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Published in:
Health, Risk & Society

DOI:
[10.1080/13698575.2021.1948507](https://doi.org/10.1080/13698575.2021.1948507)

Publication date:
2021



Document version
Publisher's PDF, also known as Version of record

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Citation for published version (APA):
Ditlevsen, K., Glerup, C., Sandoe, P., & Lassen, J. (2021). Better than antibiotics. Public understandings of risk, human health and the use of synthetically obtained livestock vaccines in five European countries. *Health, Risk & Society*, 23(5-6), 196-216. <https://doi.org/10.1080/13698575.2021.1948507>



Better than antibiotics. Public understandings of risk, human health and the use of synthetically obtained livestock vaccines in five European countries

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(Received 5 November 2019; accepted 23 June 2021)

Drawing upon data collected within 20 focus groups with consumers from five European countries, in this article we investigate how perceptions of human health risk and current anxieties regarding agricultural food production affect citizens' acceptance of the use of an emerging biotechnology, synthetic biology, in the development of vaccines for animals bred for food production. In focus group discussions in Austria, the UK, Poland and Denmark, participants tended to value the positive potential of synthetic vaccines if they could solve existing problems. Participants argued that the technology could be beneficial for animal welfare and was a potential solution to the problem of risks to human health posed by the use of antibiotics on livestock. The perceived drawbacks of antibiotic use affected the discussions towards acceptance of synthetic biology and the use of vaccines in meat production despite concerns over the potential risks. The participants from Spain stood out in that their acceptance of the synthetic vaccine appeared to be disconnected from concerns about risks related to the use of antibiotics. Participants from all countries found the vaccine to have potential uses, but also expressed concerns about health risks for consumers. In general consumers were perceived as those bearing the heaviest burden of risk, while pharmaceutical companies were perceived as likely to benefit most from production of the vaccine. We found that institutional trust and national contexts of (dis)engagement with science influenced the participants' understandings of the degree to which the synthetic livestock vaccine had a fair risk-benefit balance.

Keywords: risk; public understandings of risk; human health risk; biotechnology; synthetic biology; agricultural vaccines

Introduction

Over recent decades, applications of genetic technology in food production have given rise to considerable controversy, especially in Europe. Recently, developments in genetic technologies have introduced synthetic biology as an area of interest within the agricultural food sector. Synthetic biology is a scientific field that makes it possible to genetically and epigenetically modify organisms to suit various human goals. So far,

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application of synthetic biology has attracted limited public attention. But this could change: GM foods and use of biotechnology have been at the centre of public controversies for many years, in which experts often defend them while a significant part of the public see them as risky for human health.

In this article we present findings of our study of public understandings of the use of synthetic biology to create vaccines for animals used in food production, and addresses the research question: How do consumers in different European countries negotiate potentials of synthetic biology when used in the development and production of a livestock vaccine, and what role do perceptions of human health risk play in their reflections?

Based on focus group interviews with 154 people from five European countries, we report discussions of: a) the *usefulness* of applying synthetic biology in the production of vaccines for farm animals; b) the *fairness* of the vaccine (in relation to animals, meat consumers, agriculture and the medicines sector); and c) how understandings of *risk* and *trust* in the institutions and regulations surrounding the development and use of synthetic biology vaccines affect consumer assessments.

Synthetic biology and risk

Synthetic biology is still an emerging field, and we need more knowledge of attitudes to it, to explore whether consumers understand this new technology as a threat, or whether they are likely to accept it. New biotechnologies and their applications have often given rise to concerns among people in western countries (Giordano et al., 2018; Lassen, 2018). Emerging technologies are associated with understandings of risk that may or may not relate accurately to the specific technology and its technical properties as such (Douglas & Wildavsky, 1983). Risks related to the use of biotechnology in food production, and to public perceptions of that use, are interwoven with other latent side-effects of modern food production and risks already seen as present in people's everyday lives. Consumers have been found to be sceptical about the new biotechnologies used in food production, and reluctant to eat meat from vaccinated animals (Scudamore, 2007; Zingg & Siegrist, 2012). There is a limited literature on understandings of synthetic biology applications, but earlier studies have found that people consider synthetic biology to be risky because they regard it as a form of human interference with nature, and that people's attitudes to applications of synthetic biology depend on the degree to which the applications are seen as 'natural' (Avellaneda & Hagen, 2016; Ditlevsen et al., 2020; Dragojlovic & Einsiedel, 2013). 'Naturalness' is perceived to be a sign of safety and order, whereas 'unnaturalness' signals potential danger to many consumers and rises anxiety (Ditlevsen & Andersen, 2020; Douglas, 2002).¹ Concerns about the 'unnatural' synthetic biology resemble public concerns about genetically modified (GM) foods (Hudson et al., 2015; Lassen & Sandøe, 2009). The latter have caused food scares, distrust in some foods and biotech companies, and heated public debate. Scepticism towards animal vaccinations, anxiety of 'unnatural' modifications and distrust in the use of biotechnologies in food production in general, makes it relevant to investigate whether consumers are likely to assess synthetic livestock vaccines to be acceptable and safe for human health, or as risky for human health.

People today live in an ever-present dilemma between the attractions of modernisation and technological advance and the desire to remain within the boundaries of ecologically and socially acceptable generation of risk and danger (Beck, 1993; 1989;

Douglas & Wildavsky, 1983). Today, this dilemma has grown with the global climate crisis, and a rising number of food scares and similar cases in which the food we eat comes under suspicion to be the cause of human health problems (Draper & Green, 2002; Lassen & Sandøe, 2009). Many anxieties in the western world today evolve around invisible risks, uncertainty, and loss of control over scientific and technological advances (Beck, 1993). Where food is concerned, many consumers have developed small-scale strategies of consumption in which risk is eliminated, or reduced, through the individual's avoidance of certain foodstuffs, ingredients, modes of production, additives, and so on (Andersen & Holm, 2018; Ditlevsen et al., 2019; Lupton, 1999). Uncertainty is at the core of the sociological concept of *risk*, which always implies an element of unpredictability. Not all risks receive the same level of public recognition; only some risks are highlighted in the public debate or create anxieties among the populace (Douglas & Wildavsky, 1983). In that sense, risks are socially constructed.

The concept of risk is related to that of *trust*. Decisions about what to eat or not eat are affected by perceptions of both risk and trust (Bergman et al., 2019; Bildtgård, 2008; Tonkin et al., 2016). In modern industrialised societies, in which the production of food is global, complex, and distanced from the consumer, trust in foods operates at a generalised level, detached from interpersonal relations of trust (Bildtgård, 2008; Giddens, 1991). Trust in food is thus an expression of trust in national and international food safety regulations, labels, food systems and chains of distribution, rather than confidence in specific persons or sites of production. Consumer trust in applications of synthetic biology in food production does not depend in a simple way on the food system and its regulatory framework. It is also affected by trust in the biotechnology itself, the pharmaceutical companies producing the synthetic applications, and the national and international authorities regulating applications of synthetic biology. Past research has shown that biotechnology is often represented as risky in the media and in public debates (Petersen, 2005). It is also known that responses to this representation are shaped by institutions and rooted in social, cultural, and political contexts (Howarth, 2013). Public attitudes to new technologies differ from one European country to another, and consumer perceptions of biotechnologies are also affected by variations in public involvement in science governance and other contextual factors, such as the country's economic situation and the relative importance of the agricultural sector (Gaskell et al., 2010; Mejlgaard, 2012). While uncertainty about new biotechnologies is central to many debates, members of the public do not simply assess new technologies in terms of what they perceive to be risks to human health and the environment. They also consider questions about usefulness, and moral questions including those couched in terms of naturalness and justice. The specific content of public concerns appears to vary depending on the context and the specific application being considered (Lassen & Jamison, 2006).

Against this background, in this article we present a case study investigating dialogues among consumers about a new emerging biotechnology (synthetic biology) which in turn refers to concerns about current technologies used in food production, risk, trust, and other contextual factors. We explore focus group discussions of synthetic livestock vaccines that may well be used in animal production in the near future. Unlike traditional vaccines here the genome of the bacteria in question, mycoplasmas, are being genetically engineered so as to allow the development of a range of new vaccines to be used in all the main farm animal species. Model-driven genetic engineering is also used to include new safety features, such as kill switches, which will stop the vaccines from functioning if unintended releases occur.

The vaccines are interesting because they bring together several potentially controversial issues: the use of synthetic biology in food production; the use of vaccines in agriculture; and more widely the development and application of a new biotechnology.

Methodology

The study reported here is part of a larger in-depth study addressing lay and expert understandings of a potential livestock vaccine produced using synthetic biology.² The study investigated how citizens in five importantly different European countries discussed the potential development and production of a genetically engineered universal vaccine against *Mycoplasma* for different species of livestock, and how their hopes and concerns might be shaped by the different national contexts. Since there is limited scientific knowledge of consumer attitudes to synthetic biology generally, and the use of synthetic biology vaccines in agricultural production in particular, a qualitative approach allowing these attitudes to be explored was chosen.

Focus group discussions was selected as the most adequate method to explore how consumers assessed the potentials of using synthetic biology in agricultural production. Focus groups are useful when the object of interest is the understandings of *social groups* rather than individuals (Halkier, 2015), and here we were interested in similarities and differences between citizens in different European countries. In focus group discussions, knowledge about social norms, shared social concerns, understandings and conflicts, and about negotiations and socially acceptable arguments is shaped and made available for analysis. Knowledge obtained in focus groups is created in and by social processes and interactions between participants and the method cannot be used to create knowledge of individual attitudes as such, nor understanding of deep individual sense making (Barbour, 2018). Therefore, the data presented in this paper report on group sense-making: positions created in dialogue and negotiations between focus groups participants. Because synthetic biology is not a well-known subject for most participants, the positions reported are very much shaped with reference to shared knowledge on more well-known bio-technologies, agricultural food production, current public concerns etc. and the discussions are as much reflections of these other aspects, as they are predictors about future understandings of synthetic livestock vaccines and synthetic biology.

Focus groups

The study was designed to capture the diversity of understandings among consumers in different European countries. Focus group interviews were carried out in five European countries: Denmark, the United Kingdom, Poland, Austria, and Spain. The countries were chosen to ensure that a diversity of factors known to influence public perceptions of new technologies in the area of food and food production were represented. One dimension of that diversity is the degree to which formalised procedures for public involvement in science and technology are in place (Mejlgaard, 2012). Using the typology and categorisation made by Mejlgaard (2012), the *degree* (high/low) and *nature* (formal/informal) of public involvement in science governance in the five countries are described in Table 1. Denmark and the UK are countries in which there is a high degree of formalised public involvement in science governance. In Poland public involvement is formalised, but there is a low degree of it. In Austria formal involvement is limited, but there is nonetheless a high degree of more informal public engagement, and in Spain

Table 1. Country diversity.

	Poland	Spain	Denmark	Austria	UK
Importance of agriculture	High	High	Middle	Middle	Low
Degree and nature of public involvement	low/	high/			
formalised	low/	high/			
formalised	high/	high/			
formalised	informal	informal			
Generalised technological optimism (ranking)	4	2	1	5	3
Approval of synthetic biology*	Disapprove (-4)	Approve (+18)	Approve (+4)	Disapprove (-19)	Approve (+9)
Ambivalence about synthetic biology**	31%	29%	12%	14%	20%

* Difference between approval rates and non-approval rates

** Percentage of respondents answering 'Do not know' to the question whether they approved or disapproved of synthetic biology (Gaskell et al., 2010)

there is little formalised public involvement and a low degree of involvement. A second dimension of diversity is economic – specifically, variation in the countries' economic profiles and the relative importance in them of the agricultural sector. In UK the importance of agriculture is categorised as 'low', in Denmark and Austria it is 'middle' and in Poland and Spain it is 'high' (EU, 2013). Third, with reference to findings in European surveys (Gaskell et al., 2010), the countries were chosen to reflect differences in public attitudes to new technologies. Denmark is the country with the highest share of generalised technological optimism among the five, followed by Spain, the UK, Poland, and Austria. Austria is also the country where the highest proportion of people disapprove of synthetic biology, followed by Poland. Danes approve slightly more, as do their UK counterparts. The highest level of approval for biotechnology is found in Spain. Yet, in all five countries, there are many people with no opinion on synthetic biology.

Sampling of participants was based on the factors: gender, age, place of residence (city or countryside), income, and education to ensure diversity. The recruitment criteria were designed by the research group, and a professional company managed the recruitment itself. Participants were aged 18–69, had no specific knowledge on biotech science, agriculture, or consumer responses to biotechnology. Potential participants who (or had members of their households, who) worked with marketing, market research, journalism/PR/consumer research, biotech science or industry, or manufacturing of meat or dairy products were excluded. Four focus groups were conducted in each country. The size of the resulting 20 focus groups varied between five and ten participants. In total 154 consumers participated.

Focus group discussion guides

Discussion guides were developed deductively, meaning that they were designed based on existing knowledge about public understandings of new biotechnologies. The themes of the focus group interviews, which reflected issues known from the literature to be central, can be seen in Table 2. The guides also permitted an inductive approach in the interviews, allowing the interviewees to suggest and develop additional themes.

Table 2. Interview themes.

Risk
Perceptions of risks in general
Risks related to consumption of animal products from vaccinated animals
Risks for the animal itself
Risks related to animal diseases
Risks related to new biotechnologies
(Mis)trust
Perception of the trustworthiness of key parties involved with the vaccine (including farmers, retailers, the government and pharmaceutical companies)
Regulation
Control and regulation of the production of vaccines
Control and regulation of the use of the vaccine
Animal welfare
Understanding of animal welfare
Diseases among farm animals
Strategies for maintaining healthy livestock
Usefulness
Vaccines as a helpful technology
Synthetic vaccines as a helpful technology
Synthetic biology as a helpful technology
Justice
Perceptions of fairness and unfairness related to the production and use of the vaccine
Distribution of benefits and drawbacks among key parties involved with the vaccine (including animals, farmers, pharmaceutical companies and consumers)

Synthetic biology has so far hardly entered public awareness (Gaskell et al., 2010). Therefore, the discussion guide was designed to provide participants with basic information before debate of the specific issues raised by synthetic vaccine began.³ The focus group sections on the different themes always started, however, with a more open discussion which allowed participants to bring initial reflections and thoughts to the table before the basic information was provided.

Data collection and analysis

All of the Danish and UK focus groups were conducted by the second author. Focus groups in Spain, Austria and Poland were run by native-speaking moderators with the second author present. The interviews were recorded and transcribed, and those held in Austria, Poland and Spain were translated into English.

The transcribed interviews were analysed in a three-step procedure. First, they were coded using NVivo11 in order to gain an overview of the material. Here all text in which participants were discussing the development, production and use of the synthetic vaccine was coded and read again. Second, a more detailed selective coding process (Blair, 2015) followed in which recurrent themes in the focus groups were identified and conceptualised (Halkier, 2015). In this step, analytical codes were used to break down arguments and understandings put forward in discussions into summaries of content and themes (examples of such codes: ‘critical towards antibiotics’, ‘risky vaccine’, ‘vaccine unproblematic’, ‘human health risk because unnatural’). Third, based on these findings all interviews were re-read and perspectives on antibiotic replacement, human health risk

and animal welfare, as well as on the benefits of the vaccine and trust and distrust, were interpreted and summarised for each country (see [Table 3](#), in the Discussion section).

Findings

During the analysis of the interviews, it became clear, that the use of livestock vaccines obtained by synthetic biology was seen as having positive potentials in relation to two aspects of agricultural food production: animal welfare and use of antibiotics. The discussions and assessments of synthetic biology and the livestock vaccine, which will be presented in the following, present an example of how understandings of a new biotechnology are complexly interlinked with societal contexts, current challenges and public concerns.

Thus, concern for animal welfare, understood as the absence of pain and suffering linked to disease, and fear of antibiotic overuse in agriculture were two important reasons why focus group participants would take a positive angle on synthetic vaccine use in meat production. The basic physical welfare of the animals was valued highly. Antibiotic resistance was considered a serious risk to both animal and human health, and the synthetic vaccine was seen as a solution to this, as it can potentially render antibiotics redundant. The *usefulness* of synthetic vaccines was thus an important factor, and the extent to which the livestock vaccine obtained by synthetic biology was seen as solving existing problems was conclusive in many focus group discussions. Perceptions of who would benefit most if the synthetic vaccine was used, and of *fairness* in the distribution of any benefits of vaccination, also proved essential in the discussions of the vaccine.

A minority of participants expressed that they were sceptical about the use of synthetic biology vaccines, mostly because they had concerns about unnaturalness (see results reported in Ditlevsen et al., 2020), but most focus group participants expressed seeing potential in the use of livestock vaccines obtained by synthetic biology and talked about it as largely or wholly unproblematic. This is somewhat surprising, since focus group discussions of other interview themes – for instance, comparing synthetic vaccines with other types of vaccine – or in general discussion of the costs and benefits of new forms of vaccine, voiced many concerns.

In the following sections we explore how the discussions of the synthetic biology vaccine in focus groups are mediated by the concerns: antibiotic resistance, animal welfare, and the distribution of benefits. We investigate how each influenced the positions taken by focus group participants in discussions of synthetic vaccine use in livestock production. In the course of the exploration, we describe the national differences found in the focus groups.

Use of antibiotics in agriculture

The perception of the vaccine was, in all five countries, mediated by anxieties about antibiotic use in farm animal production, but the seriousness of the concerns, and their focus, varied. In the Danish focus groups, participants often talked about what they called the ‘overuse’ of antibiotics. However, most also accepted that antibiotics could be legitimately used in agriculture. In the following exchange, participants underlined how and why vaccines may be a better preventive measure than antibiotics:

A: It is not certain that antibiotics are the solution. It depends on the disease. If animals are ill from something that is not life-threatening or disabling their well-being as such, well then it is not certain that antibiotics are the right choice. One must also consider that antibiotics, in contrast to vaccines, are in fact a health risk too, because there is a probability that microorganisms in animals become resistant every time you use antibiotics.

N: I just need to understand: This [vaccines] is preventive, and this [antibiotic] is treatment?
[Participants indicate yes.]

J: Well, that is what I am thinking too. If you use antibiotics preventively, then you're on the wrong track, right?

Here, antibiotics are perceived as an acceptable form of treatment, but not prevention. Many other focus groups, in all five countries, coalesced around the same view. The perceived risk of antibiotic resistance played a significant role in shaping these attitudes. The Danish participants were aware of this risk, but only moderately concerned about it. In the extract below, from a British focus group, the problem of antibiotic resistance is conclusive in the debate about whether vaccines or medicine should be used on livestock:

J: But also a current human problem is giving all these antibiotics, making antibiotics not work for humans anymore. Very soon they think penicillin won't even work, because it's been given to too many animals.

E: Isn't that because we've been taking it, though, for so long as well, like humans?

J: But it's the volume they're giving to animals. [It] is significantly higher than we're using, and it's what they believe will finally [create resistance].

Here participant J is concerned about the amount of antibiotics given to animals because of the fear that antibiotic resistance will transfer to humans through the bacteria found in meat, eventually contributing to a development in which antibiotics do not work as human health measures anymore. Human health was a central concern in the group discussions of antibiotics in most of the focus groups across all five countries. The British focus groups stood out as the most vocal and articulate on the issue. But opposition to the use of antibiotics and fears about human health consequences were also conspicuous in the Austrian groups.

Here, an Austrian focus group discusses vaccination, antibiotic use and doing nothing in relation to the prevention of livestock disease:

C: Well I consider vaccines as being better than antibiotics

K: Well antibiotics for me are at the very end.

M: Yes, for me too.

N: A nightmare.

M: A nightmare, yes.

O: Well actually even worse than doing nothing.

Moderator: Why do you see it as being so bad?

O: Simply because it is dangerous for us.

Moderator: When consuming it?

O: Yes, because it goes directly into the food chain.

Whereas the Danish focus group participants were ready to accept antibiotic use in livestock, at least reluctantly and as long as it is not excessive, the Austrian participants above considered antibiotics to be ‘the worst’ option available – worse even than not doing anything in case of an outbreak of disease.

The Polish focus group participants were also aware of the risk of antibiotic resistance. *‘Antibiotics, it helps, but it also harms’*, as one participant summarised his position. Most groups linked this risk to human health, and in general, attitudes in the Polish groups appeared to be in line with those in the Danish groups: reluctantly accepted antibiotic use in livestock. Whereas the four Danish groups were rather similar in their discussions, there were differences between the four Polish groups. The two groups from the capital saw the synthetic livestock vaccine as a good replacement for antibiotics. Most participants in those groups supported its use. The other two Polish focus groups were conducted in a mid-sized city, and in those several participants did not see a real difference between antibiotic use and synthetic vaccination. Some linked this to the unnaturalness of both: *‘... antibiotic therapy, vitamin supplementation, vaccinating, this is drifting away from nature’*, as one participant said. Because neither antibiotics nor the synthetic livestock vaccine were viewed as natural, both were considered ‘the same’, and posing a health risk:

F: But vaccine is also in a way . . . the same as with antibiotics, it’s a kind of antibiotics, we may say.

H: Exactly.

S: Strains of some various compounds . . . which still remains in the meat.

For these participants, vaccination does not present a lower risk to human health than antibiotics, so it does not represent a better alternative. The participants concluded that the synthetic vaccine is not acceptable.

The view that there is no difference between vaccination and antibiotics was also voiced in one of the Spanish focus groups. But in a contrast with the Polish group, it was not linked with a critical perspective on use of medication in agriculture generally. Rather, the group seemed unaware that medication is in fact already widely used. In general, the Spanish groups were not very concerned about the use of antibiotics and had limited awareness of the risk of antibiotic resistance, which they only discussed when the theme was prompted by the moderator.

Animal welfare

Above we saw that the key concern in debates over antibiotics, vaccines and how to handle outbreaks of disease in livestock was about risks to human health. The risk of antibiotic resistance in animals and outbreaks of disease affecting animals alone (and the agricultural economy) were rarely mentioned in the focus groups. Still, animal welfare was an important topic when discussing animal vaccines, according to most focus groups. It was also a consideration cited by those in favour of using the synthetic vaccine.

In some groups, participants discussed the need to balance the care of animals and human health. One claimed that from an animal perspective preventive use of antibiotics was preferable:

A: For the individual animal, it is the opposite. Because for the animal it is clearly an advantage to have loads of antibiotics. All the animals would individually feel better if it was fed antibiotics for lunch every day, there's no doubt about it, then they would rarely be ill.

N: But that would be a way of self-medicating humans ...

[...]

C: Well, I think that my opinion is: We live in Denmark - what I buy, I can eat. There exist so many EU regulations and so on, so they don't sell me anything, that I can get ill by. I think I trust society a lot.

P: That's a lovely Danish opinion!

[Laughter]

As can be seen, this claim was quickly questioned by N. The position here, fully stated, is that antibiotic use in animals is problematic because of the ensuing risk to humans, and therefore other measures must be used to keep animals healthy. On the other hand, C questioned whether there was a need to be sceptical towards the safety of eating food, sold in Denmark. In her opinion, the Danish and EU regulation of food safety can be trusted. Whereas some participants considered 'doing nothing' (Austria) or 'killing infected animals' (UK, Spain, Poland) in the case of a disease outbreak to be better options than using antibiotics, most considered it our ethical obligation to treat diseased animals.

Many of the participants, in all five countries, expressed a critical position towards the treatment of animals in industrialised agriculture. They considered the need for medication a side-effect of this approach to livestock farming. The Austrian focus groups were particularly articulate about this, as can be seen in one participant's succinct summary: *'If we gave animals a living area as close to nature as possible ... then most vaccines would be needless'*. The reasoning behind this claim is that animals live in unhealthy, 'unnatural' conditions, which create the need for vaccinations or antibiotics in the first place. In more 'natural' conditions, livestock would not need the medication. The fact that we are even considering vaccines or antibiotics is a sign of an 'instrumentalised' perspective on animals, according to some participants. This was voiced across all five countries. But in spite of preferring animals to live in 'natural' living conditions, many participants said that medical treatments for livestock were an acceptable necessary part of the care of the animals. Consider, for example, this Polish group, in which the participants said they would vaccinate even though they lacked full knowledge:

H: I would assent, because suffering animals is for me already a situation in which I would not think too much. If I could provide relief to an animal I saw suffering, then ...

Moderator: But the effects are not known.

H: It's an experiment, well. Well, I wouldn't know the effect, but why would the animal have to suffer? I would prefer to use the vaccine.

Perspectives on animal welfare were expressed somewhat differently in different focus groups, but we were unable to identify national differences, as we saw in connection with antibiotics.

Fairness of the synthetic vaccine: who benefits?

So, in explaining what they saw as the likely potentials of the synthetic livestock vaccine, the focus group participants referred to livestock welfare and the avoidance of antibiotic overuse. However, when focus group discussions dealt with who would benefit most if the synthetic vaccine was used, neither the farm animals nor consumers were referred to frequently. It was repeated over and over again that the pharmaceutical companies were the one party that was certain to benefit. According to focus groups in most countries, these companies would also bear only a very small risk. Risk was a key issue in these debates over the distribution of benefits, and it was often stated that animals and consumers would bear most of the risk. In the extract below from one of the British focus groups, this position is stated.

P: It's tricky isn't it, because if the vaccine is really good and it works and doesn't cause any problems, then they're all winners.

D: From what I believe and what is sort of reality now with any drug dependent on what it is, pharmaceutical companies are always the winners, aren't they?

P: Yeah. They're always going to win. But the consumers only win if it works.

[...]

T: The farmer and the animal definitely benefit if it works. But if it's borderline or doesn't work, then ...

[...]

D: I think the company will spin it for some years and make the money that it needs to. And then ditch it.

M: I don't think they'd be allowed to produce it and put it into the animals unless they got some strength of work in it, surely.

D: I don't know, I keep coming back to Mad Cow. How long did that go on?

P: It's always like a few years down with any of these things. He [the company boss] made his money, he has his private jet! And then ten years later people or animals are getting these things, which they just didn't realize.

D: Exactly. The damage is done.

Here, a clear link between risk of emerging bio-technologies in general and lack of trust in the pharmaceutical industry and the authorities who are to regulate pharmaceutical companies are expressed.

The exception to the rule here was the Spanish focus groups: the participants in these groups rarely discussed risk in relation to the synthetic vaccine, and (as had also become apparent when they were discussing antibiotics) were not particularly concerned about use of medicine in agriculture. As a result, they gave very positive assessments of the fairness of the vaccine. They considered that production of the synthetic livestock vaccine would bring benefits to pharmaceutical companies, scientists, farmers, animals, and consumers. Two of the Spanish groups did indicate that the pharmaceutical industry would be likely to benefit most from vaccine use, but they still felt that other groups would see real benefits as well. In the excerpt below, while referring to pharma (the producer) as the main beneficiary, F sees no disadvantages for anyone:

F: Most benefits for the ones producing it, no doubt, and I don't know if someone would be harmed ... Why would someone be worse off? If the vaccines are good for the health, I don't see any negative consequences ...

In one Spanish focus group discussion higher meat prices were mentioned as a potentially negative result of the synthetic vaccine being used in agriculture, but, unlike in the discussions in the other countries, the potential risks to human health posed by the vaccine or synthetic biology generally were not referred to.

The Danish focus groups also appeared to regard all parties (pharmaceutical companies, scientists, farmers, animals, and consumers) as potential winners, or beneficiaries, following introduction of the vaccine. Some participants did express negative opinions about the pharmaceutical industry, which they saw as immoral and greedy. But in the debates, this view was challenged by other participants, who highlighted the synthetic vaccine as a scientific breakthrough, promising progress for all:

E: Well, I think the farmers would benefit from the vaccine, because then they can keep the animals, which will not get ill or die. And the animals as well, because they live longer and get better health. And the consumers get the meat ...

B: I agree – and then I have the producer of the vaccine.

Moderator: As a winner or loser?

B: A winner.

The pharmaceutical companies would indeed make a profit when producing the vaccine, according to the Danish participants, but at the same time farmers would have healthier animals and would profit from this, the animals would have improved well-being, and the consumer would be provided with good meat (without antibiotics). Despite their optimistic assessments, the Danish focus groups, in contrast to the Spanish, did discuss the risks of the vaccine. They were especially concerned about unintended side-effects of the 'artificial vaccine', but they seemed to take the 'best case' scenario as the point of departure for the debate. Still, two of the Danish groups did mention a potential loser, and one that was not brought up in the other countries: nature.

C: Well, I have written 'nature'. As a part who could lose. Nature could lose, if it [the synthetic vaccine] is not tested well enough or something goes wrong. I am thinking, if something leaks, right?

The Austrian focus groups were slightly more sceptical about the fairness of the synthetic vaccine and slightly more concerned about risks associated with its use. It was generally acknowledged that all of the parties involved would *potentially* benefit from the vaccine. However, the pharmaceutical industry was seen as the only party that was certain to benefit, and it was felt that all of the other parties bore the risks that are inherent in the introduction of a new biotechnology in food production. According to some Austrian participants, it is a disadvantage for consumers that the meat is '*full of vaccines*'. However, since many Austrian participants considered antibiotic treatment to be 'the worst', they considered the synthetic livestock vaccine as a better option, and therefore they accepted it.

The concern about introducing new biotechnologies were clearly shared by the British participants, particularly in relation to the safety of the vaccine. As one can see, reading the following discussion extract as well as the one quoted in the beginning of

this sub-section, the British groups were concerned about long-term side-effects on human health, and therefore consumers were pinpointed as being at risk if the synthetic vaccine was produced:

C: So, are we [consumers] gonna be losers then?

J: Potentially, potentially. But I would like to think that they'd have done a lot of studying the meat after these animals have been vaccinated with this particular new style . . .

B: We should be winners, because they're getting less drugs, less side-effects, it's cheaper . . .

L: They're healthier.

J: They won't get any extra antibiotics in them because of . . . but the potential loser, you know there could be side-effects in us, or all the research they do won't show it up, and in 30 years' time, you know . . .

L: We don't know the long-term effects.

Consumers were considered to be at *'the bottom of the pile'*, when the participants discussed the advantages of the new vaccine for parties affected by it. Synthetic biology was considered risky, according to some participants' positions, and unlike the other parties involved, consumers were not necessarily gaining something from the synthetic vaccine:

H: One thing about the consumer is they've got the least, apart from the animal, the least choice. They're not involved in it, so you kind of get what's being made. So, they really, the consumer, should [be marked as the most likely loser]. Always consider the consumer, 'cause at the end even if it's, like, three months later, the animal's gone, the businessman is on a new contract, they're doing something else, that consumer could still have that meat in the freezer, poor thing! [laughter] It's just . . . do you know what I mean?

The Polish participants were also concerned about the safety of the vaccine. They felt that consumers bear most of the risk of unintended side-effects and long-term effects. They were especially concerned about the 'unnaturalness' of the vaccine and they broadly agreed that the pharmaceutical companies are always certain to benefit from the development of a new synthetic vaccine. Interestingly, three focus groups also cited 'the state' and 'politicians' as people who *'always gain'* from the biotechnological developments. In the following Polish focus group exchange, the participants indicate that politicians benefit from the production because they are paid by pharmaceutical companies to pass the needed legislation:

Moderator: So even if it was a revolution on the market, you anyway think that pharmaceutical companies would benefit, right?

G: Of course, they would.

T: And politicians.

Moderator: And why politicians?

[Several participants chuckle.]

A: Sales approval.

L: Let's be honest, they are paid partly by pharmaceutical companies as well. And I don't believe that those who decide about our health don't know any pharmaceutical companies at all, or any of their representatives.

In this extract, lack of trust in authorities (the state, politicians) is linked to the fairness and the risk of the vaccine in the discussion. As the policy level cannot be trusted, neither can the regulation of risk related to biotechnologies.

Focus groups across the five European countries were in general rather positive in their assessment of the development and potential application of the synthetic vaccine, but as the analysis above has shown, their debates over the subject also revealed a degree of hesitation and some, more or less serious, clear reservations about the goals of the agricultural sector and pharmaceutical companies. In some countries, criticisms of the state (or of politicians) were also voiced.

Discussion

Summary of findings

The focus groups in the five European countries discussed the synthetic vaccine differently. This was particularly the case when they were assessing risks posed by the existing use of antibiotics, the risks associated with the synthetic vaccine, and their perceptions about who would benefit from the vaccine. [Table 3](#) presents a schematic summary of our empirical findings.

In relation to the use of antibiotics, the Spanish focus groups were the least concerned about the potential risks, and therefore they did not see the synthetic vaccine as a potential improvement. The Danish and Polish focus groups appeared to be more aware of the risk of antibiotic resistance building up, but were only mildly concerned about it. The focus groups from the UK were more concerned and often voiced strong concerns about the risks to human health presented by antibiotic use, and biotechnology use in general, in meat production. It was the Austrian focus groups that were most critical of antibiotics used in agricultural meat production.

The Spanish focus groups appeared to be the least concerned about the issue of fairness in the distribution of risks and benefits of the new vaccine. They took the view that no one is taking any risk, and everybody will benefit from its production and use. The Danish focus groups were equally confident that everyone would potentially experience an advantage following the introduction of the new biotechnology, but they also expressed some concerns about intervening in nature and the potential risks associated with the development of the vaccine. The Austrian focus groups were a little more concerned, and voiced worries about the risks of eating the meat from an animal which has been injected with a synthetic vaccine. Similarly, the British focus groups were noticeably concerned about the unknown long-term consequences for consumers if the vaccine is used. The Polish focus groups appeared to be most sceptical about fair distribution of the vaccine's risks and benefits. In addition to often voicing concerns about (what they saw as) immoral pharmaceutical companies, the Polish focus groups saw the state and politicians as illegitimate beneficiaries, and they expressed a lack of trust in regulative institutions.

Since this is a qualitative study one should be careful about generalisations, but it is striking that differences found link well with the criteria based on which the countries were selected. Thus, for example, the most positive attitude to the synthetic vaccine was found in the countries that, according to Gaskell et al., 2010, had the highest generalised technological optimism (Spain and Denmark). The greatest concern about potential health risks and an unfair distribution of benefits and risks was found in the countries

Table 3. Overview of results.

	Seeing synthetic vaccines in light of concern about use of antibiotics	Viewing synthetic vaccines in light of concern about animal welfare	Concern about who would benefit from the synthetic livestock vaccine
Denmark	Aware of risk of antibiotic resistance. Sometimes link use of antibiotic to human health risk, but most focus groups are only mildly concerned. Aware of possibility of limiting antibiotic use through use of vaccines.	Aware of animal welfare issues related to use of vaccines and antibiotics. See animal welfare problems as inherent in industrial agriculture	Pharmaceutical companies, scientists, farmers, animals and consumers could all potentially benefit – but ‘nature’ would lose. Concern is expressed about whether the vaccine will be safe in the long run
UK	Very aware of risk of growing antibiotic resistance. Often link use of antibiotics to human health. Most groups concerned about general human health risk related to meat production. See possibility of limiting antibiotic use through use of vaccines.	Aware of animal welfare issues related to use of vaccines and antibiotics. See animal welfare problems as inherent in industrial agriculture. Most groups link animal welfare to human health	Everyone could potentially benefit, but pharmaceutical companies seen as the obvious winner. Consumers generally perceived to be least benefited. Concern expressed about whether the vaccine is safe
Poland	Aware of risk of antibiotic resistance. Human health risk underlying factor in discussions on antibiotics. Aware of possibility of limiting antibiotic use through use of vaccines. Some consider vaccines just as risky as antibiotics for human health.	Animal welfare not discussed much. See animal welfare problems as inherent in industrial agriculture	Pharmaceutical companies (and the state) certain to benefit. Everyone could potentially benefit, but consumers are perceived to take all the risks. Concern expressed about whether the vaccine is safe
Austria	Very aware of risk of antibiotic resistance. Often link use of antibiotics to human health. Most groups concerned over general human health risks related to meat production. Aware of possibility of limiting antibiotic use through use of vaccines.	Aware of animal welfare issues related to use of vaccines and antibiotics. See animal welfare problems as inherent in industrial agriculture. Most groups link animal welfare to human health	Everyone could potentially benefit, but pharmaceutical companies seen as the obvious winner. Concern expressed about the vaccine affecting meat
Spain	Little concern over antibiotic resistance, antibiotic use not problematised. Antibiotics only a topic when prompted. In two groups, vaccines and antibiotics were seen as the same thing (medication)	Animal welfare not discussed much. Most groups link animal welfare to human health. Vaccines are highlighted as good for animal welfare unprompted	Pharmaceutical companies, scientists, farmers, animals and consumers are all considered to benefit. In two groups, pharmaceutical companies were seen as benefiting the most. Not much talk about risk

with the lowest generalised technological optimism and the greatest disapproval of synthetic biology (Poland and Austria) (*ibid.*).

Risk and trust

Throughout the focus group discussions, context and issues of risk and trust were mentioned in the negotiations over the usefulness and the fairness of the synthetic livestock vaccine. As we saw in the Findings section, concerns about the use of antibiotics in farm animal production were decisive in the positive framing of the vaccine – although at the same time the vaccine is considered risky (see also results reported in Ditlevsen et al., 2020). We see this clearly in the Spanish focus groups. There, many of the participants were unaware of the existing use of antibiotics in agriculture and therefore did not consider antibiotic resistance a danger to human health. As a result, they did not regard the vaccine as particularly useful. The risk of antibiotic resistance seems to have escaped public attention in Spain, and hence it did not create anxiety among the focus group participants.

At the other end of the scale there were the Austrian focus groups. In these groups, the participants were very concerned about the use of antibiotics, the risk of antibiotic resistance among humans and about livestock medication ‘infecting’ the meat. They expressed, what can be referred to as an anxiety of an invisible risk transforming into a visible danger (Lupton, 1999), and this influenced the discussion about the vaccine. The focus groups framed the vaccine as potentially very useful in so far as it solved a problem: the problem posed by risks to human health from the use of animal antibiotics. The Austrian focus groups stood out as particularly critical of the use of ‘unnatural’ measures in agricultural production. Many of their participants saw applications of synthetic biology as ‘unnatural’ and hence potentially risky. Despite this, they assessed the livestock vaccine positively and considered its use a potential ‘win-win situation’ for all. This positive assessment of the potential usefulness of the vaccine overrode hesitancy in their attitude to new biotechnologies in the focus group discussions.

In the Austrian focus groups we can see how the participants’ understandings of the risk to human health posed by antibiotic use influence their assessments of not only the usefulness of the vaccine, but also to some extent the fairness of it. The Austrian participants appear to place the risks created by the synthetic vaccine within a wider taxonomy of risks in which the existing fear of antibiotics is perceived as the greatest threat to human health. As a result, the use of a new biotechnology becomes a less important risk – especially as it can remove the first risk. The Austrian focus groups seem, therefore, to accept the omnipresence of risk, and to negotiate the ever-present dilemmas between biotechnological advances in food production and the acceptable production of risk (Douglas & Wildavsky, 1983, p. 4–11; Beck, 1989).

The attitudes of consumers may be influenced where the threat of growing antibiotic resistance is often highlighted by the media – unlike the risks associated with a livestock vaccine still in development. Fear of the latter could develop if vaccines used in agriculture and/or other synthetic biology applications receive more media attention and coverage in the future (Howarth, 2013; Petersen, 2005).

The British focus groups expressed much concern about human health risks connected with meat production. They related their anxieties about antibiotic resistance – which were articulated clearly – and other concerns they had to the experience of BSE in England (Pennings et al., 2002). Risk in these groups can thus be seen as constructed

around a narrative of the potentially fatal consequences of the human loss of control over scientific and technological advances (Beck, 1993). Many British participants expressed a general lack of trust in the safety of food production. They insisted that all uses of medication, and every biotechnological advance, carried a potential risk to human health, because there could be unintended, and as yet unknown, side-effects. For this reason, they considered the synthetic livestock vaccine to be potentially very useful in so far that it could replace antibiotics, but it could just as well turn out to be dangerous. Many British participants also took the view that while the vaccine might be used fairly, so as to benefit all parties, it could also potentially be used unfairly: consumers would eat the meat and therefore bear the risk of unintended side-effects. In this, we see how public trust in the institutions and regulations surrounding the development and use of an emergent technology in agriculture is crucial in assessments of a wider public (Lassen & Jamison, 2006). The British participants, with their recent history, were critical of the ability of science and governmental institutions to ensure the safety of food and drugs, and this lack of general trust in institutions made them sceptical about the introduction of new biotechnology in food production (Bildtgård, 2008).

In the Polish focus groups, and in one of the Spanish focus groups, participants expressed a different kind of institutional distrust. Whereas many Polish participants were aware of the risk of increased antibiotic resistance, and therefore considered the synthetic livestock vaccine to be useful, they did not consider it to be fair. The unfairness was explained with reference to the riskiness of the new biotechnology, and the idea that the risks would fall disproportionately on consumers. But the participants also mentioned that they did not trust national institutions to make the interests of citizens their priority. According to the Polish participants, politicians were being bribed by 'big pharma' to legislate in its favour. Hence production and use of the synthetic vaccine would probably benefit the pharmaceutical industry and the state, according to the discussions in some Polish groups – and worse, it would do so in a context in which consumers and farmers could not be sure that it was in fact safe to use.

The Danish focus groups appeared to be at the other end of the spectrum. Like the Spanish groups, they were not very concerned about the risk of antibiotic resistance, but unlike in the Spanish groups, their indifference was not a consequence of their being unaware of antibiotic resistance or uninformed about livestock production. They *were* critical of the use of antibiotics in agricultural meat production, but they were less worried about the possibility that this problem will affect human health than the participants from Poland, the UK and Austria. Trust in the institutions and authorities in the meat production sector to ensure the safety of food and drugs was voiced in these discussions. The Danish participants also trusted that the production of a synthetic livestock vaccine would benefit all of the parties involved.

Institutional context

A further issue to discuss is whether the differences we found in discussions in the five European countries are associated with contrasting national institutional contexts (see Table 1). Several things immediately stand out. First, focus group discussions from Spain in particular but also Poland, were affected by a lack of awareness of the use of drugs in livestock farming despite it being a highly important sector in the two national economies. Part of the explanation for this finding may be the low degree of public involvement in science governance reported in earlier studies (Mejlgaard, 2012). If an issue is

rarely debated in public, potential uncertainties relating to it are unlikely to be highlighted and constructed as ‘risks’. As discussed above, the risks connected with biotechnologies appeared to be prominent in the Austrian focus groups. In Austria, public involvement is informal. There are few formalised political procedures for citizen involvement in the issues raised by science and technology. At the same time, however, public involvement is ‘high’, because citizens actively use standard democratic procedures to influence the politics of science and technology. Mejlgaard (2012) reports that public debates on science and technology are limited in Austria, but our results suggest that there are nevertheless very strong values held on the issues among members of the public. In Denmark and the UK there are formalised procedures for involving citizens in decision-making processes handling science and technology, as well as high levels of citizen participation. In the focus group discussion in the UK we did see expressions of higher levels of distrust than in Denmark. One explanation for this is that the experience of BSE in the UK has damaged the kind of public trust that an open democratic process would otherwise have created and maintained.

Conclusion

In the focus group discussions across the across five European countries, the potential futures of the synthetic livestock vaccine were debated on the basis of perceptions of whether or not the vaccine would be useful in solving existing problems in animal production. The understandings of risks centred on animal welfare, and (especially) human health risks linked to the current use of antibiotics in livestock farming. The dialogue of the understandings of the vaccine was rooted in understandings of existing risks and other problems. This is apparent in that, while focus groups were rather critical of synthetic biology as such, they were relatively open to an application of such a new technology as long as this application was presented as a means to mitigate antibiotic use. In this sense understandings of human health risks and existing anxieties were vital to emerging understandings of the new synthetic vaccine.

Intertwined in understandings of human health risk were understandings of the fairness of the vaccine. In many focus groups, positive potential outcomes of the vaccine were voiced, but along with those, it was a commonly accepted position that it would benefit pharmaceutical companies more than consumers or farm animals, whose health and welfare were the most important factors considered.

Our findings are suggestive of important national differences. This underlines the importance of including institutional and national contexts in analyses of public understandings of biotechnologies and the risks associated with them. The focus group discussions and interactions appeared to be influenced by their specific recent national histories, and in particular experiences of meat production and agricultural technologies. The positions put forward in the discussions also seem to reflect differing levels of public awareness of and concerns over the agricultural use of medication and vaccines, as well as of trust in regulation and authorities.

Acknowledgements

In October 2019, our friend and colleague professor Jesper Lassen died from cancer. Jesper was a leading scholar in the study of how modern forms of biotechnology are understood by the public and by various professional stakeholders. He was a driving force in setting up the study on which this paper is based and very involved in the production of this article. We are deeply grateful for his contribution.

This article analyses some of the findings of the sociological study carried out within the Horizon 2020 project MycoSynVac (grant agreement No 634942). The authors would like to thank the participants for taking time to share their opinions with us, and the larger MycoSynVac project group for feedback and support. We would also like to thank Paul Robinson for his assistance in improving our English, and the anonymous reviewers for their constructive feedback on earlier versions of this article.

Notes

1. The aspect of naturalness in expert and lay perceptions of synthetic biology is explored in detail in Ditlevsen et al., 2020, based on findings from the same study that forms the basis of this article.
2. This study is part of a larger interdisciplinary project which had the overall aim of developing a serum-free, universal vaccine chassis against *Mycoplasma* for livestock. Other sociological results on perceptions of this vaccine have been reported in a project report (UCPH, 2017) and in Ditlevsen et al. (2020).
3. With regards to the specific vaccine and synthetic biology, we gave them the following information during focus groups: ‘Some vaccines are based on genes that are made artificially in the laboratory. They are called synthetically engineered vaccines. ... This method is very new and there are not that many examples from the medical sector’, and: ‘Synthetic biology is a new field of research bringing together genetics, chemistry and engineering. The aim of synthetic biology is to construct completely new organisms to make new life forms that are not found in nature. Synthetic biology differs from genetic engineering in that it involves a much more fundamental redesign of an organism so that it can carry out completely new functions’.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the EU Horizon 2020 [634942].

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