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Exploring the data divide through a social practice lens: A qualitative study of UK cattle farmers

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ABSTRACT

Appropriate management decisions are key for sustainable and profitable beef and dairy farming. Data-driven technologies aim to provide information which can improve farmers' decision-making practices. However, data-driven technologies have resulted in the emergence of a "data divide", in which there is a gap between the generation and use of data. Our study aims to further understand the data divide by drawing on social practice theory to recognise the emergence, linkages, and reproduction of youngstock data practices on cattle farms in the UK. Eight focus groups with fifteen beef and nineteen dairy farmers were completed. The topics of discussion included data use, technology use, disease management in youngstock, and future goals for their farm. The transcribed data were analysed using reflexive thematic analysis with a social practice lens. Social practice theory uses practices as the unit of analysis, rather than focusing on individual behaviours. Practices are formed of three elements: meaning (e.g., beliefs), materials (e.g., objects), and competencies (e.g., skills) and are connected in time and space. We conceptualised the data divide as a disconnection of data collection practices and data use and interpretation practices. Consequently, we were able to generate five themes that represent these breaks in connection.Our findings suggest that a data divide exists because of meanings that de-stabilise practices, tensions in farmers' competencies to perform practices, spatial and temporal disconnects, and lack of forms of feedback on data practices. The data preparation practice, where farmers had to merge different data sources or type up handwritten data, had negative meanings attached to it and was therefore sometimes not performed. Farmers tended to associate data and technology practices with larger dairy farms, which could restrict beef and small-scale dairy farms from performing these practices. Some farmers suggested that they lacked the skills to use technologies and struggled to transform their data into meaningful outputs. Data preparation and data use and interpretation practices were often tied to an office space because of the required infrastructure, but farmers preferred to spend time outdoors and with their animals. There appeared to be no normalisation of what data should be collected or what data should be analysed, which made it difficult for farmers to benchmark their progress. Some farmers did not have access to discussion groups or veterinarians who were interested in data and therefore could not get feedback on their data practices.These results suggest that the data divide exists because of three types of disconnect: a disconnect *between elements* within a practice because of tensions in competencies or negative meanings to perform a practice; a disconnect *between practices* because of temporal or spatial differences; and a break in the reproduction of practices because of lack of feedback on their practices. Data use on farms can be improved through transformation of practices by ensuring farmers have input in the design of technologies so that they align with their values and competencies.

1. Introduction

The rearing of youngstock has substantial economic costs for dairy and calf-rearing herds (Mohd Nor et al., 2012; Boulton et al., 2015; Boulton et al., 2017; Hawkins et al., 2019). Furthermore, the economic margins for suckler beef herds are small and tend to have lower profits

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than dairy herds (DEFRA, 2022). Mortality and morbidity due to respiratory and enteric diseases is common on dairy, calf-rearing and suckler beef herds (Johnson et al., 2017; Baxter-Smith and Simpson, 2020; Palczynski et al., 2021). Cow health and welfare are key concerns for farmers and veterinarians (Sumner et al., 2018), as well as members of the public (Clark et al., 2016; Jackson et al., 2020). This is important as societal preferences have an influence over farming practices (Britt et al., 2018). Therefore, appropriate management decisions for rearing of youngstock are key for sustainable and profitable beef and dairy farming (Boulton et al., 2017; Palczynski et al., 2021).

On-farm technologies aim to provide information with the potential to improve farmers' decision-making practices. These technologies are often framed as being able to increase profitability and improve animal health and welfare (Duncan et al., 2021; Barrett and Rose, 2022). However, the uptake of technologies on cattle farms is not consistent, with particularly low uptake on beef farms (Läpple et al., 2015; Groher et al., 2020), and therefore research has sought to understand this uptake. Factors affecting the adoption of technologies on beef and dairy farms include the size of the herd, perceived value of the technology, farmers' awareness of available products, infrastructure, and cost effectiveness (Gargiulo et al., 2018; Groher et al., 2020; Makinde et al., 2022).

Many on-farm technologies aim to collect data; for example, weighing platforms and feeding stations can automatically collect data (Costa et al., 2021). Some technologies are also data-driven and use algorithms or changes in data signals to detect events. For example, some technologies can detect early indications of disease or onset of calving (Goharshahi et al., 2021; Santos et al., 2022). Whilst studies often focus on technology adoption and how technology is used (Schewe and Stuart, 2015; Rose et al., 2018), there has been little focus on how data are collected and used by farmers, with or without technology.

Many factors on the farm can now be translated into numbers, a phenomenon referred to as "datafication" (Kuch et al., 2020). For example, technologies can sense changes in the environment, drinking behaviours of cattle, or measure colostrum quality. There is an effort to identify the potential positive and negative consequences of technology use and datafication on farms (Rotz et al., 2019; Barrett and Rose, 2022). One consequence is the emergence of the "data divide", which is characterised by Marshall et al. (2022) as a "gap between the generation and application of farm data". They suggest that although technologies provided Australian cotton farmers with lots of data, they needed to have specialist data-related skills to use this data for decision-making (Marshall et al., 2021). However, this skillset is lacking in their agriculture sector. The "data divide" is therefore a problem which seems specific to agriculture but has not been explored in sectors other than cotton farming and requires further conceptualisation.

The data divide represents a key consequence of the uptake of technologies that generates two key questions: (1) how does the data divide come to exist? and (2) how can the data divide be reduced? (Rotz et al., 2019). When investigating farmers actions, veterinary social science literature often focuses on problems of individual behaviours (Hidano et al., 2018). However, it is understood that everyday life in farming is complex, with many social, cultural, and spatial factors involved in the actions farmers take (Rose et al., 2018; Marshall et al., 2022). Therefore, these questions require an exploration of the social and ecological context of data collection and technology use (Rose et al., 2018; Marshall et al., 2022). One way of doing this is to decentre technologies in the analyses so the focus is on what technologies do rather than what they are (Carolan, 2020). Social practice theory offers a lens for decentring technology and focusing on the routine practices instead (Shove et al., 2012). This is particularly suitable for understanding data and technology activities as they are often carried out as mundane, everyday practices on the farm. Therefore, in this study we use a social practice theory lens to explore why and how the data divide exists and how the generation and application of data can be connected, both with and without technologies. We draw on focus groups with beef and dairy farmers to understand their experiences, perceptions, and feelings towards data and technologies.

1.1. Social practice theory

Social practice theory uses *practices* as the unit of analysis rather than individual behaviours or human interactions. The social world is seen as composed of practices and individuals are seen as carriers of a practice. There is no single, unified social practice theory, but they commonly share the idea that practices are "socially shared patterns of activity" (Watson and Shove, 2022). Shove et al. (2012) conceptualise practices as requiring the connection of three elements: materials, competencies, and meanings (Fig. 1). Materials refer to objects, technologies, or bodies (Maller, 2016). Competencies are the skills, background knowledge, and understandings of practices. Meanings are the symbolic meanings, motivations, and beliefs. If connections between the three elements of practice are broken, then the practice can no longer be performed as it once was, and it must be adapted (Shove et al., 2012). Thus, practices emerge, change, and disintegrate through the connection and disconnection of elements.

Practices exist as both entities and as performances. Practices-as-entities refer to collective routines in society which have a recognisable combination of elements that practitioners have reference to (Kent, 2022). Practices-as-performances refer to the actual doing of the practice by drawing on and reproducing the pattern provided by the practice-as-entity (Shove et al., 2012). For example, when commuting to work several practices may be recognised as possible options such as driving a car, catching a train, or riding a bike. They exist as practices-as-entities. When enacting the practice of driving a car, it then becomes a practice-as-performance.

One of the key problems around studies of farmers' behaviours or practices is that they tend to focus on one behaviour (or practice) and this does not take into account the complexity of the enmeshment of practices (Hidano et al., 2018). Social practice theory acknowledges that practices do not exist in a vacuum, and instead are interconnected with other practices in time and place (Heidenstrøm, 2022). Practices can be organised in time, compete for time, or situated in specific places. Social practice theory highlights the central role of materials, such as technologies and infrastructure, in performing practices. Technologies are not neutral objects and instead can shape practices and be shaped by practices (Sahakian and Wilhite, 2014). Materials such as technologies can also enable or disable connections between practices (Schatzki, 2001; Blue and Spurling, 2016).

In the agriculture literature, social practice theory has been used as a lens to understand the elements involved in technology practices on crop farms (Jakku et al., 2019; Ogunyiola and Gardezi, 2022). Technology use on livestock farms may include different practices and corresponding elements because of the inclusion of animals within the practices. Our study aims to further understand and characterise the data divide by drawing on social practice theory to recognise the emergence, linkages, and reproduction of data practices on cattle farms in the UK. As we aim to investigate perspectives of both beef and dairy farmers, we focus on

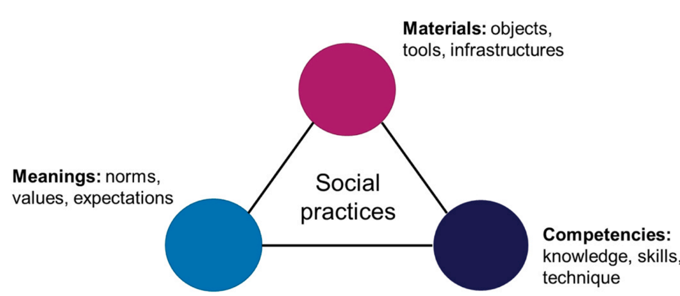

Fig. 1. Elements of social practice theory.
Adapted from Shove et al. (2012).

data practices that affect the management of youngstock.

2. Methods

2.1. Study design

We chose a focus group method because not all farmers may be familiar with technology use and therefore, we believed that interaction between different farmers would be useful. The focus group method allowed us to investigate unanticipated issues (Braun and Clarke, 2013). We use a social practice ontology for this study, which means we view the social world as being made up of practices (Heidenstrøm, 2022). Focus groups are useful for understanding social practices because participants can explore the diversity of each other's practices and highlight shared meanings and routines (Browne, 2016).

2.2. Researcher characteristics and reflexivity

CD conceptualised the study, assisted in some of the focus groups, moderated some of the focus groups, analysed the data and wrote the original draft. CD is a postdoctoral researcher in the veterinary social sciences. She does not have a strong farming background and is not a veterinarian but does have an understanding of livestock farming from her PhD work. At the beginning of the focus groups, she introduced herself as a social scientist. This perhaps positioned her as an "outsider" (Holmes, 2020). There was no prior relationship with the study participants when the focus groups took place.

JK conceptualised the study, was involved in formal analysis and reviewing and editing the original draft of the manuscript. JK is a veterinarian with extensive experience in decision-making research.

AB was involved in the conceptualisation of the study and in the reviewing and editing the original draft of the manuscript. AB is a social psychologist with extensive experience in decision making under uncertainty.

The focus groups happened after the Covid-19 pandemic lockdowns had eased in the UK. The farmers may have had greater experience with technology (e.g., using smartphones and computers) because of adapted communication during a series of lockdowns in the UK across 2020 and 2021.

2.3. Ethics approval

The study was approved by the University of Nottingham School of Veterinary Medicine and Science Ethics Committee (no. 3509 211202). Participants provided written, informed consent by completing a form.

2.4. Sampling approach

The aim of our sampling approach was to obtain a diverse sample of participants to capture a range of views. Participants were recruited through adverts on social media, through researcher networks and mailing lists. Apart from the initial pilot focus groups, all participants received a £ 40 Amazon voucher to reimburse their time. The focus groups were split into two types: dairy farmer and beef farmer. We did not group farmers by level of technology use and did not have prior knowledge of their experiences. It was important to gather opinions from a diverse range of farmers and so there was no strict inclusion criteria. The only criteria were that farmers had to rear calves and be based in the UK. We did not specify what a "farmer" was and could include anyone who works with the calves (e.g., farm owner, manager, calf rearer, worker). Eight focus groups of 2–6 participants per group were completed with, in total, thirty-four farmers. Of these, fifteen were beef farmers and nineteen were dairy farmers. Of the beef farmers, six had a suckler farm, three had a calf rearing farm, and five had both. Thirteen participants were female, and twenty-one were male. Not all farmers indicated their age, but of those that did ($n = 16$), the age range was 19–62 (mean=34 years) and the number of years working in the farming industry ranged between 5 and 46 (mean=21 years).

We used the concept of information power to determine our sample size (Malterud et al., 2016). We assessed information power by considering study aim, sample specificity, established theory, quality of dialogue and analysis strategy. For example, we needed to have multiple focus groups for beef and dairy farmers to capture experiences of different farming systems. Based on the dialogue that was generated, we saw that the sample included farmers who did not use, or used very little, technologies, and farmers who used multiple technologies. We believed that the farmers felt open to discuss their positive or negative experiences of using – or lack of using – data and technologies. This was perhaps because a lack of data monitoring is relatively normal in the management of youngstock in the UK (Palczynski et al., 2022). We assessed that the quality of dialogue was good because we were able to obtain a rich range of meanings, perspectives, and experiences. Therefore, we believed four focus groups each for beef and dairy farmers had sufficient information power to answer the research questions.

2.5. Data collection

Online focus groups were held using Microsoft Teams, for safety reasons (i.e., COVID-19) and to allow for participants who were geographically dispersed. A topic guide was used to guide the discussion around the subjects of data use, technology use, disease management in youngstock, and goals for their future farm. The guide is available in the Supplementary Material. The topic guide was informed by needfinding and appreciative inquiry approaches (Bergvall-Kåreborn and Ståhlbröst, 2009). In these approaches, the focus is on what works well and imagining what the future will be to understand what participants care about. Therefore, we included positively framed and future-oriented questions in the topic guide. The questions were tested with two dairy farmers over the phone. We then tested the topic guide with participants in the first focus group. From that experience, we decided to change the order of topics in the second focus group so that the questions around goals for their future farm were at the beginning of the discussion. We reflected that including questions about the future at the beginning improved the focus group discussion as it allowed farmers to think creatively and openly, and this set the tone for the rest of the discussion.

Focus group discussions were held between December 2021 and June 2022. The first three focus groups were moderated by LP and assisted by CD. The remainder of the focus groups were moderated by CD and were assisted by two researchers. The focus groups lasted between 60 and 90 min. All focus groups were audio and video recorded with the participants' consent. The recordings were transcribed verbatim by an independent transcription company and the transcriptions were checked against the audio recordings.

2.6. Data analysis

The transcribed data were analysed using reflexive thematic analysis (Braun and Clarke, 2019, 2020). Reflexive thematic analysis is a theoretically flexible method which allows for both inductive and deductive theme generation and therefore, we could apply social practice theory.

CD familiarised herself with the transcripts prior to coding. Initially, the transcripts were coded inductively and with a more semantic orientation. The coding process was supported by the use of NVivo (NVivo qualitative data analysis Software; QSR International Pty Ltd. Version 12, 2018). Upon further reflection, the data appeared particularly suited to a social practice lens. Coding then shifted to a more deductive and latent approach to generate codes with broader meanings relating to elements of practice (materials, meanings, and competencies), temporal and spatial practice arrangements. These codes were then clustered to depict different practices relating to data routines. We noticed that a recurring theme was that there were arrangements that broke the connection between data routines. Therefore, we developed an overarching theme around the disconnect of collecting data and using this data. This overarching theme was used as an organising structure to generate themes that represent disconnections of the practices (Clarke and Braun, 2021).

3. Results and Discussion

3.1. Overarching theme - Disconnect of data collection and data use and interpretation

The overarching theme "disconnect of data collection and data use and interpretation" was developed as a shared pattern of meaning across the data set which provided the organising structure for the resulting themes.

The analysis showed that farmers were performing three types of routine data practices: data collection, data preparation, and data use and interpretation. There were also three types of data collection practices: routine data collection, human observation of animals, and reactionary data collection.

We define routine data collection as data that farmers chose to collect for all (or most) calves on the farm. Some data was collected at regular intervals, such as weight data. Other data, such as activity, were collected constantly. Certain data were collected at only one time point in the calf's life. For example, farmers would routinely collect data on colostrum quality soon after calves were born.

Human observation of animals was where farmers would look over their animals to check their health, welfare, and performance. This could be with their own bodily senses or aided by technologies such as cameras. This type of data was not necessarily written down but was instead an internal data source in which farmers developed their experiential knowledge of the animals.

Reactionary data collection occurred when farmers identified a problem on the farm. This was often linked to the observational practice, where farmers would use their instinct and experience to identify an animal that did not look normal and react to that. Reactionary data collection happened when farmers had to make a rapid decision. Some examples of reactionary data collection were using thermometers or diagnostic tests to determine the health status of an animal.

The data preparation practice involves sorting data into a format that can be analysed and interpreted. This often included importing and merging data from different sources. The data use and interpretation practice was where farmers transformed lots of data into interpretable outcomes which they could make decisions from. It was often necessary for farmers to perform the data preparation practice in order to perform the data use and interpretation practice. However, some technologies or software could remove the need for the performance of the data preparation practice.

Fig. 2 shows how the data practices were connected. The data practices link together to form a bundle as they are co-dependent on each other. However, there was often a gap between the generation and application of data, or data divide (Marshall et al., 2022), which we have conceptualised as a disconnect between the data collection and data use and interpretation practices on farms. We use this conceptualisation to discuss the five themes which were generated from the analysis, and which represent these disconnections. These are shown as orange boxes in Fig. 2 and are summarised below in Table 1.

3.1.1. Meanings can de-stabilise data practices

This theme focuses on the way in which the meanings that are given to practices can determine whether a data practice exists or will be performed. The data preparation practice, where farmers had to merge different data sources or type up hand written data, had negative meanings attached to it. It was seen as data duplication and perhaps not an efficient use of farmers' time. During the focus groups, there was a sense of frustration around having to carry out these data preparation practices. For practices to be performed, the carriers of practice (in this case farmers or farm workers) need to connect the three elements of

Table 1
Summary of the five themes generated from the analysis.

Theme	Summary
Meanings can de-stabilise data practices	Data preparation can generate states of displeasure, whereas human observation of animals can generate states of pleasure. The emotional meanings can motivate which practices are performed.
Tensions in farmers' competencies to perform practices	Some farmers did not have the necessary skills to perform data analysis or use technologies which could aid their data practices.
Spatial disconnections of practices	Data preparation and data use and interpretation practices were often tied to an office space because of the required infrastructure.
Temporal disconnection of practices	Data collection, preparation and use and interpretation practices must compete with other farming practices for time and are not usually the priority. The human observation practice often shares time with other practices.
Unequal access to forms of feedback	Some farmers did not have standardised concepts of what data to collect and analyse, or social structures to allow them to benchmark against others or themselves.

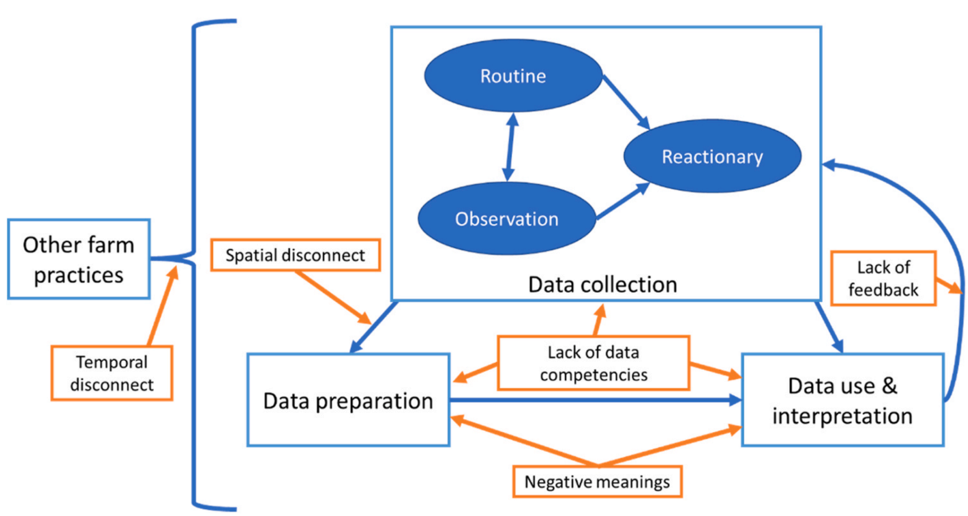

Fig. 2. Overview of how data practices on farms are connected with each other (blue) and how they become disconnected (orange).

meaning, materials, and competencies (Shove et al., 2012). However, because data preparation was associated with negative meanings such as time wasting, it was not always performed.

> *"I think sometimes for me it's that, if we just then duplicating this – we've already submitted it, you've already got it, now I'm filling it in on another form so we can tick another box for something else is where I get weary with it"* (Beef FG2, RES1)

> *"Medicine records as well could be better integrated somehow. It's a pain in the arse keeping medicine records. EID and passports and all that crap is a big burden on time managing all that paperwork where it should really just be computerised and automated and the fact that the rest of the world's got EID on cattle and we haven't, it's nowhere nearer than it has been for a long time. It's frustrating."* (Dairy FG3, RES1)

Data practices also harboured emotional meanings. Farmers have emotional ties to their animals (Doidge et al., 2020) and these emotions can incite or suppress practices (Lupton, 2013). Data preparation practices and, at times, data collection and interpretation practices generated states of displeasure. For example, the following farmer felt overwhelmed by attempting to interpret their data.

> *"I think we tested 80 animals or something and to be honest with you there was an enormous Excel spreadsheet that took up too much time to decipher and decide who to do it. We do all our own breeding ourselves, so we never used it, and we stopped doing genomic testing. I would love to get back to it, but the data was overwhelming for us."* (Dairy FG2, RES4)

In contrast, the practice of observing their animals gave farmers more positive feelings that they "Know their herd". This was a symbol of being a good farmer and gave farmers a sense of control. Furthermore, alerts and cameras that farmers can access allow them to keep this sense of control when they are in their own homes. These positive feelings can stabilise practices:

> *"We're sort of, good farmers are proactive, and you know your land, you know your stock, you know your herd."* (Beef FG2, RES1)

Therefore, data practices are affective practices (Reckwitz, 2016). Emotions are often not considered when investigating social practices (Reckwitz, 2016; Kent, 2022), but have been shown to have important influence in domains such as energy use (Sahakian and Bertho, 2018) and animal husbandry (Bassi et al., 2019). Sahakian and Bertho (2018) suggest that "practices compete for people's time, but also for people's emotions". This may be why farmers continued to carry out observation practices despite it taking up much of their time, whilst dropping performance of data preparation and interpretation practices. In other words, practices that incite positive emotions continue to be reproduced and are stabilised and practices that incite negative emotions are de-stabilised.

Meanings around, who, or what, farming system a technology is intended for can also restrict the existence of technology-based data practices. The following quote from RES2 (Beef FG2) shows an interaction between her and her husband about taking part in the focus group. It illustrates how farmers assume that data and technology are not part of daily practices on beef farms compared to dairy farms.

> *""Oh I'm doing this focus group at tea time." And he said, "What's that about?" And I said, "Data and technology." And he said, "We're beef, we're not dairy. Don't they want dairy?" And I said, "No, they want beef as well." So that was his initial [reaction], was no, it's dairy that [use] technology and data. We're beef."* (Beef FG2, RES2)

Farmers associated technologies with large-scale dairy farming. Technologies were not aimed at beef, suckler, smaller or outdoor herds, for example. These meanings around how technologies are only suited to a particular system may prevent performance of technology-based data practices on alternative farm systems.

> *"I know for different people, bigger farms, yes it may be good but for us it just all seems a bit pie in the sky."* (Dairy FG2, RES3)

Therefore, existence of technology-based data practices depends on whether the farmers are a member of the large-scale dairy farming "group". As Hui (2016) suggest, particular groups of people are regularly evoked in representing specific practices. In our analysis, large dairy farms appeared to represent a group that perform technology-based data practices. This group may then be reproduced and reinforced through companies that offer technology and data services advertising these practices towards larger dairy farms.

> *"We're kind of at the end of the scale it always seems, the forgotten end and it's not marketed towards us, the data isn't usable towards us."* (Beef FG2, RES2)

Indeed, larger dairy farms have been shown to be more likely to adopt technology (Gargiulo et al., 2018). However, technologies such as automatic milking systems may be more suited to small and medium farms (Martin et al., 2022). This suggests that technologies could consider marketing towards small and medium farms, so that farmers believe that technology can fit with their farming system.

3.1.2. Tensions in farmers' competencies to perform data practices

This theme centres on how farmers did not have the required competencies, or had incompatible competencies, to perform data practices. Some farmers struggled to understand what to do with the data they have collected. They needed to use their data to evaluate their performances in animal health, productivity, and profitability, for example. However, farmers suggested that they did not have the skills to turn the data into "meaningful" information. It would sometimes be one person's job on the farm to analyse and interpret the data, because no other worker had the required skills.

> *"Where I often failed as well is wanting to record something but to actually take that data and turn it into something meaningful to use on your farm to improve your lot is another exercise altogether and that was often where I fell down"* (Dairy FG2, RES5)

> *"Being more tech-savvy is brilliant, but you've got to have the labour there also to be able to interpret that data. Also, the labour there to be able to do something about it after you've interpreted that data."* (Dairy FG4, RES5)

Indeed, many studies have shown that farmers find it difficult to interpret generated data (Lunner-Kolstrup et al., 2018; Marshall et al., 2022). Learning the skills required to utilise data involves participating in the practice. This type of learning is not individual but instead social and participatory. Some examples include transferring knowledge through demonstration projects and peer-to-peer discussions (Sahakian and Wilhite, 2014; Adamsone-Fiskovica and Grivins, 2021; Sutherland and Marchand, 2021). Participatory learning has been successfully used in relation to antibiotic use on dairy farms in the UK, and may be useful for data practices (Morgans et al., 2021).

Farmers also had varying competencies in using technologies to aid their data practices. Data collection via smartphones was seen as particularly appealing as they were perceived as a piece of equipment that most people now own and can easily use. The ownership of smartphones and competencies surrounding using smartphones had increased in the past few years because of their use in everyday practices and this had allowed smartphone technology to enter the data collection process on farms.

> *"So anything that you can do on the phone, because we have all got phones with us now all the time haven't we. And I think there is probably a way of doing everything, probably."* (Beef FG1, RES2)

However, the following quotes illustrates that collecting data using smartphones requires competencies in knowing how to use the Apps for data entry. When farmers/farm workers did not know how to use apps, then they would revert to writing in pen and paper format. Farmers' data collection practices rely on and are restricted by their skills and the skills of their staff members.

> *"People in the parlour aren't always good at putting it on the phone so it all gets written in a paper diary, births, services and treatments and then they get transferred to a database."* (Dairy FG2, RES4)

> *"I can't get anyone else who works on our farm because they won't use Herd Watch [app]… We manually take them down, but I put them on to Herd Watch myself. The same with measuring grass, nobody else will do it, I have to do it. So, it's just everything is kind of a challenge at the moment because it's, people are finding it hard to get their head around doing it. It's kind of a bit scary to go into any of that or it's too difficult, even though it's really not. Like they won't even register a calf, and on Herd Watch it's an easy as anything, you scan the tag and you just press one or two buttons, like it's so quick but nobody will do it."* (Beef FG1, RES3)

This shows that a shift from traditional paper-based practices to technology-based data practices requires the accumulation of new skills. It can take time for farmers and their animals to transition to using a new technology (Tse et al., 2018). Practices are emergent and it may take a series of small steps to perform the desired practice (Shove et al., 2012). This may be why smartphone-based technologies such as Apps were popular amongst the participants. Past performances of using smartphones in everyday life build up competencies to use them in farming practices. As technologies become more integrated into farmers' everyday lives, they may find it easier to transition to technology on the farm. Alternatively, farming technologies can be redesigned in formats like those technologies used in everyday life so that people with less specialist skills can use them for performance of data practices (Morley, 2016).

Farmers' skills may also sometimes feel incompatible with performing data practices. For example, farmers used their observational skills to identify youngstock who were unwell. They did this by relying on their experiential knowledge. Human bodies can be trained to skilfully perform practices (Maller, 2016). Here, the memory of what healthy calves look like provided a guide for how the health status of calves was assessed. Farmers' bodies were also heavily involved in observational practices. They used their sensory capacities of sight, touch, hearing, and smell to understand their animals.

> *"You can just tell looking at them, "She's not right." It's just something, I don't know, maybe I've, we've all grown up with it and we've just been able to, it's something we're able to do but then there's obvious signs like blowing and they're not drinking, or they're sat in the back all curled up and there are obvious signs but then sometimes you just know"* (Dairy FG3, RES1)

Some farmers suggested that their observational skills mean that they can identify problems before technology can. They can evaluate their performance by looking at their animals, rather than having to collect routine data and then analyse it. Human observation of animals generates a kind of internal data source, or farmer instinct. This farmer instinct was not something that could be replaced by technology. Thus, farmers' instinct or experiential knowledge can be valued greater than what data can offer. This can sometimes mean that farmers question the need to collect data at all.

> *"I think the thing is with technology is it's working on, a lot of it is historic data you're looking at and if cow comes in and she's bulling if you've got a good stockman, they already know she's bulling and if a calf's holding back, it might not even be showing a temperature, but you know it's not right before the technology."* (Dairy FG3, RES3)

> *"Sometimes that data doesn't come to fruition – you don't end up with the animal that you should have. So, I think we're much more likely to sort of go with our gut and what we know in front of us looks a good animal."* (Beef FG2, RES1)

In contrast, some farmers thought that their skills were compatible with technologies and data. The data that technologies can collect allowed farmers to have "*a set of eyes on their animals 24/7 providing constant monitoring*" (Dairy FG2, RES5). Technology could collect more observational data than was available through the human sense of sight and therefore could sometimes identify problems before symptoms were visible. Thus, farmers have recognised that technology can aid their observation in alternative ways – an aspect called tool-mediated seeing (Goodwin and Goodwin, 1996; Lundström and Lindblom, 2018). The following quote shows how farmers can combine their observational instinct with tools and technologies to enhancing their abilities to "know their animals".

> *"There have been three occasions where you've had an animal that outwardly appears fine but when we've had the vets out to look at them because its showing that they're not eating, its diagnosed DAs [Displaced Abomasum] sort of two or three days before you'd even see it in the cow."* (Dairy FG1, RES1)

3.1.3. Spatial disconnections of practices

Spatial connections are also important for the flow of data practices. Technologies can reorganise farm work in time and space (Butler et al., 2012; Martin et al., 2022). The data preparation practice usually occurred in an office space and therefore happened when farmers were away from their animals. The following quotes illustrate how having to go back to the office to process data breaks the connection between collecting the data in the field and use and interpretation of the data.

> *"But you know, we write everything down and then come into the office and manually input our births, our sales, our meds…I want to move that onto a system where we can just have tablets at the yard. As soon as something's had meds in it, you just, you know, you'd input the data there and then as you're doing it rather than having to come into the office to duplicate it."* (Beef FG2, RES1)

> *"As I say, [brother-in-law] does it with a pen and paper but I can make the assumption at scale or when I've got my hand on the animal [using technology] whereas he will have to go back in and start working them out and then make his assumptions"* (Beef FG3, RES4)

The office acts as a space in which multiple tasks are performed because of its infrastructural background (Shove, 2016). This background included electric power, internet connectivity and safe spaces to store data, which enabled the operation of devices such as computers. The office was a space that has the specific material attributes that are required for data preparation and interpretation. Thus, the office has material-spatial qualities.

Farmers tended to prefer spaces that were outdoors or close to their animals. However, these spaces often did not have the required material-spatial qualities to perform preparation and interpretation practices. Consequently, data preparation and interpretation practices become tied to the office space. Data collection technologies also establish and reproduce the need for an office space because of the vast quantities of data that they generate that then require processing. Alternatively, technologies that can merge collecting, processing, and analysing data may allow farmers to enact such practices in spaces other than the office, providing there are the required background materials. The example given by many of the farmers was software on smartphones which allowed them to enter data and interpret data in the field. Using technology meant that the data preparation step could sometimes be skipped and allowed for the co-location of data collection and data use and interpretation practices.

"I'm totally up for farmers having these powerful tools on their phone because it just makes their life easier, and it saves them having to go back into the office and then make that recording after." (Beef FG3, RES4)

Cameras were a technology that were used by farmers to collect observational data whilst still being able to continue with other practices around the home or farm. In other words, cameras allowed the practice of observing their animals to be co-located with other seemingly unrelated practices such as resting or silaging.

"My guys absolutely love them [cameras] because they can be anywhere and they will have two or three in the calving shed and they can be three fields over, plant some grass or do some silage, they've had a ping on their phone, there's a calving alert from the collars, they will just go on the camera, "Oh yes next time I'm in the yard I'm just going to hop out and have a look at that cow."" (Dairy FG2, RES1)

3.1.4. Temporal disconnections of practices

From a temporal perspective, the data practices must happen in a specific sequence and different amounts of time were dedicated to different tasks. A lot of time was given to the observation of animals, whereas reactionary data collection and subsequent practices needed to be performed quickly. One example of reactionary data collection was the use of diagnostic tests. However, these were not often practised by farmers because the process from data collection to data use and interpretation was too slow to be practically useful for farmers. Diagnostic tests which give rapid results either do not exist or farmers do not know of their existence. Being able to generate this reactionary data faster would enable farmers to adapt their routine data collection accordingly.

"If it [diagnostic tests] could be easier and more commercially available in the hands of the farmer, then I think we would be monitoring and more quicker to react and respond." (Beef FG1, RES4)

"RES4: I think there should be more disease diagnostics available on the farm like [RES3] just said, next to the cattle crush or in the parlour always seems to be something that's on its way but I've not seen it working very well on the farm. It would be great to squeeze the milk into a tube and test it there and then for an appropriate antibiotic.

RES1: Yes, I think [RES4] has a good point, they might of times I've sent a milk sample off to the vets to be tested for anything from bovine mastitis to things like BVD and other diseases, if you've got that kit on the farm that you can just do it there and then, the quicker you diagnose the issue, the quicker you can treat it and rectify it." (Dairy FG2)

Data practices have to compete with other farming practices for the performers' time. For example, the following farmer suggests that routine data collection must compete with many other practices. It was not usually seen as the biggest priority and would therefore be one of the first practices to stop if there were too many.

"There's only so much you can do because the farmers concern straight away is that okay, milking the cows, getting those calves that are sick back up and running, keeping grass, hedges, all those day-to-day problems, because typically you are overworked and understaffed that's the gig." (Beef FG3, RES6)

Data preparation and data use and interpretation practices also competed with other practices for the farmers' time as spending time on the computer took them away from practices that involved their animals. The data preparation task demands time and being situated at a computer means that farmers cannot multi-task with animal-based practices. This is therefore another aspect which can create this disconnect between data collection and data use and interpretation.

"I think I prefer the time with the cows rather than the time at the computer, to be honest." (Dairy FG4, RES6)

In contrast, human observation data of animals happens during different practices on the farm, including feeding, weighing, and milking time. Therefore, the observation practice often shares time with other practices, rather than being in competition for the performers' time. The use of cameras for observing animals could also change the way time was allocated to tasks. The following quote demonstrates how cameras can reduce the time needed to observe animals so that they can spend time on other practices such as sleeping.

"The cameras I think just in time you know for us our shed is not near our house, it's only a quarter a mile up the road but it's these little bit of time, if you don't have to go up and check over the gates it makes a difference to your time which is valuable. And you know, if you're not knackered from going up there at four in the morning because you've had a look on your phone, go back to sleep you can invest your time somewhere more usefully" (Beef FG2, RES2)

Finally, technology can alter how time is divided between data practices. Data collection may become more efficient using technologies, but data administration and interpretation may require more time as greater quantities of data are collected.

"You use lots of data in there and then you just get washed with it. We've got quite a lot of data on our Parlour system. You got the milk yields and everything like that you can ever want… you could probably sit there all day looking at data. It gets boring then." (Dairy FG4, RES4)

"I've got from our own experience we do a lot of data collection; I think the biggest weakness is being able to have time then to analyse that data you collect and then make decisions based on that. It's very time-consuming analysing data and getting on with the day job whether that be feeding animals and looking after them or just doing day-to-day grind of what we do as a company." (Beef FG3, RES4)

3.1.5. Unequal access to forms of feedback reduces reproduction of practices

This theme focuses on how farmers were not analysing their data because there was a lack of description of what cattle farmers should be analysing. By description, we mean giving names to the outputs that farms can be measured against so that the types of data required are recognised and formalised (Shove et al., 2012). This can stabilise practices by setting some template for those who want to perform the practice. This is depicted in a series of quotes by RES2 (Beef FG1), a calf rearing farmer who also farms chickens. They suggest the chicken industry in the UK uses much more technology and data than cattle. They show that the chicken industry has set parameters that farms measure against to understand productivity, and so chicken farmers can even benchmark against each other's figures. In contrast, the cattle industry does not have a classification or standard that everyone follows.

"The chicken industry is all about data and, you know, we work out our margin in pence per meter squared per week and that's the industry yard stick. And it's quite easy to do it in a shed, you know exactly what is going in and what's coming out, it's easy to do it. But I have tried to have that sort of mentality on the sheep and the cattle, but they are much more extensive systems…"

"I don't have any data on calf rearing to share. On the chickens we have lots of data and if is shared with about a hundred and eighty other chicken growers, we have agreed to share our data and we have a league table." (Beef FG1, RES2)

Of course, some farmers did use their own units of measurement to understand their progress on their farm. Some farmers talked about measuring daily liveweight gains and key performance indicators, for example, but they were not used by all farmers. Therefore, there were not enough beef and dairy farmers measuring key performance indicators for it to become a normal, routine, socially shared practice.

What was often missing was the ability to benchmark progress against other similar farms. This means that processes of mediation, in which potential practitioners can keep up with standards of performance were absent (Shove et al., 2012). This can make it difficult to sustain data practices. Farmers that did not currently take part in benchmarking mentioned how it could motivate them to collect and analyse their data:

"Like I see how many times a day they clear the corn trough, but I am not measuring that I am just keeping an eye on it. Whereas if I could officially record that and compare it to other farms and see if I was on track or not, it would probably encourage me to find the time to do more recording, yes." (Beef FG1, RES2)

"If you could benchmark with a similar system and a smaller group, I think you'd notice more benefits and would want to get engaged more than going home at night logging into AHDB [Agricultural and Horticultural Development Board, which shows national targets and figures] and seeing oh bloody hell I'm miles out" (Beef FG3, RES2)

Those farmers that did take part in benchmarking found that it enhanced the meaning of their data. Without sharing data with other similar farmers, they "don't know" or are "just guessing" what their data actually means. Sharing data sets standards that farmers can compare against:

"We can then benchmark ourselves against other herds in the country so we can see how we compare to similar farms of our similar size, similar animals or bigger farms and things and see how we compare on those. So, I find that very useful because you can – we all think we're doing a good job but unless you have anything to compare it to, you don't know." (Dairy FG1, RES1)

Another method of benchmarking and getting feedback was through the veterinarian. For many farmers, veterinarians were the only people that they shared their data with. Veterinarians would perform the data use practice for farmers and then farmers and veterinarians would interpret the results together. On some farms, particularly dairy, this veterinary support was routine. Farmers suggested that veterinarians now spend more time looking at data rather than doing emergency work.

"We don't really overly share our data with any groups but we do share it back to the vets and the vets do take this into account and look into each farm as an individual. But then they also produce reports each month on how each group's performing and how we're doing for antibiotics and what's flaring up at the moment, disease wise." (Beef FG4, RES2)

However, not all farmers had access to a veterinarian who would make use of their data. This was sometimes because their veterinarian did not see data practices as meaningful. At times farmers would be reluctant to access veterinarians' data skills because of costs. There were therefore inequalities in farmers' access to appropriate social structures for data use and interpretation.

"My vets here don't, they don't really seem to believe in prevention and data recording and stuff, unfortunately. They are more just throw the antibiotics into them and that's it… Yes I would love if they would actually work on a health programme rather than like a fire brigade programme." (Beef FG1, RES3)

Therefore, for many of the cattle farmers in this study, there appeared to be no normalisation of what data should be collected or what data should be analysed. Similarly, there were no established meaningful boundaries for what analytical outcomes were good or bad. Some farmers did have standardised concepts of what data to collect and analyse as they are either part of farmer groups or have a veterinarian that is actively involved in the data practices so that forms of benchmarking can take place. However, not all farmers have access to these social structures. As many farmers did not have forms of feedback on their data use practices, their data use practices are unlikely to persist (Shove et al., 2012). It may be useful to develop a set of standardised concepts which are named and described so that farmers can follow these and can enable them to compare themselves against other similar farms. These concepts also need to harbour appropriate meanings if farmers are going to collect and analyse data related to them, and therefore it is important to ask farmers what they think are the most valuable data to analyse. Industry recommended key performance indicators do exist for the beef and dairy sectors in the UK (Hewitt et al., 2018; AHDB, 2019, 2021). However, interpreting data requires knowledge of the individual contexts of the farms, which is why farmer discussion groups and discussions with the veterinarian were preferred forms of feedback.

3.2. Study reflections

The analysis focuses on the broad concepts of data practices and use on cattle farms, rather than practices related to a specific data type. An analysis which centres on practices related to a specific type of data, e.g., weight data, may produce more targeted and nuanced analytic outputs and should be considered for future research. However, the detailed analysis of the broad data practices we capture may be transferable to cattle farmers in other countries with similar contexts. As social practice theory is highly contextualised, further research may be required to understand the digital divides in other species or countries where situations and perspectives differ from that of cattle farmers in the UK.

Our data collection involved online focus groups. We acknowledge that this will have an impact on our study sample as farmers who do not have the technical skills or materials to join an online meeting would be unable to participate in the study. Therefore, the results are likely to reflect farmers who can use the internet, have a computer or smartphone, and have an email address. This might reduce the number of older participants in particular (Hargittai et al., 2019). Despite these factors, there were still farmers who did not use technologies in their data practices.

As this was a qualitative study, we did not aim to obtain a statistically generalisable sample. Instead, our sample included a variety of farmers of different ages, gender, and farm type to generate a rich dataset and obtain a range of views. We provide a detailed description of the findings with illustrative quotes to aid researchers to determine whether the results are transferable to other research contexts (Smith, 2018). Furthermore, we show that the social practice lens is valuable for studying technology and data use on farms and the concepts developed may be theoretically generalisable to other farming contexts (Smith, 2018).

The size of the focus groups ranged from two to six farmers and are therefore classed as "mini focus groups" (Morgan, 2016). We had originally planned to have larger focus groups, but the turn-out of the focus groups was lower than expected. This may be because the online setting of the focus groups meant that participants were less committed to turning up. Upon reflection of the completion of first couple of "mini focus groups", we realised that the small size did not affect the interaction between participants. Instead, the small size allowed us to collect richer data because each participant was able to have more time to speak about their views and experiences (Braun and Clarke, 2013), they were able to interact with each other in more depth, and we were able to follow up questions in detail.

4. Conclusions

This study draws on social practice theory to understand UK dairy and beef farmers' data use practices and explore why and how the data divide exists. We build on a previous definition of the data divide as "a gap between generation and application of data" (Marshall et al., 2022) by conceptualising it as disconnection of data collection practices and data use and interpretation practices. Consequently, we were able to identify that the disconnection can happen because of negative meanings, lack of necessary competencies, spatial and temporal disconnects, and lack of forms of feedback on data practices. The analysis demonstrated that three types of disconnection can happen in order for the data divide to occur.

Firstly, there can be a disconnect *between elements* within a practice. The three elements of meanings, competencies and materials need to be present for a practice to be performed. However, our analysis shows that some meanings of data practices can prevent their uptake. The disconnect between elements within a practice can also happen because farmers did not always have competencies that align with data practices. This results in some data practices not being performed by farmers. As data collection, data preparation, and data use and interpretation are co-dependent, if one practice is not performed then this will affect the performance of the other practices.

The other type of disconnect that can happen was a disconnect *between practices*. Our analysis showed that data practices were often not spatially or temporally connected with other practices. Notably, data preparation and data use and interpretation practices often needed to be performed in an office space because of the required infrastructure. However, some farmers preferred to spend their time on practices that were outdoors and with their animals. Thus, spatial or temporal factors affected the bundling of data practices with other farming practices.

The third type of disconnect was a break in the reproduction of practices. This was most apparent through the lack of forms of feedback that the farmers had on their performances. Lack of feedback such as benchmarking or veterinary involvement meant that successive performances could not be connected. This led to some farmers stopping data collection, becoming defectors of the data practice, and therefore the data practice was not reproduced.

The role of materials was central to these three types of disconnect. Technologies not only acted as moments within data practices, but also as materials that connect practices together. Technology has an important part to play in removing the requirement for data preparation and facilitating the connection between data collection and data use. However, like previous research has shown, the many data collection technologies that are used by farmers do not integrate smoothly together (Marshall et al., 2022). To enable connections, technologies need to be re-designed to be compatible with each other. For example, by being able to import data from one data source to another without having to format the data differently. This likely does not happen because different technology companies are in competition with each other. Technologies can also allow for the co-location of data practices (e.g., software on smartphones) and reduce competition for time (e.g., cameras). Simultaneously, technologies require competencies that not all farmers have. Technologies can therefore enable or disable connections between practices.

4.1. Implications for reducing the data divide

We suggest that instead of focusing on individual behaviours, data use on farms can be improved through transformation of practices (Shove, 2010). This can be done by attempting to alter the elements (meanings, materials, competencies) that form practices and the connections between and within practices.

Technologies can help to facilitate spatial and temporal connections between the data collection and data use and interpretation practices. However, our analysis shows that this may require changes to the elements of practice. To ensure that technologies are designed with farmers' values and competencies in mind, we suggest that they are developed through a co-design approach in which farmers are involved throughout the innovation process (for example, Kenny and Regan, 2021). Farmers could be involved in deciding appropriate message framing so that technologies do not become associated with one specific group of practitioners. This could change the meaning around what type of farm should be using technology and performing data practices. Farmers could also test prototypes of the technologies to understand their user experience so that the design can be adapted to align with their existing technological competencies. To reduce the burden on farmers, developers should first spend time understanding the contexts and challenges that their prototypes need to work in, and ensure farmers are reimbursed for their time and expertise in the development process.

When introducing new technologies, it is also important to understand what new user practices will emerge and what practices will disintegrate, along with their corresponding elements. It could be possible to integrate social practice theory with the key dimensions of Responsible Innovation to anticipate the potential consequences of introducing a technology into a complex of social practices (Rose and Chilvers, 2018). This would facilitate our understanding of how new technologies could potentially reinforce or reduce the data divide.

Improving data use may not necessarily need a technological solution. The theme around unequal access to forms of feedback showed that data use could be improved through having necessary social structures such as farm discussion groups or veterinarians that were interested in working with data. The farmers in our study appeared open to sharing their data with their veterinarian or discussing data with other similar farmers if this was available to them. This suggests that there is a need to provide farmers with opportunities to join discussion groups in some areas of the UK. An alternative strategy could be to hold online discussion groups so that location is not a barrier to attending a group.

There is currently little research into the role that veterinarians have in data and technology practices on farms (Giersberg and Meijboom, 2021; Giersberg and Meijboom, 2023). However, it is known that the cattle veterinary profession is moving towards a proactive herd health advisory role (Ruston et al., 2016), in which use of farm data and technologies is often a necessary part (Woodward et al., 2019; Svensson et al., 2022). Our work suggests that some farmers need better access to veterinarians who are interested and skilled in working with their data. To do so, we need further studies to investigate veterinarians' perceptions and experiences of using data and technologies on farms, so that we can understand why veterinarians do, or do not, use farm data.

Ethics

The study was approved by the University of Nottingham School of Veterinary Medicine and Science Ethics Committee (no. no. 3509 211202). Participants provided written, informed consent by completing a form.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.prevetmed.2023.106030.

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