Residents’ and farmers’ perspectives on risks and benefits of intensive livestock farming

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ABSTRACT
Currently, there is a societal debate in the Netherlands about the future of intensive livestock farming and the current risks for human health and the environment. These risks could be described as systemic risks, which call for a deliberative approach to risk governance, including risk communication. However, stakeholders often have different perspectives towards intensive livestock farming and related risks which pose a challenge for communication. To support two-way communication, it is essential to identify the perspectives of residents and farmers who are directly affected by livestock farming. Using the mental models approach, we explored the current perspectives of the risks and benefits towards intensive livestock farming, in particular, on human health. Interviews were held with in total 44 farmers, residents and other stakeholders. We found that residents tend to view intensive livestock farming from the perspective of the quality of the living environment, which may clarify their overall focus on the risks to their well-being, whereas farmers tend to view intensive livestock farming from the perspective of their livelihood, which explains their focus on the (economic) benefits of intensive livestock farming. For experts as well as policy-makers, it is important to acknowledge the differences in risk perception when giving information about epidemiological health risks and communicating about policy measures.

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1. Introduction
After World War II, the primary goal of livestock farming in the Netherlands was to produce high quantities of food at low cost, which led to the intensification and expansion of the livestock industry (Boogaard 2009). However, since the 1970s, there are increasing societal concerns regarding animal welfare, landscape impairment, environmental pollution and human health risks (Breeman, Termeer, van Lieshout 2013). A recurrent topic in the Dutch
debate about the future of intensive livestock farming (ILF) is the livestock-related human health risks. This received much attention after the world’s largest Q fever outbreak between 2007 and 2011, causing more than 4000 reported patients, with 95 fatalities (Pim M Post et al. 2020; RIVM 2019). Following the Q fever epidemic and the continuous intensification of livestock farming, the potential health risks of living in the vicinity of livestock farms have received more scientific attention (Casey, Kim, Larsen, Price, Nachman 2015; Douglas, Robertson, Gay, Hansell, Gant 2018; O’Connor et al. 2010; 2017; Smits & Heederik, 2017). Apart from (emerging) zoonotic diseases, other potential health hazards include odour annoyance, particulate matter, endotoxins and antimicrobial resistance (Eijrond, Claassen, van der Giessen, Timmermans 2019; Pim Martijn Post 2021; Pim M Post et al. 2020). Latest epidemiological research points out that an increased risk for pneumonia is associated with living near goat farms. However, the potential cause(s) for this increased risk remain to be elucidated (Hagenaars, Hoeksma, de Roda Husman, Swart, Wouters 2017; Heederik et al. 2011; C. C. IJzermans et al. 2018; J. J. IJzermans, Smit, Dückers, Baliatsas 2021; Kalkowska et al. 2018; Maassen et al. 2016)

Intensive livestock farming may be described as a systemic risk, that is, the risk to human health is embedded in a wide array of concerns in the animal, environmental and economic domains and is characterised by complexity, uncertainty, ambiguity and ripple effects (Kraaij-Dirkzwager, Timen, Schuitmaker, Van Steenbergen 2014; Renn, Klinke, Van Asselt 2011). Decision-making is not about a single risk, as risk-benefit and risk-risk trade-offs have to be made (M. B. Van Asselt & Renn, 2011), such as between animal welfare and public health risks (Kraaij-Dirkzwager, Timen, Schuitmaker, Van Steenbergen 2014; Renn, Klinke, Van Asselt 2011; M. Van Asselt, Ekkel, Kemp, Stassen 2019). This calls for a deliberative approach for risk assessment, risk management and policy making taking into account the perspectives of the various stakeholders (Renn 2015, 2021). Yet, this is challenging as different stakeholders, such as farmers, neighbouring residents and scientific experts, hold diverse perspectives of the risks and benefits of ILF (Hansen, Holm, Frewer, Robinson, Sandøe 2003; Jensen, Lassen, Robinson, Sandøe 2005; Kraaij-Dirkzwager, Timen, Schuitmaker, Van Steenbergen 2014; M. Van Asselt, Poortvliet, Ekkel, Kemp, Stassen 2018). Experts commonly tend to assess risk according to the probability of exposure to a specific hazard and the consequences of this exposure to humans or the co-occurrence of negative health effects (Siegrist & Árvai, 2020). In contrast, the public view risk more broadly and qualitatively. Judgement about the seriousness and acceptability of risks is made in the context of other risks and influenced by factors such as fairness, controllability or whether a risk is man-made or natural (Fischhoff, Slovic, Lichtenstein, Read,
Combs 1978; Slovic, Fischhoff, Lichtenstein 1982). Understanding and anticipating stakeholders’ risk perceptions are necessary for understanding people’s attitudes towards a risk or hazard, their behaviour, responses to policies and measures for risk management and for risk communication (Aven & Renn, 2020).

Risk communication, using the definition of Bokma-Bakker et al.’s (2011): “meaningful interactions in which knowledge, experiences, interpretations, concerns, and perspectives are exchanged” (p. 242), is central to risk governance (Renn 2015; Renn, Klinke, Van Asselt 2011). Currently, communications about the risks of intensive livestock farming are often focused on the information formulated by scientific experts and health professionals, in which experts aim to rectify certain “knowledge gaps” of the public (Boase, White, Gaze, Redshaw 2017; Frewer 2004). Such communication may not adequately or sufficiently address the conflicts in perspectives (Benard & de Cock Buning, 2013; Boogaard, Bock, Oosting, Wiskerke, van der Zijpp 2011; Fraser 2008; Hansen, Holm, Frewer, Robinson, Sandøe 2003). The divergence in perspectives, anchored in different experiences, beliefs, interests and values, poses fundamental challenges to risk communication, for which more epidemiological knowledge on the human health risks cannot provide the ultimate solution (Boogaard, Bock, Oosting, Wiskerke, van der Zijpp 2011; Fraser 2008; Te Velde, Aarts, Van Woerkum 2002; Thompson 2012). Researchers as well as the Dutch Health Council, therefore, have called for involving stakeholders in the intensive livestock farming dialogue and addressing the issues that matter to them in the communication about the risks (Breeman, Termeer, van Lieshout 2013; Health Council of the Netherlands 2012; Pim Martijn Post 2021; Termeer 2018; M. Van Asselt, Poortvliet, Ekkel, Kemp, Stassen 2018). This is necessary for developing information that speaks to stakeholders’ perspectives, to make informed decisions and communications that build trust among stakeholders in order to create support for forthcoming local and national policies and risk mitigation measures. However, before two-way communication can take place, it is crucial to understand the perspectives of risk and benefits of the primary stakeholders who are directly affected by livestock farming and the measures and policies, namely, farmers and local residents.

Current knowledge around residents’ and farmers’ risk perceptions towards health and broader risks of intensive livestock farming is lacking, and there is the need to systematically identify the perceptions (Health Council of the Netherlands 2012). A useful approach to explore the risk perceptions, concerns and beliefs towards livestock farming in order to determine what to address in communication is the so-called mental models approach (Morgan, Fischhoff, Bostrom, Atman 2002), a method for eliciting and comparing scientific experts’
and non-experts’ mental representations about a hazard, in this case, livestock farming. This approach has been applied in various risks such as chemical fires (Claassen, Greven, Woudenberg, Timmermans 2021), landslides and flooding (Wagner 2007), electromagnetic fields (Claassen, Bostrom, Timmermans 2016) and climate change (Reynolds, Bostrom, Read, Morgan 2010). The mental models approach can be used to identify the issues stakeholders find relevant and important, specific knowledge gaps and beliefs and terminology usage. Following the mental models approach, communications should not only be based on what experts consider important but also on what non-experts think is important and what they already know and believe.

In an earlier study, we explored the perspectives of experts with scientific knowledge of the relationship between intensive livestock farming and health (Eijrond, Claassen, van der Giessen, Timmermans 2019). The study revealed that experts perceive livestock farming in the Netherlands mostly from a (measurable) technical epidemiological viewpoint. Specifically, experts pointed to the potential health risks of particulate matter emissions and the future threat of zoonotic diseases. They also generally acknowledged odour as a large problem for residents, having a significant negative impact on people’s lives but considered it only a minor risk to their health. In general, they did not consider Dutch animal husbandry a major public health risk, at least at that moment (Eijrond, Claassen, van der Giessen, Timmermans 2019). In continuation of the previous study, we aim to explore how residents and farmers perceive intensive livestock farming and to identify their major beliefs and concerns regarding human health and other risks. This will enable us to uncover disparities and similarities in risk perspectives between stakeholders and provide recommendations on how to improve risk communication.

2. Materials and methods

To systematically explore residents’ and farmers’ perspectives of the risks and benefits of intensive livestock farming of intensive livestock farming, we carried out 44 semi-structured interviews between February 2019 and August 2019 in the Netherlands.

2.1. Sampling

2.1.1. Municipalities

Three municipalities were selected in the provinces with the highest concentration of livestock farms in the Netherlands (Maassen et al. 2016) according to the following three criteria:
(1) High human-livestock density combined with a low surface area (increasing the likelihood of local residents living close to livestock farms). Data on the number of inhabitants and the number of livestock animals were gathered from Statistics Netherlands (Statistics Netherlands 2015, 2017). Based on these data, the livestock density and human density were calculated in order to calculate the human-livestock density in every municipality.

(2) Livestock type. Based on the various health hazards and their association with different livestock types, such as pigs, goats and poultry found in the work of Eijrond et al. (2019). We selected municipalities with (a combination of) many pigs and/or goats and/or poultry. Data on the types and number of animals were gathered from Statistics Netherlands (Statistics Netherlands 2017).

(3) Health concerns. Aspects covered in the health surveys of the Municipal Health Services which included strong concerns for odour nuisance, general health, zoonotic diseases and antibiotic resistant bacteria due to intensive livestock farming.

2.1.2. Stakeholders
Stakeholders were identified and selected based on a stakeholder overview by Kraaij-Dirkzwager et al. (2014). We included local residents, poultry, pig and goat farmers. In addition, we included farmer representatives and advisors, active citizens,\(^1\) government officials and health and environmental professionals. Local residents were recruited through an advertorial in local newspapers, interviewed at a public location and rewarded with a gift voucher of 20 euros. Representatives of the other stakeholder groups were recruited through convenience and snowball sampling. The interviews took place on site, and the interviewees did not receive compensation for their participation. The VU METC reviewed the research protocol and determined that this research was not subject to Dutch law for medical research involving human subjects (WMO) and therefore concluded that it was exempt from seeking further approval from the Ethical Research Committee.

Participants were interviewed one-on-one, except for two interviews where another person joined the interview. In total, 44 individuals participated in the interviews. Their socio-demographic characteristics can be found in Table 1. The majority of local residents (n = 13) were males with an average age of 61 years, retired and living on average 28 years within a few hundred metres of pig farms. In total, 9 farmers were interviewed. We also interviewed other stakeholders, including members of active citizen organisations, farmer representatives, government officials, health professionals and representatives of an environment agency.
Table 1. Socio-demographic characteristics of participants.

| Demographics        | Variable                        | Local residents (n = 13) | Active citizens (n = 5) | Farmers (n = 9) | Farmer representatives (n = 8) | Other stakeholders (n = 9) |
|---------------------|---------------------------------|--------------------------|-------------------------|----------------|-------------------------------|---------------------------|
| Gender              | Male                            | 9                        | 3                       | 9              | 7                             | 6                         |
|                     | Female                          | 4                        | 2                       | 0              | 1                             | 3                         |
| Age (years)         | 18–34                           | 1                        | 0                       | 1              | 0                             | 0                         |
|                     | 35–44                           | 0                        | 1                       | 4              | 1                             | 2                         |
|                     | 45–54                           | 3                        | 0                       | 3              | 6                             | 3                         |
|                     | 55–64                           | 3                        | 0                       | 0              | 1                             | 5                         |
| Employment status   | Retired                         | 8                        |                         |                |                               |                           |
|                     | Paid job                        | 4                        |                         |                |                               |                           |
| Education           | Unemployed                      | 1                        |                         |                |                               |                           |
|                     | Low (no or primary education)   | 0                        | 0                       | 2              | 0                             | 0                         |
|                     | Average (secondary education)   | 8                        | 0                       | 6              | 2                             | 0                         |
| General health status | Excellent                    | 2                        |                         |                |                               |                           |
|                     | Very Good                      | 5                        |                         | 1              |                               |                           |
|                     | Good                            | 5                        |                         | 1              |                               |                           |
|                     | Fair                            | 1                        |                         | 0              |                               |                           |
|                     | Poor                            | 0                        |                         |                |                               |                           |
| Distance farm (metres) | 0–199                     | 3                        |                         |                |                               |                           |
|                     | 200–399                        | 6                        |                         |                |                               |                           |
|                     | 400–599                        | 2                        |                         |                |                               |                           |
|                     | 600–799                        | 0                        |                         |                |                               |                           |
|                     | 800–999                        | 0                        |                         |                |                               |                           |
|                     | ≥1000                          | 2                        |                         |                |                               |                           |
| Farm type (more than 1 answer possible) & for farmers number of livestock animals (thousands) | Pigs 12 | 4 (3000-10,000) |                         |                |                               |                           |
|                     | Cows                            | 2                        | 3                       | (10,000-300,000) |                               |                           |
|                     | Goats                           | 0                        | 0                       | 2 (3000)       |                               |                           |
|                     |                                 |                          |                         |                |                               |                           |
|                     |                                 |                          |                         |                |                               |                           |
| Duration of residency | 0–19                          | 4                        |                         |                |                               |                           |
|                     | 20–39                           | 4                        |                         |                |                               |                           |
|                     | 40–59                           | 4                        |                         |                |                               |                           |
|                     | 60–79                           | 1                        |                         |                |                               |                           |

Notes: *Government officials (n = 4), health professionals (n = 3) and representatives of an environment agency (n = 2) 3 age in 2019

2.2 Procedure

The face-to-face semi-structured interviews were carried out by the first author and lasted 30–60 minutes. The interview guide followed the mental models approach (De Bruin & Bostrom, 2013; Morgan, Fischhoff, Bostrom, Atman 2002). After a brief introduction, the interviewer started the interview by asking
general open questions about livestock farming, such as “our research is about livestock farming, what comes to mind?” These questions aimed to uncover their beliefs, concerns regarding intensive livestock farming, without directing their answers to a specific path (Morgan, Fischhoff, Bostrom, Atman 2002). In the next stage of the interview, more specific inferences were induced. Respondents were first asked what they knew about human health in relation to livestock farming. Next, cards with potential health hazards of intensive livestock farming were presented (Eijrond, Claassen, van der Giessen, Timmermans 2019). This card-sorting task aimed to further uncover beliefs and concerns regarding the human health risks of livestock farming. Nearing the end of the interview, questions were asked about their experience with stakeholder meetings. See the Supplementary Materials for the full interview protocol. Prior to the interviews, informed consent was obtained for recording the interviews and the use of anonymised data. Afterwards, socio-demographic characteristics were administered.

### 2.3 Coding

The audio recordings were transcribed and subsequently analysed using ATLAS.ti. In the first phase, the first author applied descriptive-level coding to the text fragments. The second author independently coded four interview transcriptions from different stakeholders to validate the descriptive-level coding and ascertain that no relevant codes were missed. In the second phase, the two coders then discussed differences in the coding, examined similarities between descriptive codes and categorized and combined them in overarching topics and themes. In the final step, both coders independently coded four other transcripts using the evolved coding scheme, discussed the minor differences and refined the themes.

### 3. Results

Both local residents and active citizens held very similar beliefs and concerns. Similarly, farmers and farmer representatives shared the same perspectives. Therefore, for reporting the results, we merged the groups into two categories: residents and farmers. Residents’ and farmers’ responses covered five main topics: general views of intensive livestock farming, risk for human health and well-being, risks for animals and nature, risk mitigation and risk regulation. Within these main topics, several main themes emerged, which are described in detail with quotes below (Table 2).
3.1. General views of intensive livestock farming

3.1.1. Residents

Most of the interviewed residents expressed a negative attitude towards intensive livestock farming; they frequently described it as a factory or industry. Respondents made a distinction between “farmers” and the factories/industries:

It is an industry, it has nothing to do with farmers actually. It is an industrial company. (Female, age 69, active citizen)

They were not against livestock farming per se, but against the size, and preferred small-scale, family-owned and biological farms.

However, many residents acknowledged and showed concern that farmers are having a hard time because they are financially “trapped”:

Table 2. Residents’ (local residents and active citizens; n = 18) and farmers’ (farmers and farmer representatives; n = 17) appraisals towards intensive livestock farming.

| Topics                        | Themes (residents)                                                                 | Themes (farmers)                                                                 |
|-------------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| General views of ILF          | 1 “Livestock factories”                                                           |                                                                                  |
|                               | 2 Farmers are having a hard time and are financially trapped                       | 1 Unjust negative image in the society                                            |
|                               | 3 Negative image of farmers                                                       | 2 Society lacks knowledge about intensive livestock farming                        |
|                               | 4 Production for the world at the expense of the living environment                | 3 Farmers need to be more transparent                                            |
| Risks for human health and well-being | 5 Source of daily hinder                                                         | 5 Odour hindrance is a point of attention                                         |
|                               | 6 Threat of a zoonotic disease outbreak                                            | 6 No threat to human health (antibiotic-resistant bacteria and Q fever are “under control”) |
|                               | 7 Air pollution causes negative effects on the respiratory tract                   |                                                                                  |
| Risk for animals and nature   | 8 Negative impact on nature, animal welfare, biodiversity and landscape            | 7 More beneficial for animal welfare than traditional farming                     |
| Risk mitigation               | 9 Intensive livestock farming (in residential areas) needs to be reduced           | 8 Reduction of intensive livestock farming is not an option                         |
| Risk regulation               | 10 Technology is not the solution                                                  | 9 Technology is the solution                                                      |
|                               | 11 Policies are ambiguous and unsubstantiated                                      | 10 National authorities do not honour existing commitments and change the rules   |
|                               | 12 Farmers are supported at the expense of residents                               |                                                                                  |
|                               | 13 Rules are not enforced                                                          |                                                                                  |
I understand that these farmers work like this. They have to, because if they don’t keep up, they have to stop . . . . They want to make everything even more modern, to reduce emissions. That’s great, but it means that there will be not less, but more animals. (Male, age 60, local resident)

However, more than half of the residents had a rather negative opinion about farmers. Half of the residents seemed distrustful towards farmers, accusing them of prioritising their own financial interests:

It just seems to be mainly about money, about . . . their income . . . I think they have little feeling for what kind of nuisance they are causing. (Female, age 60, local resident)

Also, they claimed that farmers do not adhere to the rules and downplaying the health issues associated with livestock farming, such as the misuse of air washers and manure fraud.

Most interviewees associated intensive livestock farming with large-scale production, predominantly with pigs and poultry, for the worldwide market (export), at the expense of the quality and living environment in the Netherlands. What is left behind is the bothersome waste products.

The pigs go to China and the shit stays here”. (Male, age 67, active citizen)

It should be noted that three residents expressed positive attitudes towards intensive livestock farming, of which two stated that it was a deliberate choice to live among livestock farms.

### 3.1.2. Farmers

Farmers presented a more opportunistic and positive view towards intensive livestock farming. They see themselves as an economic contributor via export, an efficient food provisioner and international pioneer and innovator:

That is occasionally somewhat forgotten. We are a food producer and I think we do good things. We make good food, safe food. (Male, age 43, farmer)

In the interviews, farmers particularly expressed concerns about the unjust negative image and the lack of support in the society towards intensive livestock farming and believed that the problem is society’s lack of knowledge about what actually goes on in a farm:

. . . I am worried about how the hell do we keep society connected to what happens on a farm? Because there are so few people who actually know what we are doing and what it is about. So yes I am concerned about that. (Male, age 53, farmer representative)

They also argued that emotions unjustly drive society’s views and decisions about the future of livestock farming instead of the facts:
All discussions should be based on facts and not on emotions . . . . When it comes to emotion, it cannot be controlled. Then farmers will throw everything aside and activists will break into stables based on emotions and no longer based on facts. (Male, age 53, farmer)

Farmers often blamed the media for the negative image that is portrayed about intensive livestock farming and the so-called “loud mouthers”. Moreover, five respondents also mentioned their fear towards animal activists, in particular, referring animal activists who occupied stables at a pig farm in May 2019 (“Police end pig farm occupation, dozens of activists arrested”, 2019). The farmers also believed that in order to change the image society has of farmers, the sector needs to improve their communication and be more transparent by opening their farms to the general public:

This is a showroom of our company. So we show and also say what we do, how we do it and with whom we do our business with. So we put a magnifying glass on our company, as it were, because there is so much negativity about the agricultural sector. (Male, age 65, farmer)

3.2. Risks for human health and well-being

3.2.1. Residents

Most residents mentioned odour being emitted from livestock (pig) farms, in particular, their personal encounters in their neighbourhood as a serious problem. More specifically, the emotionally laden term stench was often used to describe the issue.

Interestingly, odour was only mentioned by two residents in relation to human health. Rather, odour was described as a source of hindrance, as some interviewees explained that it threatened their social lives and their personal lives (e.g. closing windows and waking up at night).

Although odour did not appear to be a major concern physiologically, the majority of respondents shared their concerns regarding the association with air pollution (particulate matter, (ammonia) emissions) and the potential negative effects on their respiratory system. Some respondents also claimed that at times, they experience respirational problems:

You could say, they say that odour, the stench, carries something. So, it is not clean air. (Female, age 81, local resident)

I just feel it on my airways. That air is here, it is polluted. My son has to take inhalants. He needs to be his inhaler in the morning. Often, when he returns from work, he really suffers from his respiratory tract. Then you can assume that the particulate matter levels here are far too high. That is also known. (Male, age 60, local resident)
A handful of interviewed residents also talked about noise hindering they experienced from transportation, in addition to concerns about traffic safety, and air washers:

The loud pounding noise of the so-called air washer and the stench is unbearable. (Male, age 70, local resident)

The threat of zoonotic diseases is of some concern among residents. They recalled the recent Q fever outbreak in the Netherlands and are concerned about a potential new Q fever outbreak or a different zoonotic disease outbreak in the future:

We are creating the conditions for another major outbreak, also with consequences for human health. And that is coming. We just don’t know when. But it is certain that he is coming. (Male, age 67, active citizen)

Moreover, some believed that the Q fever bacterium remains present in the Netherlands and questioned the measures, for instance, because the bacterium may mutate.

In the context of human health or zoonotic diseases, (African) swine fever, an animal disease, was also frequently mentioned as a potential threat since an outbreak in China was taking place at the time of the interviews. Also, some respondents recall an outbreak in the past in the Netherlands.

3.2.2. Farmers

All farmers stated that they were not concerned about intensive livestock farming in relation to public health. This was projected in different ways throughout the interviews. Most farmer representatives specifically referred to the limited scientific evidence of the relationships between human health and intensive livestock farming.

Also, they played down the potential health risks, in particular, by comparing them with poor air quality in urban areas, other sources of air pollutants such as car usage, airplane/airport expansion and industries, and health risks from pets and referred to their own/children’s good health.

In addition, they pointed to the progress that has been made to reduce the emissions and claimed that the sector is continuously working on finding new solutions.

Nevertheless, most farmers acknowledged that human health was important and that they were aware of odour hindrance as an issue that needed to be solved:

Smell and particulate matter … when it turns out that this is a nuisance, you also have to see if you can minimize or limit that. (Male, age 43, farmer representative)
Antibiotic-resistant bacteria were also considered an important issue, but they were not considered a large problem at present in the sector, due to the progress made in reducing antibiotic usage. Farmers saw it primarily as a problem in other countries and in the human health sector. Similarly, Q fever was also currently regarded as a small problem as it is also “under control”:

Antibiotic resistance, the Coxiella bacterium, those were very big things, but we learned a lot from that and, hopefully, it will not return. This is currently under control. (Male, age 46, farmer representative)

3.3. Risks for animals and nature

3.3.1. Residents

Interestingly, when the residents were asked if they were concerned about intensive livestock farming, the first thing that came up was animal welfare (four local residents indicated being vegetarians or make conscious meat consumption choices). Intensive livestock farming was associated with many animals treated as objects and not in their natural habitats (kept indoors and hardly any space to move):

But the factories, that is what I am referring to. There is no longer any affection for the animal. They have to stay healthy because it is a money-maker. (Female, age 81, local resident)

Residents also mentioned their concerns regarding barn fires, emphasising how these kill thousands of animals.

To a lesser extent, some residents, in particular, the active citizens (mostly representing a nature preservation organization), mentioned their concerns regarding the negative impact on nature, in particular, the visible loss of biodiversity and nitrogen pollution, and on the landscape.

3.3.2. Farmers

Farmers stated that they adhered to strict animal welfare requirements. Animals in intensive livestock farms live in a controlled environment where they are catered and treated well, in particular, compared to animals in small stables, other countries and in the past. They also pointed out that it is to their own benefit that animals are healthy:

These pigs are our top athletes. They are coached every day for world performance . . . if you coach them well, they will perform. (Male, age 65, farmer)
3.4. Risk mitigation

3.4.1. Residents
Based on the topics and themes, most residents advocate less animals or as one resident described it, “livestock shrinkage”. They also were in favour of small-scale farms which respondents associated with less export, a circular agricultural system, biological farming and no expansions:

I do like livestock farming. But not large-scale farming. I enjoy seeing cows grazing outside. Not seeing 150 cows in a row that are milked twice a day by a robot. (Male, age 71, local resident)

However, a few residents expressed more positive attitudes towards intensive livestock farming, stating that it was a deliberate choice to live among livestock and that it was acceptable for the future.

Some residents argued that technology would not be able to solve all problems with livestock farming:

So then you can start thinking of oh then I put an air washer on it or something, but then you still haven’t solved the whole problem. Then you are just putting on band-aids. (Female, age 35, active citizen)

3.4.2. Farmers
In contrast, the farmers believed that scale enlargement would continue to take place resulting in less farms but more animals per farm, as it is the only option to cover the costs in order to be able to invest in the innovation of stables:

So far, scale enlargement has been the revenue model. So if you do something big, you can earn more … But you can also invest more at the same time and you have more margin … So I also often see farmers who have those mega companies, who are at pioneers in terms innovations and building stables, because they also have the money to invest. (Male, age 54, farmer representative)

They also believed that technology would help improve stables for animal welfare purposes and reduce emissions (odour and ammonia) through investing in technology (air washers).

Yet, they also shared concerns about their future continuance. They talked about finding suitable successors and the financial consequences of investments when authorities change the rules.
3.5. Risk regulation

3.5.1. Residents
A large part of the interviews focused on residents’ dissatisfaction towards the government at municipal and national levels. Many felt neglected by the government in numerous ways. Residents also argued that current legislation offers no protection and were baffled and frustrated that governments continued granting permits for the enlargement of livestock farms:

We are the dirtiest area in the Netherlands. And then still, still they authorize the expansion of farms. (Female, age 81, local resident)

Some got the impression that national and local authorities support farmers’ interests (economy) at the expense of local residents’ health and well-being:

The worst of all is that livestock barons are subsidised, facilitated by all municipalities and we are powerless and we are not heard as citizens . . . apparently a livestock farmer manufacturer is more important than us. (Male, age 70, local resident)

Many also expressed their resentment towards the national government based on the absence of governance during the Q fever outbreak and on how chronic Q fever patients were treated. Some also disapproved of the lack of enforcement of the rules by the government:

Well, if I look at what is happening here in the region, everything is tolerated, there is no enforcement and no inspections. (Male, age 71, local resident)

As a consequence, residents felt that their problems and complaints were not taken seriously by the local authorities.

3.5.2. Farmers
Although almost half farmers said they were satisfied with the municipal authorities, most were dissatisfied with the national authorities. They mainly complained about the continuous adjustments of the rules that farmers need to adhere to:

For example, they have said that in 2028 a number of things must be arranged . . . And then they bring it back to 2020 . . . Well what impact does that have on a farmer who has no successor, for example? . . . by changing the year, the farmer has to invest again 100 thousands of euros in for instance, air washes or stable adjustments. (Male, age 65, farmer).
3.6. Other stakeholders

The responses of the other stakeholders: government officials, health professionals and representatives of an environmental agency, shared many similarities with the responses of the farmers. Most stressed the economic importance of intensive livestock farming for the Netherlands although the government officials appeared to struggle between the interests of farmers and the local residents.

Almost all stakeholders stated not being concerned about public health with regard to intensive livestock farming referred to the scientific uncertainty and compared it with the past because ammonia and odour emissions have been reduced and with risk of emissions from cars and other industries. Nonetheless, they did acknowledge that odour is a large problem since it is perceived as “annoying” and “perceptible”. Antibiotic resistance is considered a general threat, but not necessarily from intensive livestock farming. Zoonotic diseases were not seen as a large problem at the moment but were a serious potential threat, requiring alertness.

Except for one, none of them seemed concerned about animal welfare. They stated that intensive livestock farming provides opportunities to invest in animal-friendly measures and animals have more space compared to traditional and small stables.

Nature and biodiversity were only briefly mentioned by a few stakeholders as important problems.

In line with the farmers, some mentioned the negative influence of the media and the “loud mouthers”. Almost all pointed to the positive sides of intensive livestock farming, the possibility to improve stables for animal welfare purposes and the financial potential to reduce emissions (odour, particulate matter and ammonia) through investing in technology.

However, many held diverging views towards the future of the livestock farming sector, suggesting solutions such as relocating farms to an industrial terrain, local production and less farms but larger farms or leaving solutions in the hands of the government.

4. Discussion and conclusion

This qualitative study provided insights into the divergent perspectives of the risks and benefits between residents, farmers and other stakeholders towards intensive livestock farming. Their appraisals can be arranged into five main topics: general views of ILF, risks for human health and well-being, risks for animals and nature, risk mitigation and risk regulation.

Our analysis revealed that the interviewed residents seemed to view ILF mainly from the perspective of the quality of their living environment. Their main concern was the current impact of odour on their daily social and
personal lives in terms of hindrance (see also Biesheuvel, Groothuijse, Jeurissen, Melse, van Poll 2019). Another often expressed concern is the risk of zoonotic disease outbreaks in the future (Borlée et al. 2019), such as another Q fever outbreak, which they believe is possible, and African swine fever, which they consider a potential human health hazard. African swine fever is not an actual zoonotic disease but a disease only affecting animals (OIE 2020), possibly a confusion with swine flu, or a general fear of animal diseases as a human health risk. Residents also associated intensive livestock farming with the unnatural treatment of animals, emphasising the importance of animal feelings and naturalness (Asselt 2019; Bergstra, Gremmen, Stassen 2015; Fraser 2008; Te Velde, Aarts, Van Woerkum 2002; Vanhonacker, Verbeke, Van Poucke, Tuyt tens 2008). These concerns may clarify why residents had negative perceptions towards intensive livestock farming often referring to its industrial character (see also Borlée et al. 2019). In their point of view, technology (e.g. air washers) did not offer a structural solution for the problems of livestock farming. They also criticised the poor legislation, experienced governmental favouritism towards farmers, disapproved the lack of enforcement and stated that complaints were not taken seriously. Although the interviewed residents did not condemn livestock farming as such, many only saw one solution: livestock shrinkage, and expressed a preference for small-scale or biological farming.

For the interviewed farmers, they viewed ILF from the perspective of their livelihood: the future as a farmer and the economic continuity of their business. In contrast to the residents, farmers did not consider human health and well-being as being threatened but rather emphasised their progress, namely, that Q fever and antibiotic-resistant bacteria are under control. Although odour hindrance was a point of attention, it was considered a “business obstacle” by farmers, as they were confronted with regulations and discussions about smell with their neighbours. They specifically mentioned having concerns about the unjust negative image that prevails in the society and the media attention about the health risks and animal welfare issues of intensive livestock farming. They highlighted the ability to supply affordable food to people, contribute to the Dutch economy and be an international example. Farmers also highlighted the positive aspects of animal welfare stating that they adhere to strict welfare requirements and animals are catered and treated well, in particular, compared to livestock living in small stables, in other countries and how livestock was kept in the past, which mirrors the findings of previous studies (Asselt 2019; Bergstra, Gremmen, Stassen 2015; Fraser 2008; Te Velde, Aarts, Van Woerkum 2002; Vanhonacker, Verbeke, Van Poucke, Tuyttens 2008). Although they expressed positive attitudes towards municipal authorities, they often complained about the national authorities not honouring existing commitments and changing the rules unrealistically, which creates
uncertainty among farmers about the continuity of their farms (Kanne, Schelde, Leensma 2021). Because their livelihood is at stake, farmers held specific expectations towards the solutions, the future and thus the role of the authorities. Farmers argued that scale enlargement is inevitable in order to cover the costs and invest in the technological innovation of stables to further reduce emissions and improve animal welfare (Kanne, Schelde, Leensma 2021).

The negative view of the interviewed residents and the positive view of the interviewed farmers resulted in contrasting perspectives regarding the risks of ILF for human health and animal welfare and the future of intensive livestock farming using technology to mitigate the risks. Contrasting views between farmers and residents are in line with those found in previous studies (Bokma-Bakker et al. 2011; Boogaard, Oosting, Bock 2008; Te Velde, Aarts, Van Woerkum 2002; Vanhonacker, Verbeke, Van Poucke, Tuyttens 2008). Farmers seem to assess the risks and in particular, the benefits of ILF from a technical perspective: human health risks are under control, and animal health and well-being are safeguarded, because technology is used to control the risks. Farmers, being professionals, have knowledge acquired through extensive training and practical experience in this and might therefore assess the risks as under control. In combination with a positive view on ILF because of the economic benefits, farmers perceive the risks of ILF more positively than citizens. Perceiving more benefits than risks and assessing a risk being controlled have been found to lower risk perception (Fischhoff, Slovic, Lichtenstein, Read, Combs 1978; Slovic, Fischhoff, Lichtenstein 1982). Citizens appear to adopt not only a broader but also a more negative perspective towards ILF. Citizens’ knowledge and experience is limited, and they might not be well informed about ILF as media sometimes present biased information (Benard & de Cock Buning, 2013; Vanhonacker, Verbeke, Van Poucke, Tuyttens 2008). Furthermore, as citizens have no influence on, for example, the emissions of substances and a limited influence on possible extensions of stables, they assess ILF risks as less controllable and often involuntarily, leading to a higher risk perception. This is possibly exacerbated by their overall negative feeling towards intensive livestock farming related to their past experiences such as the impact and the handling of the Q fever epidemic. Thus, the overall negative feeling towards ILF might function as a heuristic or frame through which the impact of ILF on human health and the environment is evaluated, conforming the affect heuristic (Siegrist & Árvai, 2020; Slovic, Finucane, Peters, MacGregor 2007). The differences in perspectives between residents and farmers therefore cannot simply be attributed to differences in knowledge of the risk. Moreover, one-way information exchange by supplying factual knowledge, where experts formulate the content of information detached from the public’s perspective, does not adequately address the deeply rooted beliefs
and concerns of residents and farmers. Reducing the issue by communicating only about, for instance, the results of (health) risk assessments may lead to stakeholders feeling that they are not taken seriously as they often have other multifaceted concerns.

For the communication about health risks of ILF, such a technical approach focusing on the probability and severity of adverse effects is not sufficient as it does not take the wider perspective on health and other risks of ILF into account. In this study, we demonstrated what matters to people, by uncovering their beliefs and concerns, and identified the areas of potential conflicts between farmers and residents. These beliefs and concerns need to be addressed too in communications about ILF. Our study revealed that important aspects to address are exerting personal control, voluntary exposure, confidence in risk reduction measures and interests. Involving farmers and local residents is necessary in order to take the context and situation-specific circumstances into account when designing risk mitigation measures and policies that can count on societal support. Moreover, recognising and understanding the different perspectives on the risks and benefits of ILF is important for stimulating risk governance to be inclusive. Meaningful engagement of farmers and residents in risk management decisions is important to address their concerns (Renn 2021; Renn et al. 2020).

This study has some strengths and weaknesses. An important added value of this qualitative study is that it provided rich, contextualized data, revealing the various (conflicting) perspectives, including specific jargon, stakeholders can have concerning the issue of intensive livestock farming that may remain unnoticed in quantitative research (Morgan, Fischhoff, Bostrom, Atman 2002). However, as is customary in qualitative research, it is not possible to extrapolate the results to the target population. The participants may represent a specific involved subpopulation with strong views, in particular, young age groups, females and people with a low education level were underrepresented. Also, there may be relevant differences between types of farms (i.e. conventional and organic) that are not tackled in this study. Furthermore, the study took place in three areas with the highest concentration of livestock farms in the Netherlands and therefore may not have identified all relevant ideas within the whole target population. For instance, it is likely that there are differences in perspectives between people living near livestock farms and people living in urban areas. In addition, although the inferences may be relevant to other countries with high livestock population densities, the results cannot be generalised to other countries (Borlée 2018). It should also be noted that these findings reflect current beliefs and concerns. These are susceptible to ongoing debates and future events related to intensive livestock such as the debate about nitrogen emissions and zoonotic disease outbreaks or food incidents such as the fipronil crisis in 2017. For instance, since the COVID-19 outbreak, societal concerns arose about the potential
association between COVID-19 and intensive livestock farming in the areas most hardly hit by COVID-19 (and Q fever in the past) in the Netherlands.

In spite of its limitations, we think that our study, based on a mental model approach of exploring and understanding risk perspectives of different stakeholders groups, is a valuable addition to the debate about ILF. While mental model studies have mostly been applied to single hazards, exploring the perceptions of experts and the lay public, the approach is also applicable to a wicked problem such as ILF, with a broad range of hazards and exploring the perceptions of various stakeholder groups.

**Note**

1. Citizens actively involved in making their local neighbourhood more liveable.

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