



Lowering antibiotic usage and phasing out pharmaceutical zinc oxide in Danish pig herds: Pig farmers' and veterinarians' experiences and perceptions

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HIGHLIGHTS

- Animal welfare and a reduced usage of antibiotics in pig herds can go hand in hand.
- Systemic conditions play major roles in antibiotic usage in pig herds.
- Prudent use of antibiotics in pigs is challenged by uneducated employees.
- Regulations on antibiotics in pig herds feels both helpful and counterproductive.
- Hyperprolific sows challenge the agenda on prudent use of antibiotics.

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ABSTRACT

The usage of antibiotics in pig production is much debated due to the risk for antimicrobial resistance where routine usage is necessary to protect animal welfare. Denmark has a relatively low usage of antibiotics in pigs. Thus, the Danish context provides critical insight on how to achieve a lower usage of antibiotics in pigs, and experiences from Danish farmers and veterinarians are useful when debating possibilities for reduction. In this study, we conducted semi-structured interviews with ten pig farmers and six pig veterinarians in Denmark to examine how they perceived animal welfare to be affected in herds where the usage of antibiotics or pZnO had been reduced. The study aimed to explore dilemmas and difficulties in relation to protection of animal welfare while having a low usage of medicine. The interviews were conducted in spring 2022, thus, prior to the ban on pZnO in June 2022. We found that the participants in the study had many positive experiences with achieving a lowered need for antibiotics and pZnO. By upgrading on feeding and management and focusing on prevention of diseases, many herds had succeeded in lowering the usage of medicine with no harmful effect on animal welfare. Many years of strict regulatory measures was highlighted as a major reason for this success, but other contextual factors such as production within the "Pure Pork" concept, which provides an economic reward for pigs raised without use of antibiotics, were also acknowledged to play a positive role. The study illustrated how antibiotics are an integrated part of everyday practice in pig herds. Systemic conditions like difficult employee situations, breeding for high prolificacy and bad economy came forward as major explanations for usage of antibiotics. The study also pointed out how antibiotics were sometimes used routinely and thereby highlighted how reductions should still be achievable. Examples were systematic injections to all piglets at birth and to sows post farrowing. In some cases, routine use was explained by having many employees in the pig herds with no education in how to take care for pigs or how to recognize disease. Avoiding pen or batchwise medication of weaners and thereby avoid treatment of healthy animals was a point of controversy, putting spotlight on grey zones and challenges between productivity and animal welfare.

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1. Introduction

Since the 1998 ban of antimicrobial growth promoters, the Danish pig industry has had a focus on lowering the usage of antibiotics. Much of the focus has been accomplished by regulatory frameworks providing incentives to use less antibiotics. These frameworks include the Yellow Card Initiative¹ from 2010, putting limits on the permitted levels of antibiotic usage in different age groups of pigs. The current limits allow that on any given day, approximately 3.2% of sows, 17.2% of weaners and 4.4% of finishers can be treated with antibiotics. If these limits are exceeded, the farmer receives a penalty. Other important regulatory conditions in Danish pig farming affect how antibiotics are used. These include the decoupling of prescription and distribution of antibiotics and mandatory Veterinary Advisory Service Contracts (VASCs), ensuring that all professional herds have regular visits by a veterinary practitioner.²

A political and societal push for a restrictive use of antibiotics in farm animals, triggers concern about animal welfare in the farming industry (Coyne et al., 2014, 2016; Anneberg, 2019). Furthermore, in some countries – like in Denmark - the EU ban on high doses of zinc oxide in feed (up to 2500 mg pharmaceutical zinc per kg feed for the first two weeks postweaning added as zinc oxide (pZnO))³ from June 2022 has also raised concerns about animal welfare and fears that this may lead to an increased use of antibiotics in weaners (Anneberg, 2019).

Previous studies addressing the consumption of antibiotic and pZnO usage in Danish pig herds were mainly based on databases (Fertner et al., 2015b; Dupont et al., 2016, 2017; Kruse et al., 2017, 2019, 2020; Nielsen et al., 2021) and questionnaires (Visschers et al., 2016; Kongsted and Anneberg, 2021), thus providing quantitative data on the subject. Qualitative approaches on the subject are much rarer (Fertner et al., 2015a; Anneberg, 2019; Kongsted and Henriksen, 2021). Thus, we currently don't have much information on how farmers and veterinarians perceive the situation in the herds and how their concerns for animal welfare are articulated.

In this study, we aimed to address the concerns in the farming industry related to the link between usage of antibiotics and pZnO and animal welfare. Therefore, we interviewed farmers having experience with reducing their usage of either antibiotics or pZnO. We also interviewed veterinary practitioners, who had experience with a large variety of pig herds. As the study was carried out in the spring 2022, experiences with phasing out pZnO related to herds voluntarily refraining from using zinc at the permitted levels. Farmers in the study having achieved a low usage of antibiotics often, but not exclusively, were producing within the so-called “Pure Pork” label.⁴ This label is administered by Danish Crown. It guarantees for consumers that this meat is from pigs who have not been treated with antibiotics at any time during their lives. Pig producers within the label receive a premium price from Danish Crown for these pigs, and consumers pay an additional price for the meat. Any pigs from the herds having been medicated with antibiotics, do not elicit a premium.

Our study had the overall aim to investigate with qualitative methods how animal welfare has been affected in herds where the usage of antibiotics or pZnO was reduced as perceived by farmers and veterinary practitioners. Furthermore, we wanted to explore dilemmas and difficulties in relation to protection of animal welfare while having a low usage of medicine (the term “medicine” will be used to cover both

antibiotics and pZnO) as seen by these two groups of professions.

We addressed two research questions:

1. How do Danish pig farmers and veterinarians experience lowering the usage of antibiotics and phasing out pharmaceutical zinc oxide in terms of animal welfare?
2. What difficulties and dilemmas can be identified between protection of animal welfare and having a low usage of medicine in Danish pig herds?

2. Materials and methods

Recruitment of participants, both farmers and veterinarians, involved contacting the six pig veterinary practices in Denmark. The Danish pig sector is highly rationalised and intensified. This means that there are only six veterinary practices in the country are responsible for all professional pig farms. A veterinarian per practice was selected based on achieving a variation in gender and experience. They were contacted by email or phone and asked if they wanted to participate and if they could suggest farmers who had experience with reducing the usage of or stopped using pZnO and who might be interested in participating. Danish pig veterinarians typically consult 30–70 different herds on a monthly basis and therefore these vets were able to point out herds with a low usage compared to others. We pointed out, that preferably, the farmers had experienced a “before” and “after” situation (e.g., a change to Pure Pork production, a new vaccination strategy or a depopulation-repopulation intervention) such that they would be able to talk about the changes that they had experienced in terms of the effect on animal welfare. It was stressed that both positive and negative experiences were welcome. The veterinarians contacted the suggested farmers and asked for permission for us to contact them by phone to explain the study and find out if they were willing to participate. Two of the contacted farmers were not interested due to time constraints or lack of interest. Similarly, one of the contacted veterinarians could not find time to participate.

Table 1

Interviewees in the study. In herds with two owners (2 and 8), both participated in the interview. The term “low usage” refers to the judgement made by veterinary practitioners based on their experience with a portfolio of herds.⁵¹

ID code	Gender	Age	Recommended by veterinarian based on
Farmer 1 (manager)	Male	47	Low usage of antibiotics and zinc oxide
Farmer 2a (owner)	Male	61	Pure Pork production, low usage of zinc oxide
Farmer 2b (owner)	Female	58	Pure Pork production, low usage of zinc oxide
Farmer 3 (owner)	Male	53	Pure Pork production
Farmer 4 (manager)	Male	53	Low usage of antibiotics
Farmer 5 (owner)	Male	55	Pure Pork production, no usage of zinc oxide
Farmer 6 (manager)	Male	45	Pure Pork production, participation in project on phasing out zinc oxide
Farmer 7 (owner)	Male	54	No usage of zinc oxide
Farmer 8a (owner)	Male	60	Low usage of antibiotics, no usage of zinc oxide
Farmer 8b (owner)	Male	33	Low usage of antibiotics, no usage of zinc oxide
Farmer 9 (owner)	Male	43	Low usage of antibiotics and zinc oxide
Farmer 10 (owner)	Male	39	No usage of zinc oxide
Vet 1	Female	50s	
Vet 2	Female	30s	
Vet 3	Male	40s	
Vet 4	Female	50s	
Vet 5	Male	50s	
Vet 6	Male	30s	

¹ For information on the Yellow Card initiative and its limits over the years, see: [The Yellow Card Initiative on Antibiotics \(foedevarestyrelsen.dk\)](https://www.foedevarestyrelsen.dk)

² For more information see: [Distribution and use of veterinary drugs in Denmark \(foedevarestyrelsen.dk\)](https://www.foedevarestyrelsen.dk)

³ See: [Zinc oxide | European Medicines Agency \(europa.eu\)](https://www.euro.pec.eu)

⁴ “Pure Pork” production require farmers to guarantee that pigs with a label have never received antibiotics. For further explanation, see: [Raised without antibiotics - Danish Crown](https://www.danishcrown.com)

Table 2
Outline of the interview guide used for veterinarians.

Topic	Sample questions
Opening question	<ul style="list-style-type: none"> • Could you tell me about your experience as a veterinarian? • Which types of pig herds do you work with?
Reduced usage of medicine – the change and its effects	<ul style="list-style-type: none"> • Broadly viewed, what was the reason for herds choosing to reduce their antibiotic usage in recent years? • How did they achieve it? • Which changes – positive and negative – have happened in herds joining the Pure Pork concept? • Which preventive measures do you judge as the most efficient in terms of decreasing the need for antibiotics? • How do different disease conditions differ in relation to how easy or difficult they are to prevent? • How are your experiences with decreased use or phasing out of pharmaceutical zinc oxide? • What are your thoughts on the ban of pharmaceutical zinc oxide?
Animal welfare	<ul style="list-style-type: none"> • In herds with a lowered usage of antibiotics as a concrete goal – e.g., Pure Pork herds or herds close to the yellow card limits – did you experience cases where animal welfare was negatively affected? • How was it affected? Please give some examples • What problems for animal welfare have appeared in Pure Pork herds? • In those cases, how were the problems solved? • What is animal welfare to you?
Worries	<ul style="list-style-type: none"> • Did you at any point have reservations about the Pure Pork concept? • How do you view it now? • Do you feel worried about pig welfare in the herds due to a low usage of antibiotics? • Do you feel worried about pig welfare in the herds due to non-use of pharmaceutical ZnO?

Two other veterinarians from the same practice were contacted to find another, who was able to participate. [Table 1](#) describes the interviewees and in the case of farmers, the reason why they were recommended to participate. We interviewed either owners or managers based on who had their daily routines in the stables.

Semi-structured interviews were carried out by the first author, who is a qualified veterinarian and PhD. Interviews were carried out in farm lunchrooms or the interviewees' private homes with no disturbance from non-participants from March to May 2022. They lasted between one and two hours and were audio recorded. Before the interviews, interview guides were developed separately for the group of farmers and veterinarians, respectively. Furthermore, interview guides for farmers were shaped according to our prior knowledge on their productions (Pure Pork, no pZnO usage or other reasons for being recommended, see [Table 1](#)). The outline of the interview guide for veterinarians is presented in [Table 2](#) as an example. Farmer interview guides were similar but focused specifically on the situations in their own herds. All participants were given anonymity by only referring to their profession, gender, and age. In the case of veterinarians, as this group is very small and more easily recognizable, we refer to approximate ages to ensure anonymity.

Interviews were professionally transcribed verbatim. Coding and analysis were performed by the first author using an inductive methodological approach inspired by grounded theory ([Brinkmann and Kvale, 2015](#)). Coding was performed in NVivo. The main focus was on how the participants framed their experiences and reflections. Thus, the analysis identified main patterns in the participants' reflections and experiences related to using less antibiotics and pZnO. After having identified main patterns in data, minor trends were refined and consolidated into overarching trends. Analytic results and the selected citations were discussed amongst the authors. Citations used in the paper were translated into English by both authors. In the reporting [(Ed.)] indicates editorial information to citations and (...) is used to denote when quotes are shortened.

According to national regulations, no ethical approval was required for the study. Informed consent, including rights to withdraw interviews, was obtained from all participants.

⁵ In Denmark, all herd owners and veterinary practitioners have access to VetStat ([VetStat \(fvst.dk\)](#)) where they can compare the herds' usage of antibiotics with the national average in different age groups.

3. Results

The interviews brought forward a broad spectrum of everyday experiences, inspirational examples, and overall reflections and attitudes towards the systemic conditions in Danish pig production. Across interviews, sows and weaners were the animal groups most often addressed, and thus in the view of the interviewees seemed the most important groups when considering antibiotic consumption in pig production.

The analysis identified nine themes across interviews:

- Weaning management as an efficient tool for disease prevention
- Divergent opinions on the need for pharmaceutical zinc-oxide
- Focusing on the right problem - use of laboratory diagnostics
- Pure Pork production; Inspirational, eye-opening, and sometimes challenging for animal welfare
- Lack of continuity and education in staff entailing imprudent use of antibiotics
- Hyperprolific sows counteract prudent use of antibiotics
- The way sows are currently housed, bred, and fed increase the need for antibiotics
- The challenges in judging when antibiotics are necessary
- How regulations, monitoring, and bureaucracy affect mindset

3.1. Weaning management as an efficient tool for disease prevention

Many of the interviewees were accustomed to some level of routine antibiotic treatment against diarrhoea in weaners. They especially highlighted how treatments were often applied during the shift in feed from the first to the second post-weaning feed mix. However, they were generally quite optimistic about the situation in weaners and had positive experiences to draw on. These included cases, where no longer using pZnO had only required a few changes in feeding management to be successful.

Many interviewees talked about the significance of a high weight and a high age at weaning to ensure robustness. In practice, however, they experienced an average of 5.5 kg as the normal weaning weight with the smallest pigs weighing around 4 kg. Some had good experiences with weaning at five weeks, but, generally, there was no clear consensus on, what is "old enough" for weaning. Generally, the interviewees would refer to not getting below the legislatively enforced minimum weaning age of three weeks.

Sometimes vets had experienced the average weaning age in herds to

be around three weeks, and in these cases, they were very firm in their conclusions:

Vet 1: (...) then you have so many, that are weaned too early. And that's ... a big problem. Both in terms of antibiotic usage, but also with behaviour. With sucking behaviour, that is (...) that they suck each other into pieces. And that's ... we see that every week, pigs that are sucked into pieces with intestinal prolapse. The week after weaning. And that's the ones that are weaned too early. So, there are some nasty things...about the early weanings.

Vet 3: (...) the closer we get to the 21 days [above 21 days (Ed.)], the harder it gets (...) the more fragile they become in terms of...and that's logical, like with food uptake that instead of having the 300–400 gm we would like, they are only getting between 100–200 gm. And that's a significant change for this pig, as it becomes more vulnerable to diarrhoeic conditions...

Perhaps contradictory, some interviewees experienced that weaning of the smallest pigs would often be less problematic compared to the larger ones. It was explained by the fact that they would already have learned to eat solid food in the farrowing unit due to lost fights at the udders.

When sharing practical advice for management in the weaner stable, both farmers and vets especially talked about low protein feeding with high quality protein. They emphasized that, inevitably, feed costs would rise in the process of phasing out pZnO and warned that any attempts to save money by using cheap feed alternatives would fail.

Decreased stocking density and weaning with littermates and with fewer pen mates were also highlighted as beneficial methods for lowering weaning stress and thereby the need for medicine. A lowered stocking density would typically lead to more eating space in the pens, which was also viewed by the interviewees to support health. One of the farmers had implemented 5.5 weeks batch farrowings⁶ and thereby markedly improved the internal biosecurity by being able to apply strict All-in All-out procedures in both farrowing and weaner sections. He considered this to be the most significant tool to improve herd health, though he had also positive experiences with using a less prolific sow line. In Table 3, practical advice from interviewees on how to decrease the risk of post-weaning diarrhoea and thereby the need for medicine is summarized.

3.2. Divergent opinions on the need for pharmaceutical zinc-oxide

Most experiences with phasing out pZnO were positive. Reducing the dose from 2500 mg zinc per kg feed to 1500 mg zinc per kg feed was noted as having no apparent effect on the pigs. Furthermore, when prepared for, in many cases, a complete stop had been successful and had not resulted in an increased use of antibiotics. Preparatory measures were basically the same as mentioned in Table 3, but in this case with great emphasis on feed quality and feeding procedures. Many interviewees described the process of learning how to wean without pZnO as beneficial for the herds and considered the ban an incentive to improve management procedures and thereby maintain intestinal health in the pigs.

Nevertheless, some of the interviewed farmers had experienced great challenges during attempts to phase out pZnO. One farmer, who had worked on phasing out pZnO while experiencing a PRRS (Porcine Reproductive and Respiratory Syndrome) outbreak, put it this way:

Farmer 6: We have *huge* challenges on phasing out zinc from our weaning stables. And we are not the only ones. Some of the herds in

⁶ Farrowings with 5.5 weeks between - meaning that pigs are weaned at 35 days with an All-out principle and time for thorough cleaning and disinfection between batches. Nursing sows are not used in this system (no sows are available as nursing sows in this system, as no sows farrowed the week before).

Table 3

Management recommendations for prevention of weaning diarrhoea given by the interviewees. Recommendations are not in order of priority. ^a: This is a legal requirement, however, some interviewees had experienced cases with an *average* weaning age of 21 days.

Farrowing stable management	Health management of sows to ensure their capacity to nurse many piglets Vaccination of sows against rotavirus and PCV2 All-in All-out management Thorough cleaning with soap and disinfection between batches Reduce the need for nursing sows and excessive mingling of pigs by using a less proliferative sow line Extra supplement with iron Ensure all pigs have eaten 300–400 g solid feed before being weaned Wean pigs at minimum 21 days of age ^a – weaning at five weeks considered beneficial - reducing the number of sows can be a measure to achieve this
Weaning stable management	All-in All-out management Thorough cleaning with soap and disinfection between batches Thorough drying out between batches Disinfection of water pipes Increase eating space Wean with litter mates Lower stocking density Fewer animals per pen Better quality feed (high quality protein, blood plasma recommended) Low protein feed Restrictive feeding Differentiated timing of change of feed from mix 1 to mix 2 according to size (careful sorting of pigs according to size at weaning) Feeding numerous times a day Milk powder for the smallest pigs Organic acids in feed or water NSAIDs in feed at weaning Potato flour on the floor Extra heating Moving diarrhoeic pigs to sick pen with high quality feed Vaccination of pigs against E.coli and Lawsonia

the project⁷ have experienced a lot of problems with diarrhoea throughout two to three batches. After this period, they seem to have somehow found a method on how to manage without zinc. But so far, I do not know anybody having stopped using zinc who can manage it without using flock treatments with antibiotics after weaning.

Clearly, this farmer saw a dilemma in feeling forced to using more antibiotics when no longer allowed to use pZnO. When referring to his own situation, he said:

Farmer 6: *previously*, we didn't use much flock medication. But following the PRRS infection and at the same time not using zinc (...) it hasn't been possible to manage without flock medication (...) you know, previously, we just needed to treat a few of the pigs in the pens and then that was it. But currently we simply need to use flock medication.

Worries about *E. coli* induced outbreaks of edema disease and increased difficulties with handling these outbreaks when not using pZnO were general concerns amongst interviewees. One of the farmers had personal experience with edema disease during an attempt to stop using pZnO:

Farmer 9: The challenge in this facility is, that there's edema disease down there (...) It went well in the beginning, but all of a sudden the

⁷ The herd had together with other herds participated in a project on phasing out pZnO run by an agricultural research and development organisation.

pigs were collapsing with edema disease (...) And it's an E.coli, you know, and that's what the zinc is good for. It can cover it up.

Some interviewees were not only worried about edema disease but had a more general concern about the welfare impact of the ban. They referred to scientific studies⁸ suggesting a very high physiological need for zinc in weaned pigs and were frustrated, because it appeared to them, that politicians had decided to prioritize the environment at the expense of the welfare of pigs. When asked about her view on the zinc ban, one of the vets answered:

Vet 1: (...) it is in fact an act of animal neglect, because their basic needs for zinc are not fulfilled (...) I simply don't think, they get what they need. And I think it's a pity with such a small one going from nursery to kindergarten, right, that we're not allowed to take proper care of them.

Interviewer: And when you say it's animal neglect, right, can you see...is it because you can see that they...that they suffer?

Vet 1: Yes. You can see it. You see, they become ...what I call "sharp-assed" (...) bristly haired and grey. They really do, and we just have to live with that.

A farmer commented on the situation like this:

Farmer 2: ...and then we take such a whole...a whole animal group... hostage. I think it's wrong (...) now we start to under-nourish the pigs by not giving them the zinc they need. Then we'll try to repair with antibiotics. And you *can't*...you can't repair something...we know it from plant breeding, you can't... a plant that is stressed...a malnourished plant you cannot... you can't treat your way out of.

Other interviewees were less worried, and some argued, that in their opinion, managing without pZnO was beneficial, as the taste of zinc could be negative for the weight gain. A farmer explained why he stopped used pZnO many years ago:

Farmer 5: (...) Well, it's because I know that zinc...it's not that it's something that tastes really well (...) it's not something that promotes their appetite.

Some vets also saw these benefits in not using pZnO:

Vet 4: You know, there are some of them who reach 30 kgs faster, than they would have done otherwise [with pZnO (Ed.)]

Vet 5: ...It's also sometimes an advantage (...) There are good things to say (...) A higher feed uptake and probably a better weight gain, as they don't need to chew through that zinc. They don't like it. In fact, I'm not so nervous about it [the ban (Ed.)], as I used to be. I thought it would end up in Ragnarok, but in fact I think it has turned out remarkably well.

Despite positive experiences most agreed that weaning without pZnO could be a big challenge in many herds. A farmer expressed in very clear terms, that weaning without having zinc as a safety net for some would require considerable changes in the production:

Farmer 4: ...Some herds will have *extreme* difficulties. If...they're down to being close to...having a too low weaning weight. Perhaps because of their farrowing stables – that's the bottleneck (...) I do think that some farmers really need to seriously think: Should we reduce the number of sows? Or should we build more farrowing pens? (...) And if it's possible for them to build more farrowing pens, that's probably the way to go. Or else they need to accept that those 200 sows you have in excess, that in fact ... they have to get out.

⁸ E.g. Hansen, S.V., Nørskov, N.P., Nørgaard, J.V., Woyengo, T.A., Poulsen, H. D., Nielsen, T.S., 2022. Determination of the Optimal Level of Dietary Zinc for Newly Weaned Pigs: A Dose-Response Study. *Animals* 12, 1552.

By this statement he stressed that, as he saw it, minor changes in feeding or hygiene procedures would be insufficient when weaning without pZnO. In his opinion, common structures with too early weanings and too high stocking densities would have to be addressed.

3.3. Focusing on the right problem - use of laboratory diagnostics

Making focused plans to reduce disease occurrence was highlighted throughout the interviews, and vets saw this as their overall task. Many noted how always being aware of the pathogenic challenges was a prerequisite for adequate prevention as well as the importance of the correct choice of antibiotics to prevent excessive use.

Interviewer: And if we talk about preventive measures... and things that can help them [the farmers (Ed.)] to reduce the need for antibiotics...What would you say you have used the most or...which measures have made the biggest difference?

Vet 2: (...) What I've done is to get an overall view on what I have (...) Such that I know which pathogens we are dealing with. If any. (...) and all the time aligned with what we're treating. (...) And do things change? Ehmm...in this way I get to choose the right type of medicine. And in this way, I can experiment a bit with the length of treatments.⁹ And discuss with the employees, what do they think works. And then... in this way reduce the usage [of antibiotics (Ed.)]

This vet saw laboratory diagnostics as an indispensable tool for reducing the usage of antibiotics, as it can help target both prevention and treatment. As seen from the quote, she also used laboratory results as a point of departure in giving advice and involving of employees in decision making.

During the interviews, several examples were given on pathogens diagnosed in the laboratory and subsequently controlled by vaccines, thus supporting the idea of using diagnostics to reduce the need for antibiotics:

Vet 4: (...) I very much feel that e.g. PCV2 and Mycoplasma vaccines help to limit [antibiotic consumption (Ed.)] ... and I think that something such as ...ehh...influenza diagnostics...eh...(...) you find out that they have influenza, but again, you know, those vaccines certainly do not cover everything, either. But that kind, you know (...)

As pointed out in this quote, adequate diagnostics can be helpful in reducing the need for antibiotics. This would be the case when the pathogen that is detected can be efficiently managed by vaccines, like PCV2 and *Mycoplasma hyopneumoniae*. However, as exemplified here with strains of influenza not well covered by vaccines, in some cases there is no straight-forward solution. Thus, having the correct diagnosis may not in such cases limit the usage of antibiotics.

The interviewees referred to the Danish regulation, according to which, if a vet prescribes medication for flock-treatments against diarrhoea or lung disease, at least once per year, he must qualify the diagnosis using laboratory diagnostics. Often, so-called sock samples - PCR tests of faeces collected on the pen floor for *E. coli* F4, *E.coli* F18, *Lawsonia intracellularis* and *Brachyspira pilisicoli* (Pedersen et al., 2015) - are preferred for this use. The attitude towards diagnostics enforced by regulation was often negative. According to some vets, this type of sampling to detect pathogens put too much emphasis on bacteria rather than on the root of the problem:

Vet 5: And then all those sock samples, which we take in *enormous numbers* around weaning, which do not at all serve any purpose, as we know why they are there [E. coli bacteria (Ed.)]. It's the water

⁹ The vet, however, pointed out that she was no longer allowed to experiment with lengths of treatments due to The Veterinary Medicinal Products Regulation (2019/6) which does not allow vets to deviate from SPC's

pipes that need cleaning. It's pigs who are not enzymatically ready for weaning. Meaning, that it's a feed problem, we need to have solved. Or some management around heating of stables. Dry floors, hot floors and so on. Meaning that normally I even don't care to see the laboratory result because I *know* it's E. coli diarrhoea.

In this vet's perspective, laboratory results indicating bacterial infections were not helpful when aiming to manage diarrhoea without using antibiotics, as they would point out secondary issues – the bacteria – rather than the problems the farmer must focus on. Thus, in some cases, laboratory diagnostics were considered counterproductive in relation to achieving a lowered use of antibiotics.

3.4. Pure pork production; inspirational, eye-opening, and sometimes challenging for animal welfare

Pure Pork was a discussion point in many interviews, as this concept is the most obvious example of herds having a low antibiotic use as a focus. Both farmers and vets had very positive experiences on working with Pure Pork, and many learnings emerged from herds being motivated by the concept to implement changes in disease management. When asked about concrete examples on changes in disease treatment which had been implemented with success in Pure Pork herds, one vet said:

Vet 2: Pure Pork herds using some sort of...charcoal product [activated charcoal (Ed.)] against neonatal diarrhoea. That in fact surprised me a bit, that they were in fact able to keep it down by such a product. Rather than treating [with antibiotics (Ed.)]. Of course... you know...it does not work miracles, but... you know, this thing about supportive care...

The quote exemplifies how practical “old-school” tips were reintroduced as efficient substitutes for antibiotics. It also highlights how vets are often used to think of treatment as involving antibiotics and not schooled in alternative treatment strategies.

When speaking in general terms about inspiration from Pure Pork producers and what they do differently, a vet stated:

Vet 4: Hmm, I simply see them as extremely skilled people, who enjoy testing out things. And who constantly come up with thoughts on their practices: “What if we do like this? Or what about this? If we tried to make...have an increased focus on our water troughs at weaning... and more...” (...) they are very good sparring partners, you see. (...) now that we don't have antibiotics, what do we have then... things, we can do, right? (...) You see, I find it inspiring to work with.

This veterinarian stressed that Danish farmers in general, for many years had been forced to improve management and preventive measures due to strict regulations. However, she saw Pure Pork farmers as “top performers” in this respect, as they had often achieved extremely high levels of daily management.

When farmers were asked about the concept, they also highlighted positive experiences with preventing disease by doing things a bit differently. One example was a farmer, who had struggled with diarrhoea in his weaners. He had seen large improvements in their condition after having changed from factory-made feed to feed produced from his own crops. In this case, he had no space for storage of grain at the weaner facility and no facilities for grinding and mixing of feed. Therefore, he needed to be a bit creative and found a company that had trucks with equipment for grinding and mixing installed. Thereby, he could use his own grain and in a flexible way always base the feed on the herds' own recipe agreed with the vet. However, the change from factory-made feed to this concept had increased his costs:

Farmer 5: We have tried to do it like this: “OK, let's not look at the price of the feed...well, of course it does mean something, but... now we value having made some good feed, that is tolerated well by the

pigs”. Then we will have to try and see... as the most important thing is, that we succeed [in avoiding diarrhoea (Ed.)] and then we will have to see about the economy afterwards – you know, try to find out how much do we in fact need to invest in extra ingredients... or good ingredients to be successful out here.

Many of the measures used in the Pure Pork herds, like e.g., changes in feed, later weaning age, or upgraded vaccination protocols come with higher costs. Therefore, without the financial incentive of the concept, they would not be appealing to try out. With a premium for producing pigs without using antibiotics, the extra costs were seen as less of a problem.

Only few interviewees questioned the Pure Pork concept in terms of its effect on animal welfare. One Pure Pork farmer was sceptical, and questioned the welfare of pigs in his herd:

Interviewer: If you look at things a bit from a helicopter perspective, like... how was it to be a pig in your herd before you joined the Pure Pork concept and how is it now?

Farmer 3: But the pigs who are not...who get through without antibiotics, for them it's [the welfare situation (Ed.)] probably unchanged. But the others, it's... they definitely have a worse welfare. (...) You see, they actually get sick before they're treated. They didn't before.

Interviewer: So, you think that previously, you would have caught them earlier... because you were faster to...

Farmer 3: Indeed. And for example...within the first 24 h they all received a small injection with antibiotics to prevent umbilical hernia... We have twice as many hernias now as we used to... And that is... that is [bad (Ed.)] animal welfare that this pig has to walk around with a hernia. Finally, it maybe has to be killed... Certainly, that's a minus. Also, the medication we gave after weaning to get... to get them well ahead and to avoid meningitis and some of those things...You see, at that time the pigs got through without getting sick. Nowadays, some of the pigs get sick, and we need to go in and treat. So, I would say, all the pigs, we treat today, that's...it's...they have worse welfare than before. That's for sure.

Interviewer: And previously, you would have been able to avoid those [the ones getting sick (Ed.)]?

Farmer 3: Yes, they... previously, we got much more healthy pigs through. ...We have more sick pigs nowadays compared to previously.

This farmer clearly considered the Pure Pork concept as an obstacle for animal welfare, as he felt that not using routine treatments with antibiotics would hinder him from preventing disease. Thus, he saw antibiotics as a management tool to support good welfare and did feel he had other efficient tools available.

Other interviewees mentioned, that in the start-up phase of Pure Pork production, they had also sometimes experienced problems like those described by this farmer, but they did not see undertreatment in Pure Pork herds as a current problem.

When asked about animal welfare in relation to Pure Pork production, a vet put it like this:

Vet 5: Hmm...I would say...It's okay... *Just* okay. You see, the reason that I hesitate a bit is because I started thinking about the premium when the concept was launched. At that point, the premium was 2.50 kr [0.34 euro per kilo (Ed.)]. Thus, the motivation for *not* treating with antibiotics was very, very high. At that point, I would say, I often saw people making the wrong decision. They were simply too restrained on the medicine. You know, they would at all costs refuse to treat the pigs with antibiotics (...) and therefore I saw *a lot* of cases where the farmers sure had noticed that this pig was ill – but they needed to wait and see a bit. Trying out if painkillers would be

enough. Trying out if... And then, when in the end they realized that “oops, this is not going to work out” then they were in fact two to three days behind with antibiotic treatment and the pig would die... You know, from simple infections, which, *undoubtedly*, they could have treated successfully. In these cases, animal welfare was compromised for sure (...). Today, the ear tag is not worth a lot. It is worth 1.20 kr [0.16 euro per kilo (Ed.)], which means that it is just balancing around the point where it makes sense to produce within the Pure Pork concept, so I guess we'll have to close it down...

According to this vet, there was a huge difference from when the concept started with high premiums and now. In his experience, today, farmers would choose to use antibiotics rather than wait and see. He saw this as positive:

Vet 5: We don't wait and see until tomorrow (...). When the premiums were extreme, at that point, I would say, that many of the Pure Pork herds were showcases of what will happen if you lower your antibiotic usage *too* much.

Umbilical outpouchings (hernia-like conditions, during the interviews they were called hernias) were seen as one of the main challenges in systems not using routine treatment with antibiotics at birth. Routine antibiotic treatment at birth was described by both vets and farmers as the rule in conventional herds as a method to reduce the prevalence of umbilical outpouchings later in life (a subset of umbilical outpouchings is related to infectious conditions and thereby efficiently treated by antibiotics (Hovmand-Hansen et al., 2021)).

A vet expressed working with umbilical outpouchings in Pure Pork herds in this way:

Vet 4: They (Pure Pork producers (Ed.)) have experimented with... general things like hygiene and all that... iodination of the umbilical cord for example. Things like that. But all of them got more umbilical hernias when they started out. No doubt on that.”

Whilst a farmer put it like this:

Farmer 2: Usually, we say that if you look at the normal [non-Pure Pork (Ed.)] and the Pure Pork production. Then you should multiply the number of hernias with a factor 3. (...) we have participated in a project where Stalosan [a disinfectant (red)] was applied in the covered areas in the farrowing pens. (...) it works really well – and reduces a lot... The level was halved. But, you know, it doesn't always work out.

Plastering the navel at birth was mentioned by one of the vets as a quite efficient way to prevent outpouching, but most of the interviewees were not very optimistic about possibilities to prevent these problems efficiently, in the absence of routine antibiotics at birth. Umbilical outpouchings were sometimes described as mainly a food waste issue, as many pigs with hernias would be unfit for transport to the slaughterhouse. The interviewees did not agree on the possible impact on animal welfare, and whether the increased prevalence in Pure Pork herds was a welfare concern.

3.5. Lack of continuity and education in staff entailing imprudent use of antibiotics

In most interviews, employees and their role in relation to antibiotic usage had a great focus. One of the interviewees highlighted the persons taking care of the pigs as one of the most important factors affecting the usage of antibiotics. He exemplified this by the following quote:

Vet 6: ... when you look into replacement [of staff (Ed.)] in a farrowing unit, or even if you think, you try to give advice and help a whole lot on how...when to use...when to apply a treatment and things like that. Then sometimes you simply see that when there is a replacement, (...) that they simply don't use the same amounts [of

antibiotics (Ed.)] anymore. So, I would say that some of the most important issues (...) that's the different people.

As this vet saw it, employees' skills and attitudes towards antibiotic use were sometimes more significant determinants of antibiotic use than the level of disease in animals. The quote also puts in perspective how vets' efforts to influence how antibiotics are used are sometimes less important than the employees' abilities to judge whether treatments are needed. Thus, it highlights the importance of having skilled employees and at the same time explains how vets are limited in their influence when not administering the antibiotic treatments themselves.

Both vets and farmers saw staff issues as the overall key to achieving a low antibiotic usage while not compromising animal welfare. It was emphasized, how restrictive usage of antibiotics requires competent judgements and evaluations by educated personnel. On the other hand, using antibiotics as a safety measure to avoid disease – “an insurance” as formulated by some – was highlighted as a common consequence of having less educated employees:

Interviewer: And the ones, who use it [apply antibiotic to all of the sows after farrowing (Ed.)], what is their reason to do it?

Vet 4: Ehh... insurance (...) is typically a word they use... when talking about doing it. And again, you see, it's a lack of competence in those who take care of them [the sows (Ed.)], that they fail to keep track on who is sick and who is healthy.

Routinely applying antibiotics to all sows post farrowing was one example of excessive use of medicine due to lack of qualifications in personnel. Lack of qualifications was framed as having different causes, but one of the most important issues highlighted was the problem of communication. Having limited vocabulary in a common language hindered fruitful communication and competency development:

Interviewer: What about communication? Do they [the current employees from Vietnam, Uganda, Ukraine and Romania (Ed.)] understand English reasonably well?

Farmer 4: Well, it's so-and-so, you see, some of them do not understand much English. Others are OK at English. Some are super-skilled in English. Right now, with the persons I have now in the sow stable – it's bad (...)

Some interviewees felt that employees having a different cultural background and thereby a different culturally conditioned attitude towards antibiotic usage had an influence on the antibiotic usage in the herds:

Farmer 7: (...) employees from those countries¹⁰ (...) the first thing they think of – that's antibiotics (...) and it's probably hard to...to change...Yes, it sure is. And they also want to have it themselves. If they...if they have a bit of a cough, then they want antibiotics (...)

When talking about why in his herd, batch treatments with antibiotics were sometimes used, the farmer said:

Farmer 7: You know, I think that...Well, you have to, because it... it's... it depends on which employees you have. Because if they don't catch things in time, you have to... use full force, right?

In this case, the farmer saw himself as skilled and knowledgeable about better farming practices, and when his employees had time off, the farmer described how he would run the stable with minimal medicine use. However, he did not see any possibilities to develop good farming skills in his employees, as nothing he could do or say would change the employees' routines. He felt he had to live with that.

In many interviews, difficulties in recruiting and retaining

¹⁰ In this case, the farmer had employees from Poland, Venezuela, Africa, and Ukraine.

employees were an issue. Interviewees pointed out, that many workers are from low-income countries in the world, and they typically come to Denmark to earn money rather than to learn about pig production. Perceived as not having prior knowledge of pigs nor having a particular preference for working in pig production, farmers described how it can be challenging to motivate these employees to engage in the work. Another aspect pointed out by one of the participants was a tendency that personal connections from the employees' home countries formed the basis of recruitment. She described how this way of letting the staff supplement itself, using the metaphor of entering a shoal of fish, was vulnerable to falling apart, leaving the farm in a very unfortunate situation:

Vet 1: (...) You see, sometimes there's... the farm enters a shoal, where it is in fact working really well – you have six employees, and they have basically supplemented themselves, when one of them left. Then a new cousin arrived or whatever. And then suddenly they all leave. And it's not necessarily because they were treated badly. It's simply because that crew is now moving on.

This situation with crews of migrant workers travelling from job to job was not mentioned by others, but the general challenge with transient employees was recognized by others. A changeable and insecure staff situation was described as a precondition for Danish pig production:

Vet 3: (...) But clearly there is a challenge in the ones [employees (Ed.)] we have, they... some of them are in transit, and some of them do not understand the language and...

One of the interviewed vets elaborated on whether this situation could be changed and what it meant in practice to depend on short-term employees:

Vet 4: When you have only been there [in a herd (Ed.)] for half a year, there'll be thousands of things you haven't seen before and haven't reacted appropriately towards (...)

As explained by this vet, gaining experience by seeing different situations, reacting to them, and evaluating the outcome – the core of building competence – is very difficult, when employees only stay in the herds for shorter periods. During the interviews, it was pointed out that difficulties with employee retention was a common problem, and not just applicable to bad or unskilled employers. National regulations requiring that non-EU member states receive salaries comparable to managers' salaries after 18 months in the country, were seen as major obstacles. Knowing that these employees cannot stay in the herds was noted to discourage both farmers and vets to educate them.

3.6. Hyperprolific sows counteract prudent use of antibiotics

Many interviewees pointed out how proper management during the suckling period seemed to be increasingly challenged. One of the main challenges for the robustness of pigs identified by the participants was sows giving birth to many more piglets than they can nurse. The negative side effects of having highly prolific sows were described in this way:

Vet 1: But there IS a problem with the large litter sizes. Because we inevitably get some [pigs (Ed.)] who are very weak and who we have to fight hard to get them through.

Vet 6: There sure is a lot of swapping around with the piglets during the first four to five days. You can hardly find a sow nursing its own piglets.

When trying to estimate the use of nurse sows, another vet said:

Vet 3: They [the sows (Ed.)] are rarely able to nurse more than perhaps 12–13 piglets, but they give birth to close to 20 piglets, you see. (...) Thus, we have a tremendous load of nursing sows and...

unthriving piglets and you name it (...) at least 50–70 percent of pigs don't have their own mother, when they are weaned, you know.

This vet directly linked the management of highly prolific sows with a high usage of antibiotics:

Vet 3: (...) None of them (the piglets) hold their place in the farrowing unit (...). They are moved around (...) and nursing sows are being made, and... so, it is harder to keep the bacterial infections away – unless we use a protection regime [antibiotic treatment (Ed.)] ... And it's conditions like this that drive the consumption of antibiotics. And you could say, I guess, things like this probably drive the antibiotic consumption to a larger extent than leg problems in sows [which is otherwise mentioned as one of the biggest drivers (Ed.)]

One of the farmers started working with a less prolific sow line, which has more teats than the commonly used Danbred sow. He saw great advantages in having sows who manage to rear for their own piglets and therefore made nursing sows redundant. When elaborating on the reason why some farmers choose a less prolific sow line, one of the vets described how:

Vet 5: If you look at things from a veterinary perspective, not being forced to mix the piglets this much [if using a less prolific breed (Ed.)] would be a *huge* advantage for the health... with all the basic things like flu... and... you know, all the contagious diseases. Rotavirus and so on, right?

He continued by reflecting on the dilemma between recruitment of staff and having sows who require very high levels of daily management:

Vet 5: (...) We have great difficulty upskilling staff these days. You see, there are simply too few employees. And the ones who are there, they may be there for three or six months and then they leave again. And, you know, you almost need to be educated as a rocket scientist in order to handle a Danbred sow with twenty liveborn piglets.

While pointing out challenges in recruitment of educated staff however, he was also careful not to blame the employees. As he saw it, in many cases, the task for the employees was close to impossible.

Vet 5: Well...these farmers [considering TN70 sows (red.)] are *extremely* tired of weak piglets. They are nearly going crazy due to all those tiny dolphin pigs¹¹ (Ed.) who are born too early (...) And people are really, really tired of not being able to keep those piglets alive. And it's difficult for the staff. And it increases the piglet mortality. And they [the farmers (Ed.)] *dream* about having a sow who gives birth to perhaps 16 piglets and nurses them herself. (...) They are well aware that mixing of piglets increases the infectious pressure, right? And then they have this staff issue. With staff simply not being able to take proper care of this type of piglet. Not because of the staff, but simply because it's difficult, right? (...) And it's *extremely* frustrating for the staff. They get a feeling of always being too late. And it gives a bad ... it is always tiresome to go to work, if in nine out of ten days you feel, that you haven't done well enough.

The above statement highlights how difficult it is to manage sows who cannot take care of their own piglets but instead are dependant on the staff's assistance. Some of the farmers felt that the breeding companies made choices on their behalf, that did not align with their needs. One farmer was particularly frustrated about the priorities of the breeding company. He experienced major problems with hernias and had to euthanise a lot of his pigs due to this. He argued that the breeding programme ought to have focused on this rather than on the ever-increasing number of liveborn piglets:

¹¹ "Dolphin pigs" is a popular term for intrauterine growth restricted (IUGR) pigs

Farmer 7: (...) We [the Danish breeding programme (Ed.)] have focused *endlessly* on all these liveborn piglets, right? And then... we get all these...they have deprioritized getting rid of all the other defects caused by the breeding programme, as the only thing they cared to breed for was this fertility, or what do you say... And then there is no room for sorting other things [like tendency for developing hernias (Ed.)] out, right? And then we are left with this... the guy in the top of the breeding-pyramid and he will stay there until the day he dies, right? And so, there is nothing you can do to change it.

The statement clearly stresses how the farmer to a large extent feels that issues related to health and robustness of his pigs are out of his hands.

Using less prolific sow lines is uncommon in Danish herds. All but one farmer in the study used the Danbred sow line. A farmer, who was quite comfortable with highly prolific sows, explained how he considered them more profitable:

Farmer 9: (...) I can see the business in getting as many piglets out using as few resources... sows and so on...as possible.

In his case, prolificacy did not result in a high piglet mortality, and generally he felt that his employees could manage well.

Apart from increasing the number of weak piglets at birth and lowering internal biosecurity, some also pointed out how hyper-prolificacy could affect the general flow of pigs. Early weaning due to many sows being used as nurse sows was by some seen as problematic for the health of pigs post-weaning. Some highlighted that when specialized systems for weaning into "baby-sections¹²" were set up, the result was excessive moving and mixing of pigs. One of the vets elaborated on the reason for an extensive use of baby-sections like this:

Vet 4: You see... you could say... if you produce 7 kg piglets for sale then it's obviously in order to get some piglets that have this weight, right? (...) Because it really is difficult to get the piglets large enough... by the sows. Often it is, anyway. But, you see, it [container stables (Ed.)] can also be a way to gain more pen places. Over the years, in parallel with an increased productivity in the herd. And it... you see, not many herds built 20 years ago still have a weaner section which fits in size with...the number of pigs you make these days. Most of them have increased significantly in the number of liveborn piglets. (...) and then...then this solution [the establishment of baby-sections in containers (Ed.)] was the affordable and manageable way to go about it.

As explained by this quote, both the developments in breeding and the lack of up-to-date stables fitted to the situation were seen as problematic when aiming for a biosecure and low stress flow of animals. Thus, both elements were seen as central in relation to achieve a lower usage of antibiotics.

3.7. *The way sows are currently housed, bred, and fed increases the need for antibiotics*

When addressing the usage of antibiotics for sows, leg problems were brought forward as the main challenge. The interviewees explained how systems designed inadequately or worn down over time lead to a multitude of problems with increased fighting and injuries. Two of the vets put it like this:

Vet 4: The sow mortality is really too high in many herds due to euthanasia caused by leg problems. (...) hoof abscesses and arthritis, right? And some of the arthritis is of course something mechanical,

fighting, transponder systems...different systems where it's just really difficult to be a sow.

Vet 5: (...) We let all the sows loose in 2013. And this means that we have a HUGE number of hierarchical conflicts where the animals fight and it causes *unbelievable* amounts of torn dewclaws with subsequent secondary infections and broken legs, torn ligaments, etc.

In line with these statements, a farmer, working in a system with floor feeding in large pens, specified the proportion of pregnant sows expected to acquire leg problems like this:

Farmer 4: Well, typically, from the beginning, we put around 31–32 in [in each pen (Ed.)]. And then there are some that don't get pregnant, some that are taken out due to bad legs and then it typically ends up with... if it goes well...it ends up with 24–25 sows (...) If it goes badly, well, then we have only 19–20 sows left. Everything depends, how many get sick, are attacked and...yes.

In his case, it was common to have around 20–30% of sows not being able to cope with the system they were housed in, and therefore many of them had to be isolated in sick pens and treated with antibiotics.

Some interviewees had good experience with only using NSAID's in cases of fight-inflicted traumas. However, in many cases with leg and hoof injuries, antibiotics were used as a precaution – an insurance – to prevent infections.

When asked about his role in preventing problems for the sows and thereby decrease the need for medication, a vet explained:

Vet 5: (...) Many of the stables, that we work in are perhaps 20 years old, right. (...) You see, in those cases I have to say: "Well, that's where we are", but I cannot tear it all down. I have to take care of this sow having had its dewclaws torn off. That's the one, I have to treat, right (...) You see to me it's comparable with a patient who breaks her leg on a ski slope. It might be, that in 20 years' time alpine skiing is forbidden. But right now, she is lying in the snow with a broken leg, right?

The quote highlights how antibiotics were seen as means to take good care of animals. The vet would have preferred to help the farmers building better suited stables to prevent injuries, but his daily job was to cure the injured animals and make sure that they suffered as little as possible.

Most often, housing systems with instable groups of sows were seen as the major trigger of leg problems. Also, transponder feeding with very large groups, few places to hide, and competition-based floor feeding in large groups were known by many to cause fighting. In general, interviewees were discouraged to change the situation for the sows and thereby reduce the need for antibiotics. However, recognizing marked differences in prevalence of leg problems between systems, some also saw possibilities for change:

Vet 1: (...) stocking density has so much to say. So, if we don't overcrowd, you see, we have had some transponder systems, where it was much too easy to put too many [sows (Ed.)] into. And...along with systems getting older and the corners are getting sharpened and such things, you see, there are herds where we have 28–30% dead sows

In this interviewee's view, farmers, consultants and sales people are eager to over-exploit the capacity of systems, which often explained why the systems did not function according to the sows' needs. Furthermore, as she saw it, financial difficulties resulted in equipment not being properly maintained and therefore being the direct cause of traumatic injuries. When asked for good alternatives to the currently used systems,

¹² "Baby-sections" is a popular phrase for mobile pre-weaning for the smallest piglets at weaning, set up in order to accommodate the increasing number of piglets. Typically, they are housed in containers.

she elaborated on the benefits of the so-called “cafeteria systems”¹³, which are not common anymore:

Vet 1: They are super good (...) because you all the time have agile sows – you see them all. That is, nobody is allowed to lie down and hide [from the farmers’ eye (Ed.)], right.

Interviewer: Why is it, that they have turned unmodern?

Vet 1: It’s because they are labour-intensive. *Each* day, You *have* to spend two hours on these systems. You see, you cannot [in contrast to the common types of pregnancy systems (Ed.)] one Sunday say that you simply only have time for walking back and forth on the aisle to see...or smell if a sow has died.

The most frequently recommended system to avoid leg problems was the one-eating-box-per-sow system. This system was appreciated due to its ability to protect the animals from fighting, due to the sows spending most of their time protected in the boxes. In contrast to the cafeteria system, this system is not labour-intensive.

The breeding of gilts destined for a life in loose housing systems with high demands on leg and hoof quality was highlighted as an important focus area. Thus, breeding related to leg exterior, especially to avoid soft codes, and for animals to grow slower were seen by some as an important step forward. Some argued that a negative side-effect of the current breeding strategy seemed to be increased aggression in sows:

Vet 3: There are so many hierarchical fights...between the sows. And it has actually only got worse over the years. That they are more aggressive than they used to be.

This vet was quite pessimistic in relation to sow welfare, when judging the possibilities for change within the Danbred breeding program. He pointed out that with an ever-increasing capacity for fast growth, if not problems with oversized sows, then problems with hunger would inevitably occur when sows were genetically set up to optimize feed efficiency. Other interviewees argued that reducing feed intake in gilts was a solution for leg problems later in life and saw sows being much too heavy and non-agile as the main challenge. However, in this vet’s eyes, restrictive feeding would not solve the problems. With the current genetics, he saw an insoluble dilemma between ensuring agile and fit sows while avoiding hunger and aggressive behaviour related to this.

3.8. The challenge in judging when antibiotics are necessary

The necessity and benefits of using antibiotics in pig herds were elaborated on from different angles during the interviews. Generally, it came out very clear that the interviewees saw antibiotics as a tool to help and protect the pigs. As an example, a farmer explained about the background to withdraw from the Pure Pork concept, when his herd got infected with PRRS:

Farmer 6: We had huge challenges with mortality in the weaner section, that is, we really needed to help the pigs (...) So, we really needed to help with some medicine, you see, flock treatments and also... to be able to help them in the farrowing unit and to help them getting off to a good start.

In line with this statement, a vet explained how she met her primary obligation as a vet – to keep the pigs healthy:

Vet 1: So... you see, I’m not afraid of using a bit of Tylan [a type of antibiotic (Ed.)] here and there (...) Let’s get some happy pigs.

She did not feel motivated to reduce her usage of antibiotics from the

current level, as her focus was on keeping the animals free from disease. When asked about animal welfare, she explained:

Vet 1: I think they are well (...) when they are well-medicated (...) I do think so.

These quotes show how both farmers and vets saw antibiotics as a means to ensure good welfare and thus were reluctant to use less.

As already mentioned, one point highlighted to reduce the usage of antibiotics in lactating sows was eliminating the routine use for all sows at farrowing. In many cases, however, antibiotics were not applied for all sows, but higher than necessary due to farmers not critically considering their strategies. In one case, an interviewee explained how counting the number of sows being treated against postpartum dysgalactia syndrome (PDS) had been an eye-opener for change:

Vet 2: ...then we [herself and the farmer (Ed.)] counted how many sows they were treating against PDS. It turned out to be 40%. (...) It made her try to change her view on...on things, and thereby she halved her usage – simply by not having it as an automatic reaction to have the syringe with her on the daily rounds. You see, perhaps they are in fact a bit too easily accessible. The drugs.

The comment on easily accessible antibiotics related to the situation in Danish pig herds allowing farmers who hold a Veterinary Advisory Service Agreement to have antibiotics in stock.¹⁴ Even though the vet had prescribed the antibiotics herself, she questioned how this system sometimes encouraged for a higher than necessary use.

Arguing for a less liberal access to antibiotics in Danish pig herds stood in sharp contrast to others who felt that Danish restrictions on antibiotic usage for sows were ethically problematic. A vet who had practice experience from Thailand, considered the sow welfare to be better there compared to Denmark in some respects. He explained how many sow diseases were simply not seen in Thailand due to a high usage of antibiotics:

Vet 5: All these cases of arthritis and hoof abscesses and MMA and vaginal discharge and that sort – they don’t have a clue what it is [in Thailand (Ed.)]. Pneumonia and so on. Because they [the sows (Ed.)] are all the time medicated.

Even though he did not approve of indiscriminate use of antibiotics, to him it was very clear that the sows in Thailand had fewer disease problems than Danish sows, because they were medicated much more. Thus, he felt that from an animal welfare point of view, the sows in Thailand were better off.

In the Danish situation, some of the interviewed vets had experiences from situations with an insufficient usage of antibiotics affecting animal welfare negatively. When elaborating on why farmers in some cases did not medicate adequately, one of the vets said:

Vet 1: ... Well, many of the diarrhoea cases – the cases that drive much of our antibiotic usage – are not lethal, you know. (...) They [the pigs (Ed.)] just don’t thrive well. They look miserable, and everything...looks miserable. They have stomach aches and...and some [farmers (Ed.)] simply get used to pigs looking like that, you know.

According to this vet, some farmers simply did not realise that their animals were sick or perhaps found it easier not to do anything. She referred to a recent situation with a farmer, who had started buying in weaners rather than producing them himself:

Vet 1: You know, some of them [the farmers (Ed.)] simply don’t know how good things could be.... For the pigs. (...) You know, some

¹³ A system for pregnant sows, with loose housing on deep litter and feeding in groups with the farmer attending each feeding and letting the sows in and out of a cafeteria-like feeding system.

¹⁴ For further explanation on regulations related to veterinarians and medicine in pig herds see: [Distribution and use of veterinary drugs in Denmark \(foedevarestyrelsen.dk\)](https://foedevarestyrelsen.dk)

who simply ignore what's happening and think: 'This is how pigs looked at my dad's farm and that's how it should be.' Even though all the pigs are in fact diarrhoeic and look ill-thriving. (...) Now [after having started to buy in weaners (Ed.)] he was like in heaven when he called me: "I've received the best pigs in Denmark! – They are SO NICE!" And then I thought: "Well, you have received standard pigs. They're absolutely standard. The thing is, that what you have been looking at for the last 20 years was simply *so bad*."

In the eyes of this vet, the problems with sick animals not being handled in this case was due to the farmer's lack of skills. Generally, when talking about how to judge the necessity for antibiotic treatment, issues on development of skills in farmers and employees were put forward. This was discussed previously in light of the employee challenges, but it also came forward when talking about handling of weaners without pZnO. One of the vets emphasized how this new situation demanded new farmer skills. He explained how the clinical situation in the herds had changed after no longer having pZnO as an underlying protection:

Vet 6: (...) These pigs are more severely affected by these intestinal infections, the typical sort of weaning diarrhoea, that is. That's what happens when the zinc is not there. And we have been discussing which type of action plans are needed, if suddenly you come out and you have eight dead pigs in a pen who have died from E. coli... You know, straight back to the old days – close the feed and restrictive feeding and antibiotics on the water string (...)

The vet concluded that it was often difficult and more time consuming for the farmers to recognize early symptoms on dehydration and life-threatening diarrhoea. Therefore, he spent a lot of time educating the farmers in clinical evaluations under the changed conditions. In his experience, without the underlying protection of pZnO, E. coli-affected pigs were much more severely impacted than before, and therefore farmers needed to learn to react promptly on symptoms.

Some vets felt that phasing out pZnO and minimizing antibiotic usage had led to more "grey zones" and situations of doubt in their clinical judgements and judgements on animal welfare. A vet elaborated on a case with a farmer who, according to the vets' judgement, perhaps did not sufficiently treat his pigs with antibiotics:

Interviewer: But the reason that you think this farmer treats too little [with antibiotics (Ed.)], what's that?

Vet 2: Well, it's, ...when I visit him, then I see some pigs, that make me think: Ahh, *perhaps* this one should be taken out... I can point out some where I would say they needed treatment...a bit too much diarrhoea, a bit... flanks a bit hollow (...) Yes. Yes, is this equivalent to bad animal welfare? The pigs may not be *super* nice, but not like... it's not that I think I should... enforce my Veterinary Oath and euthanize the animal. (...) And I think it can sometimes be difficult... you know, when the mortality is unchanged, it's not like he has a higher mortality, so, I think it's difficult to argue against (...) But he may accept a bit lower weight gain, and the pigs get through just fine...

When asked about whether he was nervous about the future for pig welfare, a vet elaborated on the dilemma arising from the wish to use as little medicine as possible, the wish to protect the animals from disease and the wish to protect the farmers' economy:

Vet 6: (...) you can easily make a whole lot of initiatives, with vaccinations and all this, that become really expensive. But, you see, the pigs just grow really well, when zinc is added, so it's about how can we make sure they keep a good weight gain and do not experience a bout of diarrhoea (...) it's difficult when you have to take away the zinc, because sick animals need to be treated, in terms of animal welfare. And such a flock... well, a flock treatment is just extremely effective because they pretty much all get E. coli diarrhoea, you

know. (...) I've also sometimes thought about whether it actually hurts to have such an intestinal E. coli ... Well, I'm well aware that it's not *nice*... right, but... (...) So, I do think they look like they're fairly badly affected.

The quotes highlight how the vets attempted to balance different demands. While acknowledging the societal demand on using less medicine in herds, in their daily jobs, they had a high priority on productivity and farm economy. At the same time, they feel less clear about judging the potential effect on animal welfare in cases of diarrhoea left untreated or treated by other means than antibiotics.

The fact that productivity and farm economy have a great focus in the daily work of vets, came out very clear during the interviews. Thus, ensuring high daily weight gains were often framed as the main priority in the collaboration between farmers and vets. As hinted by the two vets, adding antibiotics to the feed inevitably leads to a more streamlined appearance of pigs, a more uniform growth, and a better productivity. However, in terms of production with low use of medicine and high animal welfare, the situation seems less clear.

3.9. How regulations, monitoring, and bureaucracy affect the mindset

Sometimes, rigid rules on antibiotic usage were seen as obstacles for animal welfare. As previously explained, Danish regulations state that farmers are not allowed to exceed certain limits on antibiotic usage for each age group. This so-called "Yellow Card system" was noted as a measure leading to undertreatment of sick animals, especially sows. The limit in this age group (3.2 weighed ADD's¹⁵ per 100 animals per day) was by some considered by some as unreasonably low.

In general, the interviewees appreciated how the ban on growth promoters and restrictive legislation over the years had forced them to look for preventive alternatives to antibiotics and to consider whether antibiotic treatments were necessary. However, some of them now felt that they were failing the animals and their treatment needs, due to the Yellow Card system and its lowered limits over time¹⁶:

Vet 5: ...Today, *even though* you do things right, make proper diagnostics and things like that, then they [the farmers (Ed.)] are only able to stay below the yellow limit as long as things go well. This means that when things go just a *little* bit wrong, you know, with virus or...eh...feeding mistakes or something else – then the yellow limit very soon will be dangerously close, right? (...)

Even though, in principle, virus and feeding mistakes should not require antibiotic treatment, the vet argued that bacterial infections would often follow such events. He explained how he felt forced by legislation to treat animals insufficiently:

Vet 5: (...) Consciously, and on a daily basis, I perform malpractice. I'm sure I do. And I don't think it's fair to the animals (...) I recommend treatments that are halved [compared to professionally judged treatments (Ed.)]. You see, I reduce the treatment period *being aware* that I should have treated for seven days, to a 3-days period, right? And sometimes I know that I should treat with perhaps 5 mg per kg. And anyway, I choose to reduce to 3 mg.

A specific example given by this vet was treatment of uterine infections in sows. Professionally, he would judge such cases to need antibiotic treatment for no less than five days, but to avoid farmers getting a Yellow Card, he prescribed antibiotics for maximum two days. Therefore, as he saw it, many sows had longer lasting or chronic uterine

¹⁵ Roughly translated into: Max 3.2 out of 100 sows in a herd on any given day is allowed to be treated with antibiotics. For detailed information, see: [Vægtede ADD'er \(Weighted Animal Daily Dose\) \(foedevarestyrelsen.dk\)](https://www.vetinst.dk/da/~/media/100000/100000/Vaegtede_ADD'er_(Weighted_Animal_Daily_Dose)_foedevarestyrelsen.dk) [in Danish]

¹⁶ For the limits over time, see: [Grænsærværdier for antibiotikaforbrug \(foedevarestyrelsen.dk\)](https://www.vetinst.dk/da/~/media/100000/100000/Gransvaerdier_for_antibiotikaforbrug_(foedevarestyrelsen.dk))

infections due to his self-described malpractice and therefore sow welfare was negatively affected due to the Yellow Card limits. This view on how limiting treatments to two to three day-periods would harm possibilities for animals to recover from disease was not shared by other interviewees. On the contrary, other vets noted that the EU Veterinary Medicinal Products Regulation (Regulation (EU) 2019/6¹⁷) would require them to prescribe what they perceived as unnecessarily long periods of treatment for six to seven days, when they were used to obtaining satisfying results by treatments for two to three days.

Even though other vets did not describe feeling forced to perform malpractice by the Yellow Card limits, some agreed on the Yellow Card limits having certain negative side effects. When asked about worries related to restrictions on antibiotic use, the primary concern was the lack of flexibility in the system, which did not account for extreme disease situations, like acute outbreaks of pleuropneumonia in Specific Pathogen Free¹⁸ herds:

Vet 6: ... You see, if you have an outbreak of pleuropneumonia, then the animals have to be treated, because it's well known that those... pleurisies, right, they're some of the most – it really hurts, right.

In such cases, for animal welfare considerations and not to lose the animals, he saw antibiotic treatment as inevitable. Vets and farmers described how they were all the time aware of how close the herds were to their limit for antibiotics in each age group and acted according to this. Thus, in their daily work, they tried to “leave room” in the medicine account for unexpected outbreaks of disease. The concept of having a strict limit and penalties for crossing it was generally problematized because it was seen as an incentive to leave room for unexpected situations in the medicine account at the expense of sick animals in everyday situations.

Some vets experienced that due to the restrictive Danish legislation and the great awareness on not using too much antibiotic treatment, sometimes farmers were too reluctant to treat sick animals and that they therefore had to push for a higher use:

Vet 5: (...) There aren't many of them, but to some, I sometimes have to say: “Listen, my dear friends, we simply need to carry out some treatments here – this doesn't work!” (...) And they think it's a cop-out to use a flock treatment (...) and, you know, I need to be the one to push for an *increased* usage of antibiotics. It happens more and more. Fifteen years ago, it didn't happen at all.

Generally, the vets saw it as positive that the culture of using antibiotics had changed significantly over the years, with farmers nowadays seeking to avoid it. However, some of them experienced a disproportionate fear of using antibiotics, mainly based on fear of receiving a Yellow Card.

None of the interviewed farmers had experienced receiving a Yellow Card themselves, but many of them feared it could happen. One farmer expressed his concerns like this:

Farmer 10: ... You see if the pigs [experiencing an outbreak of pleuropneumonia (Ed.)] weigh 60 kgs for example. Then we are above the Yellow Card limit immediately, right? And I do think... you see... it's just at the edge of animal cruelty...

A common feeling amongst the farmers was the fear of a disease situation where they would feel torn between being cruel to animals by

not treating and being a criminal in the eyes of the authorities by treating too much. They considered receiving a Yellow Card as being labelled a criminal, and therefore would do all they could to avoid it.

Some of the interviewees did not feel restricted by the Yellow Card limits. They considered the current limit for antibiotic usage in weaners (17 ADD's/100 pigs/day) as high. Furthermore, they stressed that receiving a Yellow Card based on a specific and limited outbreak of disease should not be a very big deal, as after a period, the usage would be stabilized at a low level again, and the yellow card would be withdrawn.¹⁹ They recognized, however, that in herds with a constant high consumption, single events with increased needs could be difficult to deal with.

The feeling of having an extreme bureaucratic burden was another element pointed out when addressing the regulatory framework around antibiotic usage in pig herds. In some cases, the filling out of forms and writing countless reports that nobody would ever read was seen as counterproductive for work satisfaction and for making real changes for the animals. In one case, a vet explained how different it felt to work in other countries compared to Denmark and how he had a feeling of making a much bigger difference and using his skills more satisfactory when abroad:

Vet 5: (...) when I started as a vet, I produced two pieces of paper (per herd visit (Ed.)) (...) Today I make forty-two. This means that two new pieces of paper have been added for each year since I started as a vet. And I'm sure it will go on. There'll be two to three pieces of paper each year. Thus, if we wait long enough, we'll have 100 pieces of paper per CHR-number. It does not lead to anything. It's a waste of time. And then it's amazing to go to Thailand or (...) Poland or (...) Hong Kong. (...) then we're right at heart of what it means [to provide veterinary advice (Ed.)]

The statement puts in perspective how it affects people to spend much time and energy on paperwork, that they don't feel makes enough of a difference for farmers and the animals.

Another example on discouragement inflicted by bureaucratic frameworks was a farmer who described his herd being inspected by a purchasing manager from an Italian supermarket chain:

Farmer 2a: ... And the things he was interested in, it was... well, he was out to see the stable, and there were NO comments. But the things that interested him were what he could make of demands for the next time. And next time, perhaps we would divide on batch numbers... this whole stable, this whole section, how much [antibiotics (Ed.)] did they receive. And then he would like it on his phone, such that he could browse through it. And I just thought: They weren't at all interested in... in how things in fact worked out [in the stables and with the animals (Ed.)] (...) Everything was about him seeing on his phone that this batch number that this piece of meat belonged to had received this or that amount [of antibiotics (Ed.)]

Also in this case, being controlled and monitored was experienced as discouraging. The farmer had a lot of procedures and methods that he worked on to improve and support health, but the control system did not appreciate or even notice these efforts. Rather, for the farmer the control system seemed to be put in place to please the system itself.

4. Discussion

Farmers and vets in this study had positive experiences with lowering the usage of antibiotics. Thereby, they were in line with the majority of survey respondents in previous studies who had positive attitudes regarding the feasibility of reducing the usage of antibiotics

¹⁷ In January 2022, the [Veterinary Medicinal Products Regulation | European Medicines Agency \(europa.eu\)](https://eur-lex.europa.eu/eli/reg/2019/6/2022/01/01) came into force. One of the elements in this regulation is that vets need to follow the Summary of product characteristics (SPC's) given by the manufacturers of the medicine, and therefore cannot decide on the dose or the length of treatment with antibiotics themselves.

¹⁸ Herds declared free from *Actinobacillus pleuropneumonia* and other specific pathogens. These herds lack immunity against the pathogens that they are free from.

¹⁹ Farmers receiving a Yellow Card have nine months to reduce their usage to below the limit. See [Bekendtgørelse om særlige foranstaltninger til nedbringelse af antibiotikaforbruget i svinebesætninger \(retsinformation.dk\)](https://www.retsinformation.dk/eli/Bekendtgørelse/2021/01/27/1)

(Visschers et al., 2016; Carmo et al., 2018; Kongsted and Anneberg, 2021). Examples were given on how preventive strategies had replaced the use of medicine and thereby ensured the health of the animals. Generally, the restrictive Danish legislation on antibiotic usage over the years was seen as positive, as it had encouraged the focus on management and improved disease prevention. Regulatory restrictions, however, and especially the Yellow Card scheme, were also described as counterproductive to animal welfare. Thus, interviewees were concerned about animals not receiving the medication they needed, due to vets' and farmers' focus on Yellow Card limits, which did not consider the biology of animals and unpredictability of disease. Studies on farmers' attitudes towards regulations and paperwork required by authorities support the findings in the current study (Escobar and Demeritt, 2017). Escobar and Demeritt conceptualized farmers' experiences how regulations and practice are decoupled, to the point where recordkeeping and regulatory systems were almost operating independently of one another. In our study, decoupling manifests when regulations on antibiotic usage are experienced to threaten animal welfare and when overwhelming bureaucratic burdens take the focus away from practical change-making. Insights from studies with European pig welfare inspectors reflect a similar tension between intractable legislation and the complexity of assessing welfare in reality (Mc Loughlin, 2022).

The Pure Pork concept was often positively highlighted, as the financial incentive to reduce the usage of antibiotics had inspired innovative solutions to disease control and prevention. Animal health was maintained by replacing antibiotic treatment with preventive measures. The positive experiences suggest that concerns about animal welfare in cases with low usage of antibiotics are unjustified. Furthermore, they contradict negative perceptions on the feasibility and impact of label production with low antimicrobial usage identified in a previous study (Carmo et al., 2018). On the other hand, they align well with Danish consumers' expectations on a positive relationship between low usage of antibiotics and animal welfare (Denver et al., 2021).

Some interviewees expressed how they felt that antibiotics in conventional herds were perhaps too easily accessible. According to some vets, working in a framework where farmers have medicine in stock was perceived as an obstacle for control and supervision of usage. Furthermore, they pointed out how having antibiotics easily available made them seem as the most logical tool when having a disease problem. In line with this, examples were given on how over the years "old farmers knowledge" on non-antibiotic solutions for disease treatment had been forgotten. Other studies have pointed out how farmers feel a lack of concrete alternatives to treatment of disease (Kongsted and Anneberg, 2021; Bradford et al., 2022). In some cases, looking back in time and re-implementing discarded methods may be a way forward.

Different examples pointing to the fact that routine and batch medications were commonly used, seem to provide room for further reductions. Furthermore, they point out how antibiotics are not only used as a reaction to disease as intended by the law. Despite political efforts to limit the usage of antibiotics to when it is strictly necessary, several studies support that in practice antibiotics are still used for metaphylactic and prophylactic purposes in pig production (Coyne et al., 2014, 2016; Hockenhull et al., 2017; Bradford et al., 2022). In our study, a harmful impact on animal welfare as a result of moving from an antibiotic strategy based on "better safe than sorry" to one based on "wait and see" was a point of debate. Some argued that the absence of blanket treatments in Pure Pork herds had negative consequences on the animals. In this relation, batch medication of weaners against diarrhoea was a main point of controversy. Some participants questioned whether uneven growth with loose stools should be considered a welfare problem, whereas others seemed confident that streamlined growth was a sign of health. As in other studies, antibiotics were often articulated as a means for helping and protecting animals (Coyne et al., 2014; Hockenhull et al., 2017; Golding et al., 2019; Kongsted and Anneberg, 2021; Bradford et al., 2022). Thus, the study highlighted how infectious diseases were considered inevitable everyday events in production.

Overuse and prophylactic use of antibiotics was noted by the interviewees to occur when the personnel were less skilled. Some argued that employees' skills and attitudes were the most important determinants for antibiotic usage. Instead of using preventive antibiotic treatments, correct management and correct clinical judgements could ensure that only animals in need of antibiotics would receive it. Other studies confirm how much the skills of employees and education of farmers affect the possibilities for reducing antibiotic usage (Coyne et al., 2016; Carmo et al., 2018). The present study, however, showed how the staff situation in Danish pig herds is extremely challenging. As the participants saw it, having employees with no dedicated interest in pigs, no farming education, and with limited English and Danish skills and many times in transit for the next job, had become the norm in Danish herds. Both farmers and vets were frustrated about the situation, and in some cases, farmers described how they had given up on training their employees. In the light of the significant challenge that the employee situation poses and the related implications for antibiotic usage, the situation calls for change.

As reviewed by Shurson et al., many studies have shown health benefits, e.g. lower levels of diarrhoea, as a result of adding high levels of zinc to feed during the first two weeks after weaning (Shurson et al., 2022). Considering this, the generally optimistic view of participants on possibilities to wean without pZnO may seem surprising. However, many noted how minor changes in feed composition and in feeding management around weaning often had been the key for successful weaning without pZnO. Despite positive experiences, many of the interviewees expected an increased use of antibiotics to protect weaners from severe diarrhoea when the ban would come into effect. These expectations align with previously published expert opinions ranking zinc in the top three according to its impact to reduce antimicrobial use (Carmo et al., 2018).

Some overall difficulties in achieving a low use of antibiotics in pig herds while still protecting the animals from disease were brought forward by the interviews. The development in breeding was one example. Many addressed how hyperprolific sows had resulted in many pigs born underweight and an intense use of nursing sows and moving and mixing the piglets. Moving and mixing was noted to decrease the robustness of the pigs, and in many cases the high number of piglets had led to lowering of the weaning age. These experiences are in line with scientific evaluations on the effect of hyperprolificacy (Baxter et al., 2019). Another welfare dilemma related to breeding brought forward in the interviews was the feeding of breeding animals. Slim and agile sows was noted as a main priority for preventing leg problems. Therefore, restricted feeding of animals with a genetic disposition for high growth seemed imperative. However, hunger in gilts and sows increased aggression and thereby the occurrence of leg injuries. Database studies confirm that leg problems are a major cause of antibiotic usage in sows (Nielsen et al., 2021). However, no previous qualitative studies have identified this link between breeding for fast growth and leg problems increasing the need for antibiotics.

A high level of aggression in pregnant sows was repeatedly articulated as inevitable and something everybody had to live with. Therefore, using antibiotics to treat leg problems was considered due diligence. Studies have confirmed that aggressive behaviour is partly hereditary (Turner et al., 2006), as suggested by some of the interviewees. In our study, housing systems were also acknowledged to have an important influence on sow behaviour and tendencies to acquire injuries. However, comparing the situations with skiers breaking their legs and in acute need for treatment, in the daily situation, dealing with sows housed in inappropriate systems, this vet felt they had to react with a prescription of medicine. The feeling of being locked in by conditions and thereby forced to use antibiotics is reflected in other studies on the subject (Coyne et al., 2014, 2016; Hockenhull et al., 2017; Golding et al., 2019; Albernaz-Goncalves et al., 2021; Bradford et al., 2022). These studies also reported inadequate farm environments and lack of ability to invest in housing system as main difficulties for achieving a lower usage of

antibiotics. Also aligning with these experiences, Visschers et al. (2015) detailed how farmers were mainly occupied by financial worries. Clearly, investment in better housing is unachievable in financially constrained situations. .

Statements on sows being better off in Thailand due to a more liberal use of antibiotics, highlighted how being free from disease – or being “well-medicated” – was often paralleled with having good welfare. Thus, controlling infectious diseases seemed a main priority when striving for good animal welfare. This view on welfare aligns well with previous studies (Coyné et al., 2016; Albarnaz-Goncalves et al., 2021). Albarnaz-Goncalves elaborate on how the farmer’s perception of animal welfare is influenced by practical and economic realities and describes how farmers in conventional pig herds rely on antibiotics to outweigh stressful environments. These findings support our findings that the need to help animals is associated with access to and administration of antibiotics, whether this is as an insurance policy or as a necessary part of care.

In this study, we selected farmers who had lowered their use of medicine as we aimed to address how they experienced the effect of the lowering on animal welfare and how they had managed not to harm animal welfare while striving for a decreased use of antibiotics and pZnO. This approach gives certain limitation in the interpretation of results. Thus, the reader should be aware, that farmers having a very high usage of antibiotics are not represented and that their opinions and experiences may differ significantly from what was brought forward by this study. It was beyond the scope of this study to incorporate their experience into the research. The veterinarians in the study drew on their experiences from herds with different levels of disease challenges and medicine usage. Thus, the fact that the interviewed veterinarians represented very broad experiences with pig health management and disease treatment strengthened the study. Not including interviews with employees was a clear limitation of the study. During the analysis, it became very clear, that the employees’ capabilities and the difficult situation Danish pig herds are faced with in terms of recruitment and retention of employees are central elements in the attempt to achieve a lowered usage of medicine. The study could have benefitted from the experiences of employees and we acknowledge that the challenges created by the employee situation cannot fully be elucidated in this study. However, Anneberg & Sandøe (2019) have identified many of the issues associated with education in the pig sector whereby there is uncertainty about the level of education of migrant farm workers.

5. Conclusion

According to the United Nations Environmental Programme, the agricultural sector has to radically change its practices and usage of antibiotics in response to the antimicrobial resistance threat (UNEP, 2023). This article provides in-depth insights into how Danish pig farmers and vets frame the challenges associated with lowering the usage of antibiotics and zinc and points out in the interviewees’ own words where the biggest challenges are

The study calls for research into the staff situation in pig herds. We need to gain more knowledge on how to recruit and maintain employees and how to motivate young people to gain interest in pig farming and take part in changing systems that currently seem unchangeable. Studies involving current and former employees in pig stables, unfolding their views on the challenges and their experiences of training and education, are essential elements to be able to change a situation which is not sustainable in its present state.

Decreasing stocking density, introducing less prolific sow lines and breeding towards animal welfare related goals represent a new way of thinking in the farming industry, which challenges wider traditions. However, with a legislative demand not to use pZnO and amidst a wider global health responsibility to reduce the usage of antibiotics, the focus in farming must shift from bottom-line profitability to systemic disease prevention.

CRedit authorship contribution statement

Hanne Kongsted: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Writing – original draft. **Eimear Theresa Mc Loughlin:** Conceptualization, Methodology, Writing – review & editing.

Declaration of Competing Interest

The authors declare to have no competing interests.

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