UNIVERSIDADE DE LISBOA

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A LOOK INTO THE IRISH PIG INDUSTRY: HOW THE FARM BIOSECURITY AND THE ANIMAL WELFARE INTERTWINE

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Faculdade de Medicina Veterinária da Universidade de Lisboa, 23 de julho de 2024

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Acknowledgements

First, I want to say thank you to my sister Rita for being there for me when I needed it and for all the mental breakdowns she gave me for stealing my things without asking. And for my parents and family, thank you for all the support you gave me and for all the food you cooked when I was too tired from studying.

To Mifos and Danila, my best friends forever, who have been with me through everything and anything, with more stories than anyone could live in a lifetime. May this thesis open another chapter in our lives and lead to many more adventures.

To Rita O'Neill, Inês Mont'Alverne, Mariana Guerra, and Mariana Teixeira, the best people college has brought to me. Even though this may be the last work we do for our dear FMV, may we never forget the thousands of others we've done for this house and all the amazing memories and stories we share and cherish.

And to Francisca Guerra thank you for being my rock. Without you, I would have never made it after the second year.

To the amazing Team Telmo: Beatriz Oliveira, Madalena Neves and Matilde Teles, may RStudio never defeat us and may the code be with you. Thank you for the amazing months we shared trying to be graphic designers for maps while taking over the C3.37 with Christmas lights.

To Professor Telmo Nunes, for all his help since the beginning, guiding me through this stage of my professional life, and for all the friendly and wise advice, my most sincere thank-you.

To Professor Virgílio Almeida, for accepting to be my co-supervisor despite an already demanding workload.

A very special thank you to Dr. Carla Correia-Gomes for taking me in Ireland and teaching me so much during those few months. Thank you for your patience and the time spent helping me grow as a veterinarian and as a person each day of my internship. To everyone on the Animal Health Ireland team for taking such good care of me, and a special thanks to Jenni O'Rourke, Lisa Hyland, and Sinead O'Doherty for all our travels around Ireland.

On a bitter-sweet end, I will now say goodbye to the dreaded 729 bus line and never have to worry again if CP is on strike again.

Abstract

Effective biosecurity measures are crucial for controlling pathogen spread in Irish pig farms, ensuring animal health, and boosting farm productivity and profitability. External biosecurity prevents pathogen entry and exit, while internal biosecurity limits their spread within the farm. Implementing comprehensive protocols reduces disease outbreaks, safeguarding animal health but also leads to improved productivity and economic benefits for the farm.

In this study, we analysed data from Irish commercial pig farms to: a) describe their biosecurity and welfare status, b) identify recommendations by private veterinary practitioners (PVPs) and whether farmers follow them, c) identify associations between biosecurity scores and welfare risks.

Tools like Biocheck.UGent, used since 2018, helps assess and improve biosecurity, while a risk-based system developed by Teagasc (Agriculture and Food Development Authority), Department of Agriculture, Food and Marine (DAFM), and Animal Health Ireland (AHI) evaluates animal welfare.

The study included 393 farms with over 50 pigs each from January 1, 2018, to December 31, 2023. External biosecurity scores were generally higher than internal ones, with Disease Management showing significant improvement, increasing from a median score of 60 in 2018 to 100 in 2023. Common recommendations included: 'Changing needles more frequently,' 'Using farm-specific boots and overalls,' 'Installing footbaths,' and 'Implementing All-in-all-out' practices".

Welfare risk assessments showed an increase in risks, such as injured ears and aggression lesions, over the years. Common welfare recommendations were: 'Enhancing the quality of environmental enrichment,' 'Improving ventilation,' and 'Reducing stocking densities'.

Finally, a risk factor assessment using two regression models—linear mixed models and generalized linear mixed models found associations between biosecurity and welfare risks, indicating that good biosecurity often correlates with fewer welfare risks. The study highlighted biosecurity improvements and the need for enhanced animal welfare programs.

Keywords: pig, welfare, biosecurity, recommendations, risk factors.

Resumo

Medidas eficazes de biossegurança são cruciais para controlar a disseminação de agentes patogénicos em suiniculturas da Irlanda, garantindo a saúde animal e aumentando a produtividade e o lucro das explorações. A biossegurança externa impede a entrada e saída de doenças, enquanto a interna limita sua propagação dentro da exploração. A implementação de protocolos reduz surtos de doenças, protegendo a saúde animal e levando a melhorias na produtividade e nos benefícios económicos para a exploração.

Neste estudo analisamos dados de suiniculturas na Irlanda para: a) descrever o estado de biosegurança e bem-estar animal, b) identificar as recomendações dos médicos veterinários assistentes (PVPs) e se os agricultores as seguem, c) identificar associações entre níveis de biossegurança e os riscos de bem-estar animal.

Ferramentas como o Biocheck.Ugent, usadas desde 2018, são usadas para avaliar e melhorar a biossegurança, enquanto que relativamente ao bem-estar animal, foi desenvolvida uma metodologia baseada na avaliação de riscos, pelo Teagasc, Department of Agriculture, Food and Marine e Animal Health Ireland.

O estudo incluiu suiniculturas com mais de 50 porcos, que totalizaram 393 explorações, analisadas entre 1 de janeiro de 2018 e 31 de dezembro de 2023. A pontuação de biossegurança externa foi mais alta do que a da biossegurança interna, sendo que a subcategoria relativamente ao maneio de doenças (“Disease Management”) mostrou a maior melhoria. As recomendações de biossegurança mais frequentes incluíram a “mudança mais frequente de agulhas”, “uso de calçado e fato de macaco específico para a exploração”, e a “instalação de pedilúvios”.

As avaliações de risco de bem-estar animal mostraram um aumento nos riscos, como lesões nas orelhas e por agressão entre os suínos, ao longo dos anos. Algumas das recomendações para o bem-estar animal incluíram: “melhoria do enriquecimento ambiental”, “melhoria da ventilação” e “redução da densidade dos porcos”.

Finalmente, uma avaliação de fatores de risco usando dois modelos de regressão - modelo linear misto e modelo linear generalizado misto - encontrou associações entre biossegurança e riscos de bem-estar, indicando que uma boa prática de biossegurança implicava um menor risco para o bem-estar dos animais. O estudo destacou uma melhoria na biossegurança, ao mesmo tempo evidência que levou a necessidade de melhorar o actual programa de bem-estar animal.

Palavras-chave: suíno, bem-estar, biossegurança, recomendações, fatores de risco.

Resumo Alargado

O porco doméstico (Sus scrofa) é um mamífero omnívoro criado principalmente para a produção de carne. Na Irlanda, a produção de porcos é o terceiro setor agrícola mais significativo, contribuindo com 8% para a Produção Agrícola Bruta, atrás apenas da carne bovina e do leite. A produção é maioritariamente do tipo ciclo completo sendo que a produção ao ar livre é negligenciável.

-Biossegurança nas Suiniculturas

A biossegurança é essencial para minimizar a introdução e a disseminação de agentes patogénicos na criação de suínos. A biossegurança eficaz protege as explorações contra ameaças externas e reduz problemas internos, melhorando a saúde e produtividade dos animais, além de diminuir a necessidade de tratamentos preventivos e paliativos.

-Componentes da Biossegurança:

Biossegurança externa (bio exclusão) corresponde à prevenção da introdução de agentes patogénicos por meio de diversas medidas, como a quarentena e controle de acesso de pessoas, animais, alimentos e veículos. Dentro dessa abordagem, várias subcategorias são consideradas: a “compra de animais e sémen”, onde o objetivo é introduzir novos animais ou material genético somente de explorações livres de doença e realizar quarentena antes da integração. O “transporte de animais e a remoção de estrume e animais mortos”, que exige a utilização de diferentes veículos para as tarefas relacionadas com os animais, a garantia da limpeza dos veículos, e tratar o estrume e os animais mortos como fontes potenciais de infeção. O “fornecimento de rações, água e equipamentos”, que requer a elevação do padrão de qualidade na produção de rações e no tratamento de água para prevenir doenças, bem como a limpeza e desinfeção dos equipamentos antes do uso. O controle de “trabalhadores e visitantes”, que deve limitar interações desnecessárias com os animais, disponibilizar roupas específicas para a exploração e seguir protocolos de higiene rigorosos. O “controle de roedores e aves”, através da implementação de medidas para evitar que pragas espalhem agentes patogénicos. E, por fim, a consideração de “fatores ambientais e regionais”, como a localização da exploração e a sua proximidade de outras ou da vida selvagem, para melhor controle do risco de transmissão de doenças.

Biossegurança interna (bio gestão) tem o seu foco na prevenção da disseminação de agentes patogénicos dentro da exploração, por meio da gestão dos recursos da exploração e da implementação de medidas de higiene e desinfeção. É compreendida pelas seguintes subcategorias: “gestão de doenças”, que envolve o

estabelecimento de protocolos para tratamento de animais doentes, sua monitorização e a implementação de programas de vacinação. A “gestão das unidades”, adotando práticas de *All-in-All-out* e controlando a densidade animal para minimizar eventual risco de stress e doenças. “Compartimentos e linhas de trabalho”, de modo a garantir a separação de grupos de animais e a adoção de práticas rigorosas de higiene para prevenir a disseminação de doenças pelos trabalhadores. E, por último, “limpeza e desinfeção”, que consiste na aplicação de protocolos abrangentes de limpeza e desinfeção para quebrar ciclos de infeção entre os diferentes lotes de produção.

-Bem-Estar Animal na Suinicultura

O bem-estar animal refere-se ao estado físico e mental dos animais, através da quantificação de indicadores, como é exemplo a condição corporal, saúde e comportamento. A mordedura da cauda é uma questão crítica de bem-estar nos porcos, causando dor e stress, que exige uma abordagem multidisciplinar para mitigação.

-Fatores de Risco para Mordedura de Cauda

Enriquecimento Ambiental: Fornecer materiais que estimulem comportamentos naturais e reduzam a agressividade.

Conforto Térmico: Garantir a temperatura e a ventilação apropriada para minimizar stress e doenças.

Saúde Animal: Potenciar o bem-estar de saúde animal por meio de programas de vacinação e tratamento.

Problemas de Competição: Gestão da competição através do enriquecimento em recursos para evitar stress e agressão.

Processos de Alimentação: Otimizar a distribuição de ração e água para atender às necessidades de todos os animais.

Design das Celas: Projetar as celas num patamar adequado aos comportamentos naturais e condições higiénicas.

Objetivos do Estudo

Neste estudo analisamos dados de suiniculturas na Irlanda para: a) descrever o estado de biossegurança e bem-estar animal, b) identificar as recomendações dos médicos veterinários assistentes (MVPs) e se os agricultores as seguem, c) identificar associações entre níveis de biossegurança e os riscos de bem-estar animal. Os sistemas de avaliação utilizados incluem:

Biocheck.UGent: Um sistema de quantificação desenvolvido pela Universidade de Ghent para avaliar a biossegurança na exploração, através de uma pontuação que vai de 0 (mau) a 100 (excelente) (Biocheck.UGent, 2023).

Sistema de Avaliação de Risco de Mordedura de Cauda: Desenvolvido pelo Teagasc, Department of Agriculture, Food and Marine e Animal Health Ireland, adaptado da ferramenta WEBHAT de Mordedura de Cauda da AHDB (AHDB, 2023). Avalia seis categorias: Enriquecimento Ambiental, Conforto Térmico, Saúde Animal, Problemas de Competição, Processos de Alimentação e Design das Celas.

Materiais e Métodos

O Targeted Advisory Service on Animal Health (TASAH) financiou avaliações anuais de biossegurança e risco de mordedura de cauda para suiniculturas, tendo sido realizadas por MVPs treinados. As avaliações incluíram a formulação de recomendações SMART (Específicas, Mensuráveis, Atingíveis, Realistas e Temporais) e o registo de dados no sistema AHI Pig HealthCheck.

As pontuações de biossegurança e dos indicadores de bem-estar foram analisados na perspetiva de poderem ser correlacionáveis, através de modelos bioestatísticos e daí retirar as devidas ilações.

Resultados do Estudo

-Avaliações de Biossegurança

Tendências Gerais: O número de avaliações aumentou ao longo dos anos, atingindo o pico em 2022. A biossegurança externa obteve pontuações mais altas do que a biossegurança interna. No entanto ambas evidenciaram clara melhoria.

-Pontuações por Subcategoria

- Compra de Animais e Sémen e Fatores Ambientais e Regionais: Mediana de 100 ao longo dos anos
- Transporte e Remoção de Estrume: Aumentou até 2020, tendo desde aí estabilizado.
- Ração, Água e Equipamentos: Melhorando ao longo dos anos.
- Trabalhadores e Visitantes: Aumento entre 2020 e 2021.
- Controle de Roedores e Aves: Melhoria significativa após 2020.
- Gestão de Doenças: Duplicou, estabilizando após 2021.
- Maternidade e Recria: Pouca evolução sendo 2019 o ano com piores registos.
- Unidade de Engorda: Diminuição em 2023.
- Compartimentos e uso de equipamentos: Melhorando ao longo dos anos.
- Limpeza e Desinfeção: Melhoria após 2021.

Avaliações de Bem-Estar

A sobrelotação é uma realidade que sofreu uma ligeira inflexão em 2020, com diminuição do número de celas sobrelotadas, para voltar a infletir novamente em 2022. Perante estes resultados, continua a verificar-se o corte de cauda, sem progresso assinalável. O esforço de enriquecimento ambiental mostrou resultados limitados. As lesões mais comuns nas explorações eram lesões nas orelhas e lesões causadas por comportamentos agressivos. As lesões descritas, além dos outros indicadores mencionados anteriormente, levam à conclusão de que há problemas persistentes de bem-estar.

Recomendações

As subcategorias de biossegurança que receberam mais recomendações foram Gestão de Doenças, Fornecimento de Ração, Água e Equipamentos, e Trabalhadores e Visitantes. As recomendações de biossegurança mais frequentes incluíram a “mudança mais frequente de agulhas”, “uso de calçado e fato de macaco específico para a exploração”, e a “instalação de pedilúvios”.

Em relação ao bem-estar animal, a subcategoria enriquecimento ambiental recebeu a maioria das recomendações, embora o progresso demonstrado não foi o esperado. Algumas das recomendações para o bem-estar animal incluíram: “melhoria do enriquecimento ambiental”, “melhoria da ventilação” e “redução da densidade dos porcos”.

-Análise de Fatores de Risco

Modelos Lineares Mistos (LMM): Foram identificadas relações estatisticamente significativas entre as pontuações de biossegurança e problemas de bem-estar.

Modelo Linear Generalizado Misto (GLMM): Foi demonstrado que a probabilidade de risco para o bem-estar animal está diretamente relacionado com a diminuição da pontuação de algumas subcategorias de biossegurança.

Práticas adequadas na gestão da biossegurança tem efeito direto na redução do risco de bem-estar animal.

Discussão

O estudo revela que, embora a biossegurança nas suiniculturas irlandesas tenha melhorado substancialmente por meio de esforços da indústria e do apoio de subsídios do governo, as práticas de biossegurança interna ainda carecem de melhoria. O bem-estar animal tem avançado lentamente, exigindo colaboração mais próxima com os produtores e pela implementação de uma estratégia de gestão mais eficaz.

-Biossegurança

A biossegurança externa melhorou, mas medidas para a biossegurança interna precisam de maior atenção, especialmente nas unidades da maternidade, recria e engorda.

-Bem-Estar Animal

Problemas do corte de cauda e sobrelotação persistem, tendo o enriquecimento ambiental ficado aquém do esperado, não tendo sido obtido valores conformes com o bem-estar animal desejado.

-Recomendações e Fatores de Risco

Da análise efetuada releva-se a necessidade da aplicação do conjunto de recomendações emitidas bem como de protocolos de avaliação mais eficazes. A introdução da Inteligência Artificial irá permitir uma avaliação mais objetiva e estereotipada, abstraindo-se assim de medidas contraproducentes.

Conclusão

Existiu um forte incremento positivo na biossegurança, apoiado por iniciativas da indústria e do governo. Ainda assim, persistem desafios contínuos no bem-estar animal, especialmente em relação à mordedura da cauda e ao enriquecimento ambiental, que requerem estratégias mais eficazes. Novos protocolos e tecnologias irão permitir aprimorar o sistema de avaliações de bem-estar animal e de biossegurança, tendo por finalidade apoiar melhores práticas de gestão das suiniculturas.

Palavras-chave: suíno, bem-estar, biossegurança, recomendações, fatores de risco.

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Abbreviations and Acronyms

AH – Animal Health

AHI – Animal Health Ireland

C&D – Cleaning and Disinfection

CI – Competition Issues

DAFM – Department of Agriculture, Food and Marine

EE – Environmental Enrichment

E1 – Purchase of animals and semen

E2 - Transport of animals, removal of manure/dead animals

E3 - Feed, water and equipment supply

E4 - Personnel and visitors

E5 - Vermin/bird control

E6 - Environment and Region

FP – Feeding Processes

GLMM – Generalised Linear Mixed Models

I1 – Disease Management

I2 - Farrowing and suckling period

I3 - Nursery unit management

I4 - Fattening unit management

I5 - Measures between compartments and the use of equipment

I6 – Cleaning and Disinfection

LMM – Linear Mixed Models

NR – No risk

PD – Pen Design

PEDV – Porcine Epidemic Diarrhea Virus

PRRS – Porcine Reproductive and Respiratory Syndrome

PR – Personnel and visitors

PVP - Private Veterinary Practitioners

REC - Recommendation

R – Risk

TASAH - Targeted Advisory Service on Animal Health

TC – Thermal Comfort

WEBHAT - Web based Husbandry Advisory Tool

TASAH - Targeted Advisory Service on Animal Health

I - Description of the internship

The internship was divided into two parts. The first one from the 4th of September to the 22nd of December of 2023 in Lisboa as a preparatory stage for the internship in Ireland, and the second one from the 8th of January to the 31st of May of 2024 as the official internship in Carrick-on-Shannon, Ireland.

The internship in the Faculty of Veterinary Medicine of the University of Lisbon was organized by Professor Telmo Pina Nunes, as a training period for data handling techniques, and a course in data science using the R program (R Programming, by Johns Hopkins University, available in the Coursera platform at https://www.coursera.org/learn/r-programming) was completed. Further proficiency with this tool was achieved by completing different tasks, which required basic knowledge over data analysis techniques, from map design to work with DGAV data. Within this period another project was being run in parallel with the pharma company Vetlima and SUSTAURUSVET on the “evaluation of the effectiveness of sanitisation protocols” in Portuguese pig farms.

From January on, my internship began on Animal Health Ireland (AHI) in Carrick-on-Shannon, Ireland, supervised by Dr Carla Correia-Gomes and co-supervised by Prof. Virgilio Almeida (in Lisbon). AHI is a public-private partnership between private sector organisations and businesses in the agri-food sector and the Department of Agriculture, Food and the Marine (DAFM) in Ireland. AHI provides knowledge, education and coordination required to establish effective control programmes for non-regulated diseases of livestock. During this internship I have worked with data from the AHI Pig HealthCheck Programme, which looks at several components related to pig production: biosecurity, animal welfare, animal health, antimicrobial usage and public health. Financial aid was provided by the Erasmus+ programme to fund my stay. During this period, I was able to hone and enrich my data-handling skills while working on the data collected by AHI since 2018 and choosing which path was better suited for the research.

The internship consisted in analysing two datasets, which will be further discussed in the following sections, from the Pig HealthCheck Programme: one related to biosecurity assessments and the other related to risk factors assessments for tail biting. Both types of assessments are done at farm level. The main aims of the internship were to describe these two datasets and see if there were associations between biosecurity and animal welfare. As such the literature review presented in this thesis is going to focus on biosecurity and animal welfare on pigs.

I was offered to participate in the writing of the article “Temporal trends in biosecurity in Irish pig herds using a standardized scoring system” which has been submitted for review in May to the Irish Veterinary Journal.

In March, I developed a poster based on the article mentioned above for the 2024 SVEPM (Society for Veterinary Epidemiology and Preventive Medicine) Conference in Sweden. The poster was presented by Dr Carla Gomes as a poster pitch. I have also collaborated in the development of another poster for the 27th International Pig Veterinary Society Congress/15th European Symposium of Porcine Health Management in June 2024, on the same topic of biosecurity.

Also in March, I travelled to the Teagasc Moorepark in Fermoy to assist the AHI with the training sessions for veterinarians on the courses “Risk assessment for Tail Biting” and “Salmonella and Biosecurity in Pig Production”. Not only was I able to further my education by receiving the training myself but also gaining professional experience discussing issues with other veterinarians in the field, interacting with animals by collecting samples for lab work and helping AHI organise the event.

In May, I have developed in collaboration with AHI the activities to present to farmers during the Pig Open Days in Teagasc Moorepark in Fermoy and at the Ballyhaise Teagasc Agricultural College in Cavan. In these open days, researchers showcase their research to pig farmers and allied industry. I have interacted with several groups of farmers and allied industry presenting the activities part of the AHI Pig HealthCheck Programme.

1 - Literature review

The pig (Sus scrofa) is an omnivorous, domesticated, even-toed, hoofed mammal. Pigs are farmed primarily for meat. China is the world's largest pork producer, followed by the European Union and then the United States, (U.S. Department of Agriculture Foreign Agricultural Service, 2023). Around 1.5 billion pigs are raised each year, producing some 120 million tonnes of meat.

Pig production was the third most important sector for the Irish Gross Agricultural Output, making up 8% of the total, and staying behind beef and milk production. The Bord Bia report for 2022 accounts for an estimated 228,000 tonnes of pigmeat in total exports. With over 70 different export markets, international markets represent the largest recipient of Irish pig meat exports, with 69% going to international markets, mainly China, while the rest goes to the UK and EU. In 2023, the Irish commercial sow herd census revealed an estimated 134,200 sows and the slaughter of 3.48 million heads of pigs (Buckley et al. 2023).

1.1 - Biosecurity

Biosecurity is a combination of measures aimed at reducing the risk of introducing and spreading pathogens. Biosecurity is a measure that can and should be applied to different levels such as country-wise to a singular individual, and should not be restricted to a singular level (Dewulf et al. 2018).

Biosecurity is a dual-wielding weapon, that can function as either a protection shield from outside threats but also as a powerful prevention tool to contain the inside problems from breaking to the outside (Alarcón et al. 2021).

The measures and tools implemented to improve the biosecurity status should never be seen as a “disturbance” to the farmer but as a way to improve its animals' health status and productivity, for a better farm and work management and a better environment (Dewulf et al. 2018).

1.1.1 - Why is Biosecurity important?

It’s the foundation of a disease control programme. Once a farm has been assessed and its flaws have been pointed out, they can be reviewed and complemented, such with the introduction of new feed, a new vaccination programme, a better management of the animals, there can be a collective effort to prevent the entrance of new exotic diseases to the farm or a way to better manage or even eradicate the endemic diseases that circulate in the farm.

Better established measures, lead to better biosecurity, and as a consequence, to reduced infection and disease pressure, leading to the need for curative and palliative treatments to be kept at a minimum, not only improving production but also reducing the need for antimicrobial use (Dewulf et al. 2018).

1.1.2 - Components of Biosecurity

Biosecurity can usually be divided into two: external and internal biosecurity.

External biosecurity or bio-exclusion is the measures implemented to prevent the introduction of pathogens into farms as well as the prevention of the spread of infection agents from farms (biocontainment) (Dewulf et al. 2018). It includes measures with activities where it associates contact between the farm and the outside world, such as people and animals (quarantine, hygiene lock), on others such as visitors, feed, transport vehicles, or anything foreign to the farm infrastructure.

Internal biosecurity or bio-management consists of all the measures taken to prevent the spread of infectious agents within the farm (Dewulf et al. 2018). That means from different age groups and production groups of animals, but also between

the same group. Internal biosecurity is deeply connected with the management of the farm and daily practices of animal care, such as their hygiene and health.

Since the intensification of the production system, internal biosecurity was given proper attention for the management of endemic disease because of the closeness of the animals was much greater than before and the need to control them was more urgent than ever seen (Alarcón et al. 2021).

1.1.2.1 - Purchase of animals and semen

The highest probability of introduction of any new pathogen starts with the introduction of new animals or with animal products, such as semen and embryos, for which the farm possesses no immunity (Dewulf et al. 2018).

In order to keep the production system running, there is a need to keep new breeding animals coming into the system, but for that, the main goal should be to avoid purchasing any new animals or their genetic material if possible (Maes et al. 2016). In order to do that, farmers need to rely on their own replacement by selecting a few of their female offspring as replacement stock. If the introduction of new animals becomes unavoidable, these should be limited to the least necessary, from the number of animals and sources point of view.

For any purchase, these should be bought from farms with preferably higher or equal health status, and all animals should then pass through a quarantine period, in a proper facility separated from the main buildings to avoid the entry of new diseases or pathogens. This quarantine period should be long enough for the new animals to have time to start the vaccination programme used on the farm and also for them to have time to express any symptoms of any disease they might be carrying (Bottoms et al. 2013).

1.1.2.2 - Transport of animals, removal of manure/dead animal

Pathogens may spread not only directly through animal contact but also in an indirect manner (e.g. vehicles) (Fedorka-Cray et al. 1997).

Different types of transport should be used for different types of tasks, such as delivery of new stock or transport of animals to slaughterhouses. These lorries should arrive at the farm premises empty on arrival, clean and disinfected. They should also circulate in the dirty area of the farm. Manure and dead animals should be treated as potential risk of infection and be treated as such. The principle of the clean and dirty road on a pig farm means that there is a clear separation between the clean and the dirty (risky) sections of the premises (Filippitzi et al. 2017).

1.1.2.3 - Feed, water and equipment supply

Although there are high regulations and standardised equipment for feed production, feed is still one of the main pathways of pathogen introductions on a farm, as it was proven to be a source of Porcine Epidemic Diarrhea Virus introduction for some farms (Dee et al. 2014). But even more than the feed, water represents one of the most important infection pathways (Dewulf et al. 2018). Regular maintenance of the water system as well as proper water treatment facilities inside the farm are mandatory to prevent the risk of new diseases. Any equipment that is used inside the farm, especially if it is going to be in contact with animals should be cleaned and disinfected and not be used in other farms.

1.1.2.4 - Personnel and visitors

Anything can act as a vector even a human (Dewulf et al. 2018). So the first step for a safer farm is to restrict the number of unnecessary interactions of visitors with the animals. That means only allowing the strictly necessary visitors, and having in place standard safety procedures such as using clothing and boots provided by the farm, complying with the hygiene lock and recording the presence of every stranger to the farm. For the staff, they should be equipped with adequate work clothes and boots and ideally, it should be changed whenever they change work station.

1.1.2.5 - Vermin and bird control

Pests can be a direct or indirect source of several pathogens, not only from the outside world to the inside of the farm but also by spreading it through different farm compartments. They also function as pathogen reservoirs, contributing to the maintenance of endemic diseases on the farm. While airborne transmission has not been proven from more than hundreds of meters, studies showed the presence of infectious Porcine Reproductive and Respiratory Syndrome virus in a proportion of houseflies captured at 1.7 Km from infected farms, highlighting the importance of a good fly repellent programme on farms to combat this mechanical vectors (Schurrer et al. 2004). The role of birds in the spread of some pathogens such as *Salmonella, Lawsonia intracellularis,* and *E.coli* has already been proven and it is thought they may also act as a reservoir perpetuating circulation on the farm (Pearson et al. 2016).

1.1.2.6 - Environment and region

As some diseases are transmitted through the air, it is important to factor in the location of the farm, in relation to other farms, roads and slaughterhouses. Also, the

presence of wild animals, especially wild boars, near the farm premises also increases the risk of disease introduction. For example, for PRRSV a 2-year study showed that, regarding airborne transmission, cool temperatures, low sunlight levels, winds of low velocity in conjunction with gusts and rising humidity and pressure were the ideal conditions for its dissemination, so farms located in places with these conditions would be at a greater risk for infection if neighbouring farms were positive (Dee et al. 2010).

1.1.2.7 - Disease management

In order to obtain a final product on the farm, the farmer needs to be able to keep his animals alive and in good health conditions. To ensure this, it is necessary for every farm to have a protocol to handle the sick animals, which should include not only the treatment plans, but also record keeping, and getting proper diagnosis (Dewulf et al. 2018). Investing in a sick bay or hospital pen to keep the diseased animals isolated, having proper vaccination programmes in place to prevent animals getting infected or decrease the burden in case they are infected, all help to decrease disease incidence. The reintroduction of the recovered animals must be carefully considered attending to the shedding period of the pathogen.

1.1.2.8 - Unit management

Refers to the analysis of every productive stage to which a farm can have: farrowing and suckling period, nursery unit management, fattening unit management.

Important aspects to consider in unit management are if all-in/ all-out (AI/AO) practices are implemented and the stocking density of animals in the unit. AI/AO practices allow for the cleaning measures to be correctly applied in between batches of animals, preventing cross-contamination and reducing the risk of pathogens persisting between production cycles. Stocking density, which is regulated by law, is a risk factor known to induce stress, which can result in increased susceptibility to pathogens and increased shedding of pathogens, it is also a welfare concern that can incur into more fights between the animals in the pen (Dewulf et al. 2018).

1.1.2.9- Compartments and working lines

While working on farms with different production stages, there will be present animals of different ages and with different competencies of their immunity system. Which means that diseases that affect certain groups on the farm can be harmless to others and vice versa. It is important to be able to separate different working lines in order to benefit the animals' health, with cleaning and disinfecting measures applied at

the entrance of each of these compartments. These measures should be even more strict when working with risk groups, such as the animals in the hospital pen or the quarantine room, with even more efficient measures applied like a hygiene lock, apart from the more used foot/boot wash, hand washing station, and appropriate clothing (Dewulf et al. 2018).

Working lines are the groups of animals present on the farm, and they are affected by the movements of staff through the farm and the types of risk associated with these movements (Bernaerdt et al. 2023).

1.1.2.10 - Cleaning and disinfection

The first step to prevent infection and to break the infection cycle between production batches is to ensure the animals arrive to a clean space. To achieve that, a cleaning and disinfection (C&D) protocol should be employed in every farm. An effective C&D protocol comprises seven steps but can be summarized as removing organic matter, pressure washing, disinfecting the pen after it has dried, and periodically testing the efficiency of this procedure (Dewulf et al. 2018).

1.2 - Animal welfare

Although the perception of animal welfare varies according to a country's socio-economic status, according to WOAH, it ultimately means the physical and mental state of an animal in relation to the conditions in which it lives and dies. In order to measure it, some criteria were established to monitor the well-being of the animals (WOAH. 2023). To measure welfare, one should focus more on the animal's state rather than resource-based criteria (such as the environment), due to animals' adaptability to their surroundings. Key performance and health parameters to analyse include body condition and weight, the percentage of diseased and injured animals on farm, and behaviour such as social interactions, resting, vocalizations, and fear. The Council Directive 2008/120/EC of 18 December 2008 lays the groundwork for Pig Welfare in the European Union.

Tail biting in pigs is a critical animal welfare issue, causing significant pain, health problems, and stress to the animals and economic losses to the farmers. This behaviour disrupts social hierarchies and affects the well-being of the entire group. Addressing tail biting involves a multi-disciplinary approach in order to tackle its potential origins (WOAH. 2023).

This literature review is going to focus on the risk factors for tail biting. The risk factors for tail biting have been categorised into six different categories as per the

Commission Staff Working Document on best practices with a view to the prevention of routine tail-docking and the provision of enrichment materials to pigs (COMMISSION… 2016).

1.2.1 - Environmental enrichment

Environmental enrichment is defined as when modifications get carried out in a captive environment with the objective of targeting species-specific behaviours, in other words, to improve the biological functioning of captive animals. It is also a way to manage undesired and damaging behaviour, such as tail biting and other aggressive behaviours towards pen mates. In a way, it is a way to manipulate the pig's behaviour and to redirect their natural behaviours to an appropriate outlet (de Weerd et al. 2019). Different types of materials and in different ways can be added to a pen not only attending to the age of the animals but also considering the interest the animals have and the availability of those materials to farmers. Some examples are: straw, short or long, on the floor or in a dispenser, for optimal enrichment; peanut shells, ground wood, natural ropes for suboptimal items; and objects, such as hard plastic piping or chains for marginal items (Nielsen et at. 2022).

1.2.2 - Thermal comfort

Although as with any endothermic animals, pigs can adapt to a range of thermal environments, but specific anatomical characteristics make them especially sensitive to temperature fluctuations, predisposing them to pathologies and even death due to thermal stress (WOAH. 2023). Finding the equilibrium that can provide the best living conditions for the animals is essential to every farm. Ensuring that a proper ventilation system is in place and that the living space for the animals is draft-free are some of the requirements to achieve this status.

1.2.3 - Animal health

Health is defined as the absence of disease or the normal functioning of an organism and normal behaviour expressed by that species based on the results of a standard of individuals (Ducrot et al. 2011). For production sectors, a pig's health is also defined as the state allowing them the highest productivity levels. Having in place a vaccination programme and treatment protocol to correctly treat and manage sick and injured pigs are some measures to improve the health status of a farm.

1.2.4 - Competition issues

Due to the living conditions of an intensive farm, oftentimes restricting a pig's normal behaviour leading to the appearance of abnormal behaviours can be prevented or minimised with appropriate management procedures. Some of these behaviours can be the competition for feed and water, or the competition to access enrichment materials. These problems are often multifactorial and their causes often begin from neglected welfare practices around the farm, to minimising their occurrence requires an examination of the whole environment and of several management factors (WOAH. 2023). Competition issues act as an initial indicator that there may be issues in other welfare categories.

1.2.5 - Feeding processes

Food and water are a necessity for any animal. Any farm must optimize this process not only to ensure that every animal receives the nutrition they require but also to expedite the staff's daily job. As pigs grow, not only does their diet change but also the average daily feed intake, meal size, and feeding rate increase, whereas small variations or even decreases in time spent eating and daily feeder visits have been reported. This results in the existence of four types of pigs: pigs that eat their daily feed intake in many short meals (nibblers) or in a few large meals (meal eaters) combined with eating fast (faster eaters) or slow (slow eaters) (Fornós et al. 2022). Pigs that spend less time eating have a better feed conversion rate of all types, but all animals' needs must be met to ensure healthy pigs on the farm.

1.2.6 - Pen design

Since being made to live in a space-limited environment and oftentimes overstocked, the natural cleanliness behaviour of pigs cannot be met since they are not able to have designated areas for resting, feeding and eliminating due to the lack of space (Ocepek et al. 2022). This often leads to the animals resting over their faeces creating problems not only for the animals and the pen hygiene but also for the air quality, and human and pig health. This leads to “Dirty Flanks” pigs and can cause serious impacts on farm productivity. A pen design that allows for the pig to differentiate between these areas will fulfil the pig's needs and improve welfare. Fully slatted pens are one of the main risk factors for tail biting as the potential to offer materials as bedding is often times not possible.

Objective of this study

This study had several objectives: a) first to describe the biosecurity and welfare status of the commercial Irish pig farms, b) second to identify what type of recommendations are given by private veterinary practitioners (PVPs) to improve biosecurity and animal welfare at farm level and if these are followed by the farmers, and c) finally to identify associations between biosecurity scores and welfare risks at farm level.

2 - Materials and methods

2.1 – Description of the Assessments

2.1.1 - Biosecurity

Two assessment systems were used in this study. For biosecurity the Biocheck.UGent risk-based scoring system was used for assessing biosecurity at farm level; while for assessing the risk for tail biting a system developed in Ireland was used. Both types of assessment are described below in more detail.

Biocheck.UGent is a risk-based scoring system developed by the University of Ghent to evaluate on-farm biosecurity using an objective, weighted scoring system (https://www.biocheck.ugent.be/). The biosecurity risks can then be divided into external and internal subcategories to address the different pathways of pathogen spread or introduction. The external subcategories are: purchase of animals and semen (E1), transport of animals, removal of manure/dead animals(E2), feed, water and equipment supply (E3), personnel and visitors (E4), vermin/bird control (E5), and environment and region (E6). While the internal subcategories are: disease management (I1), farrowing and suckling period (I2), nursery unit management (I3), fattening unit management (I4), measures between compartments and the use of equipment (I5), and cleaning and disinfection (I6). I2 to I4 are only scored if there are breeding animals, weaners or fatteners, respectively, on the farm.

The biosecurity questionnaire was composed of 109 questions divided into 12 sections (as described above) with the question types divided into yes/no questions, Always/ Sometimes/ Never and some other options. The combinations of the responses results in the scores for each subcategory, and the total score for the external, internal, and overall results. The scores for each subcategory vary from 0 (poor biosecurity) to 100 (very good biosecurity).

As part of Ireland's efforts to prevent the introduction of African Swine Fever in the country and improve biosecurity at national level, Targeted Advisory Service on

Animal Health (TASAH) under the Rural Development Programme (2014-2020) funded one free biosecurity assessment for commercial pig farms (loosely defined as sending at least 200 pigs to slaughter per year or having 200 pigs in the farm) per calendar year. These assessments were done by private veterinary practitioners (PVPs). It was a pre-requisite of TASAH that all participating PVPs had to be trained on using the Biocheck.UGent tool before doing the assessments.

PVPs would organise the visits with the farm owner/manager, do the assessment on farm following the Biocheck.UGent questionnaire, provide a maximum of three SMART (specific, measurable, attainable, realistic, time-bounded) recommendations for improving biosecurity that were agreed with the farmer, and input the questionnaire answers (and get the BiocheckUgent weighted scores through an application programming interface) and recommendations in the AHI Pig HealthCheck web system.

2.1.2 – Tail Biting

The welfare risk-based system used ("Assessment and Management of Risk Factors in Animal Welfare in Pig Production") was developed by Teagasc, DAFM and AHI based on the already existing AHDB Tail Biting WEBHAT tool (https://webhat.ahdb.org.uk/tail-biting-risks). The WEBHAT was adapted to the reality found in the Irish pig farms (for example no outdoor commercial pig production). In relation to tail biting risks, six categories were evaluated: Environmental Enrichment (EE), Thermal Comfort (TC), Animal Health (AH), Competition Issues (CI), Feeding Processes (FP), and Pen design (PD).

As part of the welfare questionnaire, six pens per farm were assessed. General characteristics of the pen (size) and the animals within it (number, weight and sex of animals, tail length) were assessed as well as other questions related to: feeders and drinkers, number and type of environmental enrichment items per pen, number and type of lesions observed in the animals, and an activity to record the number of abnormal behaviour demonstrated in 5 minutes by the animals in that pen.

Behaviours were categorised as follows:

Damaging behaviour is an oral, mouth or nose, behaviour directed towards another pig's body (tail, ear or other) which can cause physical damage or pain without being motivated by aggression.

Fixtures and fittings is an oral behaviour directed to any physical part of the pen, such as the drinkers or the walls, that are not designed to be chewed or rooted by pigs.

Enrichment refers to any interaction of the pig towards the enrichment materials provided in the pen, such as chewing, nosing, and rooting.

Aggressive biting is a behaviour motivated by aggression unlike damaging behaviour, where the aggressor pig can be seen pursuing others accompanied by quick snapping movements by the jaws (i.e. open mouthed).

Based on the characteristics of the pens and observations of lesions and behaviours the PVPs then had to quantify the risk per pen for each of the 6 categories (EE, TC, AH, CI, FP and PD). This assessment should be only applied to pens that had weaner or fattener pigs, however early in the programme (2019 and 2020) some other types of houses were also assessed by mistake by the PVPs, not included in this study.

As part of Ireland's efforts to improve animal welfare in pig production and move to raise more pigs with intact tails, TASAH under the Rural Development Programme (2014-2020) funded one free tail biting risk assessment for commercial pig farms per calendar year. These assessments were done by PVPs. It was a pre-requisite of TASAH that all participating PVPs had to be trained on using the “Assessment and Management of Risk Factors in Animal Welfare in Pig Production” before doing the assessments.

Similar to the biosecurity programme, the PVPs would provide a maximum of three SMART recommendations for improving animal welfare per pen assessed, and input the questionnaire answers and recommendations in the AHI Pig HealthCheck web system as per biosecurity assessments.

2.1.3 - Data analysis of the two datasets

For the biosecurity dataset, boxplots were made depicting the scores per year for overall, external, and internal biosecurity scores and for each of the external and internal biosecurity subcategories. Then a line plot was produced illustrating the evolution of the mean and median values throughout the years.

For the welfare dataset, each welfare category was paired with the appropriate welfare indicator that was biologically significant, as indicated in Table 1.

The evolution of each welfare indicator was analysed by year and displayed using a bar chart. To properly compare the information yearly and understand the evolution displayed by these variables, the number of lesions observed was then transformed into a proportion by dividing it by the total number of animals assessed per year; while the behaviours observed were transformed into a rate, by dividing it by the total number of animals assessed per year.

Table 1 - Management practices and welfare indicators considered to be associated with each risk category

	Risk Categories					
Management practices	**Enrichment**	**Thermal comfort**	**Animal Health**	**Competition**	**Pen design**	**Feeding processes**
Vaccination programme			✓			
Space allowance			✓	✓		
Feeder allowance				✓		✓
Drinker allowance				✓	✓	
Proportion slatted flooring					✓	
Welfare indicators	-	-	-	-	-	-
Tucked tails	✓			✓		
Injured tails	✓		✓	✓		✓
Injured/imperfect ears	✓		✓			
Flank lesions			✓	✓		
Aggression lesions			✓	✓		✓
Dirty flanks/ haunches		✓			✓	
Damaging behaviour	✓					✓
Aggressive behaviour				✓		✓
Enrichment behaviour	✓			✓	✓	

The available length and width of the pen, the number of animals in the pen and final weight that those animals are expected to achieve were used to, first, calculate the stocking density per pen and then compare the stocking density to what is allowed per law for that weight of pigs. Based on this the proportion of pens per year that are overstocked was calculated.

2.2 – Data Analysis of the Recommendations Data

For each biosecurity and animal welfare assessment recommendations were provided by the assessor (PVP) on how to improve biosecurity and animal welfare respectively.

The recommendations analyses were processed individually (i.e. manually assessed) and categorised into one of the 12 subcategories for biosecurity (as per Biocheck.UGent subcategories) and into one of the six categories for animal welfare (as per welfare protocol used). In some cases, the recommendations were further broken down into subgroups to provide further detail about the recommendations. In case we could not classify a recommendation to one of the 12 biosecurity subcategories or the 6 welfare categories, they were classified as 'OTHER'.

For both databases, the number of times each recommendation was used each year were tabulated. In the biosecurity database, the total number of recommendations per year by “category” was divided by the number of farms analysed each year. For the

welfare database, the total sum of pens with a recommendation was divided by the number of pens analysed in that year.

To analyse if there were any criteria related to the risk identified in the pens/farm that would prompt the PVP to choose it as one of the recommendations to the farmer, further analysis of these data was done.

In the welfare questionnaire, there was already a question that would identify the pens that were at risk. That did not happen for the biosecurity questionnaire; therefore we have selected a cut-off to differentiate between risk (<50 score) and no risk (≥50 score) for each biosecurity subcategory (Table 2).

In the analysis, having a recommendation for a specific category was coded as “R” and no recommendation was coded as “NR”. For both the biosecurity and welfare databases the code “0” means no risk for the farm or pen, respectively, and “1” when a risk was identified.

Table 2 - Possible Outcomes to Define a Risk

Possible Outcomes	**Risk (1)**	**No Risk (0)**
Biosecurity Score	<50	≥50
Welfare Risk	Risks have been identified	No risk identified

2.3 – Risk Factor Analysis

In the final part of the study, we have looked at associations between the biosecurity scores and the welfare risks. For this analysis, records of the biosecurity assessments and the welfare assessments for each farm and for each year were matched.

As the data follow a hierarchical structure (repeated observations over time per farm) regression mixed models were used. When the outcome variable of the model was a biosecurity subcategory (0 to 100), a linear mixed model (LMM) was used; when a welfare risk subcategory (0 – no risk, 1 – risk) was used as an outcome variable, a generalised linear mixed model (GLMM) was used. The lme4 package (Bates, D. et al, 2015) was used in these analyses (lmer function for LMM and glmer function for GLMM). The matrix used was the default for the package. For the GLMM as the outcome variable follows a binomial distribution the link “logit” was chosen. The family argument sets the error distribution for the model, while the link function argument relates the predictors to the expected value of the outcome.

Correlation between independent variables was assessed by using Spearman correlation test. If the variables were showing a high correlation ($0.7 \leq |\rho| \leq 1$) the one that had more biological significance was chosen to enter the model.

2.3.1 - Linear Mixed Models (LMM)

For the LMM analyses, 12 different models were built, one for each biosecurity subcategory, plus 3 models for the overall, external and internal biosecurity categories (Tables 12 to 14).

The predictor variables chosen to incorporate in the models were: the welfare subcategories, *Farm Type*, Dirty Flanks as a hygiene measure, Overstoking as a welfare measure, *Year* as a fixed factor, and as a random effect both the *Veterinarian* responsible for the assessment and the *Farm.*

Each predictor was tested in a univariable model and if the p-value <0.25 for that predictor, it was selected to be tested in the multivariable model. For the construction of the multivariable models, a backwards selection process was followed, where all predictors with p<0.25 were put together in a model and the ones with the highest p-value were removed one by one until all predictors had a p-value <0.05.

Since the welfare assessment was designed to evaluate risk within pens while the biosecurity assessment identified practices within farms, we aggregated the welfare risks from pen to farm level for these models. In that way, the chosen methodology was to create new variables which would take the value of “0” if there was no pen in that farm at risk for welfare (this was done by welfare category), and the value of “1”, if there is at least one pen in the farm at risk for that category of welfare risks.

2.3.2 - Generalised linear mixed models (GLMM)

For the GLMM 18 different models were built: 6 for the welfare categories with the 12 biosecurity subcategories as fixed effects, 6 more with the biosecurity overall score as fixed effect and the remaining 6 with the external and internal biosecurity scores as fixed effects (Tables 15 to 20).

The predictor variables chosen to incorporate in the model were: the biosecurity subcategories, Farm Type, Pen Type, Year as a fixed factor, and as a random effect both the Veterinarian responsible for the assessment and the *Farm.* Also based on Table 1 for each welfare category, the biological significant management practices associated with each welfare category were also chosen.

Some variables were not included in the models even though they were biologically significant, such as Vaccination, Sex and Tail Length, because there is not much variation in the data for these variables.

Model building and selection was the same as for the LMM.

For the GLMM to be able to converge, the biosecurity scores were rescaled using the scale function, which calculates the vector's mean and standard deviation, and then “scales” each element by removing the mean and dividing by the standard deviation.

The estimates of the final models were then converted to odds ratio for the interpretation of the results.

3 – Results

3.1 – Characterisation of the datasets

Data collection started in 2018 for the biosecurity assessments and in 2019 for the welfare assessments. Almost all herds in Ireland with more than 50 pigs registered participated in these assessments, having a total of 393 farms being assessed. A total of 1014 biosecurity assessments and 935 welfare assessments were made from the start of the assessments until the 31st of December of 2023.

3.1.1 – Biosecurity

Since the start of the assessments in 2018, the number of farms assessed has been increasing, with 2022 being the year when most farms and animals were assessed.

Table 3 - Number of Farms and Animals assessed per year in the Biosecurity study

Variable	2018	2019	2020	2021	2022	2023
Farms	29	93	148	173	303	268
Animals	141,826	324,493	645,058	944,092	1,330,009	1,151,648

External biosecurity scored higher than internal biosecurity in all years (Figure 1). There was an increase in the median values of external, internal and overall biosecurity over the years.

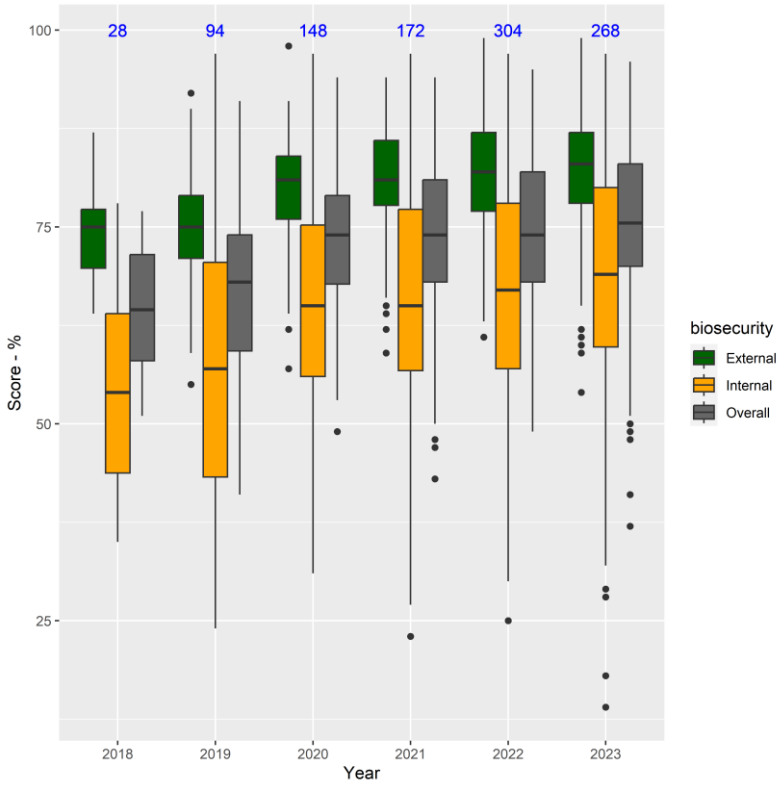

Figure 1 - Boxplot of the distribution of the scores for external, internal and overall biosecurity from 2018 to 2023. The blue numbers are the number of farms assessed per year.

Results per biosecurity subcategory:

-E1 – Purchase of Animals and Semen

This biosecurity subcategory has the same median score throughout the years and shows little evolution during the study (Figure 2 – left graph) as its score is quite high. From 2022 to 2023 the value of the first interquartile was lower.

-E2 - Transport of animals, removal of manure/dead animals

For this subcategory there was a positive increase over the years with the median scores rising till 2020 and then keeping stable during the following years (Figure 2 – right graph). Comparing 2023 to 2022, the first interquartile value was higher and so was the minimum value.

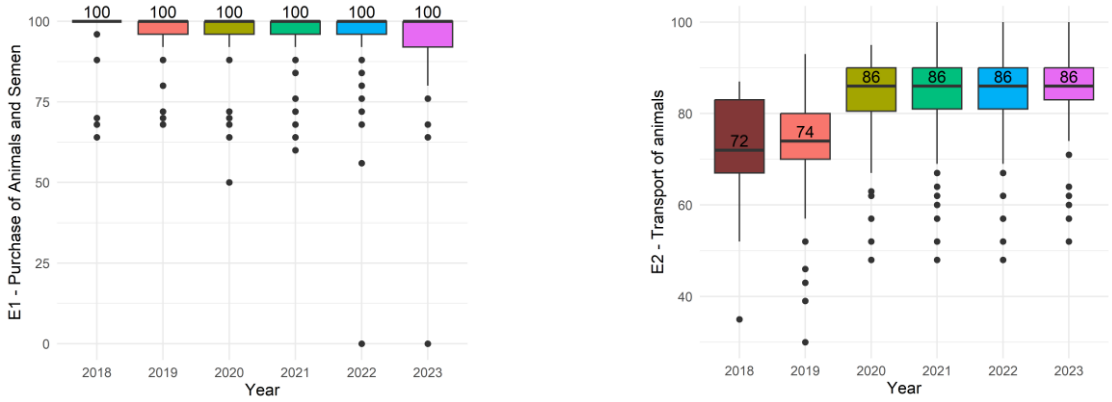

Figure 2 - Graph of E1 - Purchase of Animals and Semen (left) and E2 - Transport of animals, removal of manure/dead animals (right). Numbers shown are the median values.

-E3 - Feed, water and equipment supply

The median score for this subcategory also increased over the years, having 2019 being the worst year in terms of score since the first interquartile value was the lowest and the third interquartile was the same as the median value. Since 2021 the scores have been stable (Figure 3 – left graph).

-E4 - Personnel and visitors

Similar to the other subcategories, over the years the scores have been improving, with 2020 to 2021 showing the biggest improvement. Since then, the scores have been stable but 2022 results showed to have a bigger variation, with a smaller value for the first interquartile and a smaller minimum value compared to 2021 and 2023 (Figure 3 – right graph).

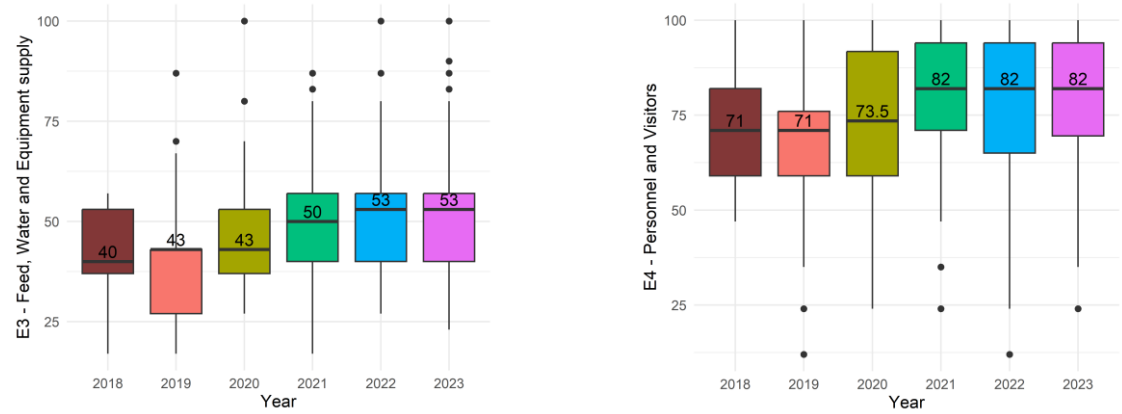

Figure 3 - Graph of E3 - Feed, water and equipment supply (left) and E4 – Personnel and Visitors (right). Numbers shown are the median values.

-E5 - Vermin/bird control

For this subcategory, the scores can be divided into two groups: up to 2020 and from 2021 onwards. The first group has a median score of 80 and the second group a median score of 90 (Figure 4 – left graph).

-E6 - Environment and region

Although the median score is stable throughout the years with a maximum score of 100, for the years 2018, 2021, and 2023 the first interquartile value and the minimum value were much lower compared to the other years (Figure 4 – right graph).

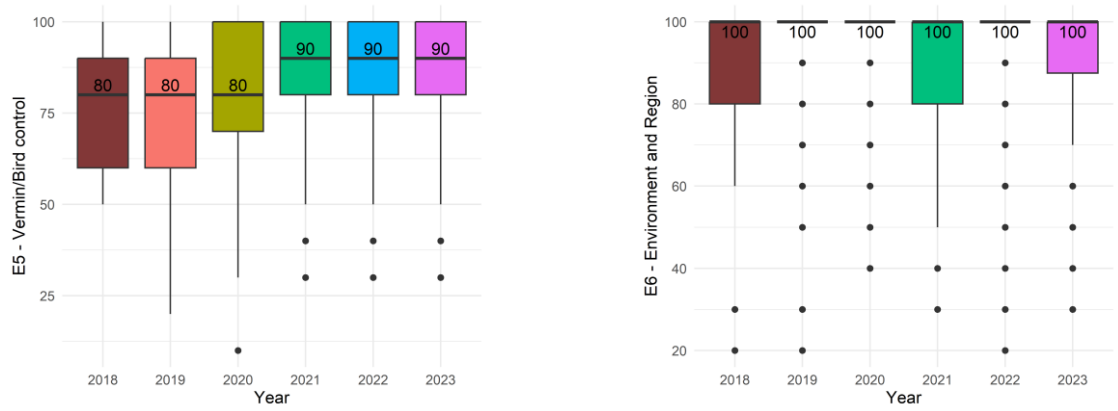

Figure 4 - Graph of E5 - Vermin/bird control (left) and E6 - Environment and region (right). Numbers shown are the median values.

-I1 - Disease management

For this subcategory, there was an increase over the years from a median score of 60 that almost doubled in the space of 2 years. Since reaching its peak in 2021 the scores have been stable (Figure 5 – left graph).

-I2 - Farrowing and suckling period

For this subcategory, 2019 represents the worst year in terms of median score, with a slow improvement afterwards (Figure 5 – right graph).

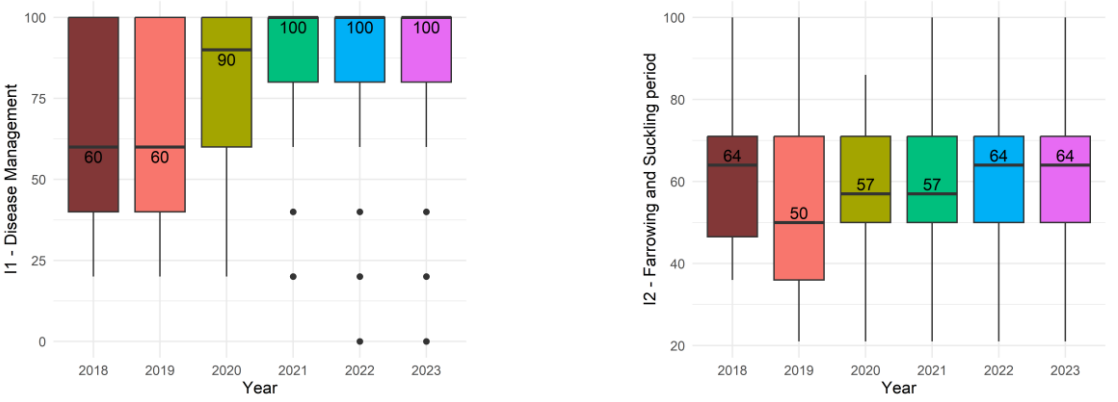

Figure 5 - Graph of I1 - Disease management (left) and I2 - Farrowing and suckling period (right). Numbers shown are the median values.

-I3 - Nursery unit management

Similar pattern as for Farrowing and suckling period (I2), with slight improvement in the median scores from 2020 onwards (Figure 6 – left graph).

-I4 - Fattening unit management

Although until 2022 the records showed a positive evolution with the median scores increasing from 2018 and then keeping stable in the following years, 2023 marked a decrease in scores (Figure 6 – right graph). This is the only biosecurity subcategory where the most recent assessment year marks a decrease in the median compared to 2022.

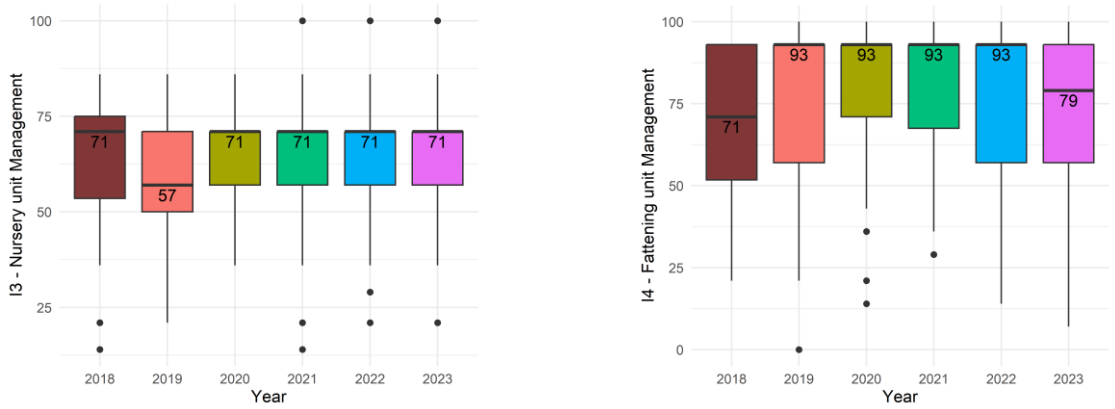

Figure 6 - Graph of I3 - Nursery unit management (left) and I4 - Fattening unit management (right). Numbers shown are the median values.

-I5 - Measures between compartments, and the use of equipment

Starting with one of the lowest scores out of all the subcategories, over the years, there has been significant progress marking 2023 as the year with the highest median scores (Figure 7 – left graph).

-I6 - Cleaning and disinfection

For this biosecurity subcategory, although there has been progress over the years (Figure 7 – right graph) this has not been as linear as the one observed for I5.

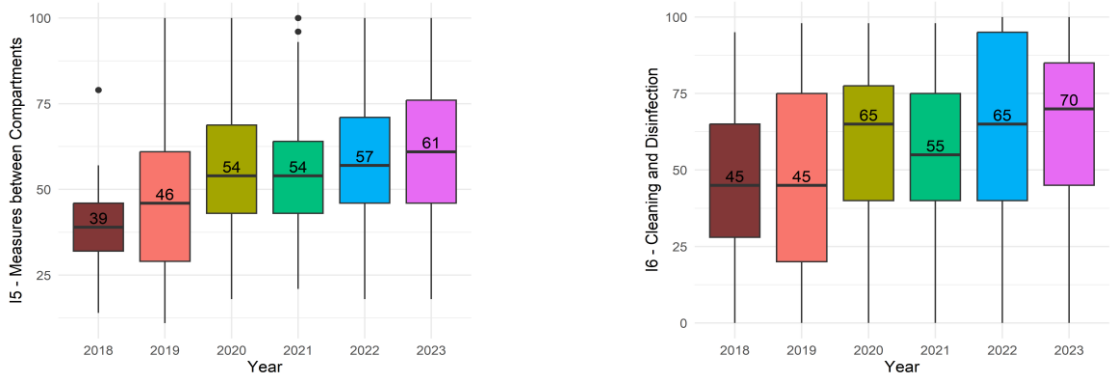

Figure 7 - Graph of I5 - Measures between compartments, and the use of equipment (left) and I6 - Cleaning and disinfection (right). Numbers shown are the median values.

3.1.2 – Tail Biting

The welfare assessments started in 2019 and the uptake has grown since then. Six pens per farm are assessed focusing on weaner and fattening pens only. During the first years (2019 and 2020) of the assessments other pen types were also assessed by mistake but they were not included in this analysis.

Table 4 shows the number of farms, pens and animals assessed over the years. The year when more farms were assessed was 2022. The majority of farms had all 6 pens assessed, however, some farms had less than 6 pens assessed – these were smaller farms that had not 6 weaners and/or fatteners pens.

Table 4 - Number of Farms, Pens, and Animals assessed per year and percentage of pens with identified risks for the different welfare categories in the Welfare study

Variables	2019	2020	2021	2022	2023
Farms	4	160	203	299	268
Pens	24	922	1201	1760	1576
Animals	1244	34866	43692	58265	50720
Pens with risks for Environmental Enrichment	91.6%	60.5%	83.7%	78.2%	71.7%
Pens with risks for Thermal Comfort	29.2%	13.7%	22.6%	27.4%	28.8%
Pens with risks for Animal Health	41.7%	20.7%	29.3%	27%	32.2%
Pens with risks for Competition Issues	0 %	7.3%	5.1%	4.5%	4.9%
Pens with risks for Feeding Processes	20.8%	14.2%	6.9%	5.2%	10.8%
Pens with risks for Pen Design	8.3%	7.8%	5.7%	5.6%	8.3%

Overstocking

The proportion of pens overstocked per farm over time shows a decrease from 2020 onwards, with a slight increase in 2023 compared to 2022 (Figure 8).

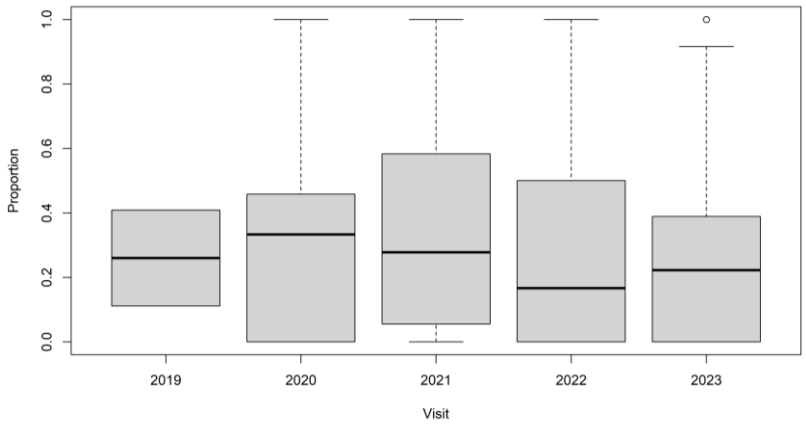

Figure 8 - Proportion of overstocking pens per farm.

The maximum value obtained from 2020 to 2022 meant that for those farms all pens were overstocked. From 2021 there has been an improvement in lowering the third interquartile values and keeping the interquartile range smaller.

Tail docking

During the assessment the PVP recorded if the animals in the pen were docked or not. As shown in the Figure 9, it is still the norm to dock the animals and that number overshadows the number of pens left undocked, so this variable was not included in any other analysis done since there was almost no variation.

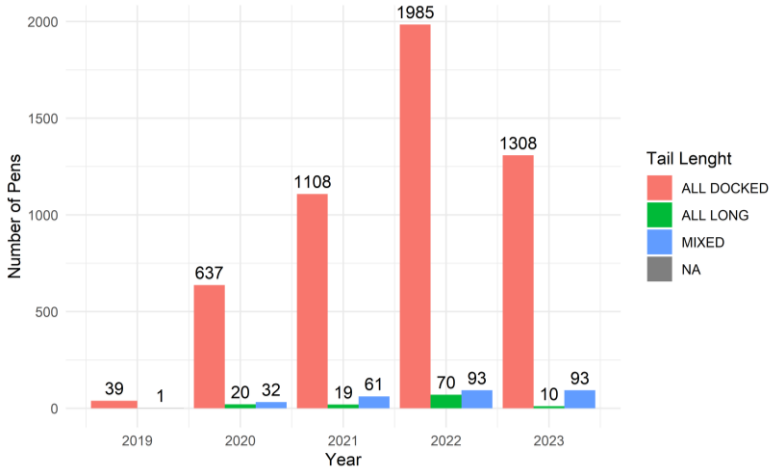

Figure 9 - Tail length over the years.

Environmental Enrichment materials

The most common items used were the marginal type ones, having at least one per pen each year. There was no evolution recorded (Figure 10 – right panel) for the provision of marginal enrichment. For suboptimal enrichment, the median score was of 0 per pen with the third interquartile being below 1 in all years (Figure 10 – central

panel). The maximum median score reached 2 in 2023. For optimal enrichment, the median score was also 0 items per pen (Figure 10 – left panel).

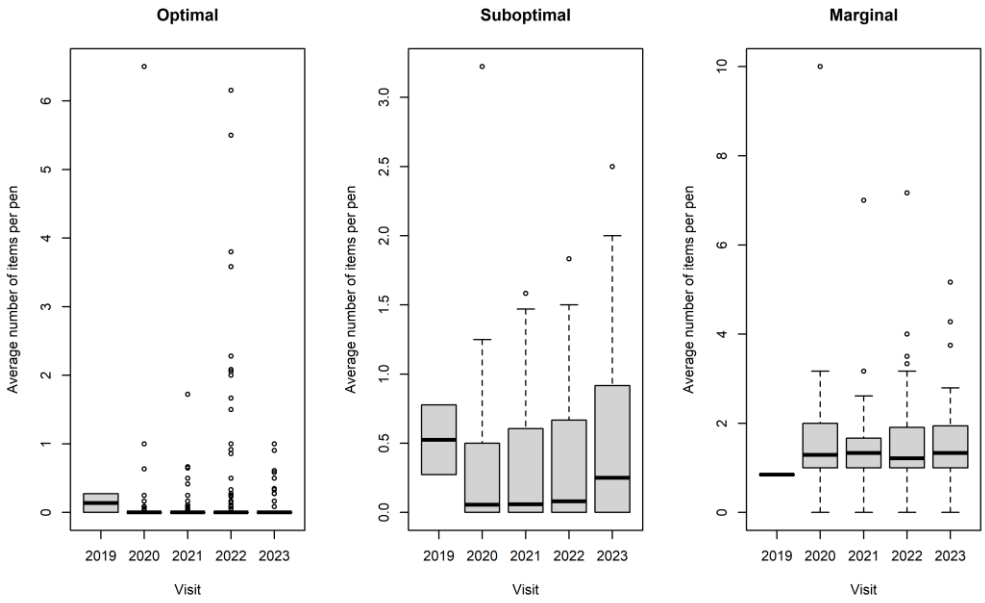

Figure 10 - Average number of environmental enrichment items per farm over the years categorised by type of enrichment.

*Lesions/*findings observed at farm level

- Tucked tails

Although the overall proportion of animals is small, from 2020 to 2021 the proportion of affected animals doubled. From then on some progress in reducing this behaviour has been made (Figure 11 – left graph).

-Injured Tails

Having 2019 with the highest proportion of affected animals, contrasting with the Tucked tails score where 2019 had the lowest proportion of all years. After the proportion decreased in 2020, there was a slow rise till 2022, decreasing again in 2023 having then the lowest proportion of all years (Figure 11 – right graph).

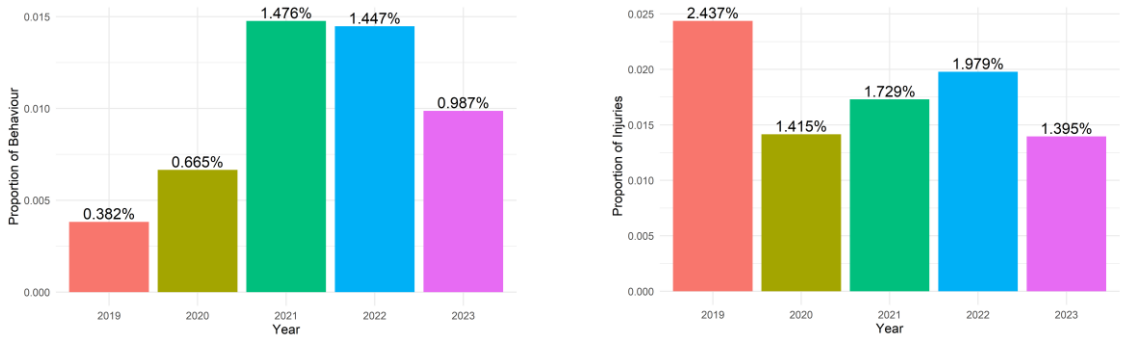

Figure 11 - Bar chart depicting the proportion of Tucked tail behaviour (left) and Injured Tails (right) over the year. The numbers on top of the bars show the percentage (%).

- Injured ears

Ear lesions are much more common than tail lesions in Irish farms, with 2022 being the year with the lower proportion of ear lesions recorded, but this number almost doubled in the next year (Figure 12 – left graph).

-Flank lesions

Flank lesions are described as the “circular” lesions observed on the pig's body resulting from another pig's bite. The results have not changed much during the years of the assessments (Figure 12 – right graph).

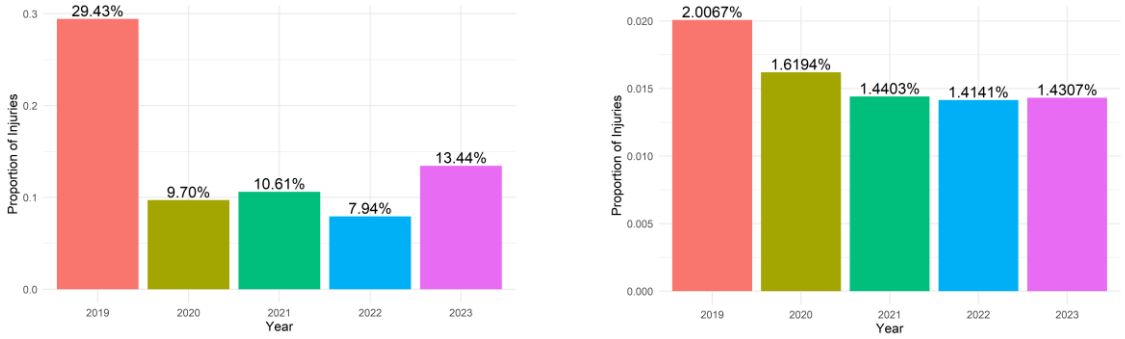

Figure 12 – Bar chart of Injured Ears (left) and Flank lesions (right) over the years. The numbers on top of the bars show the percentage (%).

-Aggression Lesions

Aggression lesions are described as the “straight” lesions observed on the pig's body as a result of a scratch mark. Similar to the ear lesion, it shows a similar distribution between the years, having the proportion of pigs affected almost doubling from 2022 to 2023, having now more than 10% of the total population affected (Figure 13 – left graph).

-Dirty Flanks/Haunches

Being used as a measure of health and quality of life in the pen, the year 2021 showed that over 10% of animals were in dirty conditions. That number is slowly decreasing since then (Figure 13 – right graph).

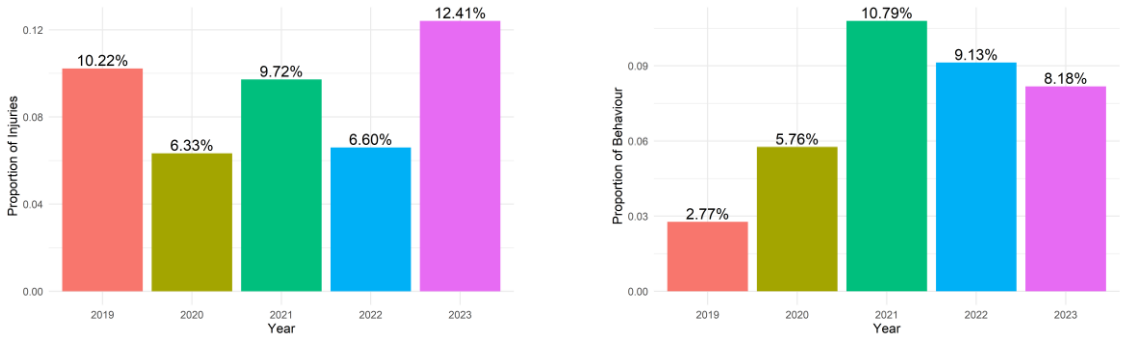

Figure 13 – Bar chart of Aggression lesions (left) and Dirty Flank (right) over the years. Numbers on top of the bars show the percentage (%).

Behaviour observations in a 5-minute period:

-Damaging Behaviour – Tail

While 2021 registered the highest score for this type of behaviour (Figure 14 – left panel), there was a slight improvement in the following year, but 2023 ended with the second-highest score in the five-year study

-Damaging Behaviour – Ear

Even though 2022 registered a positive evolutions, the results from 2023 demark the worst year, having doubled the scores from 2019 (Figure 14 – right panel). Ear lesions are the most common lesions found on the animals according to the results from the category above.

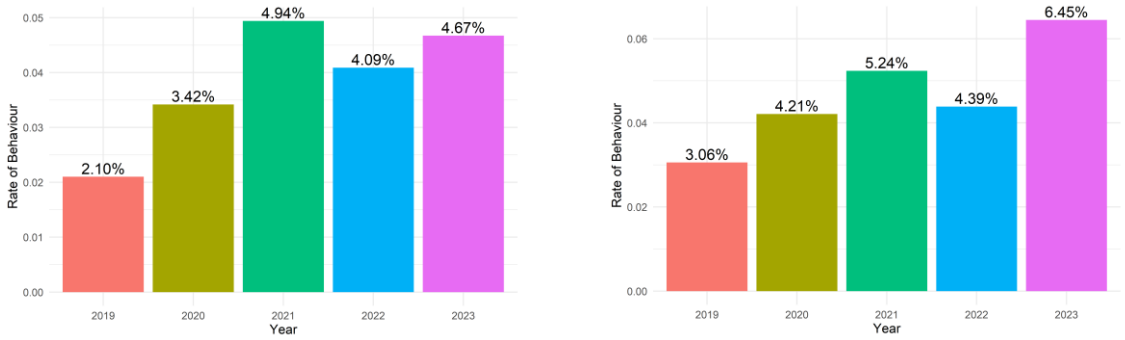

Figure 14 - Bar chart of the Damaging Behaviour in Tail (left) and in Ear (right) over the years.

-Damaging Behaviour – Other

Among the three damaging behaviour subcategories, this one had the highest score. In 2020 and 2021, it reached a rate over 7, but the results improved in the last two years (Figure 15 – left panel).

-Fixtures and Fittings

This welfare indicator had the highest rate among all those analysed. With 2021 (35.41) and 2023 (34.24) showing the highest values, this indicator provides extremely relevant information (Figure 15 – right panel).

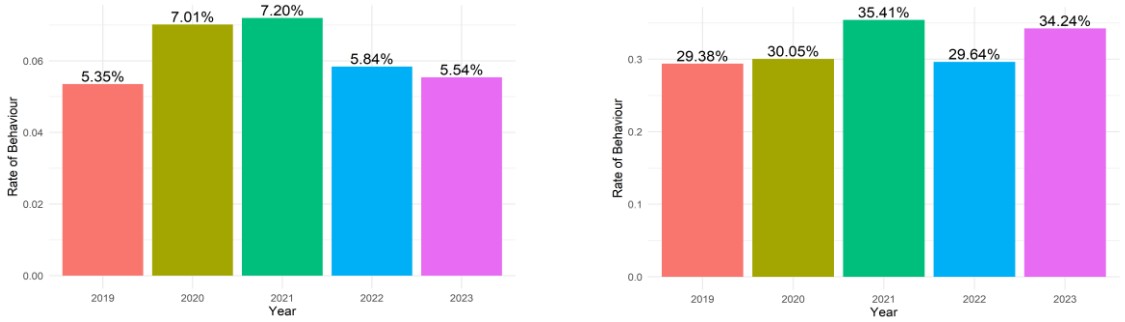

Figure 15 - Bar chart of the Damaging Behaviour in Others (left) and Fixtures and Fittings behaviours (right) over the years.

-Enrichment

Comparing the scores from 2019 to 2023 (Figure 16 – left panel), the score doubled. As shown in Figure 10 – middle panel, only the number of suboptimal enrichment materials has increased over the years

-Aggressive Biting

With the rate almost doubled from 2022 to 2023 (Figure 16 – right panel), some stress factors or some modifications to the pens might have led to this. The number of aggressive lesions recorded in 2023 also increased. The median value of overstocked pens also increased.

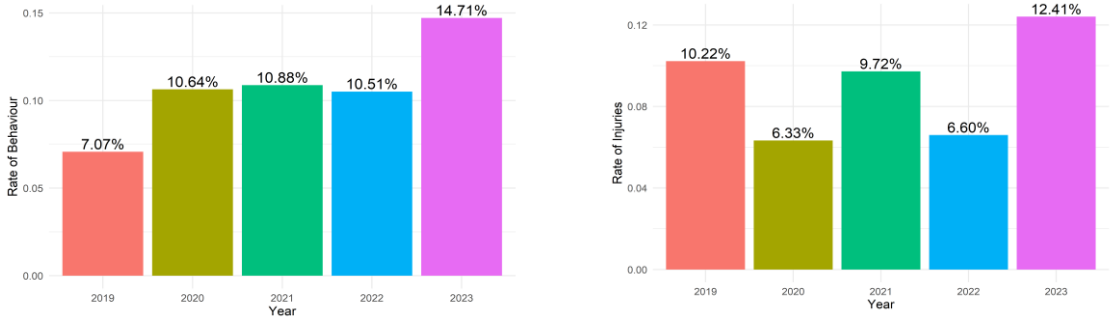

Figure 16 - Bar chart of the Enrichment (left) and Aggressive Bitting behaviours (right) over the years.

3.2 – Recommendations Data

The biosecurity and animal welfare recommendations were aggregated by categories to which they belong and tabulated to summarise them (Tables 5 and 6).

3.2.1 – Biosecurity Recommendations

Table 5 - Proportion of each biosecurity recommendation per biosecurity category per year. The proportion was calculated by year.

Category	2018	2019	2020	2021	2022	2023
E1 - Purchase	0	0.018	0.009	0.006	0.003	0.009
E2 - Dead animals	0.036	0.035	0.095	0.095	0.083	0.070
E2 – Transport of Animals	0.024	0.007	0.002	0.006	0.008	0.006
E3 – Equipment & Materials	0.202	0.149	0.192	0.198	0.123	0.110
E3 - Feed	0	0	0.002	0.016	0.016	0.025
E3 - Water	0.036	0.021	0.018	0.021	0.015	0.015
E4 - Staff	0.012	0.011	0.032	0.070	0.026	0.010
E4 - Visitors	0.107	0.167	0.128	0.081	0.068	0.091

Table 5 - Proportion of each biosecurity recommendation per biosecurity category per year. The proportion was calculated by year (cont.).

Category	2018	2019	2020	2021	2022	2023
E5 - Pests	0.071	0.074	0.065	0.060	0.077	0.083
I1 – Disease Management	0.250	0.135	0.113	0.068	0.143	0.207
I5 - Footbaths	0.071	0.074	0.077	0.083	0.090	0.083
I5 – Working Lines	0.024	0.007	0.020	0.017	0.019	0.035
I6 – Cleaning and Disinfection	0.143	0.220	0.146	0.165	0.141	0.117
OTHER	0.012	0.043	0.038	0.029	0.040	0.051

As we can see from Table 5, not every biosecurity subcategory received recommendations for improvement (e.g. no recommendations were provided for subcategories E6, I2, I3 and I4). In Appendix (Table S21 to S39) further details is provided related to the recommendations.

Some subcategories were further broken into subgroups for this analysis to provide further detail on what was recommended (e.g. subcategory E3 was further broken into subgroups if the recommendation was related to feed, water or equipment).

In terms of biosecurity subcategories, recommendations addressing I1 - Disease management were the most frequent. In 2018, it made up a quarter of all recommendations provided that year having that value decreased in the following years, reaching the lowest number in 2021. The most frequent recommendation in this subcategory was “monitor disease/mortality levels”.

The E3 - Feed, Water, and Equipment Supply biosecurity subcategory was divided into three recommendation subgroups. The most popular, “Equipment & Materials”, was the second most frequent overall, comprising a fifth of the total recommendations in 2018 and oscillating between 0.2 and 0.1 in subsequent years, with “Changing needles more often” being the most common recommendation. The “Feed” subgroup began in 2020, growing from 0.002 to 0.025 by 2023, with 'Clean feed spills and feed equipment' as the top recommendation. The “Water” subgroup saw a decrease in recommendations, with 2023 having half the number compared to 2018, and “Test water supply frequently” was the most common recommendation.

The E4 - Personnel and Visitors biosecurity subcategory was divided into two recommendation subgroups. The “Staff” subgroup had lower scores over the years, with a notable rise in 2021, doubling from the previous year and increasing sevenfold compared to 2023, with “Wash hands at entrance of farm” being the most frequent recommendation. The “Visitors” subgroup was the fourth most frequent, comprising a

tenth of the total recommendations, with “Use of farm-specific boots and overalls” and “Installation of hygiene lock at entrance of stables” being the most common recommendations.

For the E2 – Dead Animals subgroup the recommendation category “Carcasse storage outside farm perimeter” was the most common recommendation and for E5 - Vermin/bird control subgroup, “Bird-proofing the stables” was the most common recommendation.

The I5 - Measures Between Compartments and Use of Equipment biosecurity subcategory was divided into two recommendation subgroups. The “Footbaths” subgroup saw an increase in recommendations over the years, peaking in 2022, with “Installation of Footbaths” being the most common recommendation. The “Working Lines” subgroup had the lowest use in 2019, but its use increased, making 2023 the year with the highest frequency for this subgroup. The most frequent recommendation was “From healthy animals to diseased animals”.

The I6 - Cleaning and Disinfection Biosecurity subcategory was the third most frequent recommendation subcategory making up more than a fifth of the total recommendations of 2019. Since then, the number of recommendations provided in this subcategory has decreased. The most common recommendation in this subcategory was “Clean and disinfect between production batches”.

3.2.2 – Tail Biting

Table 6 - Proportion of each Welfare Recommendation category per year

By year	2019	2020	2021	2022	2023
Environmental Enrichment	0.442	0.446	0.530	0.519	0.454
Thermal Comfort	0.173	0.094	0.140	0.176	0.176
Animal Health	0.231	0.159	0.198	0.186	0.216
Competition Issues	-	0.044	0.039	0.028	0.023
Feeding Process	0.096	0.097	0.042	0.031	0.069
Pen Design	0.038	0.053	0.035	0.033	0.046
OTHER	0.019	0.033	0.016	0.019	0.011

Most of the recommendations provided by PVPs fall into the Environmental Enrichment category (represents almost half of the recommendations given each year). These were mostly recommendations about the quantity and quality of environmental enrichment materials to be provided.

In second place, in relation to the category of recommendations provided, was the Animal Health category. For this category, the recommendation "reduce stocking rates" was the most frequent.

The Thermal Comfort category was the third most frequent with variations over the years. For this category, the recommendation "improve ventilation" was the most frequent.

The other categories of recommendations were less frequently provided. The recommendation "add extra drinkers in the pen" was the most frequent recommendation for the category Competition Issue; while "review diet formulation" and "review feeding settings" were the most frequent recommendations for the category Feeding Process. For the category Pen Desing, the most frequent recommendation was "check water flow rates frequently".

3.2.3 – Recommendations versus Risks

3.2.3.1 – Biosecurity

This section aims to identify patterns in how an identified farm risk within a biosecurity subcategory triggers a recommendation from the assessing PVP.

Table 7 - Recommendation Versus Risk for the Biosecurity Assessment. Percentage is calculated within each subcategory and year.

Subcategory	Category	2018	2019	2020	2021	2022	2021
E1 - Purchase of animals and semen	Rec and Risk	NA	NA	NA	NA	NA	1 (0.38%)
	Rec and no Risk	NA	4 (4.35%)	3 (2.05%)	3 (1.79%)	3 (1.05%)	6 (2.26%)
	No Rec and Risk	NA	NA	1 (0.68%)	NA	4 (1.39%)	NA
	No Rec and no Risk	28 (100%)	88 (95.65%)	142 (97.26%)	165 (98.21%)	280 (97.56%)	258 (97.36%)
E2 - Transport of animals, removal of manure/dead animals	Rec and Risk	1 (3.57%)	3 (3.26%)	1 (0.68%)	NA	NA	NA
	Rec and no Risk	4 (14.29%)	9 (9.78%)	38 (26.03%)	46 (27.38%)	75 (26.13%)	56 (21.13%)
	No Rec and Risk	NA	3 (3.26%)	NA	1 (0.6%)	1 (0.35%)	NA
	No Rec and no Risk	23 (82.14%)	77 (83.7%)	107 (73.29%)	121 (72.02%)	211 (73.52%)	209 (78.87%)

Table 7 - Recommendation Versus Risk for the Biosecurity Assessment. Percentage is calculated within each subcategory and year (cont.)

Subcategory	Category	2018	2019	2020	2021	2022	2023
E3 - Feed, water and equipment supply	Rec and Risk	10 (35.71%)	32 (34.78%)	45 (30.82%)	52 (30.95%)	55 (19.16%)	39 (14.72%)
	Rec and no Risk	5 (17.86%)	8 (8.7%)	23 (15.75%)	43 (25.6%)	70 (24.39%)	59 (22.26%)
	No Rec and Risk	9 (32.14%)	41 (44.57%)	47 (32.19%)	38 (22.62%)	72 (25.09%)	71 (26.79%)
	No Rec and no Risk	3 (10.71%)	8 (8.7%)	27 (18.49%)	29 (17.26%)	88 (30.66%)	92 (34.72%)
E4 - Personnel and visitors	Rec and Risk	1 (3.57%)	10 (10.87%)	11 (7.53%)	13 (7.74%)	8 (2.79%)	8 (3.02%)
	Rec and no Risk	8 (28.57%)	15 (16.3%)	23 (15.75%)	29 (17.26%)	56 (19.51%)	52 (19.62%)
	No Rec and Risk	5 (17.86%)	11 (11.96%)	13 (8.9%)	7 (4.17%)	33 (11.5%)	16 (6.04%)
	No Rec and no Risk	14 (50%)	56 (60.87%)	99 (67.81%)	119 (70.83%)	190 (66.2%)	189 (71.32%)
E5 - Vermin/bird control	Rec and Risk	1 (3.57%)	10 (10.87%)	3 (2.05%)	4 (2.38%)	10 (3.48%)	12 (4.53%)
	Rec and no Risk	4 (14.29%)	10 (10.87%)	24 (16.44%)	24 (14.29%)	53 (18.47%)	48 (18.11%)
	No Rec and Risk	2 (7.14%)	12 (13.04%)	11 (7.53%)	12 (7.14%)	9 (3.14%)	9 (3.4%)
	No Rec and no Risk	21 (75%)	60 (65.22%)	108 (73.97%)	128 (76.19%)	215 (74.91%)	196 (73.96%)
I1 - Disease management	Rec and Risk	7 (25%)	10 (10.87%)	6 (4.11%)	1 (0.6%)	2 (0.7%)	15 (5.66%)
	Rec and no Risk	7 (25%)	21 (22.83%)	26 (17.81%)	26 (15.48%)	71 (24.74%)	83 (31.32%)
	No Rec and Risk	2 (7.14%)	14 (15.22%)	15 (10.27%)	53 (31.55%)	23 (8.01%)	14 (5.28%)
	No Rec and no Risk	12 (42.86%)	47 (51.09%)	99 (67.81%)	68 (40.48%)	191 (66.55%)	153 (57.74%)
I5 - Measures between compartments, and the use of equipment	Rec and Risk	5 (17.86%)	18 (19.57%)	14 (9.59%)	21 (12.5%)	34 (11.85%)	34 (12.83%)
	Rec and no Risk	3 (10.71%)	5 (5.43%)	26 (17.81%)	26 (15.48%)	55 (19.16%)	54 (20.38%)
	No Rec and Risk	19 (67.86%)	41 (44.57%)	46 (31.51%)	53 (31.55%)	65 (22.65%)	53 (20%)
	No Rec and no Risk	1 (3.57%)	28 (30.43%)	60 (41.1%)	68 (40.48%)	133 (46.34%)	124 (46.79%)
I6 - Cleaning and disinfection	Rec and Risk	8 (28.57%)	29 (31.52%)	23 (15.75%)	26 (15.48%)	50 (17.42%)	36 (13.58%)
	Rec and no Risk	2 (7.14%)	16 (17.39%)	28 (19.18%)	34 (20.24%)	60 (20.91%)	46 (17.36%)
	No Rec and	10 (35.71%)	26 (28.26%)	31 (21.23%)	52 (30.95%)	58 (20.21%)	49 (18.49%)

	Risk						
	No Rec and no Risk	8 (28.57%)	21 (22.83%)	64 (43.84%)	56 (33.33%)	119 (41.46%)	134 (50.57%)

For the biosecurity assessment risk was determined when the farm score was under 50 (out of 100). Since this cut-off for determining risk can be considered a low cut-off we should focus on cases where no recommendations were provided but the farm was at risk.

For the E3 - Feed, Water, and Equipment Supply subcategory, the “No Rec and Risk” category had the highest score for the first three years of the study, and from 2021 onwards, it became the second-highest category.

For the E4 - Personnel and Visitors subcategory, the “No Rec and Risk” category was the third highest throughout the years of the study, with the highest result being approximately 18% in 2019 and the lowest at 4% in 2021.

For the I5 - Measures Between Compartments and Use of Equipment subcategory, the “No Rec and Risk” category had the highest score in 2019 with approximately 68%. In the following years, the scores for this category decreased, reaching 20% in 2023.

For the I6 - Cleaning and Disinfection subcategory, the “No Rec and Risk” category was the highest-scoring category in 2019 at approximately 36%. From 2020 onwards, it became the second-highest category.

Table 8 - Recommendations versus Risks over the years for Biosecurity

Total by Year	Rec and Risk	Rec and no Risk	No Rec and Risk	No Rec and no Risk	Total
2018	33 (14.73%)	33 (14.73%)	47 (20.98%)	110 (49.11%)	224
2019	112 (15.22%)	88 (11.96%)	148 (20.11%)	385 (52.31%)	736
2020	103 (8.82%)	191 (16.35%)	164 (14.04%)	706 (60.45%)	1,168
2021	117 (8.7%)	231 (17.19%)	182 (13.54%)	808 (60.12%)	1,344
2022	159 (6.93%)	443 (19.29%)	265 (11.54%)	1427 (62.15%)	2,296
2023	145 (6.84%)	404 (19.06%)	212 (10%)	1355 (63.92%)	2,120

Throughout the years, the “No Rec and Risk” category has been decreasing in scores, from approximately 21% in 2018 to 10% in 2023, representing a decline of more than half, Table 8.

3.2.3.2 – Tail Biting

As in section 3.2.3.1, the same approach was used for the Welfare database. The objective remains to determine if the Welfare data follows the same pattern of recommendations following a risk from the assessing PVP as observed in the Biosecurity database.

Looking at the group “No Rec and Risk” (risks present but no recommendations provided), and not considering the year 2019 (as only 4 farms were assessed that year), for all welfare categories in general there was increase in the proportion of this group from 2020 to 2022 and a decrease afterwards (except for the “Environmental Enrichment” category).

Table 9 - Recommendation Versus Risk for the Welfare Assessment. Percentage is calculated within each subcategory and year.

Subcategory	Category	2019	2020	2021	2022	2023
Environmental Enrichment	Rec and Risk	20 (83.33%)	392 (42.79%)	877 (76.93%)	1221 (73.73%)	1030 (65.44%)
	Rec and no Risk	2 (8.33%)	166 (18.12%)	65 (5.7%)	74 (4.47%)	100 (6.35%)
	No Rec and Risk	2 (8.33%)	6 (0.66%)	105 (9.21%)	281 (16.97%)	370 (23.51%)
	No Rec and no Risk	NA	352 (38.43%)	93 (8.16%)	80 (4.83%)	74 (4.7%)
Thermal Comfort	Rec and Risk	1 (4.17%)	40 (4.37%)	84 (7.37%)	224 (13.53%)	249 (15.82%)
	Rec and no Risk	6 (25%)	83 (9.06%)	175 (15.35%)	232 (14.01%)	205 (13.02%)
	No Rec and Risk	3 (12.5%)	8 (0.87%)	21 (1.84%)	439 (26.51%)	373 (23.7%)
	No Rec and no Risk	14 (58.33%)	785 (85.7%)	860 (75.44%)	761 (45.95%)	747 (47.46%)
Animal Health	Rec and Risk	5 (20.83%)	69 (7.53%)	119 (10.44%)	310 (18.72%)	331 (21.03%)
	Rec and no Risk	5 (20.83%)	120 (13.1%)	216 (18.95%)	135 (8.15%)	176 (11.18%)
	No Rec and Risk	4 (16.67%)	24 (2.62%)	43 (3.77%)	466 (28.14%)	267 (16.96%)
	No Rec and no Risk	10 (41.67%)	703 (76.75%)	762 (66.84%)	745 (44.99%)	800 (50.83%)
Competition Issues	Rec and Risk	0	13 (1.42%)	15 (1.32%)	56 (3.38%)	57 (3.62%)
	Rec and no Risk	0	54 (5.9%)	44 (3.86%)	18 (1.09%)	20 (1.27%)
	No Rec and Risk	0	39 (4.26%)	93 (8.16%)	605 (36.53%)	453 (28.78%)
	No Rec and no Risk	0	810 (88.43%)	988 (86.67%)	977 (59%)	1043 (66.26%)

Table 9 - Recommendation Versus Risk for the Welfare Assessment. Percentage is calculated within each subcategory and year (cont.).

Subcategory	Category	2019	2020	2021	2022	2023
Feeding Process	Rec and Risk	1 (4.17%)	30 (3.28%)	32 (2.81%)	23 (1.39%)	69 (4.38%)
	Rec and no Risk	4 (16.67%)	101 (11.03%)	47 (4.12%)	63 (3.8%)	102 (6.48%)
	No Rec and Risk	2 (8.33%)	44 (4.8%)	85 (7.46%)	661 (39.92%)	428 (27.19%)
	No Rec and no Risk	17 (70.83%)	741 (80.9%)	976 (85.61%)	909 (54.89%)	975 (61.94%)
Pen Design	Rec and Risk	2 (8.33%)	7 (0.76%)	9 (0.79%)	41 (2.48%)	62 (3.94%)
	Rec and no Risk	NA	64 (6.99%)	53 (4.65%)	52 (3.14%)	69 (4.38%)
	No Rec and Risk	4 (16.67%)	15 (1.64%)	32 (2.81%)	639 (38.59%)	491 (31.19%)
	No Rec and no Risk	18 (75%)	830 (90.61%)	1046 (91.75%)	924 (55.8%)	952 (60.48%)

Comparing the total results from the “No Rec and Risk” category over the years, a trend emerges that was also identified in some of the individual analyses presented in Table 9. In 2020 and 2021, there was a significant decline in this category, dropping from 12.5% in 2019 to 2.5% in 2020. Subsequently, in 2020, this percentage increased from approximately 6% to over 30%, elevating the category from the fourth-highest in score to the second-highest in both 2022 and 2023.

Table 10 - Recommendations versus Risks over the years for Welfare

Total by Year	Rec and Risk	Rec and no Risk	No Rec and Risk	No Rec and no Risk	Total
2019	29 (24.17%)	17 (14.17%)	15 (12.5%)	59 (49.17%)	120
2020	551 (10.03%)	588 (10.70%)	136 (2.47%)	4221 (76.80%)	5,496
2021	1136 (16.61%)	600 (8.77%)	379 (5.54%)	4725 (69.08%)	6,840
2022	1875 (18.87%)	574 (5.78%)	3091 (31.11%)	4396 (44.24%)	9,936
2023	1798 (19.04%)	672 (7.12%)	2382 (25.22%)	4591 (48.61%)	9,444

3.3 – Risk Factors Analysis

Table 11 shows the number of farms used for the risk factor analysis models. This dataset (match of the biosecurity and welfare risk assessments) was smaller than the ones from each database since not all farms have done both assessments every year. The result of this 4-year analysis was that 366 farms out of the 393 total farms were used in the risk factor analysis models and this corresponded to 783

assessments out of the 935 from the welfare and the 1014 from the biosecurity assessments.

Table 11 - Number of farms assessed per year per dataset.

Number of Farms	2020	2021	2022	2023
Risk Factors Models	141	160	245	237
Biosecurity	148	173	303	268
Welfare	160	203	299	268

3.3.1 – Linear Mixed Models

For the linear mixed models (LMM) models, fifteen simulations were made, twelve for each biosecurity subcategory (E1-E6 and I1-I6) (Tables 12 and 13) and another 3 for the Overall, External and Internal categories (Table 14).

Table 12 - Results of the final multivariable LMM for the external biosecurity subcategories.

Variables	Categories	Model E1		Model E2		Model E3		Model E4		Model E5		Model E6	
		Est. (SE)	P value	Est. (SE)	P value	Est. (SE)	P value	Est. (SE)	P value	Est. (SE)	P value	Est. (SE)	P value
Intercept		97.20 (1.10)	>0.0001	82.64 (1.10)	>0.0001	50.76 (3.73)	>0.0001	73.45 (3.14)	>0.0001	85.02 (2.13)	>0.0001	92.08 (1.33)	>0.0001
Environmental enrichment	No risks			ref	-	ref	-	ref	-	ref	-		
	Risks			-2.53 (1.14)	0.0268	-3.41 (1.71)	0.0470	-4.75 (1.91)	0.0131	-9.30 (2.07)	>0.0001		
Animal Health	No risks	ref	-										
	Risks	3.60 (0.96)	>0.0001										
Competition Issues	No risks	ref	-										
	Risks	-4.66 (1.09)	>0.0001										
Feeding processes	No risks									ref	-		
	Risks									-3.52 (1.53)	0.0230		
Year of assessment	2020			ref	-	ref	-	ref	-	ref	-	ref	-
	2021			2.49 (1.14)	0.0295	3.85 (1.66)	0.0197	7.01 (1.81)	>0.0001	8.25 (2.05)	>0.0001	0.16 (0.87)	0.8589
	2022			5.24 (1.14)	>0.0001	8.88 (1.70)	>0.0001	9.75 (1.88)	>0.0001	8.07 (2.05)	>0.0001	2.04 (0.87)	0.0197
	2023			4.55 (1.13)	>0.0001	8.25 (1.70)	>0.0001	8.11 (1.88)	>0.0001	8.60 (2.03)	>0.0001	1.99 (0.85)	0.0203
Type of Farm	Farrow-to-finish	ref	-					ref	-				
	Fattening	-2.78 (0.89)	0.0020					-6.84 (1.61)	>0.0001				
Random effects		Variance	SD	Variance	SD.	Variance	SD	Variance	SD	Variance	SD.	Variance	SD
Herd		31.68	5.63	35.83	5.99	72.48	8.51	166.20	12.89	204.33	14.29	155.49	12.47

Assessor	5.23	2.29	3.85	1.96	173.03	13.15	95.06	9.75	12.55	3.54	9.20	3.03

Legend: Model E1 – Purchase of animals and semen, Model E2 - Transport of animals, removal of manure/dead animals, Model E3 - Feed, water and equipment supply, Model E4 - Personnel and visitors, Model E5 - Vermin/bird control, Model E6 - Environment and region.

- E1 - Purchase of animals and semen

The only statistically significant welfare subcategories were Animal health and Competition Issues. For the first one, the positive value of the estimate indicates that when there are animal health risks present on the farm, it is accompanied by higher E1 biosecurity scores. For Competition Issues, the negative value of the estimate indicates that when there are risks for competition between the pigs in a farm it is expected for the E1 scores to decrease. Fattening farms compared to Farrow-to-finish farms have a lower score for E1.

-E2 - Transport of animals, removal of manure/dead animals

The only statistically significant welfare subcategory was Environmental Enrichment. The negative value of the estimate indicates that when enrichment is neglected and constitutes a risk for the pigs, it is expected for the E2 score to decrease. Comparing 2021 till 2023 to 2020, the most recent years have a higher score for E2.

-E3 - Feed, water and equipment supply

Similar to what happened in E2, the only statistically significant welfare subcategory was Environmental Enrichment. The estimate negative value suggests that when enrichment poses a risk for the pigs, it is expected a decrease in the E3 score. Looking at the evolution throughout the years, from 2021 onwards compared to 2020, the most recent years have a higher score for E3.

-E4 - Personnel and visitors

For this biosecurity subcategory, the statistically significant welfare subcategory was also Environmental Enrichment. The negative estimate indicates that when an EE risk is present for the pigs, the E4 score should decrease. The evolution of this variable over the years also shows that compared to 2020, the following years registered an increase in the E4 score. Fattening farms compared to Farrow-to-finish farms have a lower score for E4.

-E5- Vermin/bird control

The only statistically significant welfare subcategories were Environmental Enrichment and Feeding Process. Both of them are associated with a negative estimate which means if there is an Environmental Enrichment risk present for the pigs it is expected for the E5 score to decrease and if there is a Feeding Process risk present for the pigs it is also expected for the E5 score to decrease. Comparing 2021 till 2023 to 2020, the most recent years have higher scores for E5.

-E6 - Environment and region

For this biosecurity subcategory, no welfare subcategories were statistically significant. Compared to 2020, the years 2022 and 2023 have higher scores for E6.

Table 13 - Results of the final multivariable LMMs for the internal biosecurity subcategories

Variables	Categories	Model I1		Model I2		Model I3		Model I4		Model I5		Model I6	
		Est. (SE)	P value	Est. (SE)	P value	Est. (SE)	P value	Est. (SE)	P value	Est. (SE)	P value	Est. (SE)	P value
Intercept		74.26 (4.31)	>0.0001	63.02 (2.84)	>0.0001	60.68 (2.73)	>0.0001	76.44 (3.40)	>0.0001	50.47 (3.90)	>0.0001	66.90 (5.43)	>0.0001
Environmental enrichment	No risks			ref	-								
	Risks			-9.21 (2.86)	0.0014								
Thermal comfort	No risks					ref	-						
	Risks					-3.31 (1.62)	0.0424						
Competition Issues	No risks							ref	-				
	Risks							4.77 (2.25)	0.0337				
Feeding processes	No risks					ref	-						
	Risks					4.01 (1.86)	0.0319						
Dirty Flanks	No							ref	-			ref	-
	Yes							-5.98 (2.64)	0.0241			-11.49 (3.62)	0.0016
Year of assessment	2020	ref	-	ref	-	ref	-			ref	-		
	2021	5.65 (2.11)	0.0078	7.20 (2.97)	0.0159	2.83 (1.83)	0.1240			-0.91 (1.61)	0.5731		
	2022	5.14 (2.09)	0.0143	10.22 (3.00)	>0.001	8.38 (1.76)	>0.001			3.14 (1.60)	0.0502		
	2023	4.79 (2.06)	0.0207	7.17 (2.99)	0.0171	5.86 (1.77)	0.0011			3.59 (1.57)	0.0231		
Type of Farm	Farrow-to-finish							ref	-	ref	-	ref	-

	Fattening							7.18 (1.81)	>0.001	12.67 (1.61)	>0.001	5.40 (2.47)	0.0293
Random effects		Variance	SD	Variance	SD	Variance	SD	Variance	SD.	Variance	SD	Variance	SD
Herd		215.80	14.69	124.53	11.16	70.43	8.39	120.90	10.99	145.10	12.04	328.7	18.13
Assessor		199.20	14.11	33.05	5.75	45.86	6.77	103.30	10.16	174.60	13.21	252.6	15.89

Legend: Model I1 – Disease management, Model I2 - Farrowing and suckling period, Model I3 - Nursery unit management, Model I4 - Fattening unit management, Model I5 - Measures between compartments, and the use of equipment, Model I6 - Cleaning and disinfection.

-I1 - Disease management

For this biosecurity subcategory, no welfare subcategories were statistically significant. Compared to 2020, the following years (2021-2023) have higher scores for the biosecurity subcategory.

-I2 - Farrowing and suckling period

Environmental Enrichment was statistically significant, with a negative estimate indicating that risk from this welfare subcategory on the farm, is accompanied by a decrease in the I2 score. Analysing the evolution through the years, from 2021 the I2 score is higher compared to 2020.

-I3 - Nursery unit management

The only statistically significant welfare subcategories were Thermal Comfort and Feeding Process. For the first one, a negative value for the estimate indicates that when there is a Thermal Comfort risk present for the pigs at the farm, it is expected for the I3 score to decrease. For the Feeding Process, the positive estimate indicates that when a risk is present at the farm, the I3 score is expected to rise. Comparing 2022 and 2023 to 2020, the most recent years have higher scores for I3.

-I4 - Fattening unit management

Competition Issues was the only statistically significant welfare subcategory. With a positive estimate, indicates that with a risk of competition between the pigs present at the farm, the I4 score is expected to increase. Fattening farms compared to Farrow-to-finish farms have a higher I4 score. Farms having pigs with Dirty Flanks compared to farms with clean pigs have lower I4 scores.

-I5 - Measures between compartments, and the use of equipment

For this biosecurity subcategory, no welfare subcategory was statistically significant. Comparing 2023 to 2020, the most recent year has higher I5 results. Fattening farms have higher I5 scores compared to Farrow-to-finish ones.

-I6 - Cleaning and disinfection

For this biosecurity subcategory, no welfare subcategory was statistically significant. Compared to Farrow-to-finish farms, fattening farms have higher I6 scores. Farms having pigs with Dirty Flanks compared to farms having clean pigs have lower I6 scores.

- Overall

There was no welfare subcategory statistically significant for the overall biosecurity score. Compared to 2020, the years 2022 and 2023 have higher overall biosecurity scores. Fattening farms also have higher scores compared to Farrow-to-finish farms.

- Internal

For the Internal biosecurity score, no welfare subcategory was statistically significant. Compared to 2020, 2022 had a higher internal biosecurity score. Fattening farms compared to Farrow-to-finish ones had higher internal biosecurity scores. Farms, where animals with Dirty Flanks were present compared to the ones with clean animals, had lower internal biosecurity scores.

-External

No welfare subcategory was statistically significant to the external biosecurity score. Compared to 2020, the following years showed an increase in the external biosecurity score. Fattening farms compared to Farrow-to-finish farms had lower external biosecurity scores.

Table 14 - Results of the final multivariable LMMs for the external, internal, and overall biosecurity.

Variables	Categories	Model External		Model Internal		Model Overall	
		Est. (SE)	P value	Est. (SE)	P value	Est. (SE)	P value
Intercept		79.99 (1.14)	>0.0001	63.52 (3.47)	>0.0001	70.69 (2.03)	>0.0001
Dirty Flanks	No			ref	-		
	Yes			-3.89 (1.97)	0.0490		
Year of assessment	2020	ref	-	ref	-	ref	-
	2021	1.34 (0.60)	0.0267	1.41 (1.26)	0.2655	1.34 (0.76)	0.0780
	2022	3.18 (0.60)	>0.0001	2.48 (1.26)	0.0493 *	2.70 (0.76)	0.0004
	2023	2.94 (0.59)	>0.0001	1.97 (1.24)	0.1135	2.36 (0.75)	0.0017
Type of Farm	Farrow-to-finish	ref	-	ref	-	ref	-
	Fattening	-2.40 (0.65)	0.0002	7.72 (1.34)	>0.0001	2.74 (0.87)	0.0018
Random effects		Variance	SD	Variance	SD	Variance	SD
Herd		25.66	5.07	107.3	10.36	50.33	7.09
Assessor		11.66	3.42	112.0	10.59	47.65	6.90

Legend: Est – estimate, SE – standard error, SD – standard deviation.

3.3.2 – Generalised Linear Mixed Models

For the generalised linear mixed models (GLMM) models, eighteen different simulations were made (Tables 15 to 20), divided into three models per welfare category: Model 1 which included the overall biosecurity score, Model 2 which included the external and internal biosecurity scores, and Model 3 which included all the 12 biosecurity subcategories scores.

Table 15 - Results of the final multivariable GLMM for the Environmental Enrichment Welfare category.

EE		Model 1 - Overall			Model 2 – External & Internal			Model 3 – Biosecurity Subcategories (E1 to I6)		
Variable	Categories	Est	OR (95%CI)	P value	Est	OR (95%CI)	P value	Est	OR (95%CI)	P value
Overall biosecurity		-1.41	0.24 [0.12;0.48]	<0.0001						
External biosecurity					-3.34	0.04 [0.01;0.10]	<0.0001			
Internal biosecurity					1.00	2.73 [1.14; 6.51]	0.0237			
Feed, water and equipment supply								-1.77	0.17 [0.02;0.40]	<0.0001
Vermin and bird control								-2.98	0.05 [0.02;0.14]	<0.0001
Farrowing and suckling period								-1.57	0.21 [0.07; 0.56]	0.0020
Fattening unit								1.34	3.83 [1.10; 13.38]	0.0355
% of slatted floor	76-100%				ref	-	-	ref	-	-
	51-75%				-0.52	0.59 [0.03;10.46]	0.7223	-0.19	0.83 [0.02;36.38]	0.9213
	26-50%				1.52	4.56 [0.16;128.78]	0.3731	0.34	1.41 [0.02; 67.81]	0.8621
	1-25%				0.90	2.46 [0.17;34.60]	0.5056	4.85	1.28 [0.01; 0.06]	0.3036
	0%				-9.88	<0.0001 [8.05e-07; 3.25e-03]	<0.0001	-10.67	<0.0001 [9.13e-09;0.0590]	0.0077
Year	2020	ref	-	-	ref	-	-	ref	-	-
	2021	9.21	>1000 [2531.50; 3,9847.23]	<0.0001	11.63	>1000 [1.77e+04; 7.11e+05]	<0.0001	13.26	>1000 [2.49e+04; 1.32e+07]	<0.0001
	2022	10.55	>1000 [7359.78; 1.98e+05]	<0.0001	13.40	>1000 [7.19e+04; 6.02e+06]	<0.0001	16.79	>1000 [5.05e+05; 7.62e+08]	<0.0001
	2023	10.29	>1000 [5663.55; 1.53e+05]	<0.0001	14.20	>1000 [1.20e+05; 1.79e+07]	<0.0001	18.75	>1000 [1.85e+06; 1.04e+10]	<0.0001
Damaging behaviours	No	ref	-	-	ref	-	-	ref	-	-
	Yes	-0.89	0.41 [0.22;0.78]	0.0067	-1.02	0.36 [0.18;0.74]	0.0050	-0.99	0.37 [0.15; 0.92]	0.0322
Number of optimal enrichment items		-0.85	0.43 [0.29;0.62]	<0.0001	-0.94	0.39 [0.26;0.60]	<0.0001	-0.78	0.46 [0.27; 0.77]	0.0039
Type of Farm	Farrow-to-finish	ref	-	-	ref	-	-	ref	-	-

	Fattening	1.68	5.37 [1.28; 22.60]	0.0219						
Random effects			Variance	SD		Variance	SD		Variance	SD
Herd			21.44	4.63		46.30	6.80		39.08	6.25
Assessor			26.12	5.11		57.29	7.57		110.10	10.49

Legend: Est – estimate, OR – odds ratio, 95% CI – 95% Confidence interval, SD – standard deviation.

-Environmental Enrichment

The biosecurity subcategories statistically significant were E3 - Feed, water and equipment supply, E5 - Vermin/bird control, I2 - Farrowing and suckling period, and I4 - Fattening unit management (Table 15). For Overall, External, E3, E5, and I2 by increasing the biosecurity score for this subcategory, the odds of the risk in terms of Environmental Enrichment decreases. For Internal and I4 by increasing the biosecurity score for this subcategory the odds of risk for Environmental Enrichment increased.

For model 2 and 3, farms with no slatted floor have decreased odds of risk for environmental enrichment compared to farms with 76-100% slatted floors. For model 1, Fattening farms have an increased odds of having environmental enrichment risks compared to birth-to-bacon farms.

For all models, farms with Damaging behaviour have decreased odds of having environmental enrichment risk compared to farms without this behaviour; an increasing the number of optimal enrichment items in a farm reduces the risk for environmental enrichment; and the years 2021 to 2023, compared to 2020, have increased odds of risk for this welfare category.

- Thermal Comfort

The biosecurity subcategories that have proven to be statistically significant are E3 - Feed, water and equipment supply and E6 – Environment and Region (Table 16). For E3, the odds of the risk in terms of Thermal Comfort decreased with the increase in the score. For E6, by increasing the biosecurity score for this subcategory the odds of risk for Thermal Comfort also increased.

For model 1, compared to 2020, 2021 to 2023 have an increased odds of risk to Thermal Comfort. For models 2 and 3, compared to 2020, 2022 and 2023 have an increased odds of risk for this welfare category.

- Animal Health

The biosecurity subcategories that proved statistically significant were External, E1 - Purchase of animals and semen and E5 - Vermin/bird control (Table 17). For External, E1, and E5 by increasing the biosecurity score for this subcategory the odds of risk for Animal Health also increased.

For all models, farms with slatted floors 26-50% had an increased odds of risk for Animal Health compared to farms with 76-100% slatted floors. While farms with slatted floors 51-75% had decreased odds of risk. Farms with records of injured pigs have an increased odds of risk for animal health compared to farms with no injuries recorded. The years 2022 and 2023, compared to 2020, had increased odds of risk for Animal Health.

Table 16 - Results of the final multivariable GLMM for the Thermal Comfort Welfare category.

TC		Model 1 - Overall			Model 2 – External & Internal			Model 3 – Biosecurity Subcategories (E1 to I6)		
Variables	Categories	Est	OR (95%CI)	P value	Est	OR (95%CI)	P value	Est	OR (95%CI)	P value
External biosecurity					-0.34	0.71 [0.58; 0.87]	0.0010			
Feed, water and equipment supply								-0.48	0.62 [0.49; 0.77]	<0.0001
Environment and region								0.30	1.35 [1.04; 1.75]	0.0293
Year	2020	ref	-	-	ref	-	-	ref	-	-
	2021	1.10	2.30 [1.55; 5.79]	0.0011	0.52	1.69 [0.80; 3.57]	0.1699	0.45	1.57 [0.76; 3.23]	0.2260
	2022	3.48	32.45 [17.56; 59.98]	<0.0001	2.17	8.76 [4.37; 17.53]	<0.0001	2.04	7.65 [3.94;14.86]	<0.0001
	2023	3.42	30.52 [16.35; 56.96]	<0.0001	2.26	9.54 [4.70; 19.38]	<0.0001	2.09	8.12 [4.13; 15.98]	<0.0001
Random effects			Variance	SD		Variance	SD		Variance	SD
Herd			2.25	1.499		2.75	1.659		2.96	1.721
Assessor			10.64	3.262		14.58	3.818		15.25	3.906

Legend: Est – estimate, OR – odds ratio, 95% CI – 95% Confidence interval, SD – standard deviation.

Table 17 - Results of the final multivariable GLMM for the Animal Health Welfare category

AH		Model 1 - Overall			Model 2 – External & Internal			Model 3 – Biosecurity Subcategories (E1 to I6)		
Variables	Categories	Est	OR (95%CI)	P value	Est	OR (95%CI)	P value	Est	OR (95%CI)	P value
External biosecurity					0.37	1.45 [1.14; 1.86]	0.0029			
Purchase of animals and semen								0.58	1.79 [1.24; 2.59]	0.0019
Vermin and bird control								0.30	1.34 [1.06; 1.70]	0.0146
% of slatted floor	76-100%	ref	-	-	ref	-	-	ref	-	-
	51-75%	-1.16	0.31 [0.13; 0.77]	0.0118	-1.13	0.32 [0.12; 0.89]	0.0297	-1.12	0.33 [0.12; 0.89]	0.0292
	26-50%	1.15	3.17 [1.10; 9.12]	0.0328	1.48	4.41 [1.37; 14.20]	0.0129	1.51	4.52 [1.42; 14.39]	0.0107
	1-25%	0.27	1.31 [0.45; 3.83]	0.6243	0.39	1.47 [0.44; 4.92]	0.5300	0.29	1.33 [0.40; 4.40]	0.6395
	0%	-0.43	0.65 [0.13; 3.16]	0.5956	-0.47	0.62 [0.12; 3.67]	0.6015	-0.47	0.62 [0.11; 3.67]	0.6002
Year	2020	ref	-	-	ref	-	-	ref	-	-
	2021	0.09	1.10 [0.68; 1.76]	0.7012	-0.29	0.75 [0.44; 1.26]	0.2788	-0.21	0.81 [0.48; 1.37]	0.4332
	2022	2.74	15.51 [10.05; 23.95]	<0.0001	1.47	4.35 [2.67; 7.08]	<0.0001	1.60	4.98 [3.06; 8.09]	<0.0001
	2023	1.77	5.89 [3.81; 9.13]	<0.0001	0.58	1.79 [1.09; 2.93]	0.0212	0.69	1.99 [1.22; 3.25]	0.0062
Presence of animals with injuries	No	ref	-	-	ref	-	-	ref	-	-
	Yes	0.94	2.55 [1.88; 3.45]	<0.0001	1.00	2.72 [1.94; 3.82]	<0.0001	1.00	2.73 [1.95; 3.83]	<0.0001
Random effects			Variance	SD		Variance	SD		Variance	SD
Herd			3.82	1.955		5.04	2.245		4.56	2.14
Assessor			15.55	3.943		20.70	4.550		18.96	4.36

Legend: Est – estimate, OR – odds ratio, 95% CI – 95% Confidence interval, SD – standard deviation.

Table 18 - Results of the final multivariable GLMM for the Competition Issues Welfare category.

CI		Model 1 - Overall			Model 2 – External & Internal			Model 3 – Biosecurity Subcategories (E1 to I6)		
Variable	Categories	Est	OR (95%CI)	P value	Est	OR (95%CI)	P value	Est	OR (95%CI)	P value
External biosecurity					-0.42	0.66 [0.49; 0.89]	0.0073			
Purchase of animals and semen								-0.34	0.71 [0.57; 0.90]	0.0043
Personnel and visitors								0.45	1.57 [1.06; 2.33]	0.0249
Year	2020	ref	-	-	ref	-	-	ref	-	-
	2021	0.71	2.03 [1.08; 3.81]	0.0285	1.06	2.90 [1.15; 7.29]	0.0240	0.88	2.42 [0.97; 6.03]	0.0570
	2022	3.47	32.14 [17.05; 60.59]	<0.0001	3.55	34.72 [13.46; 89.53]	<0.0001	3.10	22.09 [8.53; 57.20]	<0.0001
	2023	2.12	8.31 [4.49; 15.37]	<0.0001	1.87	6.49 [2.52; 16.71]	<0.0001	1.62	5.05 [1.96; 13.01]	0.0008
Presence of behaviours towards enrichment	No				ref			ref		
	Yes				0.82	2.27 [1.43; 3.61]	0.0005	0.70	2.01 [1.24; 3.26]	0.0045
Presence of animals with injuries	No	ref	-	-	ref	-	-	ref	-	-
	Yes	0.53	1.69 [1.16; 2.47]	0.0057	0.60	1.82 [1.15; 2.90]	0.0112	0.55	1.74 [1.07; 2.83]	0.0263
Number of suboptimal enrichment items		-0.55	0.58 [0.41; 0.81]	0.0014	-0.52	0.59 [0.39; 0.90]	0.0131	-0.68	0.51 [0.32; 0.81]	0.0043
Random effects			Variance	SD		Variance	SD		Variance	SD
Herd			2.64	1.63		3.79	1.95		4.27	2.07
Assessor			14.78	3.84		18.89	4.35		18.58	4.31

Legend: Est – estimate, OR – odds ratio, 95% CI – 95% Confidence interval, SD – standard deviation.

- Competition Issues

The biosecurity subcategories proven to be statistically significant were External, E1 - Purchase of animals and semen and E4 - Personnel and visitors (Table 18). For External and E1, the odds of the risk in terms of Competition Issues decrease by the increase in the biosecurity score. For E4, when its score increases the odds of risk for competition issues increases.

For all models, farms with injured pigs have increased odds of risk for Competition Issues compared to farms without injured animals; increasing the number of suboptimal enrichment items in a farm reduces the risk for Competition Issues; and 2021 to 2023, compared to 2020, have an increased odds of risk to Competition Issues.

For models 2 and 3, farms with recorded presence of pig interacting with enrichment items have an increased odds of risk for Competition Issues compared to the ones without it.

- Feeding Process

The biosecurity subcategories proven to be statistically significant were External, E3 - Feed, water and equipment supply, E5 - Vermin/bird control, and E6 - Environment and region (Table 19). For External, E3, E5 and E6 by increasing the biosecurity score for these subcategories the odds of risk in terms of Feeding Process decrease. For all models, farms with slatted floors 1-25% have decreased odds of risk for Feeding Process compared to farms with 76-100% slatted floors.

For model 1, 2021 to 2023, compared to 2020, have an increased odds of risk for this welfare category. For model 2, compared to 2020, while 2021 and 2022 have increased odds of risk for this welfare category, 2023 has decreased odds of risk.

- Pen Design

The only biosecurity subcategory statistically significant was E2 - Transport of animals, removal of manure/dead animals (Table 20). For this welfare category, the odds of risk decrease by increasing the E2 biosecurity score.For models 1 and 2, increasing the number of suboptimal enrichment items in a farm reduces the risk for Pen Design.

While in model 3, increasing the number of marginal enrichment items in a farm increases the risk for Pen Design.

For all models, 2021 to 2023, compared to 2020, have increased odds of risk for this welfare category.

Table 19 - Results of the final multivariable GLMM for the Feeding Process Welfare category.

FP		Model 1 - Overall			Model 2 – External & Internal			Model 3 – Biosecurity Subcategories (E1 to I6)		
Variable	Categories	Est	OR (95%CI)	P value	Est	OR (95%CI)	P value	Est	OR (95%CI)	P value
External biosecurity					-0.59	0.55 [0.40; 0.78]	0.0006			
Feed, water and equipment supply								-0.46	0.63 [0.46; 0.87]	0.0051
Vermin and bird control								-0.65	0.52 [0.36; 0.75]	0.0005
Environment and region								-1.01	0.36 [0.24; 0.56]	<0.0001
% of slatted floor	76-100%	ref	-	-	ref	-	-	ref	-	-
	51-75%	-0.79	0.45 [0.17; 1.23]	0.1198	-0.59	0.56 [0.16; 1.98]	0.3653	-0.56	0.57 [0.15; 2.20]	0.4136
	26-50%	-0.23	0.79 [0.18; 3.59]	0.7647	0.70	2.02 [0.31; 13.01]	0.4604	0.816	2.26 [0.32; 16.10]	0.4151
	1-25%	-3.51	0.03 [0.005; 0.17]	<0.0001	-3.81	0.02 [0.002; 0.22]	0.0011	-4.56	0.01 [0.0007; 0.15]	0.0009
	0%	-0.57	0.56 [0.09; 3.70]	0.5502	-1.09	0.33 [0.03; 3.34]	0.3513	-1.20	0.30 [0.02; 4.04]	0.3655
Year	2020	ref	-	-	ref	-	-	ref	-	-
	2021	0.29	1.34 [0.78; 2.28]	0.2852	0.52	1.68 [0.89; 3.19]	0.1086			
	2022	2.21	9.08 [5.55; 14.86]	<0.0001	0.75	2.12 [1.10; 4.06]	0.0242			
	2023	0.85	2.34 [1.41; 3.89]	0.0010	-0.65	0.52 [0.26; 1.04]	0.0654			
Random effects			Variance	SD		Variance	SD		Variance	SD
Herd			4.03	2.007		7.84	2.800		9.34	3.06
Assessor			18.88	4.345		35.27	5.939		39.14	6.26

Legend: Est – estimate, OR – odds ratio, 95% CI – 95% Confidence interval, SD – standard deviation.

Table 20 - Results of the final multivariable GLMM for the Pen Design Welfare category.

PD		Model 1 - Overall			Model 2 – External & Internal			Model 3 – Biosecurity Subcategories (E1 to I6)		
Variable	Categories	Est	OR (95%CI)	P value	Est	OR (95%CI)	P value	Est	OR (95%CI)	P value
Transport, removal of manure/dead animals								-0.52	0.59 [0.45; 0.79]	0.0003
Year	2020	ref	-	-	ref	-	-	ref	-	-
	2021	0.41	1.50 [0.58; 3.88]	0.3983	0.41	1.50 [0.58; 3.88]	0.3983	0.63	1.87 [0.51; 6.83]	0.3427
	2022	5.33	206.37 [84.93;501.41]	<0.0001	5.33	206.37 [84.93; 501.42]	<0.0001	4.24	69.18 [21.69; 220.58]	<0.0001
	2023	4.07	58.74 [24.74; 139.45]	<0.0001	4.07	58.74 [24.74; 139.45]	<0.0001	3.38	29.32 [9.09; 94.55]	<0.0001
Number of suboptimal enrichment items		-0.51	0.60 [0.42; 0.85]	0.0044	-0.51	0.60 [0.42; 0.85]	0.0044			
Number of marginal enrichment items								0.20	1.22 [1.02; 1.45]	0.0281
Random effects			Variance	SD		Variance	SD		Variance	SD
Herd			3.13	1.769		3.13	1.769		3.95	1.99
Assessor			12.85	3.585		12.85	3.585		20.04	4.48

Legend: Est – estimate, OR – odds ratio, 95% CI – 95% Confidence interval, SD – standard deviation.

4 – Discussion

4.1 – Description of Assessments

These assessments began in 2018 (biosecurity) and 2019 (tail biting), with farms initially participating voluntarily, with the number of assessments increasing over time. In September 2021 an update to the Standard of Bord Bia (Irish Food Board – it is an Irish state agency with the aim of promoting sales of Irish food and horticulture both in Ireland and abroad) Pig Quality Assurance Scheme (PQAS) (https://www.bordbia.ie/farmers-growers/get-involved/become-quality-assured/pigmeat-quality-assurance-scheme-pqas/) included the requirement for an annual biosecurity and tail biting risk assessments for members. As the majority of commercial pig farms are PQAS members, that further increased engagement levels (Table 3). Furthermore, in June/July of 2022, a government-funded exceptional payment scheme for pig farmers had as one of its eligibility criteria that a Target Advisory Service for Animal Health (TASAH) Pig HealthCheck Biosecurity and tail biting risk assessments had to have been completed between 1 January 2021 and 11 July 2022 (Terms... 2022). As a result, the majority of the cohort of farms that had not previously been assessed also participated. That is why around 84% of the pig farms with more than 100 pigs (310 out of 369 farms – National Pig Census 2022 (National… 2022) have done at least one biosecurity and tail-biting risk assessment during the study period.

The current system to assess biosecurity and tail biting risks in pig farms has some limitations as it uses different assessors and, albeit they have been trained, that introduces an element of variability as different assessors do bring their own subjectivity when interpreting the questions within the assessment, which can later interfere with the results.

Furthermore, the assessors are the farms' veterinarians and therefore have some degree of connection with the farmers that might impair them from an independent assessment of the farms. The standard frequency of assessment is only once a year, with some farms being assessed at a lower frequency. This is not conducive to supporting the farmer when they start implementing recommended practices, as most of the time some adjustments are necessary to ensure an efficient implementation.

However, using the farm's veterinarian as the assessor also brings some advantages, as it overcomes the limitation of the frequency of assessments as the farm's veterinarian will be visiting the farm frequently for other reasons (including work in other areas of the PHC programme) and can then support the farmer on the

implementation of measures. Moreover, the farm's veterinarian is familiar with the farm (including health status), the farmer and workers and therefore can co-design with the farmer the most appropriate recommendations to implement on the farm and this way ensure their effective implementation.

4.1.1- Biosecurity

In this study biosecurity scores in commercial Irish pig farms were assessed over time using a widely used biosecurity assessment system (Filippitzi et al. 2018; Laanen et al. 2013) and areas for improvement were identified.

External biosecurity generally scores higher than internal biosecurity due to the significant emphasis placed on the purchase of animals and semen. Since most Irish farms operate on a farrow-to-finish production model (closed cycle) and raise their own replacement stock, the purchase of breeding animals is minimal and primarily for genetic improvement. Additionally, the majority of these farms use semen from high-health-status sources, thereby considerably reducing the risk of introducing new diseases through the purchase of replacement animals and semen.

All farms had higher external biosecurity scores compared to internal scores, with median scores improving between 2018 and 2023 (Figure 1). However, there was significant variability in the number of farms assessed each year and in the scores between subcategories (Figures 2 to 7), with the greatest variability seen in the management of cleaning and disinfection. This likely reflects differences in farm infrastructure and/or management practices, including attitudes of farmers and staff towards biosecurity. Further research is needed to explore these differences. Cleaning and disinfection, along with measures between compartments and equipment usage, are key subcategories that significantly impact internal biosecurity scores (https://biocheckgent.com/en/weight-factors-pig), underscoring their importance in reducing the infection cycle within a farm (Filippitzi et al. 2018). Over time, improvements in these subcategories (Figure 6) suggest the current system effectively highlights areas for improvement and that farmers are actively addressing them. Notable improvements include cleaning and disinfection of rooms after each production cycle, washing hands between compartments, and using designated equipment for each room. While measures related to the fattening unit showed improvement over the years, the 2023 result was a step back from previous years. This is considered to reflect the increased stocking rates at the fattening stage in 2023 compared to 2022 (Figure 8).

Overall, the areas identified for improvement for internal biosecurity were nursery unit, farrowing unit and suckling period and measures between compartments and the use of equipment. Even though this last subcategory was reported to have shown great improvement, it still needs to continue on the same path it has been. These are the subcategories with the lowest scores, mainly because of cross-fostering practices, lack of strict all-in-all-out management, high stocking densities, lack of footbath/booth washers between the different compartments. Internal biosecurity is especially important to break the cycle of disease transmission within a farm and to control endemic diseases (such as E. coli, Salmonella spp., etc.) (Filippitzi et al. 2018). Therefore, more attention is required from farmers in these areas, albeit some of these areas require more investment such as new accommodation to reduce stocking densities or a reduction in the overall number of pigs on the farm.

The feed, water and equipment supply subcategory corresponds to the only external subcategory with a low score. This represents a way for the introduction of diseases through contaminated feed and water, infected material, and contaminated feed lorries. The lower scores in this subcategory are mainly due to poor management of water quality and the location of feed silos (which means that feed lorries have access to the areas of the production site which should be restricted).

In 2022 the Irish pig industry experienced its lowest profitability in 40 years as the invasion of Ukraine led to escalating feed ingredient and energy costs (Buckley et al. 2023). The situation in 2023 improved but the accumulated cashflow losses from that period (end of 2021 to the beginning of 2023) had not yet been recovered (Buckley et al. 2023). Even so, the biosecurity scores for 2022 and 2023 have overall been maintained or increased, showing that there were still “low-hanging fruit” biosecurity practices that could be implemented. However, in the future, further gains in biosecurity may require capital investments (e.g. new buildings with better layout to separate high-risk procedures from low-risk procedures or easier to clean and disinfect) or extra labour, which the sector might not be able to afford (due to lack of financial resources or difficult in sourcing staff) in the short term. Therefore, it is essential to demonstrate to farmers the cost-benefit of implementing different biosecurity measures so that information can help their decision-making process for better returns on their investments. The data obtained through this study will be used for those cost-benefit estimations.

4.1.2 – Tail Biting

Using the Tail Biting risk assessment, the various welfare indicators were analysed through the years and the more concerning areas were identified.

Tail docking as a routine procedure is prohibited in Europe and should only be performed when no other measures to mitigate tail biting work (2008/120/EC of 18 December 2008). This behaviour is an iceberg indicator of other problems and welfare challenges, as a range of suboptimal management and housing conditions, being a multifactorial condition related to stress, nutrient deficiencies and health challenges, (Valros et al. 2015). The procedure causes acute pain and stress, as indicated by both behavioural and physiological changes, (Valros. 2022). The results from the study showed that no improvement was made over the years, with the number of batches with docked pigs only increasing, and the number of undocked batches being almost non-existent.

One way to reduce aggression and other problems in pens is to provide an environment where pigs can express their natural behaviours. Having appropriate environmental enrichment materials in the pens, suited to the number and age of the animals, is crucial for developing healthy, stress-free pigs and reducing the number of docked pigs. Despite efforts to increase both the quantity and quality of enrichment items over the years, little to no change was observed, with only a slight increase in suboptimal items. These concerning results indicate that a significant opportunity to address many ongoing farm management issues remains unfulfilled.

Overstocking of pens presents both biosecurity and welfare problems. Despite being common, overcoming this issue is challenging as it requires maintaining appropriate stocking densities. To mitigate the risk of biting by reducing stocking density, producers may need to either decrease sow numbers or build additional facilities, which from a commercial point of view is not a feasible option in the short run, (Haigh et al. 2019).

For some categories of lesions/findings observed at the farm level, the results from 2019 are different from the following years, and knowing that in the first year of the study, only a small number of farms were assessed, this could be due to a biased problem of those farms. During those years, the most concerning lesion types are ear lesions and aggressive lesions, with a doubling in score since 2022. These types of lesions could indicate problems with the behaviour of the animals, suggesting a rise in aggressive behaviours occurring within the pen. It was also shown that other stress factors have increased in 2023, which could contribute to this rise, and the lack of improvement in enrichment is now showing its worth. Another important factor is dirty flanks. This can indicate increasing problems with the cleanliness of the pens or with ventilation and temperature since 2022.

The last section analysed was behaviour observations during 5 minutes. The most concerning category was Fixtures and Fittings, with a rate more than double the enrichment category rate. This indicates that although many animals still use the enrichment provided, more animals direct their behaviour towards pen fixtures and fittings such as drinkers, feeders, and walls as a way to relieve stress. This indicates that the provision of environmental enrichment in enough quantity, quality and accessibility needs to be improved.

In 2023, several categories showed a worsening record, indicating that the measures to improve were either not being implemented or were insufficient to address the current problems on the farms.

4.2 – Recommendations Data

4.2.1 - Biosecurity

Among the twelve biosecurity subcategories, only eight had recommendations for improvement. Of the remaining four categories, while E6 has a high score and therefore no recommendations are expected, subcategories I2 to I4 are important management categories with potential for improvement but with no recommendation. Among the other eight categories, I1 and E3 have the highest representation in recommendation numbers.

The impact of recommendations on I1 is evident, as they have transformed one of the worst biosecurity categories into one of the highest-scoring ones. Despite being a low-scoring category, the improvement observed in E3 over the years demonstrates the effectiveness of recommendations. It is also noticeable for I5 and I6 that for a high percentage of the assessments done scores below 50% have not triggered recommendations by PVPs (Table 7), which might suggest that improvements in these areas require further investments or labour that what is currently available and therefore not easily implemented by farmers.

There needs to be a way to incentivise the PVPs to find recommendations for the I2 to the I4 subcategories in order for the farmers to improve these management units in their farms and to focus their recommendations in areas with lower scores.

4.2.2 – Tail Biting

Overall, Environment Enrichment accounts for half the recommendations given each year, and from the result in the section 3.1, there seems to be little to no improvement in that aspect. Even though the other 5 categories contribute to the other

half of the recommendations, their importance in understanding the problems of the farms is imperative.

The last year (2023) turned out to be a year where most assessments got an increase in recommendations. One could argue that this is because more problems have arisen or were not correct. The other possibility is that the PVPs are more attentive to the recommendations they are giving in order to help the farmers improve.

Since the Welfare categories cannot be directly evaluated, having to use the welfare indicators shown in Table 1, the outcome from the recommendations can be assessed by the evolutions of these parameters.

There is still too little evolution in the welfare indicators that can be explained as a result from the recommendation work since the beginning of this study in 2019.

In the Welfare database from the year 2021 onwards, most “Rec and Risk” (Table 9) belong to the Environmental Enrichment category as clarification was given to the PVPs that the absence of optimal enrichment items in a pen is considered a risk. That has increased the pens at risk for this welfare category.

It is also noticeable that in 2022 and 2023 there was an increase in the percentage of “No Rec and Risk” in all welfare categories compared to previous years. This is in line with an increase in the pens at risk for most of the welfare categories over the years.

4.3 – Risk Factors Analysis

4.3.1 - Linear Mixed Models

Year and farm type were for most of the LMMs statistically associated with biosecurity scores. The scores were increasing over time, as expected when advice is taken by farmers showing that the system in place is delivering improvements. Farrow-to-finish farms, with most farmers relying on their own stock, had a higher external biosecurity score than fattening farms, while fattening farms had a higher score of overall and internal biosecurity compared to farrow-to-finish farms. This probably reflects the complexity of managing all stages of pig production on the same farm, especially when managing the internal biosecurity, i.e., the measures within the farm. Fattening farms are easier to manage (i.e. only one stage/compartment of the pig production).

The score for internal biosecurity was lower in farms where animals were showing dirty flanks compared to farms where animals were not showing dirty flanks. Dirty flanks are probably a reflection of bad management of cleaning procedures at farm level.

No statistically significant associations were found between biosecurity and animal welfare risks when considering external, internal and overall scores but when looking into the different subcategories of biosecurity some associations were found. For many the presence of risks for animal welfare (especially related with environmental enrichment) at farm level were associated with a lower biosecurity score. This highlights our hypothesis that good biosecurity is associated with good animal welfare. However, that was not always the case. Some surprising associations were the association between higher scores for purchase of animals and presence of risk for animal health, the association between higher scores for nursery management and presence of risks of feeding processes and associations between higher scores for fattening unit and presence of risks for competition. As the welfare protocol used does not detail the risks observed is difficult to make sense of these results. However, anedoctically it is not the first time that unexpected associations are observed between welfare and biosecurity.

In that context, it was reassuring the association of having lower biosecurity scores for cleaning and disinfection and presence of dirty flanks in the farm. Highlighting that the cleaning and disinfection process can influence how clean an animal is.

The herd effect had a higher variance than the assessor effect, highlighting that much of the variation in the models is due to variation between farms and not so much due to variation between assessors. This is reassuring as having different assessors is not influencing greatly the scores of the farms. This could be due to the system for assessing biosecurity used and/or the training the PVPs received before doing the assessments.

4.3.2 – Generalised Linear Mixed Models

For most of the GLMMs over the years there was an increase in the risk for the different welfare categories. For the environmental enrichment models, the odds ratios for the year variable were very high and are a reflection of the change done in assessing risks for this category of welfare from 2021 onwards (all pens without optimal enrichment were considered to have risks for this welfare category) compared to 2020. However, the results of the models for the other welfare categories do indicate that there was no minimal improvement over the years. This is an indication that this programme needs to be revised and that advice is not being taken by farmers.

Some statistical associations between animal welfare and biosecurity were found. For most of the models, an increase in biosecurity scores was associated with a decrease in the risks for animal welfare. However, as for the LMMs, some unexpected

associations were found, especially for the animal health risks models, where increased external biosecurity was associated with increased risk of animal health. Some possible explanation are that at the time of the assessments, animal health risks were present at the farms and so farmers have adopted measures to improve biosecurity to compensate this problems, leading to conflicting results in the models.

The high variance of the GLMMs was attributed to the assessor rather than to the farm, which is opposite to what was observed for the LMMs. This probably indicates that there is high variability in the way PVPs determine risks for animal welfare. The subjective nature of the assessment tool, whereby PVPs were required to use their judgement in assigning risk levels, without strict guidance, is likely one of the reasons for this variance. Some ways to improve this would be to re-design the animal welfare tool to make more clear what constitutes risks for animal welfare, improve the quality of the training and provide more training to the PVPs. All should be considered in parallel.

All these reflect how difficult it is to access animal welfare when using subjective protocols. Other ways to measure animal welfare (e.g. using some productivity parameters as mortality), can and should be also explored as a way of adding value to these analyses. One possibility for the future is to employ artificial intelligence technology on farms to continuously monitor the pigs' behaviour. This way we could achieve significant benefits by eliminating human subjectivity and ensuring consistent and objective assessments. This leads to fairer evaluations and more reliable data for managing animal welfare. While this type of technology promises improved animal management, widespread adoption is currently limited by technological and economic constraints (Han et al. 2023).

5 - Conclusion

Through the continued efforts of the Irish pig industry and their nominated veterinary practitioners, with government support, the last few years have registered improvements in the biosecurity scores of the farms. Although external biosecurity is considered high, internal biosecurity has room for improvement and with this will mitigate disease spread within the units and consequently reduce disease prevalence for endemic diseases such as salmonellosis, PRRS, colibacillosis and other common pathogens bringing additional economic benefits and improving the overall scores and performances of the farms (VanderWaal and Deen 2018).

While improvements in animal welfare over the years are not as promising as those in biosecurity, collaborating closely with farms and emphasising the importance of enhancing quality of life, while also seeking practical solutions aligned with farmer availability (e.g. use of enrichment materials that are easily available for farmers as for example grass instead of straw that is not easily available in Ireland), could be the next step to follow on the PVP training programme. Coupled with this there is also the necessity of capital investment for new buildings with pen designs that are welfare-friendly, comfortable and with enough space (more than what is required by legislation) for pigs.

As expected, associations between biosecurity and welfare were found suggesting that good biosecurity leads to good animal welfare. However, that is not always the case and potential conflicts should be identified and solutions to mitigate these should also be investigated. Furthermore, in terms of assessing animal welfare, this study has indicated the current protocol has limitations. A new protocol is being developed by Teagasc to address those limitations and will be tested soon in commercial pig farms.

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7 – Supplementary Material

Table S21 – Recommendations for E1 subcategory

Category - Purchase	2019	2020	2021	2022	2023
Buy animals only from one source	0	0	0	3	3
Buying stock from farms with higher health status	1	1	1	0	3
Limit the number of animals introduced	0	1	0	0	1
Limit the number of times that animals are introduced	3	1	1	0	0
Quarantine of purchased stock	1	1	1	0	0
Total	5	4	3	3	7
By year	0.018	0.009	0.006	0.003	0.009

Table S22 – Recommendations for E2 subcategory – Dead Animals

Category - Dead animals	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Carcasse storage outside farm perimeter	2	4	14	17	39	23
Clean carcass storage	0	1	10	19	23	13
Cover carcass storage	0	0	0	1	0	2
Locked carcass storage	0	2	6	3	0	1
Other	0	0	0	0	0	2
Use and change gloves frequently	1	3	12	9	14	15
Total	3	10	42	49	76	56
By year	0.036	0.035	0.095	0.095	0.083	0.070

Table S23 - Recommendations for E2 subcategory – Transport of animals

Category - Transport of animals	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Avoid hauliers to enter the stables	1	0	0	0	1	0
Only allow washed and disinfected vehicles to enter the farm	1	2	0	2	5	3
Avoid animals re-entering the stable	0	0	1	0	0	2
Clean after lorries	0	0	0	1	1	0
Total	2	2	1	3	7	5
By year	0.024	0.007	0.002	0.006	0.008	0.006

Table S24 - Recommendation for E3 subcategory - Equipment & Material

Category – Equipment & Material	2018	2019	2020	2021	2022	2023
Changing gloves more often	0	0	0	0	1	0
Changing needles more often	10	28	52	68	70	27
Clean and disinfect equipment after being used	1	3	15	11	26	32
Slurry farm specific hoses	5	4	10	12	6	15
Disinfect equipment used with piglets	0	0	1	2	1	1
Implement intradermal vaccination	1	1	1	3	3	1
Use compartment specific equipments/ do not share equipment between compartments	0	5	4	4	3	8
Disinfect any material before entering the farm	0	0	0	0	2	3
Disinfect shared material before entering the farm	0	0	2	0	0	0
Drop off point	0	0	0	2	0	0
Use UV cabinet for incoming material	0	1	0	0	0	0
Use own farm material	0	0	0	0	1	1
Total	17	42	85	102	113	88
By year	0.202	0.149	0.192	0.198	0.123	0.110

Table S25 - Recommendation for E3 subcategory - Feed

Category - Feed	2020	2021	2022	2023
Clean feed spills and feed equipment	0	8	14	18
Clean the feedlines	0	0	1	1
Move feed bins to dirty area	1	0	0	1
Total	1	8	15	20
By year	0.002	0.016	0.016	0.025

Table S26 - Recommendation for E3 subcategory - Water

Category - Water	2018	2019	2020	2021	2022	2023
Clean drinkers, water tank and pipelines	0	0	0	0	2	2
Ensure water well, storage tank and the pipelines are properly closed	0	0	0	1	0	0
Test water supply frequently	3	4	8	10	12	10
Use clean water	0	2	0	0	0	0
Total	3	6	8	11	14	12
By year	0.036	0.021	0.018	0.021	0.015	0.015

Table S27 - Recommendation for E4 subcategory - Staff

Category - Staff	2018	2019	2020	2021	2022	2023
Changing boots and overalls between stables	1	1	8	16	10	1
Improvement of hand washing facilities	0	0	0	1	0	4
Wash hands at entrance of farm	0	2	6	19	14	3
Total	1	3	14	36	24	8
By year	0.012	0.011	0.032	0.070	0.026	0.010

Table S28 - Recommendation for E4 subcategory - Visitors

Category - Visitors	2018	2019	2020	2021	2022	2023
Improvement of the hygiene lock	0	0	2	2	4	10
Installation of hygiene lock at entrance of herd	1	1	0	1	0	2
Installation of hygiene lock at entrance of stables	0	19	21	21	9	5
Separation between clean and dirty area	0	2	8	10	1	0
Downtime of 24/48 hours	0	0	2	0	0	1
Install drop off point at entrance of the farm for courier delivers	0	1	0	0	0	0
Keep farm gate closed/ proper maintenance of external fences	0	2	4	1	1	2
Limit the number of visitors allowed in the farm	0	0	0	0	3	18
To wash the hands before entering the farm	0	0	5	0	0	3
To wash the hands before entering the farm/wear gloves	0	0	2	3	4	0
Use entrance books	0	0	0	0	17	12
Use of farm specific boots and overalls	7	19	13	4	21	20
Visitors car park located outside farm	1	3	0	0	2	0
Total	9	47	57	42	62	73
By year	0.107	0.167	0.128	0.081	0.068	0.091

Table S29 - Recommendation for E5 subcategory - Pests

Category - Pests	2018	2019	2020	2021	2022	2023
Avoid companion animals entering the farm	0	8	2	2	6	5
Bird-proofing the stables	5	8	15	8	20	22
Control of insects	0	0	1	0	9	9
Rodent control: remove waste/debris from buildings	0	4	6	16	24	11
Control rodents	1	1	5	4	11	19
Total	6	21	29	31	70	66

By year	0.071	0.074	0.065	0.060	0.077	0.083

Table S30 - Recommendation for I1 subcategory - Disease Management

Category - Disease management	2018	2019	2020	2021	2022	2023
Decrease stocking density	0	2	1	1	8	2
Health checks to be carried frequently	2	3	1	3	21	12
Hospital pen/sick bay	3	2	3	5	4	9
Implement All-in-all-out	5	10	14	5	10	11
Implement protocol for antibiotic treatments on farm	0	0	11	1	6	0
Maintain All-in-all-out	0	2	1	0	0	0
Reduce cross-fostering	6	9	13	13	13	8
Wash sows before entering farrowing room	2	7	1	3	10	3
Changing of bedding material frequently	0	0	1	0	0	1
Depopulation	0	0	0	0	1	4
Implement proper vaccination plan	0	0	0	2	10	14
Improve treatment protocols	0	0	0	0	18	15
Isolate sick animals	3	2	2	2	2	2
Monitor disease/mortality levels	0	0	0	0	28	80
Reduce number of manipulations	0	1	0	0	0	4
Separate rooms per production stage to contain diseases	0	0	2	0	0	0
Total	21	38	50	35	131	165
By year	0.250	0.135	0.113	0.068	0.143	0.207

Table S31 - Recommendation for I5 subcategory - Footbaths

Category - Footbaths	2018	2019	2020	2021	2022	2023
Installation of footbaths	6	19	29	39	73	55
Make sure that footbaths are regularly cleaned and re-stocked	0	2	2	3	6	9
Cover of footbaths	0	0	3	1	3	2
Total	6	21	34	43	82	66
By year	0.071	0.074	0.077	0.083	0.090	0.083

Table S32 - Recommendation for I5 subcategory - Working Lines

Category - Working lines	2018	2019	2020	2021	2022	2023
Do not mix pigs from different ages	1	0	2	0	1	3

From healthy animals to diseased animals	1	1	6	6	13	20
From younger to older pigs	0	1	0	3	3	5
Install a loading area	0	0	1	0	0	0
Total	2	2	9	9	17	28
By year	0.024	0.007	0.020	0.017	0.019	0.035

Table S33 - Recommendation for I6 subcategory - Cleaning and Disinfection

Category - C&D	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
C&D passages/corridors after moving pigs	0	4	2	9	33	24
Clean and disinfect between production batches	8	38	38	35	46	23
Ensure enough time for drying after washing and before applying the disinfectant	2	4	5	2	2	3
Change disinfectant product	0	0	4	0	2	5
Clean buildings	0	0	0	2	0	5
Enough downtime before new animals are introduced in the pen/room	0	2	0	4	12	5
Install more hand washing facilities	0	1	6	0	13	11
Maintain good hygiene levels	0	0	0	1	2	0
Power wash	0	0	0	0	1	1
Test efficacy of C&D process	0	0	0	0	0	3
Use boot washers	1	4	0	5	7	7
Use detergent as part of the C&D	1	9	10	25	3	4
Use disinfectant as part of the C&D	0	0	0	2	8	2
Total	12	62	65	85	129	93
By year	0.143	0.220	0.146	0.165	0.141	0.117

Table S34 - Recommendation for Environmental Enrichment subcategory

Category - Environmental Enrichment	2019	2020	2021	2022	2023
Improve accessibility of enrichment material to the animals	0	51	62	103	90
Improve the quality of environmental enrichment	6	293	493	436	409
Increase the number and type of environmental enrichment	1	88	229	791	463
Increase the number of environmental enrichment	16	189	221	84	246
Maintain the levels of environmental enrichment materials	0	3	0	0	12
Monitor interaction with enrichment	0	0	7	6	16
Replace enrichment material frequently	0	12	32	49	67
Total	23	636	1,044	1,469	1,303

By year	0.442	0.446	0.53	0.519	0.454

Table S35 - Recommendation for Thermal Comfort subcategory

Category - Thermal Comfort	**2019**	**2020**	**2021**	**2022**	**2023**
Clean windows/improve lighting	3	24	65	162	162
Decrease house temperature	0	12	5	10	0
Improve bedding	0	1	1	0	3
Improve insulation	0	7	38	56	52
Improve ventilation	2	64	112	182	180
Increase house temperature	3	3	1	1	13
Maintain correct house temperature	0	1	0	0	4
Monitor temperature variation in the pens	1	22	54	88	88
Clean windows/improve lighting	0	0	0	0	4
Total	9	134	276	499	506
By year	0.173	0.094	0.14	0.176	0.176

Table S36 - Recommendation for Animal Health subcategory

Category - Animal Health	2019	2020	2021	2022	2023
All in-all-out system per batch	0	2	0	0	2
Control of pests	0	16	4	1	6
Implement a de-worming programme	2	1	1	0	0
Improve cleaning and disinfection of pens and adjacent areas	0	14	24	22	3
Improve hygiene levels	0	5	4	3	0
Improve vaccination programme	7	48	61	32	47
Increase the promptness of treatment of sick and injured pigs and the rate of euthanasia as required	0	1	1	3	14
Investigate causes of disease	0	3	9	12	15
Maintain hygiene levels	0	0	5	0	0
Maintain stock rate	0	0	1	6	0
Monitor animal behaviour	0	9	6	16	8
Monitor disease	0	13	54	78	94
Other	0	3	4	5	9
Prevent/monitor ear necrosis	0	46	30	14	25
Record tail biting outbreaks/cases	0	0	40	47	50
Reduce stocking rates	1	52	83	199	84
Remove bitten	0	1	3	2	3

Remove bitters	2	9	36	52	134
Remove zinc oxide	0	0	2	4	1
Treat injured pigs	0	4	22	30	126
Total	12	227	390	526	621
By year	0.231	0.159	0.198	0.186	0.216

Table S37 - Recommendation for Competition Issues subcategory

Category - Competition Issues	2020	2021	2022	2023
Add extra drinkers in the pen	57	40	52	35
Avoid mixing different groups of pigs	4	3	4	2
Avoid mixing pigs of different sizes	0	3	0	6
Extra feeder space	6	17	20	35
Remove bitters as soon as identified	0	0	0	2
Total	67	63	76	80
By year	0.044	0.039	0.028	0.023

Table S38 - Recommendation for Feeding Process subcategory

Category - Feeding Process	2019	2020	2021	2022	2023
Add acid to feed/water	0	2	3	0	1
Add in suplement to feed	0	4	7	0	13
Adjust height of drinkers to the pig size	0	4	4	1	0
Cleaning and disinfection of feeders/drinkers more frequently	0	9	17	5	13
Increase frequency of feeding	0	0	0	5	1
Increase magnesium in diets	3	15	0	6	45
Other	0	0	1	3	1
Reduce dust associated with feeding	0	1	0	0	0
Reduce mycotoxins in feed	0	5	1	0	0
Repair damage drinkers quickly	0	8	15	4	1
Review diet formulation	2	34	19	35	59
Review feed particle size	0	1	0	0	0
Review feeding settings	0	55	16	29	63
Total	5	138	83	88	197
By year	0.096	0.097	0.042	0.031	0.069

Table S39 - Recommendation for Pen Design subcategory

Category - Pen Design	2019	2020	2021	2022	2023
Alter pen flooring to increase space available for pigs	0	2	2	0	11
Carry on with the modification of pen design	2	7	0	1	5
Check water flow rates frequently	0	46	43	78	68
Improve the floor quality	0	1	1	0	1
Other	0	0	0	2	1
Remove partition between pens to increase feeder access	0	2	0	1	0
Repair broken slats/floor	0	10	8	5	13
Repair feeders	0	1	7	3	2
Repair feeders/drinkers	0	0	0	2	21
Reposition feeder and drinkers to increase floor space available to pigs	0	7	8	1	11
Total	2	76	69	93	133
By year	0.038	0.053	0.035	0.033	0.046

Table S40 - Results of the univariable and multivariable LMM for the E1 biosecurity subcategory

E1 - Purchase of animals and semen		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Variance^{o}	P-Value/ Std.Dev.^{o}
ENVIRONMENTAL ENRICHMENT	0/1	-0.05197	0.96841		
THERMAL COMFORT	0/1	-0.08325	0.932		
ANIMAL HEALTH	0/1	-0.08325	0.01501 *	3.5980	0.000193 ***
COMPETITION ISSUES	0/1	-3.159151	0.00308 **	-4.6583	2.67e-05 ***
FEEDING PROCESS	0/1	0.165468	0.86354		
PEN DESIGN	0/1	0.32049	0.75052		
YEAR	2020	REF			
	2021	0.3710	0.744		
	2022	-0.7168	0.509		
	2023	-0.1232	0.908		
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	-2.8468	0.00171 **	-2.7800	0.001953 **
OVERSTOCKING	1	-0.351624	0.73639		
	0	REF			
DIRTY FLANKS	YES	-1.37628	0.2682		
	NO	REF			
Random effects					
Herd				31.681	5.629
Assessor				5.227	2.286

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

^{o} Variance Std.Dev. for RANDOM EFFECTS

Table S41 - Results of the univariable and multivariable LMM for the E2 biosecurity subcategory

E2 - Transport of animals, removal of manure/dead animals		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Variance^{o}	P-Value/ Std.Dev.^{o}
ENVIRONMENTAL ENRICHMENT	0/1	-2.529	0.0268 *	-2.529	0.0268 *
THERMAL COMFORT	0/1	-0.7969	0.337506		
ANIMAL HEALTH	0/1	-0.4643	0.556236		
COMPETITION ISSUES	0/1	0.1853	0.83661		
FEEDING PROCESS	0/1	-0.7135	0.389276		
PEN DESIGN	0/1				
YEAR	2020	REF			
	2021	1.0822	0.259363	2.491	0.0295 *
	2022	3.7325	6.16e-05 ***	5.241	5.97e-06 ***
	2023	3.0308	0.000898 ***	4.550	7.48e-05 ***
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	-1.1300	0.187		
OVERSTOCKING	1	-1.1076	0.25738		
	0	REF			
DIRTY FLANKS	YES	-0.5623	0.630550		
	NO	REF			
Random effects					
Herd				35.83	5.986
Assessor				3.85	1.962
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 ^{o} Variance Std.Dev. for RANDOM EFFECTS					

Table S42 - Results of the univariable and multivariable LMM for the E3 biosecurity subcategory

E3 - Feed, water and equipment supply		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Varianceº	P-Value/ Std.Dev.º
ENVIRONMENTAL ENRICHMENT	0/1	-3.286	0.0562 .	-3.413	0.0470 *
THERMAL COMFORT	0/1	-1.366	0.291		
ANIMAL HEALTH	0/1	-0.08961	0.940		
COMPETITION ISSUES	0/1	0.4662	0.746		
FEEDING PROCESS	0/1	1.258	0.347		
PEN DESIGN	0/1	0.250	0.854		
YEAR	2020	REF			
	2021	1.943	0.15	3.850	0.0197 *
	2022	6.735	6.35e-07 ***	8.876	3.00e-07 ***
	2023	6.084	4.98e-06 ***	8.246	1.86e-06 ***
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	-1.543	0.218		
OVERSTOCKING	1	-1.379	0.342		
	0	REF			
DIRTY FLANKS	YES	-0.8943	0.620		
	NO	REF			
Random effects					
Herd				72.48	8.513
Assessor				173.03	13.154
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 º Variance Std.Dev. for RANDOM EFFECTS					

Table S43 - Results of the univariable and multivariable LMM for the E4 biosecurity subcategory

E4 - Personnel and visitors		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Variance^{o}	P-Value/ Std.Dev.^{o}
ENVIRONMENTAL ENRICHMENT	0/1	-4.748	0.013135 *	-4.748	0.013135 *
THERMAL COMFORT	0/1	-2.372	0.096631 .		
ANIMAL HEALTH	0/1	0.2467	0.851617		
COMPETITION ISSUES	0/1	1.400	0.375601		
FEEDING PROCESS	0/1	-1.642	0.268494		
PEN DESIGN	0/1	-0.1244	0.933975		
YEAR	2020	REF			
	2021	4.223		7.010	0.000127 ***
	2022	6.501	8.82e-06 ***	9.753	3.14e-07 ***
	2023	4.862	0.000678 ***	8.111	1.91e-05 ***
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	-6.734	3.59e-05 ***	-6.843	2.71e-05 ***
OVERSTOCKING	1	-1.974	0.304899		
	0	REF			
DIRTY FLANKS	YES	0.1746	0.941152		
	NO	REF			
Random effects					
Herd				166.20	12.892
Assessor				95.06	9.750
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 ^{o} Variance Std.Dev. for RANDOM EFFECTS					

Table S44 - Results of the univariable and multivariable LMM for the E5 biosecurity subcategory

E5 - Vermin/bird control		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Varianceº	P-Value/ Std.Dev.º
ENVIRONMENTAL ENRICHMENT	0/1	-9.220	1.18e-05 ***	-9.297	1.07e-05 ***
THERMAL COMFORT	0/1	-3.315	0.0377 *		
ANIMAL HEALTH	0/1	0.1507	0.9194		
COMPETITION ISSUES	0/1	1.034	0.545		
FEEDING PROCESS	0/1	-4.131	0.0120 *	-3.518	0.023004 *
PEN DESIGN	0/1	-0.5344	0.7477		
YEAR	2020	REF			
	2021	2.390	0.1644	8.249	6.90e-05 ***
	2022	2.244	0.1814	8.074	0.000106 ***
	2023	2.922	0.0761 .	8.600	3.36e-05 ***
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	-1.589	0.379		
OVERSTOCKING	1	0.7942	0.7051		
	0	REF			
DIRTY FLANKS	YES	-0.3627	0.8853		
	NO	REF			
Random effects					
Herd				204.33	14.294
Assessor				12.55	3.543
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 º Variance Std.Dev. for RANDOM EFFECTS					

Table S45 - Results of the univariable and multivariable LMM for the E6 biosecurity subcategory

E6 - Environment and region		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Variance^{o}	P-Value/ Std.Dev.^{o}
ENVIRONMENTAL ENRICHMENT	0/1	-0.6769	0.5661		
THERMAL COMFORT	0/1	0.9330	0.2794		
ANIMAL HEALTH	0/1	-0.7854	0.3247		
COMPETITION ISSUES	0/1	-1.3431	0.1519		
FEEDING PROCESS	0/1	-1.2072	0.1753		
PEN DESIGN	0/1	-1.1744	0.1943		
YEAR	2020	REF			
	2021	0.1549	0.8589	0.1549	0.8589
	2022	2.0400	0.0197 *	2.0400	0.0197 *
	2023	1.9866	0.0203 *	1.9866	0.0203 *
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	1.060	0.431		
OVERSTOCKING	1	-1.0074	0.5359		
	0	REF			
DIRTY FLANKS	YES	-1.6628	0.3886		
	NO	REF			
Random effects					
Herd				155.490	12.470
Assessor				9.203	3.034
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 ^{o} Variance Std.Dev. for RANDOM EFFECTS					

Table S46 - Results of the univariable and multivariable LMM for the I1 biosecurity subcategory

I1 - Disease management		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Varianceº	P-Value/ Std.Dev.º
ENVIRONMENTAL ENRICHMENT	0/1	-2.1702	0.42499		
THERMAL COMFORT	0/1	0.31283	0.87785		
ANIMAL HEALTH	0/1	0.96093	0.61068		
COMPETITION ISSUES	0/1	-2.57788	0.25210		
FEEDING PROCESS	0/1	-0.20893	0.92070		
PEN DESIGN	0/1	-1.55447	0.46636		
YEAR	2020	REF			
	2021	5.651	0.00785 **	5.651	0.00785 **
	2022	5.143	0.01428 *	5.143	0.01428 *
	2023	4.787	0.02067 *	4.787	0.02067 *
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	0.2556	0.899		
OVERSTOCKING	1	-0.17115	0.94329		
	0	REF			
DIRTY FLANKS	YES	0.57857	0.84557		
	NO	REF			
Random effects					
Herd				215.8	14.69
Assessor				199.2	14.11
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 º Variance Std.Dev. for RANDOM EFFECTS					

Table S47 - Results of the univariable and multivariable LMM for the I2 biosecurity subcategory

I2 - Farrowing and suckling period		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Variance^{o}	P-Value/ Std.Dev.^{o}
ENVIRONMENTAL ENRICHMENT	0/1	-9.080	0.00171 **	-9.211	0.001449 **
THERMAL COMFORT	0/1	0.1418	0.947		
ANIMAL HEALTH	0/1	0.6365	0.774		
COMPETITION ISSUES	0/1	0.8919	0.7123		
FEEDING PROCESS	0/1	2.338	0.3298		
PEN DESIGN	0/1	-2.105	0.3706		
YEAR	2020	REF			
	2021	2.115	0.4096	7.196	0.015913 *
	2022	4.369	0.0716 .	10.215	0.000755 ***
	2023	1.306	0.5871	7.170	0.017103 *
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	-9.975	0.212		
OVERSTOCKING	1	-0.2694	0.9202		
	0	REF			
DIRTY FLANKS	YES	1.918	0.5523		
	NO	REF			
Random effects					
Herd				124.53	11.159
Assessor				33.05	5.749
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 ^{o} Variance Std.Dev. for RANDOM EFFECTS					

Table S48 - Results of the univariable and multivariable LMM for the I3 biosecurity subcategory

I3 - Nursery unit management		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Variance^{o}	P-Value/ Std.Dev.^{o}
ENVIRONMENTAL ENRICHMENT	0/1	-1.9632	0.37049		
THERMAL COMFORT	0/1	-2.568	0.10650	-3.307	0.04240 *
ANIMAL HEALTH	0/1	0.20744	0.8997		
COMPETITION ISSUES	0/1	0.5984	0.74656		
FEEDING PROCESS	0/1	3.2664	0.07655 .	4.010	0.03186 *
PEN DESIGN	0/1	1.22665	0.48520		
YEAR	2020	REF			
	2021	3.310	0.07294 .	2.831	0.12396
	2022	8.251	5.33e-06 ***	8.378	3.53e-06 ***
	2023	5.063	0.00424 **	5.859	0.00106 **
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	-0.1047	0.982		
OVERSTOCKING	1	-2.1102	0.29663		
	0	REF			
DIRTY FLANKS	YES	-2.9982	0.22110		
	NO	REF			
Random effects					
Herd				70.43	8.393
Assessor				45.86	6.772
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 ^{o} Variance Std.Dev. for RANDOM EFFECTS					

Table S49 - Results of the univariable and multivariable LMM for the I4 biosecurity subcategory

I4 - Fattening unit management		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Varianceº	P-Value/ Std.Dev.º
ENVIRONMENTAL ENRICHMENT	0/1	-3.0338	0.268		
THERMAL COMFORT	0/1	-0.7313	0.726		
ANIMAL HEALTH	0/1	0.8852	0.646		
COMPETITION ISSUES	0/1	5.0710	0.026 *	4.786	0.0337 *
FEEDING PROCESS	0/1	1.1622	0.583		
PEN DESIGN	0/1	0.8067	0.711		
YEAR	2020	REF			
	2021	0.8266	0.709		
	2022	-0.9661	0.660		
	2023	-2.9624	0.170		
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	7.290	7.77e-05 ***	7.180	9.16e-05 ***
OVERSTOCKING	1	-4.2967	0.051362 .		
	0	REF			
DIRTY FLANKS	YES	-6.3674	0.0171 *	-5.979	0.0241 *
	NO	REF			
Random effects					
Herd				120.9	10.99
Assessor				103.3	10.16
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 º Variance Std.Dev. for RANDOM EFFECTS					

Table S50 - Results of the univariable and multivariable LMM for the I5 biosecurity subcategory

I5 - Measures between compartments, and the use of equipment		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Variance^{o}	P-Value/ Std.Dev.^{o}
ENVIRONMENTAL ENRICHMENT	0/1	-1.1015	0.5989		
THERMAL COMFORT	0/1	0.5889	0.7066		
ANIMAL HEALTH	0/1	0.04607	0.9746		
COMPETITION ISSUES	0/1	1.1676	0.5015		
FEEDING PROCESS	0/1	0.9346	0.5641		
PEN DESIGN	0/1	-1.7925	0.2754		
YEAR	2020	REF			
	2021	-0.7368	0.6503	-0.906	0.5731
	2022	3.5662	0.0280 *	3.136	0.0502 .
	2023	3.7795	0.0181 *	3.586	0.0231 *
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	12.834	2.51e-14 ***	12.671	3.47e-14 ***
OVERSTOCKING	1	-1.2217	0.524		
	0	REF			
DIRTY FLANKS	YES	-1.6898	0.4759		
	NO	REF			
Random effects					
Herd				145.1	12.04
Assessor				174.6	13.21
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 ^{o} Variance Std.Dev. for RANDOM EFFECTS					

Table S51 - Results of the univariable and multivariable LMM for the I6 biosecurity subcategory

I6 - Cleaning and disinfection		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Variance^{o}	P-Value/ Std.Dev.^{o}
ENVIRONMENTAL ENRICHMENT	0/1	-6.5605	0.0475 *		
THERMAL COMFORT	0/1	-1.414	0.5686		
ANIMAL HEALTH	0/1	0.4191	0.8555		
COMPETITION ISSUES	0/1	-3.837	0.1618		
FEEDING PROCESS	0/1	0.2844	0.2844		
PEN DESIGN	0/1	-2.414	0.3534		
YEAR	2020	REF			
	2021	-3.057	0.236		
	2022	2.404	0.346		
	2023	1.626	0.518		
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	5.480	0.029 *	5.404	0.02928 *
OVERSTOCKING	1	-3.949	0.1824		
	0	REF			
DIRTY FLANKS	YES	-11.213	0.0020 **	-11.490	0.00162 **
	NO	REF			
Random effects					
Herd				328.7	18.13
Assessor				252.6	15.89
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 ^{o} Variance Std.Dev. for RANDOM EFFECTS					

Table S52 - Results of the univariable and multivariable LMM for the Overall biosecurity category

Overall		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Varianceº	P-Value/ Std.Dev.º
ENVIRONMENTAL ENRICHMENT	0/1	0.1334	0.857		
THERMAL COMFORT	0/1	0.7518	0.508		
ANIMAL HEALTH	0/1	0.8286	0.233		
COMPETITION ISSUES	0/1	-0.1820	0.828		
FEEDING PROCESS	0/1	0.04355	0.954		
PEN DESIGN	0/1	0.7760	0.777		
YEAR	2020	REF			
	2021	1.3727	0.072661 .	1.3388	0.078032 .
	2022	2.8033	0.000273 ***	2.7024	0.000416 ***
	2023	2.4138	0.001415 **	2.3569	0.001715 **
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	2.8775	0.0012 **	2.7419	0.001836 **
OVERSTOCKING	1	-1.693	0.112		
	0	REF			
DIRTY FLANKS	YES	-2.318	0.0768 .		
	NO	REF			
Random effects					
Herd				50.33	7.094
Assessor				47.65	6.903
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 º Variance Std.Dev. for RANDOM EFFECTS					

Table S53 - Results of the univariable and multivariable LMM for the Internal biosecurity category

Internal		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Variance^{o}	P-Value/ Std.Dev.^{o}
ENVIRONMENTAL ENRICHMENT	0/1	0.09964	0.935		
THERMAL COMFORT	0/1	-0.5794	0.639		
ANIMAL HEALTH	0/1	0.5474	0.632		
COMPETITION ISSUES	0/1	0.3097	0.822		
FEEDING PROCESS	0/1	1.408	0.261		
PEN DESIGN	0/1	0.1378	0.914		
YEAR	2020	REF			
	2021	1.442	0.2586	1.410	0.2655
	2022	2.748	0.0313 *	2.484	0.0493 *
	2023	2.056	0.1012	1.966	0.1135
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	7.864	1.01e-08 ***	7.719	1.56e-08 ***
OVERSTOCKING	1	-2.504	0.134		
	0	REF			
DIRTY FLANKS	YES	-4.060	0.0485 *	-3.885	0.0490 *
	NO	REF			
Random effects					
Herd				107.3	10.359
Assessor				112.0	10.585
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 ^{o} Variance Std.Dev. for RANDOM EFFECTS					

Table S54 - Results of the univariable and multivariable LMM for the External biosecurity category

External		Uni		Multi	
Variable	Category	Estimate	P-value	Estimate/ Variance^{o}	P-Value/ Std.Dev.^{o}
ENVIRONMENTAL ENRICHMENT	0/1	0.1733	0.768		
THERMAL COMFORT	0/1	-0.4135	0.485		
ANIMAL HEALTH	0/1	1.1551	0.0346 *		
COMPETITION ISSUES	0/1	-0.5462	0.405		
FEEDING PROCESS	0/1	-1.2945	0.0304 *		
PEN DESIGN	0/1	0.3553	0.559		
YEAR	2020	REF			
	2021	1.3045	0.0293 *	1.3366	0.026705 *
	2022	3.0668	3.89e-07 ***	3.1839	1.71e-07 ***
	2023	2.8535	1.52e-06 ***	2.9347	9.02e-07 ***
FARM TYPE	FARROW-TO-FINISH	REF			
	FATTENING	-2.255	0.000641 ***	-2.4022	0.000225 ***
OVERSTOCKING	1	-0.9734	0.221		
	0	REF			
DIRTY FLANKS	YES	-0.7928	0.418		
	NO	REF			
Random effects					
Herd				25.66	5.065
Assessor				11.66	3.415
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 ^{o} Variance Std.Dev. for RANDOM EFFECTS					

Table S55 - Results of the univariable and multivariable GLMM for the EE welfare subcategory

ENVIRONMENTAL ENRICHMENT		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
E1		0.4242	0.0392 *			
E2		-0.8523	0.00011 ***			
E3		-1.2160	1.09e-07 ***	-1.7747	0.17 [0.02;0.40]	5.33e-05 ***
E4		-0.8960	0.00151 **			
E5		-1.6599	-1.6599	-2.9776	0.05 [0.02;0.14]	2.97e-09 ***
E6		-0.5332	0.0742 .			
I1		-0.01375	0.952			
I2		-0.7849	0.00345 **	-1.5747	0.21 [0.07; 0.56]	0.00203 **
I3		-0.7296	0.0322 *			
I4		0.5336	0.0611 .	1.3422	3.83 [1.10; 13.38]	0.03552 *
I5		0.1563	0.569			
I6		-0.5184	0.0336 *			
OVERSTOCKING	0	REF				
	1	0.3583	0.183			
% Slattered floor	0%	-10.5194	<2e-16 ***	-10.6706	<0.0001 [9.13e-09;0.0590]	0.00765 **
	1-25%	1.7407	0.0682 .	4.8505	1.28 [0.01; 0.06]	0.30360
	26-50%	-0.4804	0.6459	0.3431	1.41 [0.02; 67.81]	0.8621
	51-75%	-0.8328	0.2300	-0.1907	0.83 [0.02;36.38]	0.92132
	76-100%	REF				
TUCKED TAILS	NO	REF				
	YES	-0.07599	0.814			
Fixtures & fittings	NO	REF				
	YES	0.4859	0.173			
INJURY	NO	REF				
	YES	-0.3196	0.234			
DAMAGING	NO	REF				
	YES	-0.8648	0.00083 ***	-0.9884	0.37 [0.15; 0.92]	0.03217 *
OPTIMAL ENRICHMENT		-0.5694	4.32e-05 ***	-0.7845	0.46 [0.27; 0.77]	0.00368 **
SUBOPTIMAL ENRICHMENT		0.29160	0.000398 ***			
MARGINAL ENRICHMENT		0.06003	0.301266			
YEAR	2020	REF				
	2021	6.9112	<2e-16 ***	13.2600	>1000 [2.49e+04; 1.32e+07]	< 2e-16 ***
	2022	8.4015	<2e-16 ***	16.7924	>1000 [5.05e+05; 7.62e+08]	< 2e-16 ***
	2023	9.3268	<2e-16 ***	18.7485	>1000 [1.85e+06; 1.04e+10]	< 2e-16 ***

FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.7794	0.011789 *			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	-0.1806	0.183			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			39.08		6.251
VET	RANDOM EFFECTS			110.10		10.493
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1						

Table S56 - Results of the univariable and multivariable GLMM for the TC welfare subcategory

THERMAL COMFORT		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
E1		-0.16559	0.0194 *			
E2		-0.21850	0.0179 *			
E3		-0.4739	2.28e-05 ***	-0.4822	0.62 [0.49; 0.77]	1.99e-05 ***
E4		0.03459	0.761			
E5		-0.1586	0.122			
E6		0.2742	0.032 *	0.2977	1.35 [1.04; 1.75]	0.0293 *
I1		-0.06026	0.532			
I2		-0.0213	0.849			
I3		-0.2455	0.0455 *			
I4		-0.03519	0.753			
I5		0.02463	0.841			
I6		0.004124	0.969			
OVERSTOCKING	0	REF				
	1	0.09771	0.54769			
% Slattered floor	0%	0.06804	0.923775			
	1-25%	0.01828	0.965671			
	26-50%	0.05270	0.929244			
	51-75%	0.53403	0.183344			
	76-100%	REF				
DIRTY FLANKS	NO	REF				
	YES	-0.2892	0.118693			
YEAR	2020	REF				
	2021	1.0978	0.00107 **	0.4483	1.57 [0.76; 3.23]	0.2260
	2022	3.4798	< 2e-16 ***	2.0350	7.65 [3.94;14.86]	1.88e-09 ***
	2023	3.4183	< 2e-16 ***	2.0947	8.12 [4.13; 15.98]	1.28e-09 ***
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	-0.1469	0.503			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	-0.02069	0.868			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			2.96		1.721
VET	RANDOM EFFECTS			15.25		3.906
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1						

Table S57 - Results of the univariable and multivariable GLMM for the AH welfare subcategory

ANIMAL HEALTH		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
E1		0.5649	0.00204 **	0.5825	1.79 [1.24; 2.59]	0.00194 **
E2		0.17223	0.0568 *			
E3		0.01649	0.8787			
E4		0.2421	0.0624 .			
E5		0.2859	0.00809 **	0.2959	1.34 [1.06; 1.70]	0.01460 *
E6		-0.1215	0.3382			
I1		0.05097	0.6040			
I2		0.1557	0.29251			
I3		-0.1158	0.4539			
I4		-0.2106	0.1101			
I5		0.04023	0.7513			
I6		-0.01503	0.8921			
OVERSTOCKING	0	REF				
	1	0.03823	0.8216			
% Slattered floor	0%	-0.55777	0.48038	-0.4744	0.62 [0.11; 3.67]	0.60019
	1-25%	0.07137	0.89358	0.2857	1.33 [0.40; 4.40]	0.63947
	26-50%	0.98500	0.06126 .	1.5084	4.52 [1.42; 14.39]	0.01068 *
	51-75 %	-1.23027	0.00577 **	-1.1207	0.33 [0.12; 0.89]	0.02921 *
	76-100%	REF				
INJURY	YES	REF				
	NO	0.9302	1.64e-09***	1.0048	2.73 [1.95; 3.83]	5.02e-09 ***
YEAR	2020	REF				
	2021	0.01576	0.9467	-0.2092	0.81 [0.48; 1.37]	0.43319
	2022	2.52959	< 2e-16 ***	1.6045	4.98 [3.06; 8.09]	9.50e-11 ***
	2023	1.57363	3.49e-13 ***	0.6872	1.99 [1.22; 3.25]	0.00619 **
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.2901	0.252			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	0.0544	0.669			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			4.564		2.136
VET	RANDOM EFFECTS			18.964		4.355
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1						

Table S58 - Results of the univariable and multivariable GLMM for the CI welfare subcategory

COMPETITION ISSUES		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
E1		-0.30362	0.00194 **	-0.3366	0.71 [0.57; 0.90]	0.004351 **
E2		-0.1035	0.3955			
E3		-0.2024	0.1199			
E4		0.2546	0.0942 .	0.4507	1.57 [1.06; 2.33]	0.024908 *
E5		0.2291	0.0939 .			
E6		-0.2587	0.0863 .			
I1		-0.007688	0.9473			
I2		-0.03773	0.78963			
I3		0.1779	0.248103			
I4		0.7462	1.12e-05 **			
I5		0.1115	0.494			
I6		-0.1081	0.4518			
OVERSTOCKING	0	REF				
	1	-0.05717	0.7459			
% Slattered floor	0%	0.25651	0.7490			
	1-25%	-0.35164	0.4825			
	26-50%	-1.10023	0.1769			
	51-75%	0.21883	0.6521			
	76-100%	REF				
TUCKED TAILS	NO	REF				
	YES	0.2241	0.4166			
INJURY	NO	REF				
	YES	0.4322	0.0123 *	0.5528	1.74 [1.07; 2.83]	0.026307 *
OPTIMAL ENRICH		-0.0006646	0.99517			
SUBOPTIMAL ENRICH		-0.5447	0.00163 **	-0.6765	0.51 [0.32; 0.81]	0.004336 **
MARGINAL ENRICH		0.002025	0.00163 **			
FEED AT SAME TIME	NO	REF				
	YES	-0.4922	0.0529 .			
ENRICHMENT BEHAVIOUR	NO	REF				
	YES	0.3147	0.0574 .	0.6992	2.01 [1.24; 3.26]	0.004541 **
AGGRESSIVE BITING	NO	REF				
	YES	0.2528	0.2270			
PROPORTION DRINKER PER PIG		-0.06311	0.6259			
YEAR	2020	REF				
	2021	0.4908	0.1320	0.8849	2.42 [0.97; 6.03]	0.056995 .
	2022	3.0180	< 2e-16 ***	3.0951	22.09 [8.53; 57.20]	1.82e-10 ***
	2023	1.8380	9.23e-10 ***	1.6195	5.05 [1.96; 13.01]	0.000797 ***
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.02679	0.916			

PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	0.1776	0.210			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			4.268		2.066
VET	RANDOM EFFECTS			18.578		4.310
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1						

Table S59 - Results of the univariable and multivariable GLMM for the FP welfare subcategory

FEEDING PROCESS		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
E1		-0.08128	0.41949			
E2		-0.05369	0.6526			
E3		-0.3988	0.00278 **	-0.46103	0.63 [0.46; 0.87]	0.005052 **
E4		-0.08223	0.56446			
E5		-0.3919	0.00340 **	-0.65006	0.52 [0.36; 0.75]	0.000455 ***
E6		-0.7143	0.000208 ***	-1.00915	0.36 [0.24; 0.56]	5.02e-06 ***
I1		0.1063	0.37662			
I2		0.1848	0.26771			
I3		0.2571	0.2227			
I4		0.1839	0.18837			
I5		0.09329	0.53865			
I6		-0.3383	0.01405 *			
OVERSTOCKING	0	REF				
	1	-0.2656	0.145917			
% Slattered floor	0%	-0.5482	0.56907	-1.19789	0.30 [0.02; 4.04]	0.365548
	1-25%	-3.4732	7.62e-05 ***	-4.56449	0.01 [0.0007; 0.15]	0.000881 ***
	26-50%	-0.2451	0.75014	0.81613	2.26 [0.32; 16.10]	0.415052
	51-75%	-0.8045	0.11619	-0.56476	0.57 [0.15; 2.20]	0.413620
	76-100%	REF				
INJURY	NO	REF				
	YES	0.3266	0.041110 *			
DAMAGING	NO	REF				
	YES	0.1497	0.41137			
FEED AT SAME TIME	NO	REF				
	YES	-0.5326	0.042436 *			
AGGRESSIVE BITING	NO	REF				
	YES	-0.1416	0.5201			
YEAR	2020	REF				
	2021	0.3386	0.210256			
	2022	2.2103	< 2e-16 ***			
	2023	0.8757	0.000645 ***			
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.2192	0.436			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	0.1482	0.298			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			9.34		3.056
VET	RANDOM EFFECTS			39.14		6.256
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1						

Table S60 - Results of the univariable and multivariable GLMM for the PD welfare subcategory

PEN DESIGN		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
E1		0.03751	0.726			
E2		-0.4812	0.000413 ***	-0.52218	0.59 [0.45; 0.79]	0.00031 ***
E3		-0.1957	0.1509			
E4		-0.1814	0.2288			
E5		-0.1585	0.2509			
E6		-0.7143	0.000208 ***			
I1		-0.03663	0.7677			
I2		-0.01101	0.943			
I3		-0.04158	0.8167			
I4		0.1845	0.2330			
I5		-0.2732	0.1049			
I6		-0.07194	0.6135			
OVERSTOCKING	0	REF				
	1	-0.0238260	0.906536			
% Slattered floor	0%	-0.39438	0.646550			
	1-25%	-0.51539	0.364167			
	26-50%	-0.54980	0.490203			
	51-75%	0.66716	0.188177			
	76-100%	REF				
DIRTY FLANKS	NO	REF				
	YES	0.2670	0.268788			
OPTIMAL ENRICH		-0.08991	0.555			
SUBOPTIMAL ENRICH		-0.5125	0.00436 **			
MARGINAL ENRICH		0.10594	0.123210	0.19745	1.22 [1.02; 1.45]	0.02805 *
ENRICHMENT BEHAVIOUR	NO	REF				
	YES	-0.0110	0.949150			

PROPORTION DRINKER PER PIG		0.08213	0.451608			
YEAR	2020	REF				
	2021	0.2942	0.547577	0.62657	1.87 [0.51; 6.83]	0.34265
	2022	4.9307	< 2e-16 ***	4.23664	69.18 [21.69; 220.58]	8.03e-13 ***
	2023	3.9487	< 2e-16 ***	3.37828	29.32 [9.09; 94.55]	1.56e-08 ***
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.05614	0.828			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	-0.05058	0.724			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			3.954		1.989
VET	RANDOM EFFECTS			20.041		4.477
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1						

Table S61 - Results of the univariable and multivariable GLMM for the EE welfare subcategory by Overall category

ENVIRONMENTAL ENRICHMENT		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
Overall		0.3373	0.0115 *	-1.4107	0.24 [0.12;0.48]	4.42e-05 ***
OVERSTOCKING	0	REF				
	1	0.3583	0.183			
% Slattered floor	0%	-10.5194	<2e-16 ***			
	1-25%	1.7407	0.0682 .			
	26-50%	-0.4804	0.6459			
	51-75%	-0.8328	0.2300			
	76-100%	REF				
TUCKED TAILS	NO	REF				
	YES	-0.07599	0.814			
Fixtures & fittings	NO	REF				
	YES	0.4859	0.173			
INJURY	NO	REF				
	YES	-0.3196	0.234			
DAMAGING	NO	REF				
	YES	-0.8648	0.00083 ***	-0.8892	0.41 [0.22;0.78]	0.00668 **
OPTIMAL ENRICHMENT		-0.5694	4.32e-05 ***	-0.8536	0.43 [0.29;0.62]	1.16e-05 ***
SUBOPTIMAL ENRICHMENT		0.29160	0.000398 ***			
MARGINAL ENRICHMENT		0.06003	0.301266			
YEAR	2020	REF				
	2021	6.9112	<2e-16 ***	9.2147	>1000 [2531.50; 3,9847.23]	< 2e-16 ***
	2022	8.4015	<2e-16 ***	10.5516	>1000 [7359.78; 1.98e+05]	< 2e-16 ***
	2023	9.3268	<2e-16 ***	10.2917	>1000 [5663.55; 1.53e+05]	< 2e-16 ***
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.7794	0.011789 *	1.6811	5.37 [1.28; 22.60]	0.02185 *
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	-0.1806	0.183			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			21.44		4.630
VET	RANDOM EFFECTS			26.12		5.111
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1						

Table S62 - Results of the univariable and multivariable GLMM for the TC welfare subcategory by Overall category

THERMAL COMFORT		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
OVERALL		-0.1172	0.301			
OVERSTOCKING	0	REF				
	1	0.09771	0.54769			
% Slattered floor	0%	0.06804	0.923775			
	1-25%	0.01828	0.965671			
	26-50%	0.05270	0.929244			
	51-75%	0.53403	0.183344			
	76-100%	REF				
DIRTY FLANKS	NO	REF				
	YES	-0.2892	0.118693			
YEAR	2020	REF				
	2021	1.0978	0.00107 **	1.0978	2.30 [1.55; 5.79]	0.00107 **
	2022	3.4798	< 2e-16 ***	3.4798	32.45 [17.56; 59.98]	< 2e-16 ***
	2023	3.4183	< 2e-16 ***	3.4183	30.52 [16.35; 56.96]	< 2e-16 ***
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	-0.1469	0.503			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	-0.02069	0.868			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			2.246		1.499
VET	RANDOM EFFECTS			10.639		3.262
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1						

Table S63 - Results of the univariable and multivariable GLMM for the AH welfare subcategory by Overall category

ANIMAL HEALTH		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
OVERALL		0.1926	0.111			
OVERSTOCKING	0	REF				
	1	0.03823	0.8216			
% Slattered floor	0%	-0.55777	0.48038	-0.43	0.65 [0.13; 3.16]	0.5956
	1-25%	0.07137	0.89358	0.26845	1.31 [0.45; 3.83]	0.6243
	26-50%	0.98500	0.06126 .	1.15221	3.17 [1.10; 9.12]	0.0328 *
	51-75	-1.23027	0.00577 **	-1.16015	0.31 [0.13; 0.77]	0.0118 *
	76-100%	REF				
INJURY	YES	REF				
	NO	0.9302	1.64e-09***	0.93515	2.55 [1.88; 3.45]	1.75e-09 ***
YEAR	2020	REF				
	2021	0.01576	0.9467	0.09257	1.10 [0.68; 1.76]	0.7012
	2022	2.52959	< 2e-16 ***	2.74154	15.51 [10.05; 23.95]	< 2e-16 ***
	2023	1.57363	3.49e-13 ***	1.77408	5.89 [3.81; 9.13]	1.86e-15 ***
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.2901	0.252			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	0.0544	0.669			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			3.82		1.955
VET	RANDOM EFFECTS			15.55		3.943
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1						

Table S64 - Results of the univariable and multivariable GLMM for the CI welfare subcategory by Overall category

COMPETITION ISSUES		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
OVERALL		-0.009044	0.945			
OVERSTOCKING	0	REF				
	1	-0.05717	0.7459			
% Slattered floor	0%	0.25651	0.7490			
	1-25%	-0.35164	0.4825			
	26-50%	-1.10023	0.1769			
	51-75%	0.21883	0.6521			
	76-100%	REF				
TUCKED TAILS	NO	REF				
	YES	0.2241	0.4166			
INJURY	NO	REF				
	YES	0.4322	0.0123 *	0.5275	1.69 [1.16; 2.47]	0.00586 **
OPTIMAL ENRICH		-0.0006646	0.99517			
SUBOPTIMAL ENRICH		-0.5447	0.00163 **	-0.5506	0.58 [0.41; 0.81]	0.00140 **
MARGINAL ENRICH		0.002025	0.00163 **			
FEED AT SAME TIME	NO	REF				
	YES	-0.4922	0.0529 .			
ENRICHMENT BEHAVIOUR	NO	REF				
	YES	0.3147	0.0574 .			
AGGRESSIVE BITING	NO	REF				
	YES	0.2528	0.2270			
PROPORTION DRINKER PER PIG		-0.06311	0.6259			
YEAR	2020	REF				
	2021	0.4908	0.1320	0.7056	2.03 [1.08; 3.81]	0.02854 *
	2022	3.0180	< 2e-16 ***	3.4701	32.14 [17.05; 60.59]	< 2e-16 ***
	2023	1.8380	9.23e-10 ***	2.1171	8.31 [4.49; 15.37]	1.53e-11 ***
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.02679	0.916			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	0.1776	0.210			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			2.644		1.626
VET	RANDOM EFFECTS			14.775		3.844
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1						

Table S65 - Results of the univariable and multivariable GLMM for the FP welfare subcategory by Overall category

FEEDING PROCESS		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
OVERALL		-0.2702	0.0643 .			
OVERSTOCKING	0	REF				
	1	-0.2656	0.145917			
% Slattered floor	0%	-0.5482	0.56907	-0.5740	0.56 [0.09; 3.70]	0.55021
	1-25%	-3.4732	7.62e-05 ***	-3.5079	0.03 [0.005; 0.17]	5.81e-05 ***
	26-50%	-0.2451	0.75014	-0.2303	0.79 [0.18; 3.59]	0.76471
	51-75%	-0.8045	0.11619	-0.7931	0.45 [0.17; 1.23]	0.11979
	76-100%	REF				
INJURY	NO	REF				
	YES	0.3266	0.041110 *			
DAMAGING	NO	REF				
	YES	0.1497	0.41137			
FEED AT SAME TIME	NO	REF				
	YES	-0.5326	0.042436 *			
AGGRESSIVE BITING	NO	REF				
	YES	-0.1416	0.5201			
YEAR	2020	REF				
	2021	0.3386	0.210256	0.2907	1.34 [0.78; 2.28]	0.28515
	2022	2.2103	< 2e-16 ***	2.2061	9.08 [5.55; 14.86]	< 2e-16 ***
	2023	0.8757	0.000645 ***	0.8514	2.34 [1.41; 3.89]	0.00101 **
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.2192	0.436			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	0.1482	0.298			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			4.028		2.007
VET	RANDOM EFFECTS			18.880		4.345
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1						

Table S66 - Results of the univariable and multivariable GLMM for the PD welfare subcategory by Overall category

PEN DESIGN		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
OVERALL		-0.1086	0.412			
OVERSTOCKING	0	REF				
	1	-0.0238260	0.906536			
% Slattered floor	0%	-0.39438	0.646550			
	1-25%	-0.51539	0.364167			
	26-50%	-0.54980	0.490203			
	51-75%	0.66716	0.188177			
	76-100%	REF				
DIRTY FLANKS	NO	REF				
	YES	0.2670	0.268788			
OPTIMAL ENRICH		-0.08991	0.555			
SUBOPTIMAL ENRICH		-0.5125	0.00436 **	-0.5125	0.60 [0.42; 0.85]	0.00436 **
MARGINAL ENRICH		0.10594	0.123210			
ENRICHMENT BEHAVIOUR	NO	REF				
	YES	-0.0110	0.949150			
PROPORTION DRINKER PER PIG		0.08213	0.451608			
YEAR	2020	REF				
	2021	0.2942	0.547577	0.4086	1.50 [0.58; 3.88]	0.39829
	2022	4.9307	< 2e-16 ***	5.3297	206.37 [84.93;501.41]	< 2e-16 ***
	2023	3.9487	< 2e-16 ***	4.0731	58.74 [24.74; 139.45]	< 2e-16 ***
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.05614	0.828			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	-0.05058	0.724			
				Variance		Std.Dev.

HERD_NO	RANDOM EFFECTS			3.13		1.769
VET	RANDOM EFFECTS			12.85		3.585
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1						

Table S67 - Results of the univariable and multivariable GLMM for the EE welfare subcategory by External and Internal category

ENVIRONMENTAL ENRICHMENT		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
EXTERNAL		0.2913	0.00995 **	-3.3427	0.04 [0.01;0.10]	2.66e-10 ***
INTERNAL		0.2375	0.0744 .	1.0037	2.73 [1.14; 6.51]	0.02367 *
OVERSTOCKING	0	REF				
	1	0.3583	0.183			
% Slattered floor	0%	-10.5194	<2e-16 ***	-9.8807	<0.0001 [8.05e-07; 3.25e-03]	3.10e-06 ***
	1-25%	1.7407	0.0682 .	0.8985	2.46 [0.17;34.60]	0.50560
	26-50%	-0.4804	0.6459	1.5178	4.56 [0.16;128.78]	0.37315
	51-75%	-0.8328	0.2300	-0.5199	0.59 [0.03;10.46]	0.72232
	76-100%	REF				
TUCKED TAILS	NO	REF				
	YES	-0.07599	0.814			
Fixtures & fittings	NO	REF				
	YES	0.4859	0.173			
INJURY	NO	REF				
	YES	-0.3196	0.234			
DAMAGING	NO	REF				
	YES	-0.8648	0.00083 ***	-1.0194	0.36 [0.18;0.74]	0.00503 **
OPTIMAL ENRICHMENT		-0.5694	4.32e-05 ***	-0.9406	0.39 [0.26;0.60]	1.27e-05 ***
SUBOPTIMAL ENRICHMENT		0.29160	0.000398 ***			
MARGINAL ENRICHMENT		0.06003	0.301266			
YEAR	2020	REF				
	2021	6.9112	<2e-16 ***	11.6300	>1000 [1.77e+04; 7.11e+05]	<2e-16 ***
	2022	8.4015	<2e-16 ***	13.3971	>1000 [7.19e+04; 6.02e+06]	<2e-16 ***
	2023	9.3268	<2e-16 ***	14.1999	>1000 [1.20e+05; 1.79e+07]	<2e-16 ***
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.7794	0.011789 *			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	-0.1806	0.183			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			46.30		6.804
VET	RANDOM EFFECTS			57.29		7.569
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1						

Table S68 - Results of the univariable and multivariable GLMM for the TC welfare subcategory by External and Internal category

THERMAL COMFORT		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
EXTERNAL		-0.17115	0.0774 .	-0.3371	0.71 [0.58; 0.87]	0.00104
INTERNAL		-0.04045	0.722			
OVERSTOCKING	0	REF				
	1	0.09771	0.54769			
% Slattered floor	0%	0.06804	0.923775			
	1-25%	0.01828	0.965671			
	26-50%	0.05270	0.929244			
	51-75%	0.53403	0.183344			
	76-100%	REF				
DIRTY FLANKS	NO	REF				
	YES	-0.2892	0.118693			
YEAR	2020	REF				
	2021	1.0978	0.00107 **	0.5236	1.69 [0.80; 3.57]	0.16990
	2022	3.4798	< 2e-16 ***	2.1698	8.76 [4.37; 17.53]	8.92e-10 ***
	2023	3.4183	< 2e-16 ***	2.2556	9.54 [4.70; 19.38]	4.38e-10 ***
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	-0.1469	0.503			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	-0.02069	0.868			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			2.751		1.659
VET	RANDOM EFFECTS			14.579		3.818
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1						

Table S69 - Results of the univariable and multivariable GLMM for the AH welfare subcategory by External and Internal category

ANIMAL HEALTH		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
EXTERNAL		0.4947	1.08e-05 ***	0.3731	1.45 [1.14; 1.86]	0.00291 **
INTERNAL		-0.0372	0.763			
OVERSTOCKING	0	REF				
	1	0.03823	0.8216			
% Slattered floor	0%	-0.55777	0.48038	-0.4721	0.62 [0.12; 3.67]	0.60152
	1-25%	0.07137	0.89358	0.3864	1.47 [0.44; 4.92]	0.53002
	26-50%	0.98500	0.06126 .	1.4837	4.41 [1.37; 14.20]	0.01290 *
	51-75	-1.23027	0.00577 **	-1.1341	0.32 [0.12; 0.89]	0.02974 *
	76-100%	REF				
INJURY	YES	REF				
	NO	0.9302	1.64e-09***	1.0022	2.72 [1.94; 3.82]	5.92e-09 ***
YEAR	2020	REF				
	2021	0.01576	0.9467	-0.2896	0.75 [0.44; 1.26]	0.27877
	2022	2.52959	< 2e-16 ***	1.4695	4.35 [2.67; 7.08]	3.47e-09 ***
	2023	1.57363	3.49e-13 ***	0.5809	1.79 [1.09; 2.93]	0.02120 **
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.2901	0.252			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	0.0544	0.669			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			5.041		2.245
VET	RANDOM EFFECTS			20.700		4.550
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1						

Table S70 - Results of the univariable and multivariable GLMM for the CI welfare subcategory by External and Internal category

COMPETITION ISSUES		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
EXTERNAL		-0.2964	0.00924 **	-0.4162	0.66 [0.49; 0.89]	0.007275 **
INTERNAL		0.1760	0.179			
OVERSTOCKING	0	REF				
	1	-0.05717	0.7459			
% Slattered floor	0%	0.25651	0.7490			
	1-25%	-0.35164	0.4825			
	26-50%	-1.10023	0.1769			
	51-75%	0.21883	0.6521			
	76-100%	REF				
TUCKED TAILS	NO	REF				
	YES	0.2241	0.4166			
INJURY	NO	REF				
	YES	0.4322	0.0123 *	0.6014	1.82 [1.15; 2.90]	0.011155 *
OPTIMAL ENRICH		-0.0006646	0.99517			
SUBOPTIMAL ENRICH		-0.5447	0.00163 **	-0.5212	0.59 [0.39; 0.90]	0.013080 *
MARGINAL ENRICH		0.002025	0.00163 **			
FEED AT SAME TIME	NO	REF				
	YES	-0.4922	0.0529 .			
ENRICHMENT BEHAVIOUR	NO	REF				
	YES	0.3147	0.0574 .	0.8212	2.27 [1.43; 3.61]	0.000498 ***
AGGRESSIVE BITING	NO	REF				
	YES	0.2528	0.2270			
PROPORTION DRINKER PER PIG		-0.06311	0.6259			
YEAR	2020	REF				
	2021	0.4908	0.1320	1.0634	2.90 [1.15; 7.29]	0.024028 *
	2022	3.0180	< 2e-16 ***	3.5473	34.72 [13.46; 89.53]	2.14e-13 ***
	2023	1.8380	9.23e-10 ***	1.8710	6.49 [2.52; 16.71]	0.000105 ***
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.02679	0.916			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	0.1776	0.210			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			3.786		1.946
VET	RANDOM EFFECTS			18.888		4.346
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1						

Table S71 - Results of the univariable and multivariable GLMM for the FP welfare subcategory by External and Internal category

FEEDING PROCESS		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
EXTERNAL		-0.3468	1.89e-06 ***	-0.5905	0.55 [0.40; 0.78]	0.000581 ***
INTERNAL		0.02017	0.887			
OVERSTOCKING	0	REF				
	1	-0.2656	0.145917			
% Slattered floor	0%	-0.5482	0.56907	-1.0940	0.33 [0.03; 3.34]	0.351321
	1-25%	-3.4732	7.62e-05 ***	-3.8137	0.02 [0.002; 0.22]	0.001132 **
	26-50%	-0.2451	0.75014	0.7020	2.02 [0.31; 13.01]	0.460451
	51-75%	-0.8045	0.11619	-0.5870	0.56 [0.16; 1.98]	0.365283
	76-100%	REF				
INJURY	NO	REF				
	YES	0.3266	0.041110 *			
DAMAGING	NO	REF				
	YES	0.1497	0.41137			
FEED AT SAME TIME	NO	REF				
	YES	-0.5326	0.042436 *			
AGGRESSIVE BITING	NO	REF				
	YES	-0.1416	0.5201			
YEAR	2020	REF				
	2021	0.3386	0.210256	0.5216	1.68 [0.89; 3.19]	0.108629
	2022	2.2103	< 2e-16 ***	0.7493	2.12 [1.10; 4.06]	0.024170 *
	2023	0.8757	0.000645 ***	-0.6541	0.52 [0.26; 1.04]	0.065377 *
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.2192	0.436			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	0.1482	0.298			
				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			7.841		2.800
VET	RANDOM EFFECTS			35.274		5.939
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1						

Table S72 - Results of the univariable and multivariable GLMM for the PD welfare subcategory by External and Internal category

PEN DESIGN		Uni		Multi		
Variable	Category	Estimate	P-value	Estimate	OR with 95%	P-Value
EXTERNAL		-0.1103	0.339			
INTERNAL		-0.06202	0.640			
OVERSTOCKING	0	REF				
	1	-0.0238260	0.906536			
% Slattered floor	0%	-0.39438	0.646550			
	1-25%	-0.51539	0.364167			
	26-50%	-0.54980	0.490203			
	51-75%	0.66716	0.188177			
	76-100%	REF				
DIRTY FLANKS	NO	REF				
	YES	0.2670	0.268788			
OPTIMAL ENRICH		-0.08991	0.555			
SUBOPTIMAL ENRICH		-0.5125	0.00436 **	-0.5125	0.60 [0.42; 0.85]	0.00436 **
MARGINAL ENRICH		0.10594	0.123210			
ENRICHMENT BEHAVIOUR	NO	REF				
	YES	-0.0110	0.949150			
PROPORTION DRINKER PER PIG		0.08213	0.451608			
YEAR	2020	REF				
	2021	0.2942	0.547577	0.4086	1.50 [0.58; 3.88]	0.39829
	2022	4.9307	< 2e-16 ***	5.3297	206.37 [84.93; 501.42]	< 2e-16 ***
	2023	3.9487	< 2e-16 ***	4.0731	58.74 [24.74; 139.45]	< 2e-16 ***
FARM TYPE	FARROW-TO-FINISH	REF				
	FATTENING	0.05614	0.828			
PEN TYPE	FATTENING HOUSE	REF				
	WEANER HOUSE	-0.05058	0.724			

				Variance		Std.Dev.
HERD_NO	RANDOM EFFECTS			3.13		1.769
VET	RANDOM EFFECTS			12.85		3.585
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1						

ANIMAL HEALTH IRELAND

Assessment and Management of Risk Factors in Animal Welfare in Pig Production

Farmer Name:

09062023 PIGS TAIBITRIS FORM V1.2

www.animalhealthireland.ie

NATIONAL PIG HEALTH PROGRAMME

Animal Health Ireland, 2-5 The Archways, Carrick-on-Shannon, Co. Leitrim, N41 WN27

Pig HealthCheck
AnimalHealthIreland.ie

Ireland's European Structural and Investment Funds Programmes 2014-2020
Co-funded by the Irish Government and the European Union

The European Agricultural Fund for Rural Development
Europe investing in rural areas

SECTION A: 1 of 6

SECTION	
Weaner House	
Fattening House	

PIG TYPE	
Weaner Stage 1	
Weaner Stage 2	
Fatteners	

PEN ID#											
PEN LOCATION											
NUMBER OF PIGS IN THE PEN											
PEN LENGTH (M)				M							
PEN WIDTH (M)				M							
SLATTED FLOOR	0%		1-25%		26-50%		51-75%		76-100%		
SEX	Male		Female		Mixed						
FINAL WEIGHT ACHIEVED BY PIGS IN THIS PEN				KG (Avg)							
TAIL LENGTH	All docked		All long		Mixed						
CAN ALL PIGS FEED AT THE SAME TIME?	Yes		No								
HOW MANY DRINKERS ARE IN THE PEN?											

HAVE THE PIGS IN THIS PEN AN EFFECTIVE VACCINATION PROGRAMME?	
There is an effective vaccination programme for animals in this house	
An improved vaccination programme needs to be considered for animals in this house	
Vaccination for animals in this house is not sufficient to address ongoing health deficits	

		Examples (as per Commission working document)	Other examples
COUNT THE NUMBER OF TYPES OF ITEMS IN THE PEN FOR EACH CATEGORY	Optimal	Straw, green fodder (hay, grass, silage, alfalfa, etc.), miscanthus pressed or chopped, root vegetables when used as bedding	
	Sub-optimal	Peanut shells, ground wood, ground maize corn cobs, natural ropes, compressed straw cylinders, pellets, hessian cloth, shredded paper or natural soft rubber as bedding, or optimal (above) in a rack	Sawdust, woodchips, fresh soft wood planks (e.g. pine, spruce), branches of fresh wood
	Marginal	e.g. objects, such as hard plastic piping or chains.	Toys (hanging or on floor), tyres, empty cans/oil drums, balls (hanging at end of chain or on floor), hard wood planks or pieces of wood at end of chain, synthetic ropes
	None		

COUNT THE NUMBER OF PIGS IN THE PEN WITH:	Tucked tails				Flank lesions (circular)				
	Injured tails				Aggression lesions (straight)				
	Injured or imperfect ears				Dirty flanks/haunches				

RECORD OF PIG BEHAVIOURS
Stand quietly and for a 5 minute period record the number of occasions that each of the following behaviours defined below is observed in the pen

Damaging behaviour	This is oral (mouth/nose) behaviour that is directed towards another pigs' body, which can cause physical damage or pain, but is not motivated by aggression. The behaviour can range from gentle slow chewing to focused bites (usually to the ears or tails). Damaging behaviour can also take the form of sustained nosing of a body part (usually the flanks) resulting in a circular lesion. We have sub-divided it into tail, ear, flank and 'other' directed behaviours.
Fixtures and fittings	This is oral behaviour that is directed towards any physical part of the pen such as walls, floors, feeders, drinkers or pen dividers that are not designed to be rooted at or chewed by the pigs
Enrichment	This refers to any interaction the pigs direct towards the enrichment provided, including chewing, sniffing, nosing, rooting, pushing etc.
Aggressive biting	This behaviour is motivated by aggression, and unlike damaging behaviour, is normally associated with swift, forward movements by the 'attacking' pig accompanied by quick snapping movements by the jaws (i.e. open mouthed). The attacking pig may even chase the victim pig. The behaviour is normally directed towards the front part of another pig (although it can be directed towards the rear if the attacker is aiming to get access to a resource such as the feeder).

▸ BEHAVIOUR CATEGORY Damaging behaviour	Count	Total
Category (Tail, Ear etc.)	𝍸 I	6
Tail		
Ear		
Other		
Fixtures and fittings		
Enrichment		
Aggressive biting		

▸ BASED ON YOUR OBSERVATIONS OF BEHAVIOURS AND BODY LESIONS OBSERVED IN THIS PEN IS THERE A RISK OF TAIL BITING FOR THESE PIGS?	Yes	
	No	

RISK VALUES	
Risk Statement	**Risk Value**
Not Observed	0
Risk Category Statement is correct	1
I was not able to identify risks associated with this Risk Category	2
I have identified that risk exists for this Risk Category	3
There are clearly risks associated with this Risk Category	4

▸ **VETERINARY OPINION ON MEASURES ASSOCIATED WITH TAIL BITING RISK FOR THIS PEN**

Risk Category	RISK VALUE 0-4
Environmental Enrichment provision represents no risk for tail biting	
There is adequate thermal comfort and air quality for these pigs	
The health of these pigs provides no risk of tail biting	
Competition issues for the pigs in this pen do not give rise to risks for tail biting	
The pen design and use for these pigs does not present risk for tail biting	
Feeding processes for these pigs do not contribute to risks for tail biting for these pigs	

▸ **MANAGEMENT RECOMMENDATIONS**
To reduce factors considered to increase the risk of tail-biting and other aggressive behaviours at this stage of production.

1.

2.

3.

Other Comments:

SECTION A: 2 of 6

SECTION	
Weaner House	
Fattening House	

PIG TYPE	
Weaner Stage 1	
Weaner Stage 2	
Fatteners	

PEN ID#										
PEN LOCATION										
NUMBER OF PIGS IN THE PEN										
PEN LENGTH (M)				M						
PEN WIDTH (M)				M						
SLATTED FLOOR	0%		1-25%		26-50%		51-75%		76-100%	
SEX	Male		Female		Mixed					
FINAL WEIGHT ACHIEVED BY PIGS IN THIS PEN				KG (Avg)						
TAIL LENGTH	All docked		All long		Mixed					
CAN ALL PIGS FEED AT THE SAME TIME?	Yes		No							
HOW MANY DRINKERS ARE IN THE PEN?										

HAVE THE PIGS IN THIS PEN AN EFFECTIVE VACCINATION PROGRAMME?	
There is an effective vaccination programme for animals in this house	
An improved vaccination programme needs to be considered for animals in this house	
Vaccination for animals in this house is not sufficient to address ongoing health deficits	

		Examples (as per Commission working document)	Other examples
COUNT THE NUMBER OF TYPES OF ITEMS IN THE PEN FOR EACH CATEGORY	Optimal	Straw, green fodder (hay, grass, silage, alfalfa, etc.), miscanthus pressed or chopped, root vegetables when used as bedding	
	Sub-optimal	Peanut shells, ground wood, ground maize corn cobs, natural ropes, compressed straw cylinders, pellets, hessian cloth, shredded paper or natural soft rubber as bedding, or optimal (above) in a rack	Sawdust, woodchips, fresh soft wood planks (e.g. pine, spruce), branches of fresh wood
	Marginal	e.g. objects, such as hard plastic piping or chains.	Toys (hanging or on floor), tyres, empty cans/oil drums, balls (hanging at end of chain or on floor), hard wood planks or pieces of wood at end of chain, synthetic ropes
	None		

COUNT THE NUMBER OF PIGS IN THE PEN WITH:								
	Tucked tails				Flank lesions (circular)			
	Injured tails				Aggression lesions (straight)			
	Injured or imperfect ears				Dirty flanks/haunches			

RECORD OF PIG BEHAVIOURS
Stand quietly and for a 5 minute period record the number of occasions that each of the following behaviours defined below is observed in the pen

Damaging behaviour	This is oral (mouth/nose) behaviour that is directed towards another pigs' body, which can cause physical damage or pain, but is not motivated by aggression. The behaviour can range from gentle slow chewing to focused bites (usually to the ears or tails). Damaging behaviour can also take the form of sustained nosing of a body part (usually the flanks) resulting in a circular lesion. We have sub-divided it into tail, ear, flank and 'other' directed behaviours.
Fixtures and fittings	This is oral behaviour that is directed towards any physical part of the pen such as walls, floors, feeders, drinkers or pen dividers that are not designed to be rooted at or chewed by the pigs
Enrichment	This refers to any interaction the pigs direct towards the enrichment provided, including chewing, sniffing, nosing, rooting, pushing etc.
Aggressive biting	This behaviour is motivated by aggression, and unlike damaging behaviour, is normally associated with swift, forward movements by the 'attacking' pig accompanied by quick snapping movements by the jaws (i.e. open mouthed). The attacking pig may even chase the victim pig. The behaviour is normally directed towards the front part of another pig (although it can be directed towards the rear if the attacker is aiming to get access to a resource such as the feeder).

▸ BEHAVIOUR CATEGORY Damaging behaviour	Count	Total
Category (Tail, Ear etc.)	𝍸 I	6
Tail		
Ear		
Other		
Fixtures and fittings		
Enrichment		
Aggressive biting		

▸ BASED ON YOUR OBSERVATIONS OF BEHAVIOURS AND BODY LESIONS OBSERVED IN THIS PEN IS THERE A RISK OF TAIL BITING FOR THESE PIGS?	Yes	
	No	

RISK VALUES	
Risk Statement	**Risk Value**
Not Observed	0
Risk Category Statement is correct	1
I was not able to identify risks associated with this Risk Category	2
I have identified that risk exists for this Risk Category	3
There are clearly risks associated with this Risk Category	4

▸ **VETERINARY OPINION ON MEASURES ASSOCIATED WITH TAIL BITING RISK FOR THIS PEN**

Risk Category	RISK VALUE 0-4
Environmental Enrichment provision represents no risk for tail biting	
There is adequate thermal comfort and air quality for these pigs	
The health of these pigs provides no risk of tail biting	
Competition issues for the pigs in this pen do not give rise to risks for tail biting	
The pen design and use for these pigs does not present risk for tail biting	
Feeding processes for these pigs do not contribute to risks for tail biting for these pigs	

▸ **MANAGEMENT RECOMMENDATIONS**
To reduce factors considered to increase the risk of tail-biting and other aggressive behaviours at this stage of production.

1.

2.

3.

Other Comments:

SECTION A: 3 of 6

SECTION	
Weaner House	
Fattening House	

PIG TYPE	
Weaner Stage 1	
Weaner Stage 2	
Fatteners	

PEN ID#											
PEN LOCATION											
NUMBER OF PIGS IN THE PEN											
PEN LENGTH (M)				M							
PEN WIDTH (M)				M							
SLATTED FLOOR	0%		1-25%		26-50%		51-75%		76-100%		
SEX	Male		Female		Mixed						
FINAL WEIGHT ACHIEVED BY PIGS IN THIS PEN				KG (Avg)							
TAIL LENGTH	All docked		All long		Mixed						
CAN ALL PIGS FEED AT THE SAME TIME?	Yes		No								
HOW MANY DRINKERS ARE IN THE PEN?											

HAVE THE PIGS IN THIS PEN AN EFFECTIVE VACCINATION PROGRAMME?	
There is an effective vaccination programme for animals in this house	
An improved vaccination programme needs to be considered for animals in this house	
Vaccination for animals in this house is not sufficient to address ongoing health deficits	

		Examples (as per Commission working document)	Other examples
COUNT THE NUMBER OF TYPES OF ITEMS IN THE PEN FOR EACH CATEGORY	Optimal	Straw, green fodder (hay, grass, silage, alfalfa, etc.), miscanthus pressed or chopped, root vegetables when used as bedding	
	Sub-optimal	Peanut shells, ground wood, ground maize corn cobs, natural ropes, compressed straw cylinders, pellets, hessian cloth, shredded paper or natural soft rubber as bedding, or optimal (above) in a rack	Sawdust, woodchips, fresh soft wood planks (e.g. pine, spruce), branches of fresh wood
	Marginal	e.g. objects, such as hard plastic piping or chains.	Toys (hanging or on floor), tyres, empty cans/oil drums, balls (hanging at end of chain or on floor), hard wood planks or pieces of wood at end of chain, synthetic ropes
	None		

COUNT THE NUMBER OF PIGS IN THE PEN WITH:	Tucked tails				Flank lesions (circular)				
	Injured tails				Aggression lesions (straight)				
	Injured or imperfect ears				Dirty flanks/haunches				

RECORD OF PIG BEHAVIOURS
Stand quietly and for a 5 minute period record the number of occasions that each of the following behaviours defined below is observed in the pen

Damaging behaviour	This is oral (mouth/nose) behaviour that is directed towards another pigs' body, which can cause physical damage or pain, but is not motivated by aggression. The behaviour can range from gentle slow chewing to focused bites (usually to the ears or tails). Damaging behaviour can also take the form of sustained nosing of a body part (usually the flanks) resulting in a circular lesion. We have sub-divided it into tail, ear, flank and 'other' directed behaviours.
Fixtures and fittings	This is oral behaviour that is directed towards any physical part of the pen such as walls, floors, feeders, drinkers or pen dividers that are not designed to be rooted at or chewed by the pigs
Enrichment	This refers to any interaction the pigs direct towards the enrichment provided, including chewing, sniffing, nosing, rooting, pushing etc.
Aggressive biting	This behaviour is motivated by aggression, and unlike damaging behaviour, is normally associated with swift, forward movements by the 'attacking' pig accompanied by quick snapping movements by the jaws (i.e. open mouthed). The attacking pig may even chase the victim pig. The behaviour is normally directed towards the front part of another pig (although it can be directed towards the rear if the attacker is aiming to get access to a resource such as the feeder).

▸ BEHAVIOUR CATEGORY Damaging behaviour	Count	Total
Category (Tail, Ear etc.)	𝍸 I	6
Tail		
Ear		
Other		
Fixtures and fittings		
Enrichment		
Aggressive biting		

▸ BASED ON YOUR OBSERVATIONS OF BEHAVIOURS AND BODY LESIONS OBSERVED IN THIS PEN IS THERE A RISK OF TAIL BITING FOR THESE PIGS?	Yes	
	No	

RISK VALUES	
Risk Statement	**Risk Value**
Not Observed	0
Risk Category Statement is correct	1
I was not able to identify risks associated with this Risk Category	2
I have identified that risk exists for this Risk Category	3
There are clearly risks associated with this Risk Category	4

▸ **VETERINARY OPINION ON MEASURES ASSOCIATED WITH TAIL BITING RISK FOR THIS PEN**

Risk Category	**RISK VALUE 0-4**
Environmental Enrichment provision represents no risk for tail biting	
There is adequate thermal comfort and air quality for these pigs	
The health of these pigs provides no risk of tail biting	
Competition issues for the pigs in this pen do not give rise to risks for tail biting	
The pen design and use for these pigs does not present risk for tail biting	
Feeding processes for these pigs do not contribute to risks for tail biting for these pigs	

▸ **MANAGEMENT RECOMMENDATIONS**
To reduce factors considered to increase the risk of tail-biting and other aggressive behaviours at this stage of production.

1.

2.

3.

Other Comments:

SECTION A: 4 of 6

SECTION	
Weaner House	
Fattening House	

PIG TYPE	
Weaner Stage 1	
Weaner Stage 2	
Fatteners	

PEN ID#											
PEN LOCATION											
NUMBER OF PIGS IN THE PEN											
PEN LENGTH (M)				M							
PEN WIDTH (M)				M							
SLATTED FLOOR	0%		1-25%		26-50%		51-75%		76-100%		
SEX	Male		Female		Mixed						
FINAL WEIGHT ACHIEVED BY PIGS IN THIS PEN				KG (Avg)							
TAIL LENGTH	All docked		All long		Mixed						
CAN ALL PIGS FEED AT THE SAME TIME?	Yes		No								
HOW MANY DRINKERS ARE IN THE PEN?											

HAVE THE PIGS IN THIS PEN AN EFFECTIVE VACCINATION PROGRAMME?	
There is an effective vaccination programme for animals in this house	
An improved vaccination programme needs to be considered for animals in this house	
Vaccination for animals in this house is not sufficient to address ongoing health deficits	

		Examples (as per Commission working document)	Other examples
COUNT THE NUMBER OF TYPES OF ITEMS IN THE PEN FOR EACH CATEGORY	Optimal	Straw, green fodder (hay, grass, silage, alfalfa, etc.), miscanthus pressed or chopped, root vegetables when used as bedding	
	Sub-optimal	Peanut shells, ground wood, ground maize corn cobs, natural ropes, compressed straw cylinders, pellets, hessian cloth, shredded paper or natural soft rubber as bedding, or optimal (above) in a rack	Sawdust, woodchips, fresh soft wood planks (e.g. pine, spruce), branches of fresh wood
	Marginal	e.g. objects, such as hard plastic piping or chains.	Toys (hanging or on floor), tyres, empty cans/oil drums, balls (hanging at end of chain or on floor), hard wood planks or pieces of wood at end of chain, synthetic ropes
	None		

COUNT THE NUMBER OF PIGS IN THE PEN WITH:									
	Tucked tails				Flank lesions (circular)				
	Injured tails				Aggression lesions (straight)				
	Injured or imperfect ears				Dirty flanks/haunches				

RECORD OF PIG BEHAVIOURS
Stand quietly and for a 5 minute period record the number of occasions that each of the following behaviours defined below is observed in the pen

Damaging behaviour	This is oral (mouth/nose) behaviour that is directed towards another pigs' body, which can cause physical damage or pain, but is not motivated by aggression. The behaviour can range from gentle slow chewing to focused bites (usually to the ears or tails). Damaging behaviour can also take the form of sustained nosing of a body part (usually the flanks) resulting in a circular lesion. We have sub-divided it into tail, ear, flank and 'other' directed behaviours.
Fixtures and fittings	This is oral behaviour that is directed towards any physical part of the pen such as walls, floors, feeders, drinkers or pen dividers that are not designed to be rooted at or chewed by the pigs
Enrichment	This refers to any interaction the pigs direct towards the enrichment provided, including chewing, sniffing, nosing, rooting, pushing etc.
Aggressive biting	This behaviour is motivated by aggression, and unlike damaging behaviour, is normally associated with swift, forward movements by the 'attacking' pig accompanied by quick snapping movements by the jaws (i.e. open mouthed). The attacking pig may even chase the victim pig. The behaviour is normally directed towards the front part of another pig (although it can be directed towards the rear if the attacker is aiming to get access to a resource such as the feeder).

▸ BEHAVIOUR CATEGORY Damaging behaviour	Count	Total
Category (Tail, Ear etc.)	𝍸 I	6
Tail		
Ear		
Other		
Fixtures and fittings		
Enrichment		
Aggressive biting		

▸ BASED ON YOUR OBSERVATIONS OF BEHAVIOURS AND BODY LESIONS OBSERVED IN THIS PEN IS THERE A RISK OF TAIL BITING FOR THESE PIGS?	Yes	
	No	

RISK VALUES	
Risk Statement	**Risk Value**
Not Observed	0
Risk Category Statement is correct	1
I was not able to identify risks associated with this Risk Category	2
I have identified that risk exists for this Risk Category	3
There are clearly risks associated with this Risk Category	4

▸ **VETERINARY OPINION ON MEASURES ASSOCIATED WITH TAIL BITING RISK FOR THIS PEN**

Risk Category	RISK VALUE 0-4
Environmental Enrichment provision represents no risk for tail biting	
There is adequate thermal comfort and air quality for these pigs	
The health of these pigs provides no risk of tail biting	
Competition issues for the pigs in this pen do not give rise to risks for tail biting	
The pen design and use for these pigs does not present risk for tail biting	
Feeding processes for these pigs do not contribute to risks for tail biting for these pigs	

▸ **MANAGEMENT RECOMMENDATIONS**
To reduce factors considered to increase the risk of tail-biting and other aggressive behaviours at this stage of production.

1.

2.

3.

Other Comments:

SECTION A: 5 of 6

SECTION	
Weaner House	
Fattening House	

PIG TYPE	
Weaner Stage 1	
Weaner Stage 2	
Fatteners	

PEN ID#											
PEN LOCATION											
NUMBER OF PIGS IN THE PEN											
PEN LENGTH (M)				M							
PEN WIDTH (M)				M							
SLATTED FLOOR	0%		1-25%		26-50%		51-75%		76-100%		
SEX	Male		Female		Mixed						
FINAL WEIGHT ACHIEVED BY PIGS IN THIS PEN				KG (Avg)							
TAIL LENGTH	All docked		All long		Mixed						
CAN ALL PIGS FEED AT THE SAME TIME?	Yes		No								
HOW MANY DRINKERS ARE IN THE PEN?											

HAVE THE PIGS IN THIS PEN AN EFFECTIVE VACCINATION PROGRAMME?	
There is an effective vaccination programme for animals in this house	
An improved vaccination programme needs to be considered for animals in this house	
Vaccination for animals in this house is not sufficient to address ongoing health deficits	

		Examples (as per Commission working document)	Other examples
COUNT THE NUMBER OF TYPES OF ITEMS IN THE PEN FOR EACH CATEGORY	Optimal	Straw, green fodder (hay, grass, silage, alfalfa, etc.), miscanthus pressed or chopped, root vegetables when used as bedding	
	Sub-optimal	Peanut shells, ground wood, ground maize corn cobs, natural ropes, compressed straw cylinders, pellets, hessian cloth, shredded paper or natural soft rubber as bedding, or optimal (above) in a rack	Sawdust, woodchips, fresh soft wood planks (e.g. pine, spruce), branches of fresh wood
	Marginal	e.g. objects, such as hard plastic piping or chains.	Toys (hanging or on floor), tyres, empty cans/oil drums, balls (hanging at end of chain or on floor), hard wood planks or pieces of wood at end of chain, synthetic ropes
	None		

COUNT THE NUMBER OF PIGS IN THE PEN WITH:	Tucked tails				Flank lesions (circular)				
	Injured tails				Aggression lesions (straight)				
	Injured or imperfect ears				Dirty flanks/haunches				

RECORD OF PIG BEHAVIOURS
Stand quietly and for a 5 minute period record the number of occasions that each of the following behaviours defined below is observed in the pen

Damaging behaviour	This is oral (mouth/nose) behaviour that is directed towards another pigs' body, which can cause physical damage or pain, but is not motivated by aggression. The behaviour can range from gentle slow chewing to focused bites (usually to the ears or tails). Damaging behaviour can also take the form of sustained nosing of a body part (usually the flanks) resulting in a circular lesion. We have sub-divided it into tail, ear, flank and 'other' directed behaviours.
Fixtures and fittings	This is oral behaviour that is directed towards any physical part of the pen such as walls, floors, feeders, drinkers or pen dividers that are not designed to be rooted at or chewed by the pigs
Enrichment	This refers to any interaction the pigs direct towards the enrichment provided, including chewing, sniffing, nosing, rooting, pushing etc.
Aggressive biting	This behaviour is motivated by aggression, and unlike damaging behaviour, is normally associated with swift, forward movements by the 'attacking' pig accompanied by quick snapping movements by the jaws (i.e. open mouthed). The attacking pig may even chase the victim pig. The behaviour is normally directed towards the front part of another pig (although it can be directed towards the rear if the attacker is aiming to get access to a resource such as the feeder).

▸ BEHAVIOUR CATEGORY Damaging behaviour	Count	Total
Category (Tail, Ear etc.)	𝍸 I	6
Tail		
Ear		
Other		
Fixtures and fittings		
Enrichment		
Aggressive biting		

▸ BASED ON YOUR OBSERVATIONS OF BEHAVIOURS AND BODY LESIONS OBSERVED IN THIS PEN IS THERE A RISK OF TAIL BITING FOR THESE PIGS?	Yes	
	No	

RISK VALUES	
Risk Statement	**Risk Value**
Not Observed	0
Risk Category Statement is correct	1
I was not able to identify risks associated with this Risk Category	2
I have identified that risk exists for this Risk Category	3
There are clearly risks associated with this Risk Category	4

▸ **VETERINARY OPINION ON MEASURES ASSOCIATED WITH TAIL BITING RISK FOR THIS PEN**

Risk Category	RISK VALUE 0-4
Environmental Enrichment provision represents no risk for tail biting	
There is adequate thermal comfort and air quality for these pigs	
The health of these pigs provides no risk of tail biting	
Competition issues for the pigs in this pen do not give rise to risks for tail biting	
The pen design and use for these pigs does not present risk for tail biting	
Feeding processes for these pigs do not contribute to risks for tail biting for these pigs	

▸ **MANAGEMENT RECOMMENDATIONS**
To reduce factors considered to increase the risk of tail-biting and other aggressive behaviours at this stage of production.

1.

2.

3.

Other Comments:

SECTION A: 6 of 6

SECTION	
Weaner House	
Fattening House	

PIG TYPE	
Weaner Stage 1	
Weaner Stage 2	
Fatteners	

PEN ID#										
PEN LOCATION										
NUMBER OF PIGS IN THE PEN										
PEN LENGTH (M)				M						
PEN WIDTH (M)				M						
SLATTED FLOOR	0%		1-25%		26-50%		51-75%		76-100%	
SEX	Male		Female		Mixed					
FINAL WEIGHT ACHIEVED BY PIGS IN THIS PEN				KG (Avg)						
TAIL LENGTH	All docked		All long		Mixed					
CAN ALL PIGS FEED AT THE SAME TIME?	Yes		No							
HOW MANY DRINKERS ARE IN THE PEN?										

HAVE THE PIGS IN THIS PEN AN EFFECTIVE VACCINATION PROGRAMME?	
There is an effective vaccination programme for animals in this house	
An improved vaccination programme needs to be considered for animals in this house	
Vaccination for animals in this house is not sufficient to address ongoing health deficits	

		Examples (as per Commission working document)	Other examples
COUNT THE NUMBER OF TYPES OF ITEMS IN THE PEN FOR EACH CATEGORY	Optimal	Straw, green fodder (hay, grass, silage, alfalfa, etc.), miscanthus pressed or chopped, root vegetables when used as bedding	
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	None		

COUNT THE NUMBER OF PIGS IN THE PEN WITH:								
	Tucked tails				Flank lesions (circular)			
	Injured tails				Aggression lesions (straight)			
	Injured or imperfect ears				Dirty flanks/haunches			

RECORD OF PIG BEHAVIOURS
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▸ BEHAVIOUR CATEGORY Damaging behaviour	Count	Total
Category (Tail, Ear etc.)	𝍸 I	6
Tail		
Ear		
Other		
Fixtures and fittings		
Enrichment		
Aggressive biting		

▸ BASED ON YOUR OBSERVATIONS OF BEHAVIOURS AND BODY LESIONS OBSERVED IN THIS PEN IS THERE A RISK OF TAIL BITING FOR THESE PIGS?	Yes	
	No	

RISK VALUES	
Risk Statement	**Risk Value**
Not Observed	0
Risk Category Statement is correct	1
I was not able to identify risks associated with this Risk Category	2
I have identified that risk exists for this Risk Category	3
There are clearly risks associated with this Risk Category	4

▸ **VETERINARY OPINION ON MEASURES ASSOCIATED WITH TAIL BITING RISK FOR THIS PEN**

Risk Category	RISK VALUE 0-4
Environmental Enrichment provision represents no risk for tail biting	
There is adequate thermal comfort and air quality for these pigs	
The health of these pigs provides no risk of tail biting	
Competition issues for the pigs in this pen do not give rise to risks for tail biting	
The pen design and use for these pigs does not present risk for tail biting	
Feeding processes for these pigs do not contribute to risks for tail biting for these pigs	

▸ **MANAGEMENT RECOMMENDATIONS**
To reduce factors considered to increase the risk of tail-biting and other aggressive behaviours at this stage of production.

1.

2.

3.

Other Comments:

SECTION B: TASAH (PIGS) FARM – REVIEW DECLARATION FORM

VISIT DATE								

HERDOWNER DETAILS

Name										
Pig Herd Number										
Mobile Number	0	8								
Email Address										
Address 1										
Address 2										
County							Eircode			

ENTERPRISE TYPE			
Birth To Bacon		Fattening	
Wean To Finish		Breeder to Weaner	

VETERINARY PRACTITIONER

Name										
VCI VRN Number										
Mobile Number	0	8								
Email Address										
Practice Name										
Address										
County							Eircode			

SECTION B: TASAH (PIGS) FARM – REVIEW DECLARATION FORM

HERDOWNER

By signing, I _____ [Insert Name]

confirm as/on behalf of the herdowner, the above visit took place, that the information provided is accurate to the best of my knowledge and that I consent to the captured data being shared with Animal Health Ireland, Department of Agriculture, Food and the Marine, Teagasc and the Irish Cattle Breeding Federation (subcontracted by AHI to build and maintain the Pig HealthCheck database), for the purposes of managing the TASAH programme and my participation within it, providing farm management feedback, benchmarking and beyond the lifetime of the TASAH programme for scientific and research purposes. I am aware of my rights under the General Data Protection Regulations (available through the 'GDPR' link on AHI's homepage at www.animalhealthireland.ie).

Date D D M M Y Y Y Y

Signed _____

VETERINARY PRACTITIONER

By signing, _____ [Insert Name]

1. I certify that:
   a. I have read and understand the Standard Operating Procedure and Terms and Conditions for this activity,
   b. I have completed a three-hour animal welfare assessment for this farmer, including a farm visit on D D M M Y Y Y Y
   c. I and the farmer have signed the animal welfare assessment, as appropriate,
   d. I have uploaded the results to the Pig HealthCheck database.
2. Maintain copies of all documents up to **30th June 2031**.
3. Must provide copies of documents, on request, to AHI or DAFM.
4. I consent to the sharing of my Vet Reg No. and name (Animal Health Ireland, the Department of Agriculture Food and the Marine and Irish Cattle Breeding Federation) and contact details for the purposes of completing administration (including payment) around this review and management and evaluation of the Pig HealthCheck programme with Teagasc for the purposes of further research and am aware of my rights under the General Data Protection Regulations (available through the 'GDPR' link on AHI's website homepage at www.animalhealthireland.ie).

Date D D M M Y Y Y Y Start time of visit H H : M M

Signed _____

A 6-year Journey through the Biosecurity of Irish Pig Farms

Bárbara Terezo* & Carla Correia-Gomes**
Animal Health Ireland, Carrick-on-Shannon, Ireland
*barbara.terezo@edu.ulisboa.pt **cgomes@animalhealthireland.ie

Biosecurity is paramount to the production of healthy animals. The rising concerns about the introduction of exotic diseases such as African Swine Fever, as well as the management of endemic diseases, raises the question: How is the biosecurity of pig farms in Ireland?

- Data were collected from 2018 to 2023, encompassing a total of 1014 surveys and 393 farms accessed using Biocheck.Ugent;

- The study population comprises all herds with more than 50 pigs per farm, as well as other smaller farms;
- 46.6% (or 183) of farms have been accessed 3 times or more;

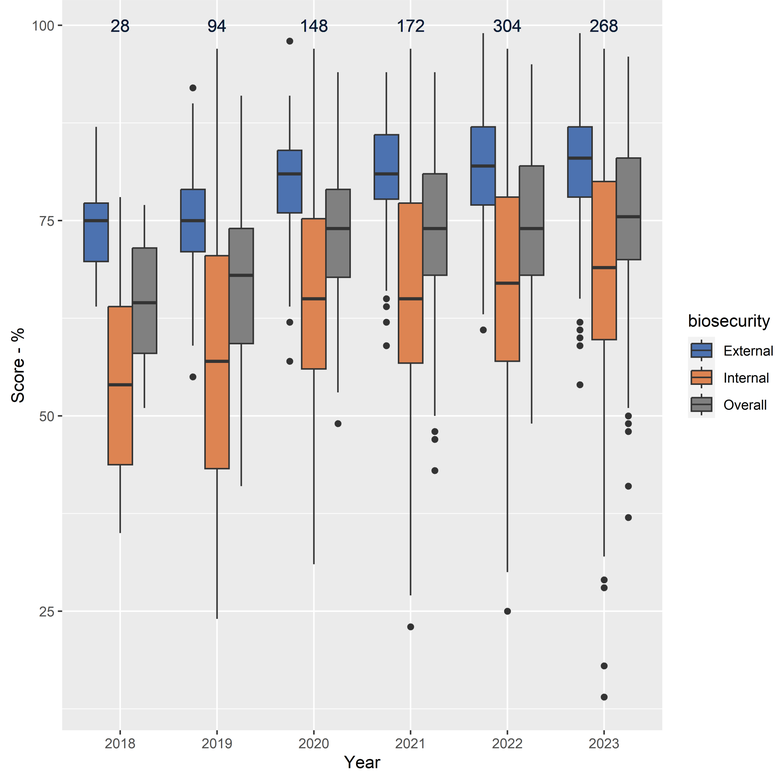


Figure 1: Boxplot of the distribution of the scores for external, internal and overall biosecurity from 2018 to 2023 and the number of farms assessed per year.

Primary Improvement

- I1 - Disease Management;
- I6 - Cleaning and Disinfection;
- I5 - Measures between compartments and the use of equipment.

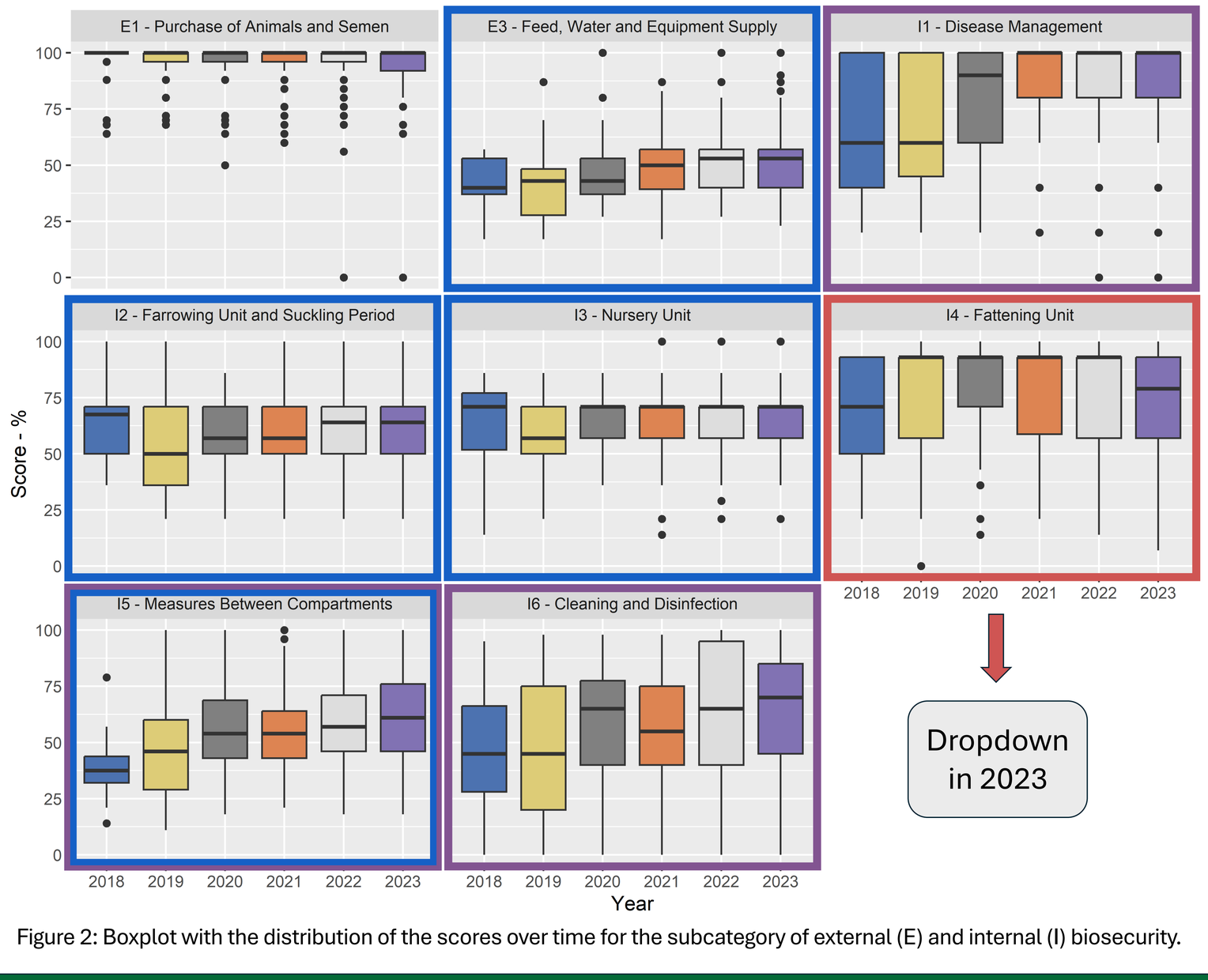


Figure 2: Boxplot with the distribution of the scores over time for the subcategory of external (E) and internal (I) biosecurity.

Areas identified for improvement

- E3 - Feed, Water and Equipment Supply;
- I2 - Farrowing Unit and Suckling Period;
- I3 - Nursery Unit;
- I5 - Measures between Compartments and the use of Equipment.

Dropdown in 2023

Discussion & Conclusion

External biosecurity scores higher than internal biosecurity, primarily due to the weight attributed to the E1 - Purchase of Animals and Semen. This trend is largely observed because most Irish farms follow a farrow-to-finish production type (close cycle).

- Median scores showed improvement between the years 2018 and 2023 for most of the categories.
- Using this framework areas requiring improvement are easily identified.

Acknowledgements: All pig vets and pig farmers participating in the assessments.

Biosecurity in pig farms over time in Ireland

Carla Correia-Gomes* & Bárbara Terezo**

Animal Health Ireland, Carrick-on-Shannon, Ireland

*cgomes@animalhealthireland.ie **barbara.terezo@edu.ulisboa.pt

Biosecurity is paramount to the production of healthy animals .
To improve it you need to measure it!
This study assessed the biosecurity levels of Irish commercial pig farms over time.

- Data were collected from 2018 to 2023, encompassing a total of 1014 surveys and 393 farms accessed using Vbiocheck.ugent
- Herds assessed accounted for 92.7% (breeding) and 92.5% (non-breeding) pig in Ireland.
- 46.6% (183) of farms have been accessed 3 times or more.

Scores at national level:

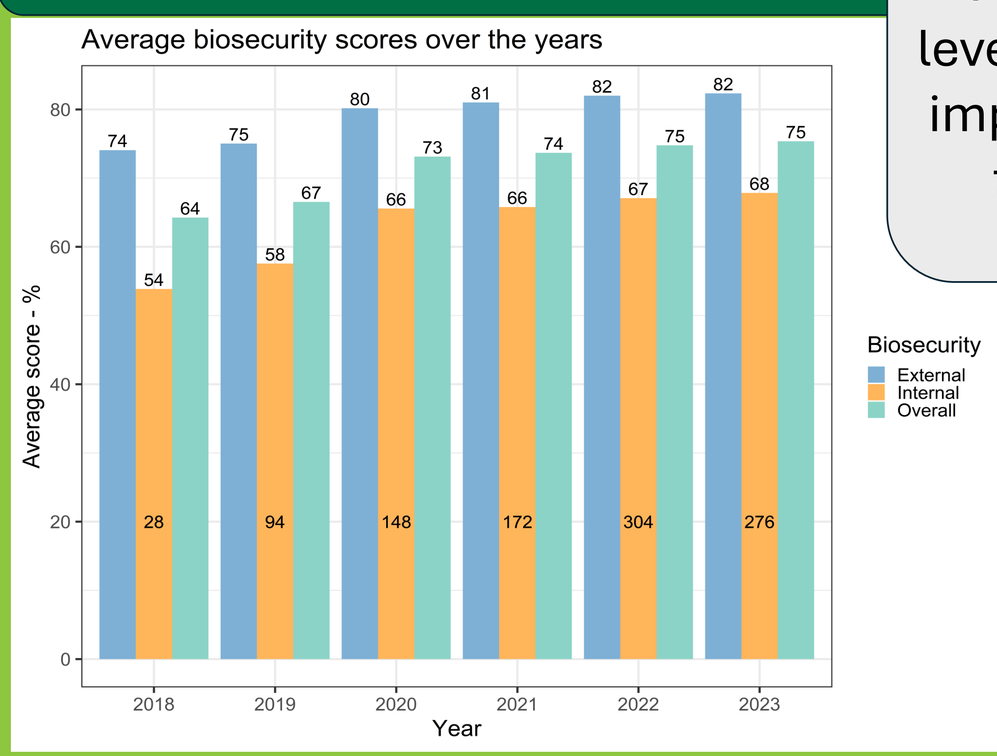


Figure 1: Average biosecurity scores for external, internal and overall biosecurity from 2018 to 2023 and the number of farms (in black) assessed per year.

At national level scores are improving over the years

Areas identified for further improvement:

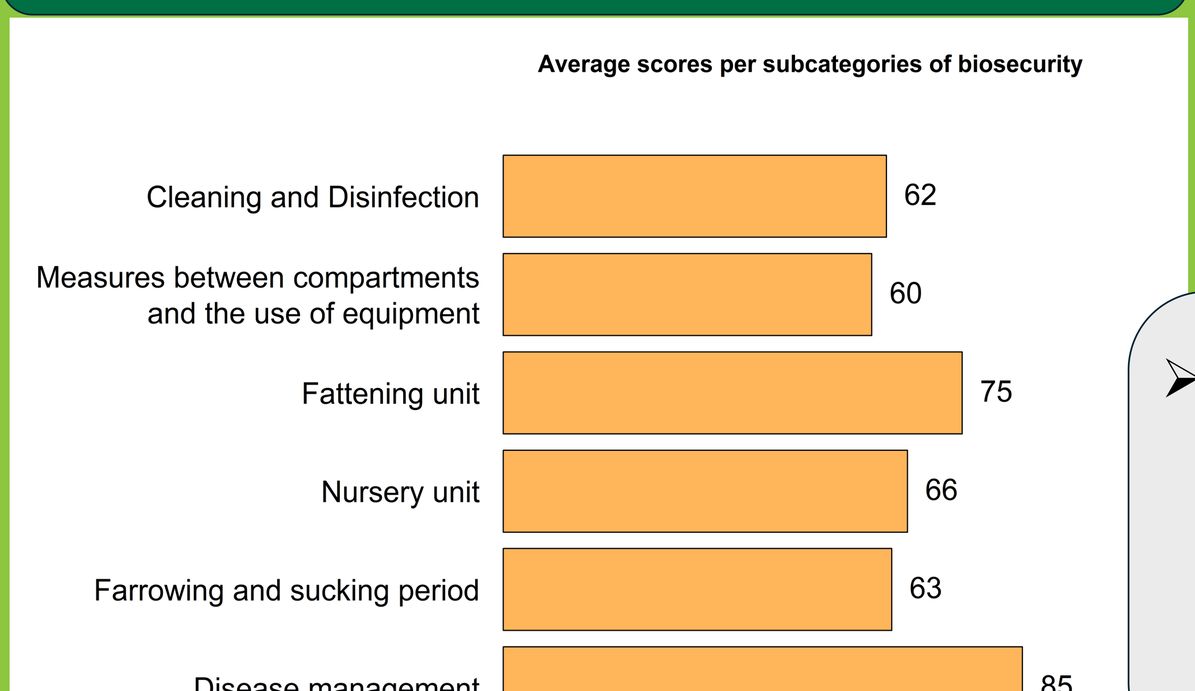


Figure 2: Average score per subcategory for the most recent assessment for all farms

- Management of feed, water and equipment supply.
- Measures between compartments
- Cleaning and disinfection
- Measures targeting the farrowing and sucking period

Improvements over the years at farm level:

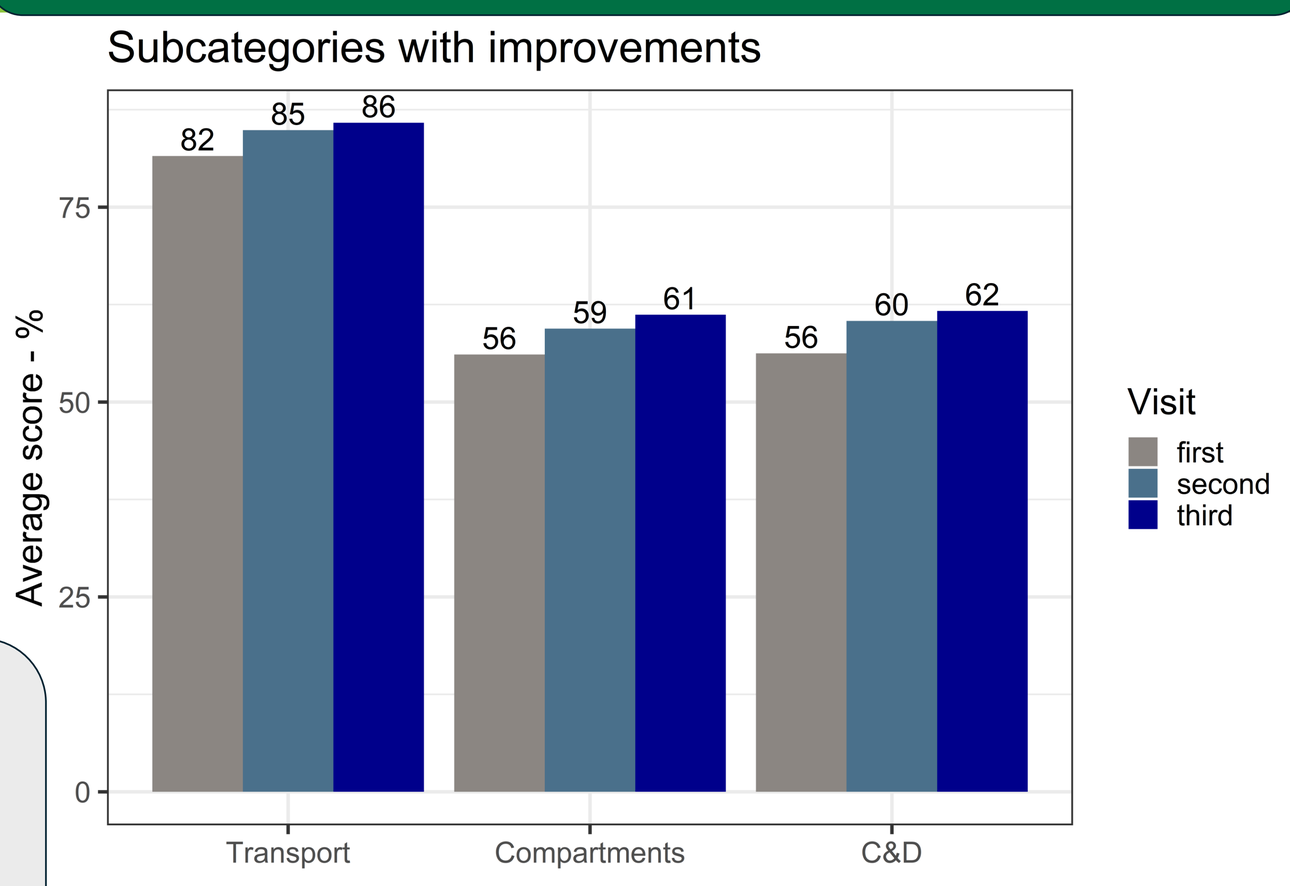
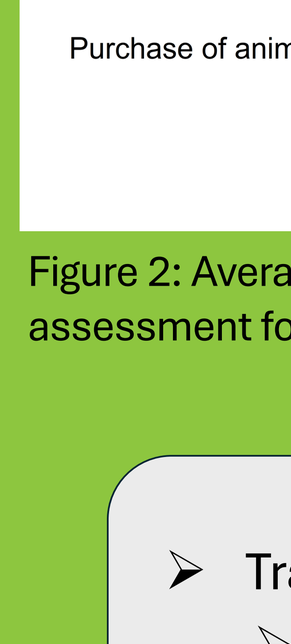


Figure 3: Average score for the subcategories with improvements over time for the 183 farms that have been assessed at least 3 times. Transport = Transport of animals, removal of manure/dead animals; Compartments = Measures between compartments and use of equipment; C&D = Cleaning and disinfection.

- Transport/ removal manure/ dead animals
- Measures between compartments
- Cleaning and Disinfection



Discussion & Conclusion

- External biosecurity scores are higher than internal biosecurity, primarily due to the weight attributed to the *Purchase of Animals and Semen*. This trend is largely observed because most Irish pig farms follow a farrow-to-finish production type (close cycle).
- Average scores at national level showed improvement between the years 2018 and 2023.
- Using this framework areas requiring improvement are easily identified.
- Some of these "weak" areas have been improving over time at farm level showing the usefulness of the system.

Acknowledgements: All vets and pig farmers participating in the assessments.