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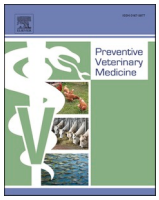

Putting sheep scab in its place: A more relational approach

Alice E.O. Smith [a], Annmarie Ruston [b], Charlotte Doidge [a], Fiona Lovatt [a], Jasmeet Kaler [a,*]

[a] School of Veterinary Medicine and Science, University of Nottingham, Sutton Bonington LE12 5RD, UK
[b] Faculty of Medicine Health and Social Care, Canterbury Christ Church University, North Holmes Road, Canterbury CT1 1QU, UK

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ABSTRACT

Since the reintroduction of sheep scab within the UK, its prevalence has increased despite several industry-led initiatives to control and manage the disease. Some studies have suggested that initiatives or policies should instead focus on specific places, such as geographically high-risk areas for sheep scab, which could allow for a more targeted approach. However, this risk of sheep scab has been measured in set geographical areas, without the reference to the interplay of topography, host, pathogen and the way in which humans socially and culturally define risk and place, potentially limiting the effectiveness of preventative initiatives. Therefore, the aim of the current study was to understand how place influences sheep farmers' approaches to the identification and management of the risk of sheep scab in their flocks. Qualitative data was collected from 43 semi-structured interviews with sheep farmers from England, Scotland, and Wales and was analysed by using the constant comparative approach. The codes were grouped into four concepts that influenced farmers' decision-making strategies for sheep scab control: perception of place; risk identification; risk categorisation; and risk management. These concepts were used as an analytical framework to identify three different 'places': 'uncontrollable places', 'liminal places' and 'protective places'. Each place reflects a different sheep scab control strategy used by farmers and shaped by their perceptions of place and risk. The 'uncontrollable places' category represented farmers who were located in areas that were geographically high-risk for sheep scab and who experienced a high frequency of sheep scab infestations in their flocks. The risk posed by their local landscape and neighbouring farmers, who neglected to engage in preventative behaviours, led them to feel unable to engage in effective risk management. Thus, they viewed scab as uncontrollable. The farmers within the 'liminal places' category were characterised as farmers who were located in high-risk areas for sheep scab, but experienced low levels of sheep scab infestations. These farmers characterised the risks associated with sheep scab management in terms of needing to protect their reputation and felt more responsibility for controlling sheep scab, which influenced them to engage in more protective measures. The farmers within the 'protective places' category were characterised as farming within low-risk areas and thus experienced a low level of sheep scab infestations. These farmers also described their risk in terms of their reputation and the responsibility they held for protecting others. However, they sought to rely on their low geographical risk of sheep scab as a main source of protection and therefore did not always engage in protective measures. These results suggest that place-based effects have significant impacts on sheep farmers' beliefs and behaviours and thus should be considered by policymakers when developing future strategies for sheep scab control.

1. Introduction

Ovine psoroptic mange (commonly known as sheep scab) is, arguably, one of the most important ectoparasitic diseases of sheep in the UK (Burgess et al., 2011). Sheep scab is caused by a hypersensitivity reaction to the faecal matter of the causative agent, the mite *Psoroptes ovis* (Burgess et al., 2012). It leads to significant animal welfare issues associated with dermatitis, pruritis, self-trauma, weight-loss and, occasionally, mortality (Kirkwood, 1986; Bygrave et al., 1993; Van Den Broek and Huntley, 2003).

The effective management of sheep scab has proved to be a long and intractable challenge in the UK (Chivers et al., 2018). In 1869, sheep scab was made notifiable across the entirety of Great Britain (GB) and all outbreaks were documented (Kirkwood, 1986; ADAS, 2008). This Order

* Corresponding author.
E-mail addresses: alice.smith2@nottingham.ac.uk (A.E.O. Smith), a.ruston414@canterbury.ac.uk (A. Ruston), charlotte.doidge@nottingham.ac.uk (C. Doidge), fiona.lovatt@nottingham.ac.uk (F. Lovatt), jasmeet.kaler@nottingham.ac.uk (J. Kaler).

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did not require the isolation, treatment or movement restrictions of infested sheep and it became apparent it was not controlling the disease by the increasing number of outbreaks reported (Rose, 2011). This prompted the implementation of several Sheep Scab Orders, including the Sheep Scab Order of 1948 which required the compulsory dipping or euthanasia of all infested sheep in index or neighbouring flocks and the restricted movement of animals in infested areas (Spence, 1951; ADAS, 2008). This national control programme was responsible for the eradication of sheep scab in 1952. However, sheep scab was reintroduced in 1973 when it was discovered in Lancashire after the importation of infested sheep from Ireland (Loxam, 1974). Sheep scab became widespread across the country until the introduction of various dipping programmes which focused on national and regional areas and although they were successful in reducing outbreaks, they failed to re-eradicate it (French et al., 1999). Sheep scab was deregulated by the UK government in June 1992 when they ruled that eradication was unsustainable and costly (ADAS, 2008). Dipping was no longer compulsory and the responsibility of the treatment of sheep scab was passed onto the sheep keeper, although the Sheep Scab Order of 1997 requires the treatment of sheep with visible sheep scab, as well as other sheep within the same flock (Ministry of Agriculture, 1997) and the Sheep Scab Order of 2010 requires the reporting of outbreaks in Scotland (Government, 2010).

This has led to the incidence of sheep scab exponentially increasing from fewer than 160 outbreaks per year between 1972 and 1992 (French et al., 1999) to more than 7000 in 2003/4 (Bisdorff et al., 2006). It is now endemic in the UK with national prevalence estimated around 9.0%, with significantly higher regional incidences in Wales, Scotland, and the North of England (Bisdorff et al., 2006). Sheep scab also imposes a major economic cost to the UK sheep industry with estimates between 78 and 202 million pounds sterling per year (Nixon et al., 2020).

Since sheep scab was deregulated there have been several industry-led initiatives to control and manage the disease (ADAS, 2008; Geddes, 2021). These initiatives have focused on raising awareness and educational resources within the industry (Rose et al., 2009), but there has been no evidence to suggest that they have been successful by reducing the prevalence of sheep scab. Other studies have suggested that new initiatives or policies should instead focus on specific places, such as high-risk areas (defined as areas that have a higher-than-average prevalence of sheep scab) (Rose et al., 2009; Phythian et al., 2013; Chivers et al., 2018). High-risk areas have been identified by previous research as areas of common grazing or areas within specific regions of GB (O'Brien et al., 1996; Phythian et al., 2013; Chivers et al., 2018). Other research has identified high-risk areas by modelling prevalence data with the addition of elevation, sheep density, temperature, and precipitation (Rose et al., 2009). A more recent study has identified high-risk areas by modelling farm-to-farm connectivity to predict between-farm transmission routes of sheep scab (Nixon, 2020). The consideration of these high-risk places has been suggested to allow for more targeted initiatives or policies, where spatial and other control measures could be implemented by all sheep farmers within them. Hinchliffe et al. (2013) argues, however, that the notion that spatial segregation alone, as a means of disease prevention, is limited as biosecurity threats do not fall neatly outside borderlines drawn between healthy and unhealthy. They suggest that disease should be examined in terms of networks rather than geographical blocs of infection given that diseases gain their effectiveness through the intensities and densities of interactions. Similarly, Shortall and Brown (2021) argue that it is important to recognise that biosecurity flows and practices take place across space. It has been insisted that place is not a simple concept and by purely focusing on these Euclidean conceptions of space as passive lines on maps, it will lead initiatives or policies to fail (Cummins et al., 2007).

Risks to the individual, posed by place, can be linked to social, cultural, economic, and environmental factors operating within places that they occupy (Fitzpatrick and LaGory, 2000). Places have both a typology of risk and protection, provided by the physical (such as buildings and roads) and social (such as people and neighbours) properties. On the one hand risk spaces can contain differing levels of hazard and on the other they can act as resource spaces with goods and services needed to protect people from harm (Fitzpatrick and LaGory, 2000). It has been argued that if an individual values a place that becomes threatened, they may cognitively manage the risk by reducing the salience of the perceived threat (Bernardo, 2013). Place attachments and place meanings can determine how individuals assign risk to local places, these in turn can influence the way they adapt to place (Quinn et al., 2018). For example, Enticott (2016) suggests that farmers lay epidemiologies can undermine government attempts to persuade farmers to adopt new approaches to disease management because they have failed to consider the local peculiarities of risk, landscape, and place.

Fitzpatrick and LaGory (2000) have suggested that the very same 'place' can be understood and defined differently by persons with different experiences and information, for place has a multidimensional nature. They suggest that places provide a stage upon which individuals make choices and actions in spaces, but also that the stage (or place) itself influences these choices and actions. It has been suggested that it is in places where our habitus developed that we are likely to feel at home and connected (Easthope, 2006). Thus, who we are is shaped by and reflected in places we occupy and the spaces we control.

By interweaving relational views, places represent more than traditional processes which express these spatial units as bounded, binary and consistent (Fitzpatrick and LaGory, 2000). They encompass more than physical positions, they are spaces which are socially and culturally defined, which are actively produced and are emergent, continuously reformed by the interweaving of interactions and practices through time and space which are frequently evolving (Graham and Healey, 1999; Hammond et al., 2017).

Quantitative studies have been limited in their ability to capture or understand the depth and complexity of farmers' place-based perceptions and practices around the management of sheep scab. This could be achieved through qualitative methods. Therefore, the aim of this study is to gain an understanding of how place influences sheep farmers' approaches to the identification and management of the risk of sheep scab through semi-structured interviews. To the best of our knowledge, this is the first qualitative study to provide insights into the way sheep farmers characterise and manage sheep scab in their flocks.

2. Method

2.1. Study context

Based on findings from previous research (O'Brien et al., 1996; Phythian et al., 2013; Chivers et al., 2018), it was assumed that the region of the farm and the frequency of sheep scab outbreaks were important when considering farmers' sheep scab strategies. Table 1 presents the farm region and sheep scab outbreak frequency of the participants in this study.

2.2. Study locations

The interviews with farmers were conducted across six areas of GB. Wales is dominated by total permanent pastureland with a high proportion of common grazing land. It is largely suited to the grazing of livestock, with a high population density of sheep; a similar structure is seen in Scotland (Armstrong, 2016). The South-West of England (Devon) comprises of smaller farm sizes (68 ha) than the English average (87 ha) with grazing livestock dominating the farm types; this is also a similar structure in the West Midlands (Herefordshire) (DEFRA, 2021). The North-East of England (Northumberland) has the largest average farm sizes in England (144 ha), and grazing livestock farms are also the most dominant farm type (DEFRA, 2021). The East-Midlands (Leicestershire) were predominated by cereal farms (49%) and therefore had a much smaller proportion of grazing livestock farms (DEFRA, 2021).

Table 1
Participants frequency of outbreaks, farm location, risk area, number of years sheep farming and number of ewes.

Interview (I) number	Number of sheep scab outbreaks in the previous 10 years	Location	Risk area	The number of years sheep farming	Number of ewes
I1	15	North Wales	High-risk	35	750
I2	6	North Wales	High-risk	20	1100
I4	1	Herefordshire	High-risk	20	380
I5	0	Northumberland	Low-risk	47	1500
I6	2	Herefordshire	High-risk	20	400
I7	0	Herefordshire	High-risk	10	700
I8	0	Devon	High-risk	52	1100
I9	1	Herefordshire	High-risk	35	650
I10	2	Northumberland	Low-risk	50	1800
I11	1	Northumberland	Low-risk	23	300
I12	4	North Wales	High-risk	40	3500
I13	0	Northumberland	Low-risk	10	2100
I14	0	Devon	High-risk	30	500
I15	2	Herefordshire	High-risk	30	500
I16	2	Leicestershire	Low-risk	15	350
I17	6	Herefordshire	High-risk	30	1800
I18	0	Devon	High-risk	10	300
I19	1	Leicestershire	Low-risk	50	260
I20	2	Devon	High-risk	21	500
I21	1	Herefordshire	High-risk	30	120
I22	10	Herefordshire	High-risk	13	2500
I23	2	Herefordshire	High-risk	30	750
I24	2	Leicestershire	Low-risk	50	600
I25	1	Leicestershire	Low-risk	7	150
I26	2	Leicestershire	Low-risk	45	400
I27	0	Leicestershire	Low-risk	44	1380
I28	1	Leicestershire	Low-risk	30	1300
I29	10	Devon	High-risk	65	1400
I30	1	Herefordshire	High-risk	40	350
I31	0	Leicestershire	Low-risk	35	400
I32	1	Leicestershire	Low-risk	33	700
I33	0	Leicestershire	Low-risk	45	1000
I35	0	Peeblesshire	High-risk	16	450
I36	0	Peeblesshire	High-risk	28	530
I37	6	Herefordshire	High-risk	40	300
I38	0	Leicestershire	Low-risk	40	550
I39	4	North Wales	High-risk	50	1050
I40	0	North Wales	High-risk	30	500
I41	1	North Wales	High-risk	43	650
I42	2	North Wales	High-risk	50	1000
I43	0	North Wales	High-risk	67	180
I44	0	Leicestershire	Low-risk	25	230
I45	4	North Wales	High-risk	15	300

2.3. Assumptions

Sheep scab is often diagnosed by observation of clinical signs such as itching and wool loss. A skin-scraping method of diagnosis is also available. However, sheep scab can manifest without any clinical signs and these approaches to diagnosis are frequently unable to detect sub-clinical sheep scab infestation (Wells et al., 2012). In contrast, a blood enzyme-linked immunosorbent assay (ELISA) test can be used which has been shown to be effective at detecting sub-clinical infestation (Nunn et al., 2011). Thus, our assumption during the analysis of farmer behaviours was that blood tests were the most appropriate method of sheep scab diagnosis.

2.4. Sampling strategy

Initially, a purposive sampling strategy was used. Based on the hypothesis that there may be differences in scab control strategies in high-risk and low-risk areas, the authors aimed to obtain responses from sheep farmers in both areas. Farmers were recruited from six areas of GB and identified by key contacts: veterinarians (will be referred to as vets from hereon), merchants, livestock markets and contract sheep dippers within these areas. The six areas were selected on their risk of sheep scab based on previous mathematical models of outbreak map (Rose, 2011) and a farm connectivity map (Nixon, 2020) and were identified as either a high-risk or low-risk area. The outbreak map identified high-risk areas by using sheep-density, elevation, temperature and precipitation data. The farm connectivity map identified high-risk areas of sheep scab based on between-farm transmission routes across sheep farms via neighbour-neighbour contact. The farmers were selected from four high-risk areas: Peeblesshire in Scotland, North Wales, Herefordshire, and Devon and two low-risk areas: Leicestershire and Northumberland. Inclusion criteria were commercial sheep farmers within the specified areas described above, which we defined as a farmer that rears sheep to produce commercial products (meat/wool/breeding animals etc.).

An introductory letter was sent to potential participants identified by the key contacts which described the aim of the study, information about the interview and a consent form. All farmers who passed on their consent were contacted by telephone by author AEOS to arrange a suitable date to interview. Then, snowball sampling was used where study participants identified and recruited suitable farmers to the study.

The sample size was guided by the "information power" concept in which the (a) aim of the study, (b) sample specificity, (c) use of established theory, (d) quality of dialogue, and (e) analysis strategy was

considered (Malterud et al., 2016). If the sample holds more information power relevant to the study, then the number of participants needed is lower. The analysis was guided by theory of risk and place which enhanced the information power of the study. However, the broad study aim, sparse sampling specificity and intention to use a cross-case analysis strategy suggested that a larger sample is required (Malterud et al., 2016). Therefore, a provisional number of 40–50 participants was estimated. The information power attained was reviewed at various points of the data collection process and a final sample size of 43 was judged to provide sufficient information for the analysis.

2.5. Data collection and ethics

A semi-structured interview guide was developed to understand how farmers interpret, make sense of, and act in relation to sheep scab in their farm. The interview guide was informed by literature on the current behaviours of managing sheep scab (Cross et al., 2010; Phythian et al., 2013; Chivers et al., 2018) and psychosocial constructs and concepts such as: risk and reflections (Michie et al., 2011). The topics covered in the interview guide included biosecurity measures, diagnostics, treatments, and relationships with others when managing sheep scab. Vignettes depicting different sheep scab management strategies were presented in the interviews and the respondents were invited to discuss their thoughts. Two pilot interviews were conducted with a convenience sample of sheep farmers known to some of the authors and further changes were made to improve the wording.

Individual interviews with farmers were conducted by author AEOS over the telephone between 20th July 2020 and 4th September 2020. The interviewer was a PhD student who had been trained to conduct qualitative interviews by other authors JK and CD who were experienced in qualitative methods. Relationships with any of the participating farmers were not established prior to the interviews. The farmers were informed that the interview data would be used for research purposes and that they will remain anonymous in any outputs.

Forty-five interviews were conducted with sheep farmers, with two excluded from data analysis as they did not meet the inclusion criteria. Therefore, the remaining 43 interviews lasted between 15 and 50 min and were audio recorded with the farmers written/verbal consent. The interviews were then transcribed verbatim by an independent transcription company.

The study was approved by the University of of Nottingham School of Veterinary Medicine and Science Ethics Committee (no. [2625 181105]).

2.6. Data analysis

The transcribed data was coded using the constant comparative method to identify categories of data (Maykut and Morehouse, 1994). The analysis was supported by the use of NVivo (NVivo qualitative data analysis Software; QSR International Pty Ltd. Version 12, 2018). Initially, all transcripts were read and re-read to get a sense of the whole sample. The initial codes were developed inductively, where codes were derived from interpreting the data. Author AEOS coded every transcript, authors AR and CD coded a subset of the data, and author JK reviewed the codes.

The authors (AEOS, AR, CD and JK) met regularly to iteratively discuss the identification and grouping of codes into concepts. It was noted at this stage that the similarities and differences found in the data could be supported by the theoretical underpinnings of risk and place (Maykut and Morehouse, 1994). Therefore, the data was then analysed deductively using this theory.

The codes were grouped into four concepts. The three concepts on risk identification, risk categorisation, and risk management were adapted from an established risk framework (Shi, 2004). The concept of the perception of place came from the place and risk theory. These concepts were used as an analytical framework to compare and contrast farmers' decision-making strategies for sheep scab control. Patterns in the data were identified to construct three categories: 'uncontrollable places', 'liminal places' and 'protective places'. These categories depicted three strategies that farmers used to control sheep scab which were shaped by their perceptions of risk and place.

3. Results

The farmers could be placed into three categories based on their perception of place (how the farmers perceived the place they farmed sheep in), risk identification (the places or people which the farmers identified as increasing their risk of sheep scab), risk characterisation (farmers motivations to carry out behaviours) and risk management (the practices the farmers did to manage their risk) (Table 2). This was driven by context specific factors of categorisation of the farm in a high-risk area and the frequency of outbreaks.

3.1. Uncontrollable places: deflecting risk and responsibility and engaging in risky practices

3.1.1. Perceptions of place

Farmers in this category were characterised as being located in high-risk areas which experienced a high frequency of sheep scab outbreaks in the last ten years. They recognised that they were farming in an area with an increased risk of sheep scab infestations and described sheep scab as highly prevalent and almost omnipresent in nature:

> *Well, there is always scab in the area, there is always scab around this area. Respondent I29 (High-risk farmer with 10 outbreaks).*

> *But it's not just your immediate neighbours, it's the areas really. Respondent I1 (High-risk farmer with 15 outbreaks).*

> *It's such a prevalent disease now it's hard not to have it. Respondent I22 (High-risk farmer with 10 outbreaks).*

3.1.2. Risk identification

Respondents identified a range of risks posed by the physical environment. They suggested that livestock markets were high risk spaces in which sheep scab was highly prevalent. They suggested the markets were one of the main factors responsible for the onwards transmission to their own flocks:

> *Another outbreak that we had, and we won't do it again, is we think we bought a tup from a local market and that one came with scab perhaps. Respondent I37 (High-risk farmer with 6 outbreaks).*

> *Well, I dunno to be honest. It's the next-door farmer or the markets fault to bringing the scab into my farm, 'cause there's hardly any sheep on my boundary so most of the farms with cattle so it's the marketplace, it needs sorted out to be really. Respondent I39 (High-risk farmer with 4 outbreaks).*

They also held their neighbours or neighbouring farms accountable or blamed them for sheep scab transmission into their flocks:

> *So I would think between the two blocks of land we have I'm sure that you'd be talking about 35 different farms really that's actually the other side of the fence to you and one of them is gonna slip up somewhere. Respondent I1 (High-risk farmer with 15 outbreaks).*

> *Yes, it does make me a bit angry because the other farmers, they're not careful enough with their sheep. Respondent I39 (High-risk farmer with 4 outbreaks).*

> *Well, like I say, one of the main problems is our immediate neighbour is organic, well two of the neighbours are organic, and managing scab is quite difficult for them. Respondent I29 (High-risk farmer with 10 outbreaks).*

Table 2
Three categories identified from the data presented with the strategies that farmers used.

	Categories:		
	Uncontrollable places	**Liminal places**	**Protective places**
Key actors	Farmers in high-risk areas who experience scab regularly (≥4 outbreaks in the previous 10 years)	Farmers in high-risk areas who do not experience scab regularly (≤2 outbreaks in the previous 10 years)	Farmers in low-risk areas
Perception of place	Regional & localised risk factors	Regional risks, neighbours offer some protection	Regional & localised protection
Risk identification	Markets, other farmers, common grazing Not viewed as poor management	Markets, other farmers, common grazing Not viewed as poor management	Markets, other farmers Viewed as poor management
Risk characterisation	Fatalistic views due to sheep scab seen as omnipresent	Responsibility, impact on others, reputation	Responsibility, impact on others, reputation
Risk management	Biosecurity not adopted, engaged in risky practices	Biosecurity adopted, use veterinary advice	Some biosecurity measures adopted

The farmers also negated their responsibility to others (and the risk of their geographical place) by identifying sheep scab as a normalised event to occur and something which was not caused by poor management. They suggested that even the 'best' farmers experienced it:

We just see it as another disease that sheep get, you know, it's not dirty or frowned upon by us that's for sure. Respondent I22 (High-risk farmer with 10 outbreaks).

Even the best farmers have this kind of problem. Respondent I1 (High-risk farmer with 15 outbreaks).

3.1.3. Risk characterisation

The appearance of sheep scab in their flocks was described to be omnipresent in nature and they felt they were unable to determine where the infestation had come from:

'cause it just pops its head up. Respondent I1 (High-risk farmer with 15 outbreaks).

We have had an incident last year or the year before, we're not really sure where it came from. Respondent I12 (High-risk farmer with 4 outbreaks).

This perceived omnipresent nature of sheep scab led the farmers to believe that developing sheep scab within their flocks was inevitable. They suggested that sheep scab was uncontrollable and that no matter what they did to try and prevent sheep scab, they would still end up getting it:

…it's inevitable if it's around the area because of the amount of land we have that we will get it at some point. Respondent I1 (High-risk farmer with 15 outbreaks).

Well, no, you can't do nothing about it, I said, 'Yeah, and I know where it's come from.' You can't do nothing about it, it's one of them things and if you… Respondent I37 (High-risk farmer with 6 outbreaks).

But yeah, we get it every autumn/winter without fail. Respondent I22 (High-risk farmer with 10 outbreaks).

3.1.4. Risk management

In addition to allocating responsibility for outbreaks to others, the respondents also suggested that their geographical location presented barriers to them being able to implement effective biosecurity measures such as double fencing. Such measures were considered impractical for them to implement due to the physical and social resources of their farm. They described a typology of risk associated with the areas around their farm which lacked protective resources, and which engendered a sense of helplessness:

So the fencing for us would just be completely impractical because we hill graze so we're gonna be with neighbours' sheep anyway and the boundaries on our farm are very, well, there wouldn't be many fields that wouldn't be attached to the neighbour's field as well. Respondent I22 (High-risk farmer with 10 outbreaks).

Well, on a hill farm like this there are always sheep getting in from neighbours and ours getting out and The Common. I mean if you do keep them completely separate then you would manage the scab but it's just impractical. Respondent I29 (High-risk farmer with 10 outbreaks).

Respondent's fatalistic views about the uncontrollable nature of sheep scab and their ability to control risky neighbours and risky spaces in turn influenced the way in which they sought to manage the disease on their farms. Their beliefs were suggestive that biosecurity measures instead do not 'fit' within the physical and social reality of this place and thus they engaged in risky practices.

Firstly, they questioned the need to seek veterinary advice to facilitate the identification and management of the disease on their farms. They argued that as they had experienced sheep scab a lot, the vet did not offer anything else to help to improve the situation:

I don't actually go to the vet or anything, which perhaps I should do, but I don't think we've ever had a case of lice before, and it might sound a bit Heath Robinson, but I probably *inject… I think I know what scab looks like by […] enough. And usually I'm right, unfortunately. <Laughs> We've experienced it before. Respondent I17 (High-risk farmer with 6 outbreaks).*

They exemplified this further by indicating that they trusted their own ability to visually identify sheep scab and suggested they would disregard any result from a diagnostic test that did not match their own perceptions. Some farmers also voiced that they would feel more confident selling animals that had been prophylactically treated to ensure they were free from sheep scab instead of using diagnostic tests. It appeared that the respondents doubted the diagnostics test to provide a source of protection against the high-risk of sheep scab posed by their geographical place:

Well, yes 'cause I'm not quite sure if you had a group of 60 lambs and if you picked 5 or 10 or 15 say of them, it's not 100%, is it […], it could be one of them out, say if you're selling *a hundred, it could be one of them out of that 85 in the field. That's how I've got it really and I would rather just do the whole hundred and be done with it […] I could be wrong but I think testing a part of the flock, you know, […] if they don't show any symptoms and I wouldn't be convinced on that. Respondent I1 (High-risk farmer with 15 outbreaks).*

Yeah, bit more confidence *then and you can tell the buyer you've injected them and he doesn't have to worry and I don't have to worry. Respondent I45 (High-risk farmer with 4 outbreaks).*

The vet bill would be more expensive and probably not as reliable I would imagine. Respondent I22 (High-risk farmer with 10 outbreaks*).*

Secondly, they argued that testing prior to taking their sheep to the market or selling them was not necessarily a strategy that they would adopt. They assumed that if they could not see any visible signs of sheep

scab, their animals were not diseased:

Probably not if I'm honest. *If they weren't showing signs of scab and we were selling them… I mean we don't generally sell animals like that anyway, but if they weren't itching, no we probably wouldn't, no, to be honest. Respondent I22 (High-risk farmer with 10 outbreaks).*

Unfortunately, I probably *wouldn't, 'cause it's just an extra cost the next day, so if they didn't look like they'd got scab, they probably … I'd just sell them. Respondent I2 (High-risk farmer with 6 outbreaks).*

This was illustrated further by some farmers expressing that they would knowingly sell scab infested sheep into the market to avoid withdrawal periods or if they could avoid damage to their reputation by doing so:

The first few weeks of May we got this problem with this scab in our lambs and ewes and our early flock, we sort *of run two flocks, we lamb one lot in February and another lot in April and the best lambs we had in the early flock that were nearly, well, they were fit to kill, of course I couldn't dip 'em because of the retention. So we had to pull 'em out, mark 'em different, they didn't go through the dip and I had a… we weaned the lambs off the ewes and we kept 'em separate for a fortnight and then I sold 'em once they were fat enough to go to market. 'cause once you dip 'em you've got to leave 'em, what is it, 42 days isn't it, the withdrawal? Respondent I37 (High-risk farmer with 6 outbreaks).*

… but if they were going to an auction, I probably wouldn't say anything 'cause it's just, they're gonna go and you don't know where they're going at that, and whoever's buying them, so it's probably gonna be buying from different places so he's probably <laughs> not gonna get back to you! Respondent I2 (High-risk farmer with 6 outbreaks).

Thirdly, they reported using multiple treatments each year to prevent or control sheep scab. Some farmers also described using the organophosphates within showers and sprayers, which are unauthorised application systems for this product:

We dip in the autumn*, sort of now, the end of August/beginning of September to prevent sheep scab but we usually have to dip or inject in the spring. […] We spray dip them and we plunge dip all the ones on The Common and all the ones on the main holding and then spray dip the ones on another holding, but I mean that's all Gold Fleece. Respondent I29 (High-risk farmer with 10 outbreaks).*

We plunge dip everything *in the autumn – it's more so for ticks more than the scab but we do shower dip probably everything during the summertime as well and that should help with the scab a bit as well. Respondent I22 (High-risk farmer with 10 outbreaks).*

This category represented a group of farmers who were high-risk for sheep scab infestations which was linked to their geographical location. This in turn influenced the way in which place related factors affected their categorisation, identification, and management of the disease on their farms. By engaging in risky practices, this allowed them to protect their income at the expense of protecting other farmers from risk of infestation. However, it also increased the risk of their own sheep scab outbreaks by the lack of biosecurity and ineffective treatment strategies used.

3.2. Liminal places: accepting risks, responsibility and engaging in biosecurity practices

3.2.1. Perceptions of place

Farmers in this category were also characterised as being located in *high-risk* areas, but as having experienced no outbreaks or a low frequency in the last ten years. The farmers were aware that they were farming in an area with a high risk of sheep scab, but also identified that their immediate surroundings might have a protective effect:

*But at the moment I would say that most of my regular neighbours around here are, as far as I k*now, touch wood, don't have it, but I know of areas close to where I farm where there *are scabby sheep and have been scabby sheep. Respondent I8 (High-risk farmer with 0 outbreaks).*

So it doesn't really *happen here but it's coming around us more and more really. Respondent I40 (High-risk farmer with 0 outbreaks).*

3.2.2. Risk identification

In similarity with farmers that characterised the 'uncontrollable places' category, the farmers identified the same risks posed by their physical and social resources, including markets and neighbours:

Our biggest problem *in [area] is the market I'm afraid. [The] market is rife with it. Respondent I7 (High-risk farmer with 0 outbreaks).*

Neighbour-wise, we've got the odd dodgy neighbour, but you just try to make sure the sheep don't *get together or keep them away… Respondent I15 (High-risk farmer with 2 outbreaks).*

3.2.3. Risk characterisation

The farmers within this category characterised risk in terms of sheep scab potentially placing their livelihood and reputation at risk:

Well it's fairly embarrassing really. If you sold a load of sheep for good money and then suddenly they ring you and say they've got scab in the flock, you'd feel fairly embarrassed and you know darned well that they won't come and buy your stock next year. Respondent I7 (High-risk farmer with 0 outbreaks).

If I was selling breeding stock onto, whether it was someone who'd been a customer previously or hadn't been, it's all about building levels of trust and the quality of stock and the parasites or anything else that you might transmit to their farm, so I think it's very important that you keep that level of trust with the purchaser at all times. Respondent I36 (High-risk farmer with 0 outbreaks).

The farmers also expressed that their motivations for preventing sheep scab came from a sense of responsibility for their neighbouring farms:

It's the inconvenience and the effect on other people, immediately you have to tell all your neighbours because if you don't and they get it and don't know they can spread it to their neighbours, I mean I really believe it's important to tell everybody. Respondent I8 (High-risk farmer with 0 outbreaks).

I have a responsibility *to protect other flocks so that if I cleared it from my flock I can't be then immediately re-infected by them not knowing they've got it. Respondent I36 (High-risk farmer with 0 outbreaks).*

They were also aware and concerned with the production impacts of sheep scab in their flocks. They believed that implementing protective measures to prevent sheep scab outweighed the costs of disease:

I think the effect, the cost of loss of production across an entire flock is more severe than the cost of *implementing the measures to prevent it. Respondent I36 (High-risk farmer with 0 outbreaks).*

The time we use to prevent something is much less than the time we would use to treat something afterwards. That's the way we see it with everything here, prevention is better than anything really and you can't put time on preventing something happening, it's much easier than if it has actually happened it's going to take more time afterwards. Respondent I40 (High-risk farmer with 0 outbreaks).

However, these farmers did not associate poor management of their flocks as a cause of sheep scab. They were aware of their increased geographical risk of sheep scab and believed it was not their fault if they contracted an infestation:

If you're just somebody that picked it up from somebody else it's not your fault, I mean you're the victim and you just wanna make sure that nobody else is affected [.] To be honest I still think they feel there's a stigma with having scab, like it's a fault of theirs, which of course it isn't at all. Respondent I8 (High-risk farmer with 0 outbreaks).

3.2.4. Risk management

Many of the farmers in the category reported implementing biosecurity measures to prevent sheep scab, including quarantining sheep brought onto the farm and double fencing. They also avoided the identified risky practices such as buying from markets:

Well when we buy our replacement ewes, they're always quarantined for at least six weeks. Respondent *I4 (High-risk farmer with 1 outbreaks).*

Like I said, we *double fence because we feel we have to keep our own stock in our own part and my neighbours fence their own side as well because they feel they need to keep their stock in. Respondent I14 (High-risk farmer with 0 outbreaks).*

Being very careful *about where we buy our replacements, only buying from well-known sources and trying to steer clear from livestock markets. Respondent I9 (High-risk farmer with 1 outbreak).*

Some farmers within this category also made use of their physical resources such as woodlands, roads, and arable fields within or next to the farm to protect against sheep scab, instead of implementing biosecurity measures:

No, I'm fairly lucky because my farm is isolated by woodlands and a main road, hardly any sheep in or… neighbouring sheep on the pens, you know, I'm very lucky like that. So the main road acts like a double fencing, doesn't it? Respondent I43 (High-risk farmer with 0 outbreaks).

We're fortunate that the fields we have are mainly… aren't touching anybody else's sheep, that's just how it is, we've got orchards and corn land so we're fortunate that they don't really touch anybody else's. Respondent I21 (High-risk farmer with 1 outbreak).

In contrast to the previous category, the farmers made use of their vet to diagnose and advise on sheep scab. They also voiced the importance of not selling sheep that potentially had sheep scab:

To identify it we get the vet to confirm it and the last couple of times we've had it, but traditionally we've just looked at sheep, seen the *symptoms and self-identified as being scab. The reason we started getting the vet involved now is there's more cases of lice and scab, so we're making sure we're treating freshly. Respondent I6 (High-risk farmer with 2 outbreaks).*

Yeah we've got some good vets here really and we've changed a lot; we have a vet that comes here to do the sheep plan every year and he's changed our minds with the dosage and everything like that and it's changed the health of the sheep a lot really. Respondent I40 (High-risk farmer with 0 outbreaks).

If I had scab my sheep don't leave here – we're absolutely definitive on this. If anybody has scab we go into *the meltdown with the whole of the valley, we would be very careful about making sure that person was isolated, that we all took very severe isolation procedures. Now, there is no buying or selling going on between anybody if there's any scab going on so that is not even a starter as a thought. Respondent I35 (High-risk farmer with 0 outbreaks).*

The farmers in this category also recognised the importance of veterinary assistance and diagnostics by implying that they were aware that the nature of sheep scab challenged those skills of identifying sheep scab visually:

But if it's there you can see and when you can see it's probably a bit too late. Respondent I30 (High-risk farmer with 1 outbreak).

Some farmers suggested the importance of using treatments appropriately for the effective control of sheep scab. They also avoided routine prophylactic treatments to prevent sheep scab infestations for concerns around resistance:

My husband's a great believer of dipping everything the way, you know, the way that you're supposed to dip kind of thing, not just pushing 'em in, you know, they have to be underneath the water a couple of minutes before he lets them back out. Respondent I40 (High-risk farmer with 0 outbreaks).

If you look at people who *are not using dipping, including some people just use a sort of shower, the scab is not being managed properly. Respondent I35 (High-risk farmer with 0 outbreaks).*

…but I'm not in favour of treating sheep just because you think they've got something. I think it's time we got away from all that and we should be treating when something has something or using quarantine and then observe whether they've got it or not. Respondent I8 (High-risk farmer with 0 outbreaks).

One farmer also highlighted this further by reporting how he tried to discourage another farmer from using unauthorised application methods:

'We treat scab by putting sheep-dip in a knapsack sprayer' and I did see red at that, I just explained very bluntly to a gentleman that should know better that is worse than doing nothing, what *he's doing. He's encouraging resistance. And that is shocking, because once you get resistance to dip, where it starts to fail… Respondent I6 (High-risk farmer with 2 outbreaks).*

However, other farmers were aware of their place-based risk of common grazing and thus still used prophylactic treatments to protect against these risks:

We haven't had a problem with it for a long time, but we dip every year just as a preventative measure because they come back from Moor… and not all farmers out there, you don't get everyone and obviously if you don't get everyone and that one's got scab then you've got a problem, haven't you? Respondent I20 (High-risk farmer with 2 outbreaks).

This category therefore represents a group of farmers who were at high-risk for sheep scab because of their geographical location but were protected against this risk by adopting certain measures. Like the farmers in the 'uncontrollable places', they also identified their neighbours and markets as risky sources of sheep scab and did not associate poor management as a risk factor. However, these farmers characterised their risk by protecting their reputation and felt a greater responsibility for preventing sheep scab spreading to their neighbours' farms. This influenced them to adopt biosecurity measures and engaged in more protective measures to prevent sheep scab infestations in their flocks or others.

3.3. Protective places: feeling safe and acting somewhat responsibly

3.3.1. Perceptions of place

This category is characterised by farmers who farm in low-risk areas with a low frequencies of outbreaks in the previous ten years. They were aware that their farm was low risk geographically for sheep scab and thus provided them with some form of protection:

We seem to be in an area where we don't, where there's not being… in the thick of a sheep area *we don't suffer at all really. Respondent I19 (Low-risk farmer with 1 outbreaks).*

As far as I know there's no incidences of sheep scab that *I've heard of in this area, at all. Respondent I31 (Low-risk farmer with 0 outbreaks).*

We don't have a lot of scab, it is just every now and again you have a wobble. It's very much a disease that will not come into

Northumberland, *as far as everyone's concerned. Respondent I13 (Low-risk farmer with 0 outbreaks)*

3.3.2. Risk identification

The farmers in this category identified the same risk factors for sheep scab as the farmers in the previous two categories. Again, the risk factors included using markets and their neighbouring sheep farms:

We buy out of a market so it's a bit of a job, we try and buy off the same people regular. I mean the one we bought the scab off, we know who that was so he got a line through the catalogues, we've never bought off them again. Respondent I19 (Low-risk farmer *with 1 outbreaks).*

If you're buying bits and bobs of stock is the worst thing to do I think. If you're trading stock, trading it quickly, it's the worst thing to do and you just want to know the source of your stock really, *where it's coming from. Respondent I33 (Low-risk farmer with 0 outbreaks).*

Its always been caught from a neighbour, you know, over the fence contact. We've never brought it into an area ourselves. *Respondent I10 (Low-risk farmer with 2 outbreaks)*

In contrast to the previous two categories, some of the farmers in this category identified poor management as a risk factor of sheep scab:

It's a sign of very, very bad animal *management if you let scab get rife in your flock. Respondent I5 (Low-risk farmer with 0 outbreaks).*

I wouldn't be very happy – something's *gone wrong. Our biosecurity's meant to prevent it coming in. So if it got into the flock we've got a problem, something's gone wrong. Respondent I13 (Low-risk farmer with 0 outbreaks).*

Secondly you feel as if you've, you know, done something incorrectly I guess. Respondent I28 (Low-risk farmer with *1 outbreaks).*

A respondent highlighted this further by reflecting on other infectious diseases in farm animals where the blame could be shifted onto something else. The respondent reported that this was not the case for sheep scab infestations, and that it had to be caused by 'someone's' poor management:

I always compare it with TB, the nice thing about… nice is the wrong word, but the thing with TB is you can always *blame the badgers. It's not your fault. But there is a thing with scab that it is somebody's fault. Somebody's done something wrong or somebody's done something badly which is why it's happened; it wasn't me it was them next door. Respondent I16 (Low-risk farmer with 2 outbreaks).*

3.3.3. Risk characterisation

The farmers within this category characterised their risk of sheep scab in a similar way to those farmers within 'liminal places'. They felt sheep scab was damaging to their reputation if they introduced sheep scab to a 'scab-free' area:

So as far as we are concerned prevention, prevention and that's the end of it. I don't want to be hated by my neighbours either, to phone up and tell them, 'Oh, by the way we've got sheep scab. Respondent I13 (Low-risk farmer with 0 outbreaks).

It's the thought of just *yours transmitting it to somebody else's and you being the start of it or could be the start of it. Respondent I33 (Low-risk farmer with 0 outbreaks).*

Oh yeah, yeah you certainly don't want anybody to come back and… because once you get and sell some*… it's like anything, if you sell something bad your reputation, that'd be sticking with you for a long time and so you make certain you clean 'em and make 'em that they are right certainly. Respondent I38 (Low-risk farmer with 0 outbreaks).*

They also believed they had a responsibility to protect their neighbours from infestations:

Well yes, aye, because you've gotta *… when you say you've got a responsibility to protect other, yes, sorry, sorry, yes, you have. Respondent I5 (Low-risk farmer with 0 outbreaks).*

You've got a duty to *your neighbours. Respondent I13 (Low-risk farmer with 0 outbreaks).*

Some farmers also considered the potential welfare and productivity impacts of scab on their sheep:

No, it's important we're doing it, it's for the health of the sheep really. Anything that upsets the sheep and it doesn't *thrive is taking money out of our pockets, isn't it? Respondent I19 (Low-risk farmer with 1 outbreak).*

3.3.4. Risk management

The respondents suggested that their geographical location provided a protection against sheep scab infestations which allowed them to avoid implementing some biosecurity measures. They described how it was not necessary to implement some biosecurity measures due to their social resources, such as good neighbours. It appeared that their management was dependent on their neighbouring farmers:

Well it depends what you're *next to. If you're next to somebody that's a stocks-person and looks at sheep and is careful and treats for scab, then no. But if you're next to somebody that's rough and ready and doesn't treat them or only treats some of them or misses sheep when they gather, then yes, I suppose it's worth it. Respondent I5 (Low-riskfarmer with 0 outbreaks).*

We don't have any *grassland bordering any other grassland neighbours and we have arable fields in between to prevent any contact. Respondent I13 (Low-risk farmer with 0 outbreaks).*

They'll be a hedge and a fence but there wouldn't be kind of sheep one side of the wire fence, we've got nothing *like that so they are away. They'll be two fields away really. Respondent I33 (Low-risk farmer with 0 outbreaks).*

They also described how their physical resources of the farm provided protection against sheep scab:

All the sheep that are bought in, we're really fortunate, if you imagine the farm's in the shape that we're *a U and we use one side of the U for the flying flock, for the Scottish Black Faces and that's where the problem is always because there's fields and fields apart from the main flock to the Scottish black faces, we can keep them apart. So we use that purely as a quarantine area so if you're buying a sheep in that's where they go. Respondent I11 (Low-risk farmer with 1 outbreak).*

We try to keep, as much as we can we try to keep sheep away from neighbours' sheep. It can't always *be done but use roads for instance as boundaries, keeps you away from neighbours' flocks. Respondent I5 (Low-risk farmer with 0 outbreaks).*

Like the previous category, the farmers also voiced the importance of using veterinary assistance to confirm sheep scab if they suspected an outbreak in their flock or to protect their sheep from potentially infested strays. They exemplified the importance of using diagnostics, rather than making decisions based on visible signs:

Well, it would be a vet. Like I say, we haven't had it, but it would be a vet that would identify it was actually scab. Respondent I5 (Low-risk farmer with 0 outbreaks).

We did have one issue this year where a ram got out from somebody else's and I couldn't actually identify who it was to start with 'cause it had no tags and then it did turn up, we found who *the owner was. But we blood tested that ram to check it for scab and other diseases to make sure there was none, that it hadn't brought anything to us. Respondent I32 (Low-risk farmer with 1 outbreaks).*

Part of the trouble with scab is that it takes a long time to appear, from a sheep being infected it takes quite a few weeks for it to appear and you're not keeping your eye on the ball because you're *assuming that they haven't got it and then suddenly it appears and you've got it and you think ah! Respondent I10 (Low-risk farmer with 2 outbreaks).*

However, one respondent doubted the need to seek veterinary advice for the management of sheep scab. It appeared that they were relying on their low geographical risk and their experience of no outbreaks:

I probably wouldn't *implement it in my own flock because at this stage I have seen no signs of it and I would be looking for those signs. If I was shipping sheep out, breeding sheep out, which is what you're talking about, I would probably isolate them anyway, so we'd quarantine them before they went just to watch for anything because I understand how difficult it is when you've got a problem when you've shipped a problem out. So probably I would do that and probably I wouldn't rely upon a vet investigation. Respondent I27 (Low-risk farmer with 0 outbreaks).*

In contrast to the 'uncontrollable places', the farmers in this category also stated that they would take steps ensure that their sheep were clear of scab before selling them to other farmers:

I categorically wouldn't *sell anything that I knew wasn't clear, whether that be by blood or by treatment or by discussion with the vet/whoever had it. Respondent I13 (Low-risk farmer with 0 outbreaks).*

If I thought the neighbours *had got scab I would call in a mobile dipper and dip 'em all, and before we sold 'em if we thought we'd got scab next door to us. Respondent I19 (Low-risk farmer with 1 outbreak).*

Yeah, yeah I'd get the vet in, especially *if… well, I would do that if I was gonna sell them 'cause I wouldn't find it right to be able to… I wouldn't wanna sell my stock with a thought of maybe spreading it. Respondent I33 (Low-risk farmer with 0 outbreaks).*

Farmers within this category were also aware of responsible use of treatments and reported only using them on new sheep joining the flock:

Yeah, Cydectin is used on anything bought in and if we had sheep scab, if we found it we would just get a mobile dipper *in. Farmer I13 (Low-risk farmer with 0 outbreaks).*

This category therefore represents a group of farmers who are low risk for sheep scab because of their geographical risk. These farmers identified the same physical and social risks as the previous two categories. In similarity to the farmers within the 'liminal places', they also characterised their risk in terms of their reputation and the responsibility they held for protecting others. However, because of their low place-based risk of sheep scab these farmers did not always engage in biosecurity measures and thus relied on other protective measures such as the physical and social resources of their farm.

4. Discussion

4.1. General discussion

To the authors' knowledge, this is the first qualitative study to provide insights into the way British sheep farmers identify and manage sheep scab in their flocks through the theoretical lens of risk and place. The purpose of our study was not to quantify opinions or behaviours, but to develop an in-depth understanding of how farmers interpret, make sense of, and act in relation to sheep scab on their farm. These insights aim to support successful behaviour change, the development of new control strategies and thus the reduction of the national sheep scab prevalence within GB.

The analysis generated three categories which the farmers could be placed into based on their relations with place and their perceptions of sheep scab control: 'uncontrollable places', 'liminal places' and 'protective places'. Although all three groups identified similar risk factors towards sheep scab infestation, they had contrasting motivations and management strategies for controlling sheep scab on their farm. These differences were a result of differing perceptions of place and frequencies of sheep scab outbreaks. As Fitzpatrick and LaGory (2000) highlight places occupied by individuals are not just physical spaces but are also mental constructs, based on cultural beliefs and positions held by individuals within society.

For many of the farmers within the 'uncontrollable places', a perception of fatalism was derived from the sense that an infestation of sheep scab in their flocks was inevitable and uncontrollable. The farmers who held these fatalistic views around managing sheep scab seemed to be more likely to engage in risky practices such as not using biosecurity measures to manage their risk of sheep scab. This is like the findings of a study of cattle farmers in England and Wales, where they held fatalistic views around the contraction of bovine tuberculosis (bTB) and had minimal motivations to do anything about it (Enticott, 2008). Biosecurity measures attempt to impose boundaries and barriers onto these spaces and places to exclude the spread of disease into or out of an area where farm animals are present (Young et al., 2015). Biosecurity measures may be practically impossible for farmers within the 'uncontrollable places' to impose due to their particular farm characteristics or farming practices. For example, it would be impossible for farmers who common graze their sheep to keep their flock closed or isolated from neighbouring flocks. Furthermore, the uncontrollable and omnipresent nature of sheep scab suggests biosecurity measures would just be as likely to fence in sheep scab as it would exclude it – something the farmers would not want to do. These farmers identified that biosecurity measures do not necessarily 'fit' within the physical and social reality of this place. In contrast, farmers within the 'liminal places' were more likely to report implementing biosecurity measures to prevent sheep scab in their flock. These farmers appeared to have physical and social properties surrounding their farms to support the implementation of these measures. This was in similarity to those farmers within the 'protective places' but they were also able to employ their 'own kind' of biosecurity by utilising roads and woodlands as a protective measure.

The farmers within the 'uncontrollable places' seemed to characterise the risk of sheep scab as a disease which was omnipresent. The farmers within the other two categories did not consider sheep scab as an omnipresent disease and instead characterised their risk in terms of protecting their reputation and others. This contrast in how the farmers characterised their risk between the 'uncontrollable places' and the other two categories may be explained by the philosophical understanding of moral responsibility. For a person to be morally responsible for an action then they must be able to control whether the action occurs (Nelkin and Rickless, 2017). However, farmers within the 'uncontrollable places' do not believe they can control sheep scab, and therefore they cannot be held morally responsible for their lack of sheep scab control. This may explain why they are not motivated by reputation and responsibility like the farmers within the other two categories.

Additionally, the lack of control may explain why those farmers in the 'uncontrollable places' may not perceive sheep scab to be caused by their own poor management. Interestingly, those farmers within the 'liminal places' also do not suggest it is caused by poor management, but they do believe it is controllable. These differences may be explained by their awareness of how prevalent scab is in their surrounding areas. In contrast, those farmers in the 'protective places' do believe scab is a sign of poor management. This may because they do not regularly experience sheep scab or are not aware of it in their surroundings, so thus believe it must be caused by poor management. These differences in the characterisation between these three categories reiterates how place impacts the beliefs and choices these farmers hold.

Some of the farmers within the 'uncontrollable places' did not seek veterinary advice for the identification or management of sheep scab in their flocks. They did not appear to be aware of the subclinical phase and believed that scab could be identified by visible signs. These behaviours may be aligned with the symbols of the 'good farmer' identity. The

Bourdieusian-inspired concept of the 'good farmer' suggests that farmers become 'good farmers' by gaining social positions through the adherence to principles which are based on the values rooted within the farming culture (Burton, 2004; Sutherland and Darnhofer, 2012; Naylor et al., 2018). Multiple symbols have been identified as 'good farming' symbols, including being able to determine the health and disease status of their animals by eye (Shortall et al., 2018; Doidge et al., 2020). Farmers in this category may associate being a 'good farmer' with these skills and thus explains why they seem to not utilise veterinary advice or diagnostics to manage sheep scab infestations. It may also explain why some of these farmers may disregard the results from the ELISA test which is able to diagnose sheep scab two weeks post infestation during subclinical stages of disease (Nunn et al., 2011). Farmers hold expertise in animal diseases, especially when it comes to those that are experienced regularly. They did not see the need to defer to veterinary expertise and diagnostic practices. In contrast, the farmers in the other two categories were aware of some of the flaws of utilising these embodied skills of visibly identifying sheep scab and consequently relied more heavily on the use of diagnostics. The clinical signs of sheep scab present very similarly to a louse infestation but the treatments can be different (Mitchell and Carson, 2019). Therefore, the diagnosis of sheep scab is paramount to ensure other diseases are excluded and that treatments used are appropriate (especially with increase reports of resistance) (Doherty et al., 2018; Sturgess-Osborne et al., 2019). The farmers from the other two categories may be used to disassemble these perceived norms associated with the 'good farmer' identity and to establish a new 'good farming' symbol which encompasses veterinary advice and diagnostics for the management of sheep scab.

It should also be mentioned that sheep farming in GB is often restricted by economic and biological margins which may influence the way farmers are able to manage and control diseases in their flocks (Doidge et al., 2021). It is likely that those farmers within the 'uncontrollable places' who experience a high frequency of sheep scab in their flocks may not use diagnostics or may knowingly sell infected sheep because of the high economic costs these would incur. It is much easier for those farmers within the 'liminal places' and 'protective places' to report that they would employ specific management practices, many of which would be time-consuming and costly, in response to situations that they have limited experience of and are unlikely to experience because of their social and physical environment and thus low risk of sheep scab.

Previous quantitative studies have shown that geographical location is an important risk factor for sheep scab (O'Brien et al., 1996; Phythian et al., 2013; Chivers et al., 2018). Our study used these mathematical models to form the framework of our sampling strategy and analysis which allowed us to critically reflect on these specific spatial claims as high or low-risk areas for sheep scab. Mathematical modelling is a valuable tool in disease research as it can provide patterns and predictions to advance knowledge, and evidence to inform control strategies and policies (Grassly and Fraser, 2008; Temime et al., 2008; Leach and Scoones, 2013; Heesterbeek et al., 2015). Although they are often understood as tools which are objective and impartial, they are still based on different scientific, cultural, and political assumptions, and can be constrained by the funding arena which influences the modelling process (Leach and Scoones, 2013; Grant et al., 2016). These models also did not employ or incorporate any information around social relations and instead held fixed assumptions of human behaviour. This is likely to be due to the lack of behavioural data available. Our qualitative approach was able to provide novel information about farmer behaviour that could improve these mathematical models.

Furthermore, the mathematical models present the disease risk as bounded and consistent, which fits into this dichotomous labelling of high or low-risk areas. However, it is acknowledged within these papers that there are some farmers within these high-risk areas who do not experience disease (Rose et al., 2009; Nixon, 2020). In contrast, our findings suggest that there needs to be this additional 'place' which reflects this disjuncture between the high-risk designation of the models and their actual reality. Although the analysis generated these three 'places', they do not represent physical borders but instead present as spaces with different social, cultural and physical environments which are adaptive and plural. Therefore, our findings provide additional perspectives and knowledges which may be invaluable to support the existing models for the most impactful future control strategies, but also reinstates the importance of multiple models and perspectives to inform control strategies.

Our findings suggest that farmers' approaches to sheep scab management was influenced by their individual beliefs, the community they belong to, and their physical and social environments. Therefore, any interventions to improve the control of sheep scab across GB needs to recognise this complexity. For example, farmers within the 'uncontrollable places' felt that they were unable to control sheep scab. Changing the attitudes of these farmers would require intervention at both the individual farmer-level and the societal-level. We could attempt to change individual attitudes through educational programmes ran by the local vet. Vets would be invaluable in delivering tailored communications to these farmers as they can suggest appropriate control measures which can be adaptive, plural, and conditional to consider the nuances of the places. However, this would also require addressing the societal level problem of the small economic margins of sheep farmers and the impact of this on farmers' access to veterinary services. Models that conceptualise individual, social, and contextual factors may be useful to identify such interventions. One example is the COM-B model which uses three factors - capability, opportunity, and motivation - to identify potential intervention functions (Michie et al., 2011). Another approach is the use of the social ecological model which recognises factors at the individual and social environmental level as targets for interventions (McLeroy et al., 1988). Our findings may be applied to these models to ensure future interventions tackle both the individual and collective problems relating to sheep scab.

The findings have applicability to sheep farmers within high-risk and low-risk areas within GB and may not be generalizable outside of this context. However, important findings such as the influence of fatalism, perceived responsibility, and place-based risk on management practices might be transferable to other disease contexts and requires further investigation.

4.2. Implications for policy

Through the insights identified in this study, several limitations in the current policy are evident. Firstly, the current policy which aims to control sheep scab through a 'one size fits all' approach does not appreciate the physical and social differences of the three different categories of sheep farmers identified in this study. Policy could instead be redeveloped to target the areas of 'uncontrollable places' where farmers experience the highest frequency of sheep scab outbreaks. Our results suggest that a reduction in sheep scab in these areas is possible with appropriate control strategies such as those formed on a basis of pooled resources and collective actions managed by a local vet.

Secondly, the notification of sheep scab outbreaks is currently only compulsory in Scotland through the Sheep Scab (Scotland) Order 2010 (Government, 2010). Therefore, the current data available from England and Wales is limited, as it is dependent on the voluntary submission of cases to the authorities by farmers and vets (Nixon, 2020). Thus, the data available is likely to be underrepresented since not all cases would have been reported (APHA, 2019). We suggest that policy could instead reinstate sheep scab as a notifiable disease in England and Wales. Although we do not suggest it will lead to control alone, it may provide data which could be used to accurately target places or communities of farmers who are experiencing high frequencies of outbreaks in order to lead to effective control. However, before the disease is made notifiable, the potential negative impacts need to be investigated such as increased stigmatisation.

The study illustrated that many of the farmers, especially in the 'uncontrollable places' category, identified sheep scab as a disease which displayed visible signs such as itching and wool loss. The Sheep Scab Order (1997) states that a sheep is visibly affected with sheep scab if it exhibits clinical signs of the disease (Ministry of Agriculture, 1997). Therefore, the legislation frames sheep scab as a clinical disease with a lack of recognition of the highly infectious, subclinical phase where sheep exhibit no or minimal signs (Busin, 2018). It has been suggested that sheep with subclinical disease are most likely the source of infestation to other flocks, as they are challenging to clinically diagnose and thus lead to an increase of transmission (Busin, 2018). Additionally, if policy only outlines clinical disease, it is difficult to encourage farmers to adopt the ELISA test pre-clinical signs if there are no requirements to treat animals until the clinical stages. Our results suggest that policy needs to reframe sheep scab as a disease, so its subclinical phase is recognised as well. This could encourage sheep farmers to recognise sheep scab before the clinical signs and thus utilise better management strategies.

5. Conclusion

In conclusion, this study used qualitative methods to provide insights into the way British sheep farmers identify and manage sheep scab in their flocks through the theoretical lens of risk and place. This study identified that place and risk have a significant impact on sheep farmers' beliefs and behaviours, which permitted the farmers to be placed into three categories: 'uncontrollable places', 'liminal places' and 'protective places'. The respondents reported contrasting motivations and management strategies to manage sheep scab. The farmers within the 'uncontrollable places' characterised sheep scab as a disease which was omnipresent and unpredictable, whereas those farmers within the other two categories reported being concerned about the potential effects on their reputation and held a responsibility to protect others. These insights are of upmost importance to policy makers to consider when changing and developing the current policy to ensure that it reflects the place-based effects found by targeting those areas appropriately by a mode of pooled resources and collective actions to have the most impactful progress to reducing the national prevalence. Future research should focus on how these collective actions can be achieved. This study also illustrates the importance of qualitative methods when understanding how sheep farmers manage sheep scab in their flocks and how behaviours may be changed by policies.

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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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