameness is perhaps the greatest single welfare problem in cattle production systems [29] it is vitally important that an overview is gathered regarding the outcomes of lame animals so that appropriate steps can be taken to improve their welfare.

National differences exist in the certification and slaughter requirements between the Nordic countries. The example certificates published on the national competent bodies all vary somewhat, this is despite an example certificate now been available in Chapter 5, Annex IV of the Commission implementing regulation (EU) 2020/2235 [30] being made available to facilitate harmonization of practices. Responsibility for the identification of the animal to be slaughtered and listing of previous treatments varies between the countries. In Finland, Norway and Denmark this is the producer's responsibility, whilst in Sweden this responsibility lies with the veterinarian.

All countries require the *ante-mortem* inspection of the animal to be slaughtered within the 24 h preceding its death. In Denmark the certificating veterinarian can reduce the time interval from *ante-mortem* inspection to slaughter, whilst this is not possible in Norway. Having the ability to reduce the time from *ante-mortem* inspection to slaughter potentially both enhances animal welfare and protects public health. In Finland the veterinarian must see the killing, whilst in all other countries this can be delegated to a third qualified person. Which may be one of the reasons there are so few OFES in Finland? Both Denmark and Norway require the veterinarian to fill in the time and date of *ante-mortem* inspection, while in Finland it is enough to fill in the time and date of stunning, as the veterinarian must oversee that action.

Despite having the possibility in law, OFES is scarcely practiced in four of the five Nordic countries. Norway and Iceland are members of the EEA, but not the EU, which affords the countries a greater degree of self-determination over agricultural policy than EU member states have, both in terms of legislative practice and economic policy. Iceland, however, has no tradition of OFES, and no facilities for it, meaning it is very hard to practice while following the legislation of meat hygiene. The situation in Finland is similar and the country currently

lacks the infrastructure which would allow for OFES to be commonplace.

The Nordic countries all have high labour costs, compared to other European countries [31]. This means that labour intensive procedures, such as travelling long distances to salvage meat quickly, become uneconomical if beef is traded freely in an internal European market [32]. Sweden, for example, had a tradition for OFES [7]. However, since the 1990's the costs associated with this procedure have led to a situation where most of the injured animals are euthanized on farm and sent to a destruction plant. In Norway there are considerable market support mechanisms which mean that beef is priced above the international market value which perhaps contributes to the large numbers of OFES in the country [32]. One of the four aims of Norwegian agricultural policy is to maintain agriculture throughout the entire country [33]. This, combined with the fact that farmer owned cooperatives dominate cattle and meat production in Norway, means that financial support mechanisms are in place to facilitate OFES, which has a long tradition in the country. Changing attitudes towards sustainability and may mean that it might be appropriate in the future to evaluate the cost-benefit calculations associated with OFES in a broader context than simply the finances of the procedure. Animal welfare, the environmental impact and the minimization of food waste, are all factors which society are increasingly attaching importance in a wider debate about the sustainability of food production and these issues are closely linked to OFES.

Meat harvesting is strictly controlled to protect the consumer from food borne disease and animals from unnecessary suffering. Clinically sick and injured animals pose a higher risk, at least theoretically, to the consumer than healthy animals slaughtered in the slaughterhouse. The shedding of zoonotic pathogens, such as enterotoxigenic *Escherichia coli*, are known to increase in stressed animals [34, 35]. It is also likely that in many cases animals may be dirtier than they might otherwise be when killed on farm because, for example, they are recumbent at the time of slaughter, or that the carcass of the animal is handled sub-optimally after killing. Concerns about food safety and meat quality have led to 89% of veterinarians working in slaughterhouses in the Republic of Ireland not wanting to accept OFES carcasses despite the practice been legal [36]. A Canadian study into the perceptions of OFES found that a significant proportion of stakeholders had concerns about OFES reducing food safety compared to regular slaughter [16].

On-farm emergency slaughter represents an exception to these regulations which benefits the primary producer. The consumer is, however, most likely unaware of the practice. Stakeholders are typically divided as to whether

the public perception of the dairy industry would be enhanced or damaged if the public became aware of OFES [16]. Swift and effective use of OFES could reduce undue suffering, particularly in the case of genuine accidents, by offering a primary producer the possibility to salvage some of the value of an animal by acting swiftly and performing OFES. It also helps prevent unassisted on farm mortality by reducing financial loss [8]. However, stakeholders have identified that the existence of OFES may mean that animals which could be preventatively culled due to, for example 'poor feet', may be rebred as there is always the possibility of OFES for animals if they become lame [16]. Other challenges to animal welfare identified were if producers choose to wait for medicine withdrawal periods before performing OFES, as opposed to immediately euthanizing the animal [16]. Current guidelines in Norway specifying that lame cattle can be treated for up to a week before OFES are a well-intentioned balance between 'salvaging meat' and preserving animal welfare by limiting the number of days animal can be lame before slaughter. However, they risk producers not contacting veterinarians until later in a disease process to preserve the option of OFES for longer.

It is worth noting that animals undergoing OFES all have suboptimal animal welfare. On farm mortality, which includes OFES, is one of the measures used in the welfare assessment protocols used throughout Europe, 'Welfare Quality' [37]. Therefore, it is surprising how few data are available about OFES [17, 38]. Even in Norway, which has the most comprehensive and available statistics on OFES, there is no information available about the reasons OFES was performed on cattle, and the extent to which the practice falls within, or outside, of the national interpretation of the legislation. If the processes around OFES, and slaughter for home consumption, are to be understood there is a need to identify the reasons animals undergo on farm slaughter and the decision-making processes around the practice. The availability of data regarding OFES would allow for genuine comparisons and evidence-based decisions to be made when evaluating practices with and between countries. The differences in the guidelines issued by the Norwegian, Finnish, and Danish Food Safety Authorities clearly demonstrates that practices are not harmonized within the EEA, despite harmonized legislation.

The differences in implementation and practices despite having near identical legislation pose problems for the consumer, who believes, an EU/EEA health marked product is produced according to identical guidelines and practices. It further poses considerable problems for veterinary practitioners who increasingly practice in different countries [39] with different traditions regarding OFES. Veterinary surgeons in Europe

and North America have highlighted frailties in the operational efficiency of OFES caused by the conflict of interests of a producer's own veterinarian deciding on the eligibility of an animal for OFES [15, 16]. The differing practices between countries shows that universities and official veterinarians should teach in such a way that learners understand that identical legislation can be practiced in very different ways depending on the national interpretation of legislation. Ultimately this level of education can only be provided if there is more concrete data available regarding the reasons for, use of, and practices associated with OFES.

Conclusions

This review has demonstrated that despite harmonised legislation in the Nordic countries practice of OFES differs considerably. There is a lack of knowledge about the reasons for the national differences in the practicing of OFES as well as the reasons why animals undergo OFES. These knowledge gaps require further investigation.

Abbreviations

DFSA: Danish Food and Safety Authority; EEA: European Economic Area; EU: European Union; FFA: Finnish Food Authority; NFSA: Norwegian Food and Safety Authority; OFES: On Farm Emergency Slaughter; SFA: Swedish Food Authority.

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Authors' contributions

All author participated in the design of the review the final manuscript GS and ADM were responsible for the data collection and text in the review. All authors read and approved the final manuscript.

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Availability of data and materials

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Competing interests

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Occurrence and reasons for on-farm emergency slaughter of cattle in Norway

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12 **Keywords: OFES, cattle, animal welfare, food safety, mortality, slaughter, public health,**
13 **sustainable cattle production,**

14 **Abstract**

15 On-farm emergency slaughter (OFES) accounts for more than 4% of all cattle slaughter in Norway.
16 The practice raises questions about animal welfare, public health, and the sustainability of cattle
17 production. The objective of this study was to describe the reasons for OFES as stated on the OFES
18 veterinary certificate. Veterinary certificates for OFES for each animal slaughtered in four chosen
19 slaughterhouses from four months (January – April – July – October) in 2018 were transcribed into a
20 database. Secondary data were extracted from national cattle databases and used to supplement
21 primary data with information on breed, sex, and birth date. Breeds were divided into dairy and beef
22 cattle. The reasons for slaughter were reported in text on the forms and were categorized in the study
23 into 5 reasons: recumbency, mammary gland, obstetrics, locomotion, and other, with a total of 20
24 subcategories for detail. In total, 2229 forms were included in the study. Thirteen breeds were
25 represented, although dominated by Norwegian Red within dairy and crossbreeds with beef. Of the
26 cattle in the study, 46% were slaughtered for locomotion reasons, thereof almost half for lameness.
27 Furthermore, 23% of the cattle in the study were slaughtered for recumbency and 17% for prolapse or
28 dystocia. A higher proportion of dairy cows were slaughtered because of reasons related to mammary
29 glands than beef cows, 10% and 2%, respectively. Almost 30% of beef cows were slaughtered for
30 obstetrics reasons compared to 12% of dairy cows. The results of this study shed light on the reasons
31 for OFES, which is highly relevant to greater discussions of sustainability in cattle production and
32 animal welfare related to on-farm mortality.

33 **1 Introduction**

34 On-farm mortality and planned culling are the main end-of-life events for production animals. On-
35 farm mortality is an unexpected event encompassing unassisted death, euthanasia, or on-farm
36 emergency slaughter (OFES). This differs from culling, where a planned decision was made to
37 remove the animal from the herd, either through sale or slaughter (1). An acutely injured animal may
38 be euthanised or undergo OFES, or be casualty slaughtered (at a slaughterhouse). Per the European

39 Union (EU) regulation (EC) No 1/2005, rules concerning the state of an animal before and during
40 transport to slaughter are getting stricter, and thus casualty slaughter is often not a viable option
41 anymore (2). After rearing an animal, it can become an economical burden on the farmer if it is lost
42 unexpectedly; length of its productive life is shortened, as the animal has not lived its expected
43 lifespan. This applies especially if the animal needs to be euthanised, whilst OFES may salvage some
44 of the value of the compromised animal and therefore limit the loss. On-farm emergency slaughter is
45 legal in the EU, the countries of the European Economic Area (EEA), the United Kingdom and some
46 jurisdictions in Canada (3). Nevertheless, some European countries do not practice OFES and in the
47 remaining EU countries, it is used limitedly because many slaughterhouses do not offer the option of
48 OFES (3-6). Conversely, Australia, New Zealand and the United States of America do not allow for
49 OFES (3, 7).

50 The prerequisites for OFES of cattle in the EU are; the animal must have had a recent accident or
51 unforeseeable incident, have an unaffected general condition, and be ineligible for transport (8). As
52 Norway is not in the EU, but a part of the EEA, the EU regulations are later committed to the
53 Norwegian legislation, with the option of provisions special to Norway, if appropriate. The
54 Norwegian Food Safety Authority has published guidelines, interpreting the legislation, to harmonize
55 the practice of OFES in Norway (9). These guidelines have been changed 2 since the start of this
56 study, in March 2021, and September 2022, while the legislation has remained unchanged. As the
57 legislation has been interpreted in 3 different ways in Norway, different implantation of the
58 legislation might affect the difference between the practice of OFES in varying countries (3). That
59 difference is clearest in the contrast between the proportion of OFES of cattle of all cattle slaughter in
60 the different reported countries, with Norway being 4.2% in 2018 (10), while the Republic of Ireland,
61 Northern Ireland, and the Netherlands have reported 0.01%, 0.11%, and 0.90% respectively (5).

62 The perception of veterinarians on the use of OFES is conflicted, between animal welfare and/or
63 public health concerns, and the economic interests of the farmer (6, 11, 12). The public health
64 concern is based on the possibility of infections carried with the animal to the consumer by way of
65 poorer slaughter hygiene (13). Casualty slaughtered cattle have been shown to have a wider range of
66 anthelmintic drug residues in the muscle of those than cattle conventionally slaughtered in a
67 slaughterhouse (14). This could be because of insufficient food-chain information, or that the
68 information is not logged, and then forgotten as the slaughter of the animal had not been planned
69 when the animal was given anthelmintic drugs. The animal welfare concerns relate to both the reason
70 for slaughter, as well as the wait time from certification to slaughter, as the animal may be suffering
71 while waiting. Neither aspect has been researched well, and there is little data available to conclude
72 on these concerns. The decision process is often quite complex, both for farmer, veterinarian, and
73 slaughterman, and could possibly be helped with good guidelines and decision trees, as discussed in
74 research from both British Columbia/Canada and the Republic of Ireland (6, 12).

75 Previously, there has only been one study published on the reasons and use of OFES (7). The
76 previously published study describes the situation in British Colombia, Canada and is not directly
77 transferable to Europe. The frequency of OFES in Norway compared to the frequency reported in
78 other countries also means further knowledge of OFES is required. Therefore, the objective of this
79 article is to describe the reasons for the OFES of cattle in Norway.

80 **2 Methods and Materials**

81 **2.1 Study Population**

82 The three largest cattle slaughterhouses in Norway, identified using data published by Animalia –
 83 The Norwegian Meat Research Centre (10) were included. Additionally, one private slaughterhouse
 84 was selected to be included in the study based on its location in a highly cattle-dense area. Veterinary
 85 certificates for OFES from the first month in each quarter (January, April, July and October) of 2018
 86 were selected to be included in the study. All slaughterhouses gave access to their numbers of total
 87 cattle slaughtered in 2018 as well as the total number of OFES processed in 2018.

88 **2.2 Data Sources**

89 **On-farm emergency slaughter**

90 The veterinary certificates for OFES are collected and stored by the Norwegian Food Safety
 91 Authority in each slaughterhouse. The Norwegian Food Safety Authority granted access to the
 92 physical copies of the handwritten veterinary certificates. The veterinary certificates contain
 93 identification information about the farmer and animal, the reason for OFES, drug history for the
 94 animal for the last 30 days, including regulated withdrawal times and the signatures from the
 95 veterinarian, farmer, and registered slaughterman. Cattle born in Norway are to be marked by an ear
 96 tag including an identification number for the farm they were born to (8 digits) and the animals' own
 97 id (4 digits) (15). The first author entered all legible data from the OFES veterinary certificate into
 98 Microsoft Access 365 database. All illegible data as well as data not recorded on the certificates were
 99 entered as missing in the database.

100 The reasons for OFES were determined based on text from the veterinary certificates for OFES. The
 101 reasons for slaughter were then categorized into 20 categories that were grouped into 5 categories:
 102 recumbency, mammary gland, obstetrics, locomotion, and other. Criteria for categories and
 103 subcategories are shown in Table 1. In cases where multiple reasons for OFES were listed by the
 104 attending veterinarian, one category was chosen based on what the authors interpreted as the primary
 105 reason for OFES. Data collection was performed in the last quarter of 2019.

106 **Cattle databases**

107 The unique animal ID obtained from the OFES veterinary certificate was used to extract secondary
 108 data from the voluntary nationwide recording systems for cattle farming. These are the Norwegian
 109 Dairy Herd Recording System (NDHRS) and the Norwegian Beef Cattle Recording System
 110 (NBCRS). In 2018, 98 % of Norwegian dairy herds were enrolled in the NDHRS and 70% of beef
 111 herds in the NBCRS (16, 17). The recording systems contain information on cow pedigree, and the
 112 production and health of individual animals for in enrolled herds. Information on birth date, slaughter
 113 date, sex, breed, and slaughter classification were extracted from the NDHRS/NBCRS to supplement
 114 the primary data. Additionally, parity and the most recent calving date were extracted when
 115 applicable. Individuals not successfully matched in the initial extraction were examined for
 116 transcription mistakes, and information was extracted for additionally identified individuals.

117 **2.3 Data management**

118 Further data management and analysis were performed using Stata SE/15 (Stata Corp., College
 119 Station, TX, USA). Data were checked for duplicates and transcribing errors were corrected. The
 120 primary dataset was merged with the supplementary data from the voluntary nationwide recording
 121 systems in Stata. Animals of the following breeds were classified as dairy; Norwegian Red, Jersey,
 122 Trønder and Nordlands, Brown Swiss, Holstein, Milk Simmental, and Raukolle while crossbreeds,
 123 Charolais, Limousine, Hereford, Aberdeen Angus, and Beef Simmental were classified as beef cattle.

124 This gave two groups of animal production systems. Animals with no data on breed were not
125 included in the analysis by production system.

126 The age of the animal in days was calculated by subtracting the birthdate from the slaughter date.
127 Age was used to group animals into five animal type categories similar to that used for slaughter
128 classification (18). Calf was any animal, both female and male, 300 days old and younger, bull is a
129 male over 301 days old, heifer is a female from 301 to 760 days old. Young cow is a female from
130 761 to 1460 days old and cow is a female older than 1460 days old.

131 2.4 Descriptive statistics

132 Frequency distributions were used to describe categorical data. Total numbers and percentages were
133 extracted for all records, and each production system for the variables slaughterhouse, slaughter
134 month, sex, and animal type. The reasons for OFES were tabulated by production system and total
135 numbers and percentages, as well as tabulated for each production system by animal type.

136 3 Results

137 A total of 2247 cases were recorded from the four slaughterhouses. Of those, 18 were from a month
138 outside the study period, because they were sorted by *postmortem* inspection date, not OFES date.
139 Thus, 2229 cases were included in the database for analysis, but 32 of those veterinary certificates
140 did not include a complete 12-digit animal ID, making it impossible to request secondary data from
141 the voluntary national cattle databases. Further, 451 could not be matched to any animals in the cattle
142 databases, leaving 1746 with secondary data. Of those, 1563 included breed information, used to sort
143 into two different production systems.

144 Slaughterhouses A, B, C and D reported that 5%, 4%, 4%, and 3% of their total cattle slaughter in
145 2018 was OFES, respectively. The cases collected accounted for 30%, 27%, 34%, and 38% of the
146 OFES records in each respective slaughterhouse in 2018. Table 2 shows the distribution of the total
147 number of cases and tabulates them by production system for each slaughterhouse, slaughter month,
148 sex, and animal type. Half of the study, 53% were dairy cattle, of which, Norwegian Red was the
149 most common breed of dairy cattle breeds in the study sample (73% of dairy cattle). Meanwhile, 17%
150 of the whole study sample were beef cattle breeds where crossbreeds were the most common breed,
151 accounting for 58% of beef cattle. However, 30% (n=666) of the whole study sample was missing
152 information on breed (and production system). The division of sex within the dairy production
153 system was about 20-80% male-female, respectively, while it was 30-70% within beef production
154 system. Further, the beef production system had a more even distribution of animal types, 7, 25, 16,
155 26, 26% of calf, bull, heifer, young cow, and cow, respectively, while (adult) cows accounted for
156 43% of the OFES from dairy production systems. This follows the statistics from Animalia that 8%
157 of all milking cows are slaughtered by undergoing OFES instead of conventional slaughter (10).
158 OFES-cases of dairy cattle were evenly distributed throughout the sampled months (23-26%). OFES
159 of beef cattle were more frequent in April and less frequent in January, accounting for 37% and 14%
160 of the total sample, respectively.

161 Table 3 shows the occurrence of reasons for OFES by production system and for the total number of
162 cases. Locomotory reasons account for 46% of total OFES in this study. Almost half of those (45%)
163 were categorised as lame. Thus, lameness accounted for 21% of the total OFES in this study. Further
164 10% of dairy cattle suffered mammary gland issues before OFES, while only 2% of beef cattle did.
165 Obstetrical reasons accounted for a larger proportion of the beef cattle certificates than the dairy
166 cattle certificates 28 and 12%, respectively, see also Figure 1. One-fifth of the OFES were reportedly

167 recumbent (23%) of which a majority were categorised as palsy. Trauma not related to locomotory,
168 or mammary gland reasons accounted for only 3% of the total sample.

169 Tables 4 and 5 show the occurrence of reasons for OFES by animal type for production system dairy
170 and beef, respectively. Of the beef heifers, almost half, 46% were OFES for obstetrical reasons, with
171 only 17% of dairy heifers being OFES for the same reasons. For the younger animals, (calves, bulls
172 and heifers, (most under 2 years of age)), fractures were more frequent than for older animals, 12-
173 18% versus 1-4%, respectively. When delving into different age brackets, it was clear that lameness
174 continued to a bigger or equal proportion of the study sample as fractures, until going as young as
175 220 days. At that age, lameness dropped from around 25%, equal to fractures, to around 10%. The
176 exception is the beef heifers, where only 8% of heifers had a fracture for OFES.

177 The proportion of locomotion as the reason for OFES for heifers is larger than for the older age
178 groups (young cow and cow; Figure 2). Furthermore, obstetrics as the reason for OFES were more
179 frequent for heifers and young cows compared to cows.

180 **4 Discussion**

181 This is the first study in Europe and the second in the world to focus on documenting the reasons for
182 OFES (7). Almost half of all the cases reported locomotory reasons for OFES. Of the locomotory
183 cases, half were subcategorised as lame. The current study found lameness the reason provided for
184 OFES for 1 out of every 10 cases, in every age group, and over 20% in overall average. In contrast, a
185 study performed in British Columbia/Canada found that only 9% of all the cattle underwent OFES
186 because of lameness which the study points out is a chronic condition (7). The OFES guidelines in
187 British Columbia clearly state that animals suffering from chronic conditions were not eligible for
188 OFES, although no specific guidance on lame animals is offered (7). Therefore, OFES of lame cattle
189 in Norway might explain some of the difference between the occurrence of OFES in Norway in
190 contrast to other countries (5, 10).

191 Lameness is a cause of suffering and an area of animal welfare concern (1, 19, 20). The Norwegian
192 guidelines for OFES in place in 2018 when this study was performed, specifically stated that lame
193 animals were eligible for OFES, despite the condition not necessarily been acute or the result of an
194 accident. In contrast, the current guidelines for OFES in Norway, updated in 2022, only allow for
195 newly acute lame animals, within certain timeframes (9). While OFES may be the best option for a
196 lame animal it has not been mentioned as one of the biggest causes of on-farm mortality in Estonia
197 (21). The reason for these apparent differences is unclear but could be caused by Estonia treating
198 their lame animals, so they can continue their production, or if they are sent to conventional slaughter
199 despite being ineligible for transport in some cases, or perhaps there are fewer lame cattle in Estonia.
200 Further, locomotor disorders were found to be more common among euthanised cows than cows
201 dying naturally in a Danish study, theorized to be because lameness is rarely the cause of natural
202 death, but can be cause for euthanasia (22). Comparing the proportion of the whole between OFES
203 and on-farm mortality might prove ill-advised, as certain categories, such as metabolic and digestive
204 disorders only occur within on-farm mortality meaning the comparison would be skewed.

205 The current study showed that the proportion of young animals (calves, bulls, and heifers) reported
206 having a fracture which resulted in OFES being 12-18%, with beef heifers being intermediate (8%).
207 This is in stark contrast to the proportions of fractures in older animals (1-4%). The outlier of beef
208 heifers can possibly be explained by the big proportion, 46%, within that group that had obstetrical
209 reasons for OFES. In Norway, beef steers and replacement heifers are commonly housed in group

210 pens, often on slatted floors. In these housing conditions, there is little shelter for each animal, which
211 may lend itself to more traumas, caused by other animals or by simply slipping. By the end of 2021,
212 67% of dairy cows were kept in free-stalls and the rest in tie stalls, with mattresses in the lying areas
213 (23). The topic of housing is a large part of the new animal welfare program on cattle in Norway (24)
214 and the results of this study could stand as further argumentation for keeping young animals in pens
215 with enough space and options for shelter. The difference in housing and the rate of growth, between
216 the different animal groups, may, therefore, be an important factor in deciding which reasons for
217 OFES are more common, but this would need further study to confirm.

218 Almost half of the beef heifers in this study, and one-fifth of other heifers and cows in this study
219 underwent OFES for obstetrical reasons. Prolapse accounts for half of those, which has been seen to
220 be more common in beef breeds, than dairy (25). Further, crossbreeds accounted for the majority of
221 beef cattle in this study, and thus there is a chance that some unfortunate breeding crosses were made
222 on heifers, causing worse dystocia (26). Research into risk factors for on-farm mortality has also
223 shown that management before, and during calving, can have a significant effect on the mortality rate
224 of cows (4). Further, it is known that the productive life of Norwegian beef cattle is far too low with a
225 third of Norwegian beef heifers only calving once (27). Many of the certificates which listed palsy as
226 the reason for OFES, also noted that the palsy was related to calving, meaning even more animals
227 than the 17% reported in Table 3, underwent OFES because of obstetrical reasons. A higher
228 proportion of cows calving for the first and second time were categorised to be slaughtered for
229 obstetric reasons, than those in their second parity or older. This aligns with earlier research on
230 dystocia, finding dystocia to be more common in heifers than in multiparous cows, and delivery to be
231 more painful and stressful (28). Needing assistance or experiencing dystocia has also been found to
232 be a risk factor for beef cows in Norway having fewer calves (27). It is unsurprising that obstetrical
233 problems, recumbency and accidents of different kinds are a big part of the reasons for OFES, as the
234 same has been found in on-farm mortality research (20, 29).

235 There is considerable focus on how to reduce the environmental impact of cattle herds and in doing
236 so improving the sustainability of cattle production systems (30). Preventing acute injuries and
237 disease or making use of OFES can reduce the waste of the animal. By reducing on-farm mortality,
238 where no meat goes to human consumption, OFES can thus reduce the number of animals needed for
239 the same yield. Dystocia is an important reason for acute suffering and sometimes leads to conditions
240 or trauma that come with a poor prognosis (28). OFES can offer a solution to these cases of dystocia
241 and prolapse, and thus salvage the meat, whereas trying treatment could yet end in euthanasia and
242 destruction. However, there are important concerns surrounding OFES performed because of an
243 obstetrical reason. Many of the cows with obstetrical causes of OFES are likely to be suffering
244 acutely. Therefore, it is questionable to have them wait long for OFES. In that concern, further work
245 is needed to analyse the wait time from accident to slaughter, or certification to slaughter. Further, as
246 with lame animals, it is unclear if the option of OFES discourages veterinarians in Norway from
247 undertaking procedures like uterine prolapse reponation and C-section in cattle. Thus, considering the
248 discussion above, one way to improve cattle production would be to improve practice around
249 management before and during calving, especially for the younger animals, that are intended to stay
250 in production to reduce the need for large groups of replacement stock. Further, looking into better
251 housing for the younger animals, to reduce acute injury would have the same effect. This could then
252 lower the overall on-farm mortality rate of younger animals, while the remaining OFES would
253 salvage the meat for human consumption, making sure that as much yield can be gotten from the herd
254 size needed.

255 Animals undergoing OFES, are often recumbent and therefore are dirtier than normal slaughter cattle
256 (31). This causes difficulty in maintaining good slaughter hygiene, risking cross-contamination from
257 the skin to meat (13). This was a concern raised by some veterinarians from focus groups and
258 interviews made in British Columbia (12). Additionally, 17% of the official veterinarians questioned
259 in an Irish study perceived there to be a greater risk to consumers from consuming OFES meat (6).
260 As 69% of the study sample in this study was categorized as either being slaughtered for recumbency
261 conditions or locomotory conditions, higher contamination risk is probable on these animals, as their
262 conditions would have them lie for longer than healthy animals. When evaluating OFES and trying to
263 improve its practice, these public health concerns should be researched further.

264 Every third month was chosen for data gathering, over one year, 2018, to include one month in each
265 season. The only significant difference in proportion between the fourth months (January-April-July-
266 October), was within the beef production group. This was a difference between January and April,
267 seen by fewer beef animals OFES for locomotory reasons in January than any other month
268 meanwhile more animals OFES for recumbency and obstetric reasons in April than any other month.
269 This could be explained by the seasonal differences in beef production where most beef herds in
270 Norway have a spring calving season (32). It is, therefore, reasonable to assume that there would not
271 be too big a difference in results if the study had included all twelve months in a year. The four
272 slaughterhouses were chosen because of either size or their geographical placement in cattle-dense
273 areas. They are found in three different regions of Norway, and therefore display practice in a big
274 part of Norway. However, it could be that less OFES is practiced in fewer cattle-dense areas,
275 although unlikely to have an effect overall, as it is offered in all areas in Norway. Nonetheless, for
276 more acute reasons, such as obstetrics, or other painful conditions, a farmer or veterinarian could
277 choose euthanasia instead of OFES if the distance to the slaughterhouse is great.

278 The validity of the veterinary certificates can be questioned, both regarding correctness and
279 completeness (33). They are handwritten and some were filled out with a specific history of how the
280 animal came to be OFES, others gave limited information, e.g., does not stand up, lame or palsy.
281 Three of the categories reported reasons not eligible for OFES in Norway (9). These were
282 management, where it was stated that the farmer asked for OFES, and then poor appetite and OFES
283 for clinical internal signs of illness. The clear difference in how veterinarians filled out the certificate
284 raised questions on how good the certification is, which then leads to questions on the food safety of
285 the practice. At the time of data collection, there was no specific training for this for the private
286 veterinarian. However, the new guidelines published in September 2022, demand that official
287 veterinarians do the *antemortem* inspection and certification (9). A continuing education course is
288 launching soon for private veterinarians to become official veterinarians for these tasks.

289 Although only four certificates were marked to have an illegible reason for OFES, many more were
290 hard to read and missing information. The correctness of the certificates is thus compromised, by the
291 human influence of what both farmer and veterinarian decide to put on the certificate (33).
292 Additionally, the identification number was in some not correct, not written out in full, or
293 handwriting hard to interpret, leading to uncertainty in food-chain information, another public health
294 concern. Further, a comparison with reports from NDHRS, shows that the following culling reasons
295 for OFES cows were most noted by farmers; 29.6% had an accident in the barn, 19.6% with other
296 disease, 13.5% with calving problems and 12.4% with milk fever (34), and these proportions do not
297 quite match the proportions in this study. The NDHRS records are hard to compare to this study, but
298 the use of “disease” and milk fever as categories complicates this further, as this shouldn’t fall under
299 OFES. Comparing the certificates with *postmortem* findings would be a field of further research, but
300 *postmortem* findings are mostly poorly documented if the carcass is not condemned. Digital

301 veterinary certificates, with additional information on *postmortem* findings, could improve data
 302 collection, both for food chain information, as well as for further research. The Animal Health Portal
 303 (DHP) in Norway, an animal registry for animal health, artificial insemination, and food-chain
 304 information by Animalia, is already used by veterinarians and farmers and would be the most
 305 obvious place to link the certificate to (35).

306 The occurrence of OFES is quite uniquely high in Norway compared to other reported countries (6,
 307 7), offered year-round 24/7 (36). In contrast, OFES is only offered in limited areas, during specific
 308 periods, or not offered at all, in other countries where the legislation allows for OFES (1, 6, 20).
 309 Countries close by, like Sweden, Finland and Iceland make do with casualty slaughter and home
 310 slaughter for their own use, when deciding options for compromised slaughter-ready animals (4). The
 311 study results are therefore quite representative of the situation of OFES in Norway and may represent
 312 similar situations within other on-farm mortality options internationally. The availability of OFES in
 313 Norway may contribute to farmer and veterinarian making faster decisions in cases of acute trauma,
 314 leading to the animal's pain being alleviated soon, yet reducing the loss of income for the farmer.
 315 However, the timeframe from accident to alleviation may not be too long, and thus, further research
 316 is needed into how fast the process surrounding OFES works. The findings of such research may then
 317 answer quite a few raised concerns about animal welfare within OFES.

318 **5 Conclusion**

319 This study is the first to report on the reasons for OFES in Europe. Almost half of the OFES cases
 320 were slaughtered for locomotion reasons, almost a quarter for recumbency and one of six for
 321 obstetric reasons. There were considerable differences in reasons for OFES between production
 322 systems and animal age groups. The results point to areas of improvement within both housing and
 323 management of cattle, through proactive culling plans and guidelines. The current system of
 324 certificates leaves some room for bias, both in their validity and in the insurance of public health, and
 325 therefore, digitalization of certification is recommended. Digitalization can further help contribute to
 326 animal health registries, animal welfare programs and epidemiology.

327 **6 Abbreviations**

328 OFES – On-farm emergency slaughter
 329 NDHRS - Norwegian Dairy Herd Recording System
 330 NBCRS – Norwegian Beef Cattle Recording System
 331 EU – European Union
 332 EEA- European Economic Area

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436 Table 1: Inclusion criteria for categories of reason for OFES, including the sorting of subcategories to
 437 categories.

438

Category	Subcategory	Inclusion criteria for category
Recumbency	Unable to stand	Cases unable to stand, but unknown cause
	Milk fever	Cases of milk fever, not recovering
	Splits	Have done the splits, recumbent.
	Palsy	Cases of muscle, nerve or tendon damage, or unexplained palsy.
Mammary Gland	Mastitis	Cases of mastitis
	Udder Damage	Cases of trauma to the udder as well as risk to mastitis
Obstetrics	Prolapse	Cases with a current vaginal or uterine prolapse, sometimes in combination with a
	Dystocia	All reasons relating to the upcoming calving or just calved. Cases of calving
Locomotion	Lame	Cases of lame animals
	Damaged Legs	Cases of trauma to legs, minus fractures.
	Fracture	Cases of fractures or tentative fractures
	Arthritis	Cases of arthritis
Other	Trauma	Cases of trauma (not to legs or udder)
	Internal	Cases of clinical signs of internal cause.
	Poor Appetite	Cases reported having poor appetite
	Wild	Including animals that can't be caught after being released outside, as well as
	Illegible	Cases where the reason for slaughter was illegible on the certificate to all authors of
	Management	Cases where no medical reason was stated, only that the farmer wished for OFES
	Empty	Cases where no reason included on the certificate
	Rectal Prolapse	Cases of rectal prolapse, not in combination with other prolapse

439

440 Table 2: Descriptive table of database, showing variables by production system, records missing data
 441 on production system are n=666 (29.9%) included in the total.

442

Variable	Production System		All
	Dairy	Beef	Total
Slaughterhouse			
A	91 (7.6%)	54 (14.5%)	275 (12.3%)
B	211 (17.7%)	77 (20.7%)	493 (22.1%)
C	580 (48.7%)	142 (38.2%)	920 (41.3%)
D	309 (26%)	99 (26.6%)	541 (24.3%)
Slaughter Month			
January	305 (25.6%)	53 (14.2%)	503 (22.6%)
April	270 (22.7%)	138 (37.1%)	606 (27.2%)
July	307 (25.8%)	91 (24.5%)	577 (25.9%)
October	309 (25.9%)	90 (24.2%)	543 (24.3%)
Sex			
Male	235 (19.7%)	107 (28.8%)	486 (21.8%)
Female	956 (80.3%)	265 (71.2%)	1741 (78.1%)
Missing	0 (0%)	0 (0%)	2 (0.1%)
Animal Type			
Calf	33 (2.7%)	25 (6.7%)	73 (3.3%)
Bull	212 (17.8%)	91 (24.5%)	354 (15.9%)
Heifer	150 (12.6%)	61 (16.4%)	239 (10.7%)
Young Cow	288 (24.2%)	97 (26.1%)	464 (20.8%)
Cow	507 (42.6%)	98 (26.3%)	702 (31.5%)
Missing	1 (0.1%)	0 (0%)	397 (17.8%)
Total	1191 (53.4%)	372 (16.7%)	2229 (100%)

443

444 Table 3: Descriptive table showing number and percentage of total of each production system within
 445 each subcategory for OFES. records missing data on production system are n=666 (29.9%) included
 446 in the total.

447

Causes	Production System		
	Dairy	Beef	Total
Recumbency			
Unable to Stand	29 (2.4%)	9 (2.4%)	55 (2.5%)
Milk Fever	25 (2.1%)	3 (0.8%)	38 (1.7%)
Splits	50 (4.2%)	18 (4.8%)	89 (4%)
Palsy	179 (15%)	47 (12.6%)	328 (14.7%)
Mammary Gland			
Mastitis	21 (1.7%)	0 (0%)	29 (1.3%)
Udder Damage	99 (8.3%)	6 (1.6%)	128 (5.7%)
Obstetrics			
Prolapse	56 (4.7%)	63 (17%)	201 (9%)
Dystocia	83 (7%)	41 (11%)	175 (7.8%)
Locomotion			
Lame	268 (22.5%)	62 (16.7%)	467 (21%)
Damaged Legs	227 (19.1%)	68 (18.3%)	418 (18.7%)
Fracture	72 (6%)	25 (6.7%)	139 (6.2%)
Arthritis	5 (0.4%)	1 (0.3%)	8 (0.4%)
Other			
Trauma	30 (2.5%)	12 (3.2%)	63 (2.8%)
Internal	25 (2.1%)	7 (1.9%)	42 (1.9%)
Poor Appetite	2 (0.2%)	0 (0%)	8 (0.4%)
Wild	8 (0.7%)	3 (0.8%)	16 (0.7%)
Illegible	1 (0.1%)	0 (0%)	4 (0.2%)
Management	8 (0.7%)	0 (0%)	10 (0.4%)
Empty	2 (0.2%)	0 (0%)	2 (0.1%)
Rectal Prolapse	1 (0.1%)	7 (1.9%)	9 (0.4%)
Total	1191 (53.4%)	372 (16.7%)	2229 (100%)

448

449 Table 4: Descriptive table showing number and percentage of total of each animal type within each
 450 subcategory of OFES, n=1190, only including animals from a dairy production system.

451

Causes	Animal Type				
	Calf	Bull	Heifer	Young Cow	Cow
Recumbency					
Unable to Stand	-	2 (0.9%)	1 (0.7%)	6 (2.1%)	20 (3.9%)
Milk Fever	-	-	-	-	25 (4.9%)
Splits	2 (6.1%)	-	7 (4.6%)	21 (7.3%)	20 (3.9%)
Palsy	2 (6.1%)	18 (8.5%)	24 (16%)	42 (14.6%)	93 (18.3%)
Mammary Gland					
Mastitis	-	-	1 (0.7%)	7 (2.4%)	13 (2.6%)
Udder Damage	-	-	3 (2%)	33 (11.5%)	63 (12.4%)
Obstetrics					
Prolapse	-	-	4 (2.7%)	25 (8.7%)	27 (5.3%)
Dystocia	-	-	22 (14.7%)	36 (12.5%)	25 (4.9%)
Locomotion					
Lame	7 (21.2%)	87 (41.0%)	20 (13.3%)	47 (16.3%)	107 (21.2%)
Damaged Legs	14 (42.4%)	61 (28.7%)	27 (18%)	45 (15.6%)	80 (15.8%)
Fracture	6 (18.2%)	29 (13.7%)	26 (17.3%)	5 (1.7%)	6 (1.2%)
Arthritis	-	3 (1.4%)	1 (0.7%)	-	1 (0.2%)
Other					
Trauma	1 (3%)	8 (3.8%)	6 (4%)	6 (2.1%)	9 (1.8%)
Internal	1 (3%)	1 (0.5%)	2 (1.3%)	9 (3.1%)	12 (2.4%)
Poor Appetite	-	-	-	2 (0.7%)	-
Wild	-	1 (0.5%)	5 (3.3%)	2 (0.7%)	-
Illegible	-	1 (0.5%)	-	-	-
Management	-	-	1 (0.7%)	2 (0.7%)	4 (0.8%)
Empty	-	-	-	-	2 (0.4%)
Rectal Prolapse	-	1 (0.5%)	-	-	-
Total = 1190 (100%)	33 (2.7%)	212 (17.8%)	150 (12.6%)	288 (24.2%)	507 (42.6%)

452

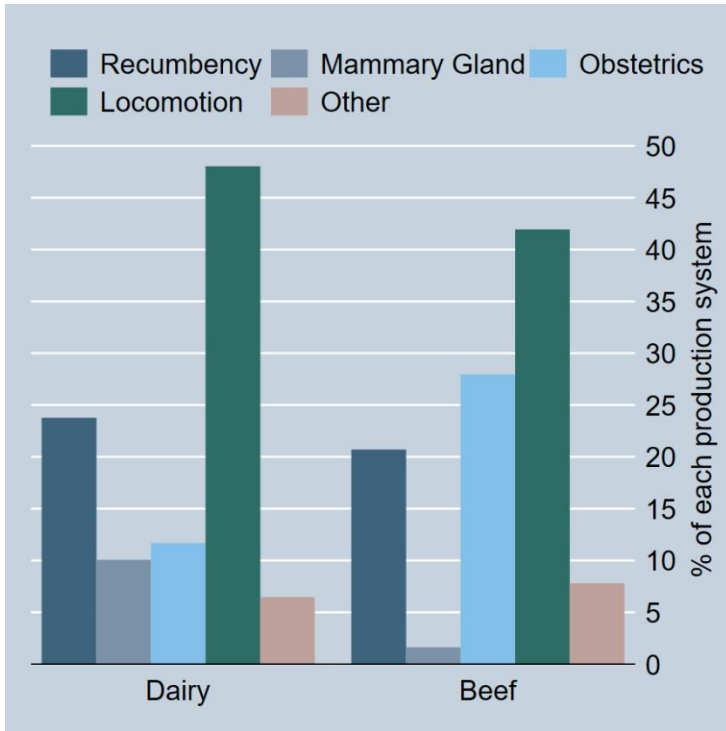
453 Table 5: Descriptive table showing number and percentage of total of each animal type within each
 454 subcategory of OFES, n=372, only including animals from a beef production system.

455

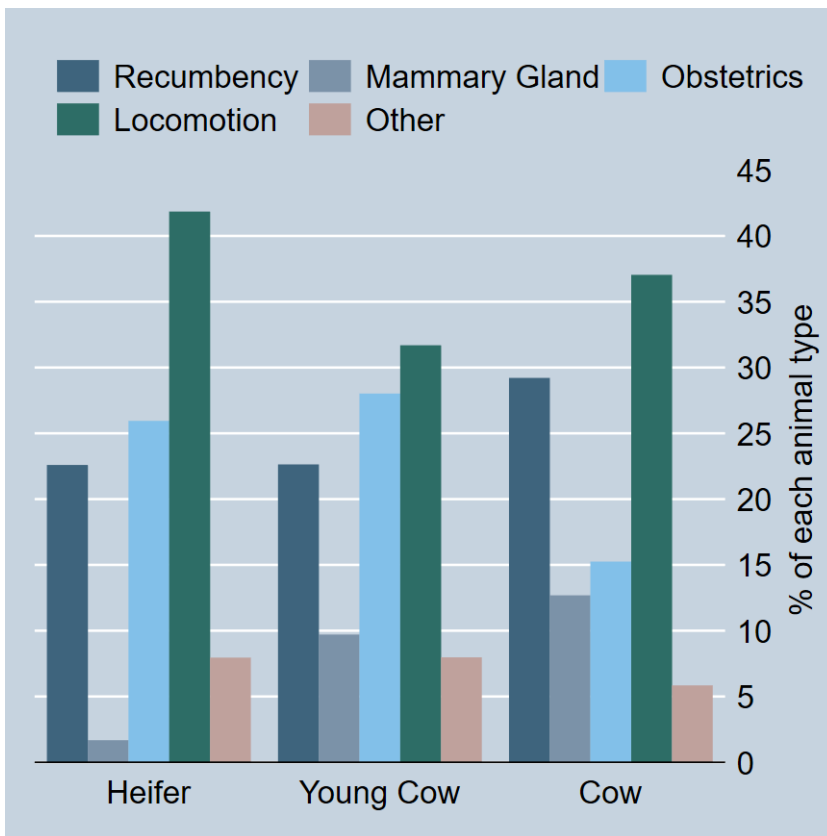
Causes	Animal Type				
	Calf	Bull	Heifer	Young Cow	Cow
Recumbency					
Unable to Stand	-	1 (1.1%)	1 (1.6%)	3 (3.1%)	4 (4.1%)
Milk Fever	-	-	-	-	3 (3.1%)
Splits	-	3 (3.3%)	5 (8.2%)	3 (3.1%)	7 (7.1%)
Palsy	4 (16%)	3 (3.3%)	10 (16.4%)	14 (14.4%)	16 (16.3%)
Mammary Gland					
Mastitis	-	-	-	-	6 (6.1%)
Udder Damage	-	-	-	-	-
Obstetrics					
Prolapse	-	-	16 (26.2%)	27 (27.8%)	20 (20.4%)
Dystocia	-	-	12 (19.7%)	16 (16.5%)	13 (13.3%)
Locomotion					
Lame	4 (16%)	32 (35.1%)	2 (3.3%)	12 (12.4%)	12 (12.2%)
Damaged Legs	7 (28%)	34 (37.4%)	7 (11.5%)	11 (11.3%)	9 (9.2%)
Fracture	4 (16%)	11 (12.1%)	5 (8.2%)	4 (4.1%)	1 (1%)
Arthritis	-	1 (1.1%)	-	-	-
Other					
Trauma	-	4 (4.4%)	3 (4.9%)	2 (2.1%)	3 (3.1%)
Internal	1 (4%)	1 (1.1%)	-	2 (2.1%)	3 (3.1%)
Poor Appetite	-	-	-	-	-
Wild	1 (4%)	1 (1.1%)	-	1 (1%)	-
Illegible	-	-	-	-	-
Management	-	-	-	-	-
Empty	-	-	-	-	-
Rectal Prolapse	4 (16%)	-	-	2 (2.1%)	1 (1%)
Total=372 (100%)	25 (6.7%)	75 (20.2%)	61 (4.3%)	97 (26.1%)	98 (26.3%)

456

457 Figure 1: Bar graph showing the proportion of each reason for OFES for the two production systems.
 458 n=1563.



459
 460 Figure 2: Bar graph showing the proportion of each reason for OFES for 3 animal types; Heifer,
 461 Young Cow and Cow. n=1405.





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