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Advice from the Director of the Office for Risk Assessment & Research

Advice on the risks in the poultry meat supply chain

It is my distinct pleasure to present you with the risk assessment of the poultry meat supply chain as drawn up by my Office. The risk assessment involved the collection of international scientific literature on food safety and animal welfare and a corresponding assessment of the relevance thereof to the Dutch poultry meat supply chain, and a subsequent assessment of the applicable risks in play. We included information available from the Netherlands Food Safety and Consumer Product Safety Authority (NVWA) itself, as well as from other knowledge institutes and other sources.

The Office for Risk Assessment & Research (BuRO) carried out the risk assessment within the framework of the comprehensive system of laws and regulations that were devised to improve and maintain the high level of food and consumer product safety, animal welfare and health, plant health and the quality of nature. Within that framework, the Netherlands Food and Consumer Product Safety Authority (NVWA) is a key player in safeguarding these public interests.

The NVWA is permanently committed providing more risk-oriented and knowledge-driven monitoring, in furtherance to the recommendation formulated by the Dutch Safety Board in relation to the 'horse meat scandal' (*Risks in the meat supply chain*, 26 March 2014; Dutch Safety Board (OVV, 2014), which is directed at your role, as Inspector-General of the NVWA:

'*Identify the risks that exist in vulnerable stages of the chain and define priorities.*'

In 2014, partly in response to this recommendation, BuRO launched its project to draft risk assessments for the production supply chains that encompass virtually the entire domain of the NVWA. The project entailed a cyclical process to be repeated every four years. These risk assessments, in conjunction with information on monitoring, compliance and fraud (the comprehensive supply chain analysis), provide an essential basis for effective risk-oriented and knowledge driven oversight.

The NVWA's improvement programme for poultry, for example, made significant strides in 2017. In addition, the volume of data on which risk assessments can, in part, be based is increasing rapidly. Nevertheless, the picture one gets of the various risks in play is by no means exhaustive or complete – a considerable amount of data is currently still absent to allow a systematic scientific risk assessment.

Based on the findings in the research, I have made a number of additional recommendations that may lead to even better food safety for poultry products for consumers, which would also allow the welfare of the animals in the poultry meat supply chain to be improved. In short, our strategy is to achieve improvements and reductions in three domains: improvements in food safety, animal welfare and health, with reductions in the use of antibiotics, pain inflicted on animals and fewer unnecessary deaths. At present, I feel there are opportunities available to achieve this primarily at the level of the supply chain.

Hazards to animals and humans are mainly introduced at the beginning of the poultry meat supply chain and proceed to impact the chain at later stages. A very limited set of food safety and animal welfare indicators implemented at these later stages, however, may encourage improvements in the preceding stages in the chain.
For example, food safety between the retailers to the primary company may be improved by tracing a contaminated piece of poultry in the store back to the slaughter flock at the slaughterhouse, to the transport flock, even further back to the farm and even back to the feed, the veterinary drugs used, and the hatchery.
A comparable approach to the supply chain, from the slaughterhouse to the transport, and from the catching team to the primary company, can be achieved for animal welfare purposes using the animal welfare indicators that are already available but are not yet being used for a supply chain-oriented approach.

As such, the recommendations not only focus on identifying the risks present in the poultry meat supply chain, as requested by the Dutch Safety Board, but also focus on the recommendations of the Board itself to ensure that:

‘*binding agreements are made with private parties in order to achieve structural improvement of the level of food safety*’

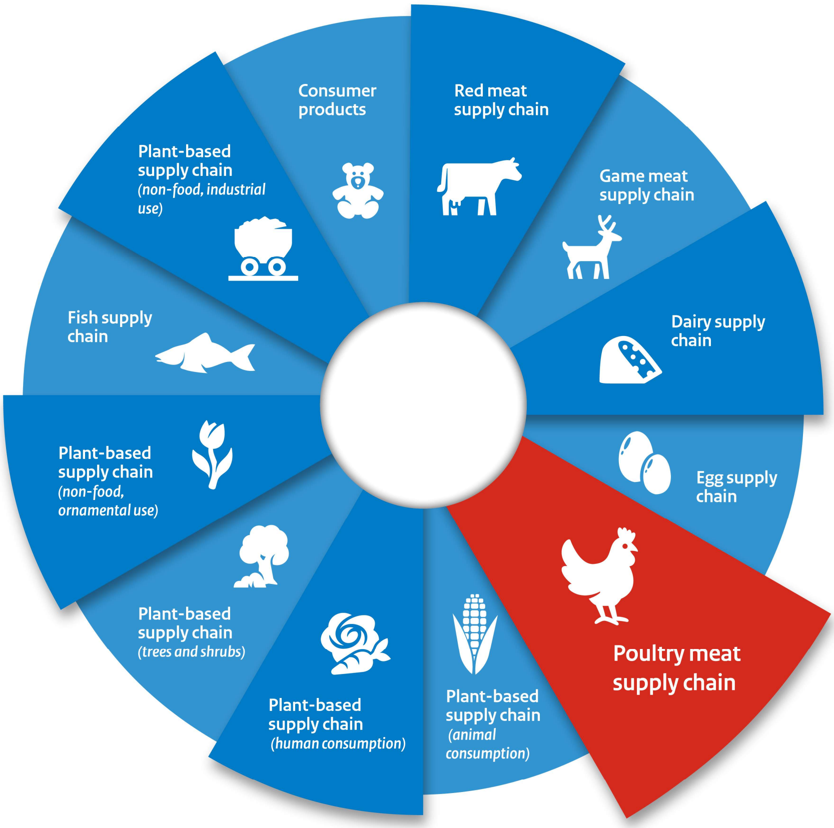
‘*companies [call] each other to account regarding high-risk behaviour, such as unsanitary slaughtering or illegal practices. Companies should inform one another, and the NVWA, of any high-risk behaviour taking place at other companies*’

‘*the traceability of products should improve and the performance of individual companies in the field of food safety should become more transparent to consumers.*’

Utrecht, February 2018

Yours sincerely,

Prof. Antoon Opperhuizen
Director of the Office for Risk Assessment & Research (BuRO)



Introduction

Before you is the risk assessment of the Dutch poultry meat supply chain, prepared by the Office for Risk Assessment & Research (*Bureau Risico-beoordeling & onderzoek*, BuRO) of the Netherlands Food and Consumer Product Safety Authority (*Nederlandse Voedsel- en Warenautoriteit*, NVWA). In this document, the BuRO has carried out an assessment of the risks to food safety for Dutch poultry meat as well as the animal welfare risks for Dutch poultry. The poultry supply chain risk assessment shows significant similarities with the risk assessment for the egg supply chain that was published virtually at the same time.

The Dutch consume a great deal of poultry meat, with chicken being a key household staple. Although total consumption of meat has decreased by 5% over the past ten years, the size of the share taken up by poultry meat has risen by approx. 10% in the same period of time (Verhoog, et al., 2015; RIVM, 2017).

Food producers bear primary responsibility for the safety of food products and, as such, for that of poultry meat products. In addition, they bear primary responsibility for the welfare of the (meat-producing) animals. A number of risks have not been included in the scope of this present assessment, such as the risks in relation to the import of poultry meat, as this relates to an extremely large volume of poultry meat from birds hatched elsewhere in the world. The risks to nature and the environment as a result of manure, air pollution, the spread of zoonoses and chemicals, such as veterinary medicines into the environment, have likewise not been included in this risk assessment.

Dutch poultry meat is chiefly produced from broilers and from turkeys and ducks to a limited extent. Poultry meat from other birds, such as pigeons and pheasants, is consumed relatively little in our country, with consumption being restricted to a limited group of enthusiasts or incidental occasions. For that reason, these species fall beyond the scope of this risk assessment. The risk assessment is limited to the production of the poultry meat and will not focus on the end consumption of the meat in great detail, nor will it focus on the processing of the meat into composite products. BuRO will, however, be focusing on those aspects in the next edition of this supply chain risk assessment.

The present risk assessment will examine the animal welfare risks to poultry, which also highlights a number of risks that are relevant to the *Risk assessment for the egg supply chain* referred to above. In the phase of the farm, additional attention is focused on the dangers of red poultry mite and histomoniasis in poultry. The former, in particular, gained notoriety in the summer of 2017 through the non-authorised use of the pesticide fipronil in the egg production sector. Due to the possible use of the chemical in private laying hen holdings, there is additional focus on this sector with its regular customers.

The risk assessment is BuRO's advisory report to the Inspector-General of the NVWA. What follows is the research method used, an extensive outline of the risk assessment, the findings and recommendations and the consulted literature. The advisory report includes annexes containing further substantiation of the risk assessment.

Questions to be addressed

The Office for Risk Assessment & Research (BuRO) formulated the following questions for its investigation of the risks in the poultry meat supply chain:

'What are the most significant risks to food safety and animal welfare in the various stages of the poultry meat supply chain?

'*How could further risk reduction be achieved?*'

'*Are there relatively simple, food safety and animal welfare indicators that could be used by the NVWA and by companies in the chain of custody to call each other to account with regard to high-risk behaviour, which would help improve the traceability of products, and which would provide consumers with clearer information?*'

Approach

The 'Microbiology' assessment is largely based on the literature review *Microbiologische gevaren in de pluimveevleesketen* ('Microbiological hazards in the poultry meat supply chain') published by Wageningen Food and Biobased Research (FBR), hereinafter referred to as the FBR report. This report includes an extensive section on the introduction of the microbiological hazards in the various distinct stages of the poultry meat supply chain. The risk assessment of the chemical and physical risks made use of the report entitled *Chemical and physical hazard in the Dutch poultry meat chain* published by Wageningen RIKILT (Banach et al., 2017). The risk assessment in relation to animal welfare made use of the *Risicoanalyse dierenwelzijn witvleesketen*('Risk assessment of animal welfare in the white meat chain') published by Wageningen UR Livestock Research (Visser, 2015). This report consists of a desk study and an expert opinion; it will be referred to hereinafter as the WLR report. In the report, 'welfare indicators' in the poultry meat chain are assessed using the 'Welfare Quality' system' which is expressed in terms of impact on the animal.

The Office for Risk Assessment & Research (BuRO) conducted an extensive literature review in relation to each aspect covered by the risk assessment, in which the recent reports of the European Food Safety Authority (EFSA) in particular played a key guiding role. In addition, BuRO has made use of the data available at the NVWA on the presence of food safety and animal welfare hazards in poultry as much as possible.

A multidisciplinary team within BuRO was responsible for preparing the draft report, which was put to external experts for review in several segments. The departments of the NVWA were asked to provide any additions and to check for any inaccuracies.

BuRO has presented the preliminary findings and recommendations of the risk assessment to the IG and the directors of the NVWA in order to enable them to formulate a risk analysis and a management response in a timely fashion. The findings and recommendations were subsequently presented to the relevant policy departments of the Ministries of Agriculture, Nature and Food Quality (LNV, formerly Economic Affairs) and Health, Welfare and Sport (VWS). On 29 December 2017, the final draft of the advisory report was made available to the Inspector General for the formal inspection prior to publication, as well as to the policy departments and the Inspector General.

The methodology of the risk assessment for the poultry meat supply chain is largely based on the methodology of the Codex Alimentarius and on the working methods of the EFSA, and is in line with the systematic risk assessment procedure stated in Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety, which consists of the following four stages.

1. Hazard identification: the hazards to food safety and animal welfare that have been described in the international scientific literature.
2. Hazard characterisation: the relevance of the hazards to food safety of Dutch poultry meat and the animal welfare of the poultry. Not everything that is described in the international literature is relevant to Dutch circumstances.
3. Exposure assessment: the probability of the occurrence of these hazards. In relation to food safety, this is the extent to which potential disease-causing agents (micro-organisms, chemicals and physical particles) will actually occur in Dutch products. In relation to animal welfare, this is the occurrence of certain conditions, situations and practices that affect the welfare of poultry.
4. Risk assessment: the overall assessment of the nature and severity of the hazards and the probability/prevalence thereof in the Netherlands.

These facets are discussed below with regard to A) Food Safety and B) Animal Welfare.

BuRO has not assessed all food safety and animal welfare aspects within the poultry meat supply chain. For an explanation of the scope, assessment methods, risk terminology and approach, please see Appendix 1 (annexes available in Dutch only).

Food safety risk assessment

Ad 1 + 2 Hazards: identification and characterisation in relation to food safety

For centuries, chickens and other poultry have been kept by humans worldwide for food supply purposes. Poultry meat is digested easily by the vast majority of the population, with hypersensitivity to poultry meat being rare. Hypersensitivity to chicken protein chiefly occurs through the consumption of eggs – the risk assessment for the egg supply chain contains a more detailed analysis of this aspect. Occasionally, there may be secondary allergies, such as 'Bird-egg syndrome', where sufferers develop a sensitisation to serum albumin, which is present in tissues such as muscle tissue and in the egg yolk. Sensitisation may occur through the airways after exposure to birds (primarily in adults) or as a result of an egg allergy during childhood (Hemmer et al., 2016). A person with this type of allergy will only benefit from avoiding ingestion of the relevant allergen. This requires correct labelling of products with a description of the allergens present.

Poor or inadequate personal hygiene of people and inadequate hygiene and/or precautions in the poultry meat processing sector may result in microbiological contaminations of the meat. Often these contaminations will not be related to the poultry meat production chain itself. Norovirus contamination, for example, during the preparation of a meal, can easily come about when handling and preparing fruit, vegetables or bread. Substances such as veterinary medicines and substances from feed and physical particles may in up end poultry meat products. Most food safety hazards, however, are caused by micro-organisms that are already present in the production animals on the farm itself and that are not or insufficiently killed off before consumption takes place.

The *Risicobeoordeling Roodvleesketen* ('Risk assessment for the red meat supply chain') published by BuRO in 2015 already concluded that food safety is not only adequately safeguarded in the Netherlands, but at a high level of quality. Food safety issues that may occur are mainly brought to the foreground in the form of mild forms of illness as a result of food infections, such as several days of nausea and diarrhea. Occasionally, the effects may be (far) worse. A total of approximately 70 - 80 people a year die as a result of a primary or secondary infection that they have contracted due to the consumption of a contaminated foodstuff. In relative terms, roughly the same number of people die prematurely every two days in the Netherlands as a result of smoking tobacco.

As a foundation for this risk assessment, BuRO conducted an extensive hazard identification and characterisation of the food safety of poultry meat (Annex 2; annexes available in Dutch only).

Many of the microbiological food safety hazards and their causes are consistent with those that occur in the red meat supply chain. The `*Risk assessment for the red meat supply chain*' focuses on the significantly elevated risk of the consumption of raw meat in relation to heated meat. Consumption of raw poultry meat, however, occurs very rarely if at all, thus reducing the likelihood of health problems. On the other hand, it is often pointed out that the micro-organisms present on poultry meat during the processing and the preparation of meals constitute a greater source of cross-contamination to other foodstuffs than red meat.

Most information on chemical and physical hazards in the Dutch poultry meat chain relates to broiler meat. Yet there is also information available to a limited extent regarding other poultry, such as turkeys and ducks. The physical risks of the poultry meat supply chain are very limited, given that there are few threats of a physical nature. These threats are listed in Annex 3.

Ad 3 Food safety exposure assessment
This risk assessment focuses on the broiler sector, given the major significance of this sub-sector of the poultry meat chain in terms of production size and consumption by comparison. Ninety percent of domestically produced poultry meat is produced from broiler chickens. By comparison: the production volume of the other poultry meat types amounts to 3% for turkeys, 2% for ducks and laying hens, and 4% for broiler breeders (FBR report). Annual poultry meat consumption per capita is roughly 22.4 kg (meat and meat products, including meat processed into composite products based on carcass weight: bone-in meat) of which 18.5 kg is from broilers, 1 kg is turkey and 0.3 kg is duck (FBR report). Given the size of the broiler sector in relation to the other sectors (turkey, duck, laying hens and broiler breeders), the most knowledge is available about broilers. Information on the contribution to the disease burden, the microbiological hazards and interventions is fragmented for other poultry species than broilers.

Exposure to micro-organisms: *Campylobacter*
Campylobacter is a natural inhabitant of the gut of poultry, resulting in virtually all poultry entering the slaughterhouse with *Campylobacter* in the intestinal tract. As a result of the slaughter process, more rapid spread takes place within the slaughterhouse, leading to all carcasses being contaminated with *Campylobacter* to a greater or lesser extent. Unlike other microbial contaminants, *Campylobacter* does not grow during processing and storage. Rather, the bacteria count will drop. Due to the fact that, to date, there are no successful, proven methods for keeping animals that are free of *Campylobacter*, the key focus is on reducing and controlling *Campylobacter* on the carcass. This, in conjunction with the implementation of a process hygiene criterion (PHC) in the slaughterhouse, results in reduced *Campylobacter* exposure for consumers. EFSA has calculated that a PHC of 1000 or 500 cfu/g neck or breast skin leads to a reduction of the risk to public health by more than 50 to 90%.

Given the decrease of the percentage of breast skin samples in terms of *Campylobacter* counts about 1000 cfu/g (9.8% in 2009, 10% in 2010, 8.8% in 2011, 8.1% in 2012, 8% in 2013, 7.0% in 2014 and 5% in 2015), the Dutch poultry sector has consistently succeeded in controlling *Campylobacter* at the slaughter line. The downward trend, in part, is also the result of an increase in the percentage of negative flocks (< 10,000 cfu *Campylobacter* / g cecal content). The cause of this is unknown. The verification study conducted by the NVWA in slaughterhouses and cutting plants on chicken breasts between 2010 - 2012 showed that only approx. 0.1% (1 in 970) samples contained more than 1000 cfu/g *Campylobacter*. In 2014 and 2015, it was the case that 0.2% of the chicken meat sampled by the NVWA from the retail sector contained more than 1000 cfu/g *Campylobacter*, with turkey meat meeting the limit requirements.

Despite improved control of *Campylobacter* in the primary and secondary phase, the disease burden in humans has yet not decreased to a significant degree. Possible explanations of this may include the fact that on estimate, roughly 50% of the fresh chicken meat on the Dutch market comes from other EU Member States. Given that these countries do not have a PHC for *Campylobacter*, the effect of the Dutch PHC could be weakened. According to the Dutch Food Retail Association (Centraal Bureau Levensmiddelenhandel, CBL), Dutch supermarket chains do make agreements regarding *Campylobacter* levels with European suppliers, however no verification takes place of the agreements made. As of 1 January 2018, the PHC approach has been implemented at an European level.

A second possibility that may account for the lack of a substantial drop in the disease burden is the fact that the bacteria enter into a type of dormant state in which they are non-cultureable but are still alive, and following transmission to humans may as yet be responsible for the disease burden.

In addition, 'viable but non-cultureable' (VBNC) *Campylobacter* may be present in the poultry meat that may not be able to grow in the laboratory but are able to grow inside humans.

Furthermore, there may be a non-food infection route in play. It is estimated that of the overall exposure to *Campylobacter* related to poultry, the food route (meaning the preparation and consumption of meat) accounts for 28% of human *Campylobacter* infections, whereas the total poultry-related percentage amounts to 66%. The chicken farms themselves seem to constitute key non-food reservoirs. During the outbreak of H7N7 avian influenza in 2003, which involved the culling of over 30 million chickens, the number of reported cases of *Campylobacter* in humans, reported by medical microbiological laboratories located in the area of the epicentre of the culls, was 44% to 50% lower than expected (Friesema et al., 2012). Most of the birds that were culled were laying hens (54% vs 8% broilers). As such, it is likely that laying hens, too, form a key source of non-food *Campylobacter* infections. Moreover, laying hen farms are often infected with *Campylobacter*. In 2016, 82.4% (117/142) of the farms that were sampled tested positive for *Campylobacter* infection. The precise nature of the non-food transmission routes is not known, however, it may be that aerogen transmission from the pens may play a key role. In poultry slaughterhouses, *Campylobacter* was shown to be in the air at a level of $8x10^3$ cfu/m3, with cases of aerogen transmission to humans being described (State of Zoonotic Diseases, 2013). Large numbers of animals in a single pen, such as is often the case poultry farms, require effective ventilation in order to remove the heat produced by the animals and, as such, cause large emissions of 'bioaerosols' into the environment (Maassen et al., 2016).

Exposure to micro-organisms: *Salmonella*
The past thirty years have shown a steady decline in the number of cases of salmonellosis in humans in the Netherlands. This is the result of the European *Salmonella* control programme in poultry (State of Zoonotic Diseases, 2015).

In 2015, the prevalence of *Salmonella* in broiler breeders was 1.1%, overshooting the European target of 1% by a small margin. Incidentally, none of the target *Salmonella* serotypes of the European control approach (S. Enteritidis, Typhimurium, Hadar, Infantis and Virchow) were shown in Dutch broiler breeders. Exceeding the target by 0.1% may seem a negligible margin of error, however, it is still worrisome given the pyramidal structure of the production chain of broilers (and laying hens) and the inherent multiplier further down the chain.

From 2000 to 2009, the prevalence of *Salmonella* for all *Salmonella* serotypes investigated steadily decreased in the broiler sector. From 2009, however, the percentage of positive flocks once again showed an increase (from 2.8% in 2011 to 7.8% in 2014). Specifically, this can be attributed to *Salmonella* Paratyphi B var. Java (S. Java) infections in the period up to 2013 and to *Salmonella* Infantis from 2014. The percentages of flocks infected with *Salmonella* Enteritis and/or *S.* Typhimurium remained stable between 0 and 0.2% during this period.

The trend toward higher *Salmonella* infection rates in broilers did not continue in 2015, during which 0.52% of the sampled flocks tested positive for *Salmonella*. The reason behind this development and the share of *Salmonella* Infantis infections in live broilers in 2015 is as yet unclear, chiefly due to the fact that during the same period significantly higher percentages of infected flocks were recorded at the slaughter line.

The data requested by the NVWA from poultry slaughterhouses on the results of the statutory *Salmonella* process hygiene criterion for 2015 shows that the percentage of slaughter flocks that tested positive for *Salmonella* varies significantly between the various companies, ranging between 2 and 24.4%. The *Salmonella* infection percentages of fresh poultry and preparations, sampled in the retail sector, have remained relatively stable with infection rates between approx. 3 and 6% (meat: between 3.2 and 6.6%; meat preparations: between 2.7 and 5.4%).

The causes of the increase of *S.* Infantis in broilers as yet are unclear. Given that *S.* Infantis has not been observed in broiler breeders in recent years, the sources of infection may lie outside the column of breeding animals. It may be a case of clonal spread of a new strain of *S.* Infantis. In Israel, for example, an emerging *S.* Infantis clone containing a megaplasmid was found, which resulted in host cells' improved ability for biofilm formation, adhesion and invasion of bird and mammalian cells (Aviv et al., 2014).

Company-wide infections with *S.* Infantis are difficult to combat, which is why it is not surprising that one of the largest poultry slaughterhouses in the Netherlands has said that half of these company-wide infections are persistent in nature (Boerderij 2016). The same company requires that new suppliers with *S.* Infantis and *S.* Java contaminations undergo a thorough *Salmonella* cleaning and disinfection process.

This cleaning and disinfection process following identification of *Salmonella* infection, as prescribed by the IKB Kip certification scheme, is meticulous. Marin et al. (2011) found that boiler pens had been contaminated with *Salmonella* in dust particles (24.6% of pens examined) and on surfaces (15.2%) prior to cleaning and disinfection, with 12.3% and 10.8% of pens, in dust particles and on surfaces respectively, still testing positive for *Salmonella* after cleaning and disinfection. The finding highlights the importance of a correctly executed cleaning and disinfection procedure. There are, however, more reasons underpinning the persistence of *Salmonella* following cleaning and disinfection. One of which may be lack of knowledge of the scientific literature on disinfection in the agricultural sector, followed by inaccurate use of disinfection chemicals, incorrect hardness and temperature of the cleaning water, overly low temperatures in the pens, high concentrations of protective substances (fats, carbohydrates, proteins) in the pen and the formation of biofilms, which may also be key factors.

Exposure to chemicals
Most chemical hazards in the poultry meat supply chain are introduced at the farm, where poultry may be exposed to chemicals as a result of feed intake, through the surrounding environment and/or as a result of the intake of veterinary medicines. During transportation from the farm to the poultry slaughterhouse, the poultry may come into contact with residues of cleaning products or plasticisers. During the subsequent processing phases in the chain, exposure to chemicals may occur as a result of processing aids, such as residues of cleaning agents for the slaughter and processing lines or food additives. In

addition, substances from the packaging materials and the various process steps, whether heated or not, may migrate into the poultry meat.

Data on the presence of residues and contaminants in food and feed from both the government and the private sector is recorded in the KAP database (Quality Programme for Agricultural Products). The data originates from both monitoring programmes (such as the National Residue Monitoring Plan) and from specific projects (such as the dioxin programme run by RIKILT) or from risk-based sampling (such as by the NVWA).

Table 1 shows a list of the total number of analysis (2212) in various types of poultry in period of 2009 to 2011. Most of the samples (76%) were taken from broilers of which the largest share was tested for the presence of veterinary medicines.

Table 1.
The number of samples per poultry flock that is measured under the Quality Programme for Agricultural Products between 2009 and 2011. The total number of measurements amounts to 2212 (Banach et al., 2017).

	Broiler meat	Duck (tame)	Hen	Ostrich	Other poultry	Pigeon	Turkey	Pheasant	Total
Halogenated organic compounds	31	0	0	4	0	0	0	0	35
Heavy metals	0	32	0	5	0	16	0	1	54
Pesticides	61	0	0	4	0	0	0	0	65
Veterinary drugs	1178	0	585	5	287	0	3	0	2058
Total	1270	32	585	18	287	16	3	1	2212
Percentage	57%	1%	26%	1%	13%	1%	0%	0%	100%

The data from the National Residue Monitoring Plan shows that in 2013 and 2014 approx. 1300 poultry samples were studied, of which 0.4% and 0.9% respectively were non-compliant and contained excessive levels of doxycycline (antibiotic). In 2013, levels of malachite green (a compound that is active against fungi and parasites) twice the permitted level were found in 35 samples.

Most reports in the Rapid Alert System for Food and Feed (RASFF) relate to exceedances of the standards for feed regarding aflatoxins, followed by far fewer reports on dioxins and DL-PCBs[1], heavy metals and pesticides (Banach et al., 2017). The RASFF, however, does not distinguish between animal feeds for different types of animals and, as such, no specific conclusions can be drawn with regard to poultry feed. Between 2009 and 2014, there were 780 RASFF reports regarding poultry meat products of which 127 related to chemical hazards. Two of those reports related to dioxins, with one report on 3-Amino-2-oxazolidinone (AOZ); both reports related to levels exceeding the minimum required performance level (MRPL) in chicken meat. The majority (63%) of the reports related to veterinary medicines, such as nitrofuran, clopidol and chloramphenicol in particular, chiefly in chicken meat. In 2012, there was a relatively large number of reports on food additives, whereas in 2009 reports were submitted on dioxins, PCBs[2], SEM (semicarbazide) and the nitrofuran

[1] DL-PCB's = Dioxin-Like PolyChlorinated Biphenyls
[2] PCBs = PolyChlorinated Biphenyls

metabolite AMOZ (3-Amino-5-Methylmoropholino-2-Oxazolidinone) in poultry meat products (Vass et al., 2008).

Both banned, non-authorised and authorised antibiotics are regularly reported in the RASFF and measured in Dutch monitoring actions. Due to their possible mutagenic and carcinogenic properties, from a food safety perspective, it is vital that these banned antibiotics are monitored. With regard to poultry meat products imported from countries outside of the EU all residues of veterinary medicines are relevant.

Exposure to physical hazards
The potential physical hazards that may be introduced during the slaughter process consist of remnants of bone and feathers and chips from the knives that are used. Nonetheless, the physical risks seem to be very limited and effectively manageable.

Ad 4 Risk assessment and food safety risks

Microbiology risk assessment: *Campylobacter* and *Salmonella*
All human disease burden estimates of poultry relate to chicken meat. Given the production and consumption data of other poultry meat than chicken, the contribution of these poultry meat types to the disease burden is negligible in comparison to chicken. In 2015, the number of cases of disease caused by the consumption of chicken meat was estimated to lie at 56,944 cases, with the disease burden at 1,022 DALYs. In that year, estimated mortality related to the consumption of chicken meat was on average roughly 17 cases (Mangen et al., 2017).

Poultry meat is considered to be one of the key transmitters of *Campylobacter* and *Salmonella* infections to humans. In terms of DALY, out of all the bacterial, food-related pathogens, *Campylobacter* and *Salmonella* make the highest contribution to the disease burden of the Dutch population estimated by experts. According to expert estimates of the Netherlands National Institute for Public Health and the Environment (RIVM), poultry is responsible for approximately 17% of food-related disease burden. Of the contribution made by poultry, 7,5% can be traced back to *Campylobacter* and nearly 7% to *Salmonella*.

Table 2.
Pathogenic micro-organisms

Pathogenic micro-organisms	RASFF[1] 2015		Disease burden[2] 2015	Legislation[3]
	Number	Cases	DALYs	
Total		**1.624.667**	**12.838**	
Foodstuffs	412	657.478	5.767	
Poultry	108 (26,2%)	56.944	1.022	
Campylobacter spp.	10 (9,3%)	20.020	748	
Salmonella spp.	93 (86,1%)	2.228	73	1

1 number of notifications with regard to pathogenic organisms without border rejection
2 estimated incidence and disease burden in DALYs for the Netherlands 2017 (Mangen et al., 2017)
3 specific legislation at EU level

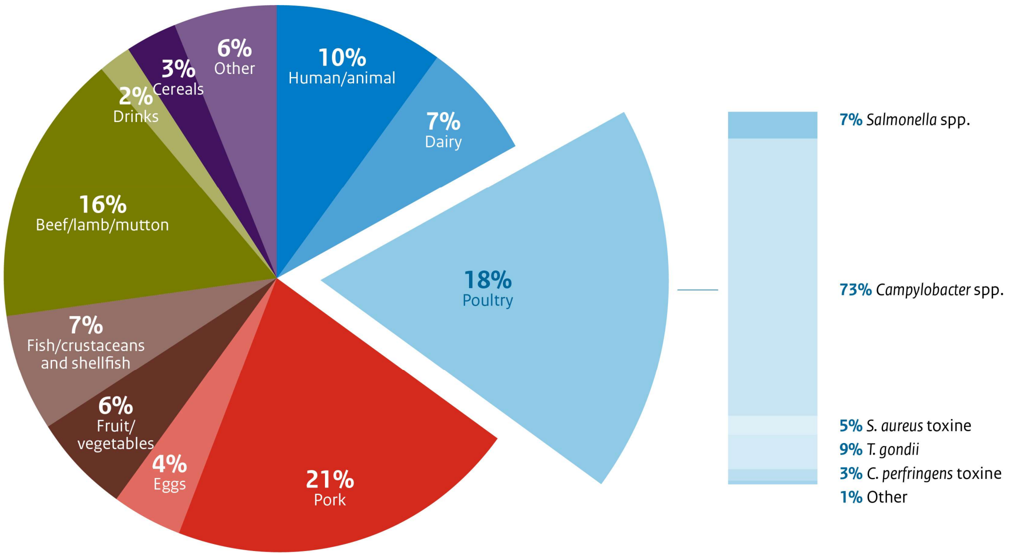


Figure 1.
Estimated attribution of disease burden caused by food-related pathogenic micro-organisms into food in 2015, with a breakdown according to the contribution of various pathogens within poultry meat (Mangen et al., 2017).

The National Institute for Public Health and the Environment (RIVM) has signalled a decline in the number of *Campylobacter* infections in humans since 2012, indicating that this is associated with a decrease in the use of antacids. This would mean that the reduction of the *Campylobacter* contamination levels on poultry meat (as yet) has not yet had an effect on human incidence.

The health risks due to the presence of *Salmonella* are shifting, despite the prevalence of this pathogen on poultry meat having remained approximately stable over the years. Of the human *Salmonella* isolates identified by the RIVM in 2015, 3.6% were *S.* Infantis. In 2011, this was only 1% of the typified isolates (2014: 2.6%, 2013: 3%, 2012: 1%, *State of Zoonotic Diseases* 2015). Consequently, there seems to be a rapid increase of the incidence of *S.* Infantis in humans. Similarly, there was an increase of the number of cases of *S.* Infantis in humans between 2011 and 2013 on an European level (Antunes et al., 2016).

The increase of *S.* Infantis in the poultry meat supply chain at the expense of *S.* Java is worrisome; *S.* Java is rarely found in humans. To the extent that humans have become infected, these infections chiefly relate to persons who have been abroad and have become infected there. At present, after *S.* Enteritidis, *S.* Typhimurium and the monophasic variety of *S.* Typhimurium, *S.* Infantis is the fourth most frequently observed serotype in humans. Increased food-related exposure to *S.* Infantis through poultry meat would, in time, lead to a further increase of the human incidence.

Microbiological risk assessment: other agents
Bacillus cereus, Clostridium perfringens and Staphylococcus aureus are common bacteria that can be found in many different foods. This type of disease burden is not so much the result of the bacteria's presence on (raw) poultry meat, but rather the result of poor hygiene and incorrect storage temperatures. Listeria monocytogenes should also be included in this list. There may, however, be additional indications that, within the poultry meat chain, Listeria is able to hitchhike onto fresh poultry meat from the primary phase throughout the chain

and cause disease burden at the consumer level. At present, poultry is not regarded as a key source of human Toxoplasma infections.

Norovirus, Escherichia coli and Giardia spp. also contribute to the estimated disease burden as a result of the consumption of poultry meat, even though, in a number of cases, exposure to the pathogen only takes place in later stages of the chain, with the disease burden only relating to hygiene during the processing and handling of the meat. Helicobacter pullorum and Arcobacter butzleri originating from poultry are currently regarded as emerging. At present, it is not yet known whether these bacteria also cause an actual burden of disease in the Netherlands.

Risk assessment at farm / primary phase
The farm phase comprises the production column of broilers by way of breeding and rearing farms and broiler farms. The significant microbiological hazards to food safety at this stage in the chain are constituted by various serotypes of *Salmonella* enterica sub-species such as *S.* Infantis, *S.* Typhimurium, *S.* Enteritidis and *S.* Paratyphi var Java and *Campylobacter* jejuni.

The risk factors for the introduction of both agents largely coincide. Violations and omissions in hygiene and biosecurity processes, for example, are a major source of introduction into poultry pens for both agents. There are some key differences however. *Salmonella* transmission may take place through eggs; and feed may also be a source of *Salmonella* infection. It should be noted that *Salmonella* is a micro-organism that is relatively resistant to dehydration (Namata et al., 2009) and, as such, it is able to survive in the dry conditions of poultry feed. It is primarily unheated poultry feeds that are a risk factor for the introduction of *Salmonella* (Securefeed 2016: unheated 0.24% infected versus 0.02% infected for heated poultry feed). Vertical and horizontal transmission play a key role in transmission via the egg. In vertical transmission, the egg will become infected by the parent animal in the ovaries or fallopian tubes before the formation of the shell, whereas in horizontal transmission the egg shell will become faecally contaminated after the egg is laid (FAO, 2002). In the former case, day-old chickens will emerge from the egg already infected with *Salmonella*, whereas in the latter case, day-old chickens will immediately become contaminated with *Salmonella* after hatching.

There are few or no instances of day-old chickens becoming infected with *Campylobacter* in the egg from the parent animal through vertical transmission. The high level of *Campylobacter* excretion of infected birds (up to10^8 *Campylobacter* / g of cecal content) and the corresponding startlingly rapid spread of *Campylobacter* in the unit makes it easier to produce *Salmonella*-free broilers than *Campylobacter*-free broilers (FBR report).

If there is no or reduced *Campylobacter* contamination at farms, this allows contamination of the environment (non-food route) to be restricted. For *Salmonella*, environmental contamination by farms seems to be more limited. For both agents, it is the case that low levels of contamination among live broilers may contribute to a reduction of the risk of cross contamination later on in the chain, for example, cross contamination of an inadequately controlled slaughter process or lack of hygiene processes in the processing and preparation phase of the chain.

Measures aimed at (mandatory) cleaning and disinfection procedures following *Salmonella* contamination or preventive periodic checks regarding the presence of *Campylobacter* in a flock of broilers are not only essential to animal health and animal welfare at the individual farm, but are also crucial to the sector as a whole.

The control of *Campylobacter* and *Salmonella* in the primary phase has the potential to yield more significant health benefits than later on in the chain. Contamination at farm level will result in exposure to consumers and expressed in the burden of disease. Due to the connected links of the chain, any microbiological contaminations of poultry meat that are identified in the retail sector can in principle be traced back to the farm, to the hygiene and living conditions of the animals, the feed and the hatchery.

Risk assessment at slaughter / secondary phase
Insufficient control of faecal contamination during the slaughter phase is the main cause of contamination of poultry meat with *Campylobacter* and *Salmonella*. In addition, at this stage and during the subsequent cutting phase, it may become contaminated with agents from the production environment (*Listeria*), agents transmitted by the employees (*Staphylococcus aureus*, Norovirus) or with traces of common micro-organisms (*Clostridium perfringens, Bacillus cereus*). Personal hygiene and effective cleaning and disinfection procedures contribute to the control of these risks.

The vast majority of slaughtered animals in the Netherlands are broilers. In 2015, 574,797,100 broilers were slaughtered (by comparison: ten years earlier, in 2005, the number of broilers slaughtered was 401,923,400). This translates into a carcass weight of nearly one million tonnes (952,531,000 kg). These slaughters are largely carried out by a limited number (18) of major poultry slaughterhouses. The large number of slaughtered broilers highlights the fact that tens of thousands of chickens are slaughtered daily at the major slaughterhouses. This is realised using belt speeds at the slaughter line of 13,000 chickens per hour, or over 200 birds per minute in a highly mechanised slaughter process. Correct calibration of the slaughtering equipment is extremely important for the maintenance of a hygienic slaughter process. This is chiefly the case for the removal of the gastro-intestinal system: a technically challenging process during which the contents of the gastro-intestinal system that is removed easily being able to contaminate the poultry meat. In cases where individual animals significantly vary in size, this may result in an elevated number of carcasses contaminated with faecal content. In comparison to the slaughter of pigs or cattle, the slaughter process for broilers does allow the use of water, resulting in a damp work environment. Water is primarily used to keep the equipment clean and to rinse away any possible contamination of carcasses, for example through traces of manure. The use of large volumes of water allows for aerosol formation in the slaughterhouse, which may easily lead to cross contamination of other slaughter products. In practice, this is prevented as much as possible, for example through the (logistic) slaughter of flocks of broilers that have tested positive for *Salmonella* at the end of the slaughter day.

The inspection of poultry at the slaughterhouse consists of an assessment of the food chain information and the visual inspection of live (ante mortem, AM) and slaughtered poultry (post mortem, PM). EFSA (2012) conducted an assessment of the advantages and disadvantages of the various components of the poultry inspection process in light of their relevance to the control of hazards to public health, and concluded that shortcomings were inherent to all components.

Given that broilers only rarely show symptoms of the agents that constitute the most significant hazards to public health, the added value of the AM inspection as considered limited from a public health perspective. EFSA considers the added value of the AM inspection to lie chiefly in the potential to identify flocks heavily contaminated with manure and in the implementation of risk-reducing measures for those flocks, such as logistic slaughter. During the PM inspection, visually contaminated carcasses, which may indicate an inadequately controlled slaughter process, may be identified to a certain extent. Such carcasses must be adequately treated, meaning not only rinsed off with water.

Decontaminating these carcasses (using chlorine or peracetic acid) or heating them results in the meat being made safe for consumption. The Food Safety and Inspection Service (FSIS) in the United States has determined that the trimming of contaminated carcasses in itself is insufficient and that they must subsequently be treated with chlorine (Russel, 2009). In Europe, EFSA has assessed the use of peracetic acid to be safe (EFSA, 2014). In Europe, however, the use of both chlorine and peracetic acid is not (yet) permitted for the decontamination of carcasses.

The key agents that originate from poultry which may form a hazard to public health will generally not produce any symptoms in birds and will also rarely produce any visible pathological or anatomical abnormalities. The presence of *Campylobacter* and *Salmonella* in poultry meat is chiefly the result of contamination of the carcasses with faecal matter during slaughter. Naturally, these micro-organisms cannot be visually identified during an inspection. For that reason, the assessment of the hygiene level of the slaughter is carried out based on contamination with manure or other contaminants (feathers, bile, gastric contents) on meat that is intended for consumption. Pacholewicz (2016) found that, even at a low level, carcasses with visible faecal contamination carried a significantly higher E. coli load than carcasses that were visually clean. Boysen et al. (2016) concluded that less faecal contamination was accompanied by lower levels of *Campylobacter* contamination on the meat. With regard to the effects of the faecal contamination of broiler carcasses, Swart et al. (2013) calculated that improved control in 2011 could have prevented an estimated 11,800 cases of disease. This is because improved control of faecal contamination results in a lower level of *Campylobacter* contamination, but additionally affects the contamination levels of other foodborne agents such as *Salmonella* or ESBL-carrying bacteria.

The high belt speed limits the detection sensitivity of the visual PM inspection with regard to lesions and faecal contaminants, ultimately resulting in only a fraction of all birds on the slaughter line being subject to a thorough inspection (EFSA, 2012). Process hygiene criteria and chain information constitute suitable additions to the AM and PM inspections. Poultry slaughterhouses are required by law to put in place a process hygiene criterion for *Salmonella* and Dutch slaughterhouses have committed themselves to implementing a process hygiene criterion for *Campylobacter* on a voluntarily basis – this will be mandatory for all slaughterhouses in the EU in a modified form from 1 January 2018 pursuant to Regulation (EC) No. 2073/2005. In the event of deviations for the required standards for the process hygiene criteria, slaughterhouses are required to review and improve the slaughter process. In addition to data requested from slaughterhouses on the *Salmonella* process hygiene criterion, the report of Nepluvi (Nepluvi, 2012) on the *Campylobacter* process hygiene criterion and relevant research (Pacholewicz, 2016, Boysen et al., 2016) show that there is a significant difference between slaughterhouses with regard to their capacity to control bacterial concentrations on poultry meat.

The idea behind the food chain information (FCI) is that flocks of poultry for slaughter can already be sorted into risk categories before slaughter. This allows slaughter procedures or decisions on the suitability for human consumption to be able to be adapted to the health status of the flock. In this context, EFSA (2012) referred to logistic slaughter, increasing of the number of inspectors at the slaughter line or the decrease of the belt speed as potential risk management options. At present, however, the value of the FCI is limited due to the fact that except for *Salmonella* in broilers and turkeys, there are no adequate and standardised indicators for the key microbiological risks. The use of knowledge on the possible extent of contamination of animals at the level of flocks that are supplied from the farms may make a significant contribution to realising improved hygiene results in the slaughterhouses. This information, in turn, may be valuable to the cutting plants and the retail sector as subsequent links in the poultry meat chain.

Tracking the *Salmonella* contamination levels (all serotypes) throughout the chain yields the following picture. In 2015, during the live phase three weeks before slaughter, 0.5% (82/15,725) of the sampled flocks were *Salmonella* positive; during the slaughter phase, this rose to 8.6% (11/127) of the slaughter flocks examined; and in retail, 3.9% (23/593) of the samples of fresh poultry meat that was sampled tested positive for *Salmonella* (all data: EFSA, 2015). Although the statistical power of this data has not been examined and various types of samples (manure on shoe covers, pooled neck skins and individual meat samples) were examined, it is striking that in 2015 there was a low level of contamination in the primary phase, followed by an increase of the contamination level in the slaughter phase, with a subsequent reduction in the retail phase. The causes for this are not clear. The NVWA, however, has indicated that it is not known whether or not the results of *Salmonella* studies with serotypes other than *S.* Enteritidis or *S.* Typhimurium, as required, are consistently listed on FCI forms. As a result, flocks that test positive for *Salmonella* are not subject to logistic slaughter. In addition, the NVWA that *S.*E and *S.*T. positive flocks are also thinned. If these animals were to be transported to the slaughterhouse alongside *Salmonella*-free animals, or were to come into close contact with *Salmonella*-free animals, this may lead to horizontal transmission of *Salmonella*.

The reasons for the decrease in *Salmonella* contamination levels following the slaughter phase are unclear, however may be related to improved control by companies.

Risk assessment of resistance to antibiotics

In addition to the direct disease burden caused by food pathogens, the indirect elevation of the disease burden through selection of antibiotic resistance in agriculture, directly into zoonoses or commensals, followed by transfer to human pathogens, is playing an increasingly important role (Ter Kuile and Brul, 2013; Andersson and Hughes 2014; Ter Kuile et al., 2016). The use of antibiotics during the rearing of broilers significantly contributes to the selection of bacteria that are resistant to these agents (Veldman et al., 2016). This resistance development contributes to the increase of the human disease burden both directly and indirectly. On the one hand, the treatment and healing process of patients will become more difficult if a human pathogen has developed resistance to the first-choice antibiotic and, as such, increase the burden of disease. On the other hand, transfer of antibiotic resistance may take place from harmless bacteria to human pathogenic bacteria – with the same effects on the burden of disease (Mole, 2013). The extent to which this occurs is unclear (Thanner et al., 2016).

An estimate was conducted for the EU based on data from 2007 regarding the additional burden of disease and the associated costs that infections caused by antibiotic resistant pathogens entailed. At the time, it was estimated that annually in the EU some 25,000 patients died of an infection caused by one of the five selected antibiotic resistant pathogens from the study, and that infections caused by those pathogens entailed € 1.5 billion in additional costs each year, including through additional hospital days, treatment costs and additional loss of productivity in respect of an infection caused by a pathogen that was treatable with antibiotics.[3]

It is unknown how large the contribution of the agricultural sector is to the extent of resistance of human pathogens. Expert estimates on this matter range from 10 - 75% (*Risk assessment of the red meat supply chain*). What is certain, however, is that there is a link. For that reason, it is clear that the selection of antibiotic resistance in the agricultural sector must be combatted and, preferably, should be prevented. In recent years, the policy of the Dutch government and the poultry sector has focused on this aspect. This policy is in line with the European action plan that focuses on combating resistance in the agricultural sector (Action plan against the rising threats from Antimicrobial Resistance, 2011). The formularies of the Royal Dutch Society for Veterinary Medicine (KNMvD) are instrumental to the prescription of antibiotics for poultry in the Netherlands. These formularies are categorised into first, second and third-choice antibiotics. First-choice agents for treatment of all conditions refer to antibiotics that cause little or no selection for ESBL resistance (Formularium Pluimvee, 2012).

Since 2007, a substantial reduction in the consumption of antibiotics in the agricultural sector has been achieved, from 565 tonnes in 2007 to 217 tonnes in 2013, however no further reductions have been achieved since (Veldman et al., 2016). For the treatment of poultry (broilers and turkeys), however, more antibiotics were used in 2014 and 2015 than in 2013 (49.3, 51.8 and 54.3 tonnes in 2013, 2014 and 2015 respectively). It is worrying that a great deal of (fluoro)quinolones are still used for broilers and turkeys. It has been observed that use of this class of antibiotics leads to resistance more quickly than in other antibiotics (Van der Horst et al., 2011). As such, the application of (fluoro)quinolones is particularly undesirable. According to the EU action plan and the Poultry formularium (*Formularium Pluimvee*, 2012), these agents may only be used if other agents are not effective and then only following a sensitivity determination. Within the formularium, fluoroquinolone enrofloxacin is often listed as a third-choice agent. In order to prevent the selection of ESBL-carrying bacteria, the application of all beta-lactam antibiotics, in principle, is undesirable (Andersson and Hughes, 2014). In practice, it will not always be possible to avoid the application of these antibiotics. The third and fourth generation cephalosporins are the final drugs for the treatment of certain infections in humans that are otherwise untreatable. That is why the use of these antibiotics in the agricultural sector is particularly undesirable and, as such, they are not used in this sector in accordance with the EU action plan of 2011 and the formularium.

Salmonella that is isolated from broilers is usually more resistant against antibiotics than human isolates and isolates from other animals (Veldman et al., 2016). Only in recent years, has there been an ostensible reduction in resistance rates. Hard data to prove a direct link between the presence of resistance in microbiota of chickens and additional human disease burden is absent. Nevertheless, it is clear from the report published by Veldman et al. (2016) that chicken meat contains significant amounts of resistant micro-organisms, both pathogenic types such as *Salmonella* and commensals such as E. coli. The human population therefore is in actuality being exposed to resistant bacteria through the poultry supply chain.

[3] http://www.ema.europa.eu/docs/en_GB/document_library/Report/2009/11/WC500008770.pdf

Recently, the EU Commission issued guidelines for the use of antibiotics for animals kept for farming purposes, 2015/C 299/04.[4] In relation to poultry, the guidelines state that the use of antimicrobial agents in eggs or day-old chickens in hatcheries must be avoided. Preventive administration and flock treatment of day-old chickens before or after transport must be limited as much as possible and the necessity of routine treatment of day-old chickens upon arrival at the farm can be avoided through good hygiene practices at the hatchery and the implementation of good agricultural practices. In addition, vaccination must take place stress free. Furthermore, correct management of the farm and good agricultural practices should also be able to alleviate the need for the treatment of non-infectious diseases with limited secondary infections. The necessity for antibiotics can be reduced through the further advancement and improvement of animal welfare and animal health. In this regard, it should be noted that according to Regulation (EC) No. 1177/2006, *Salmonella* in chickens should not be controlled using antibiotics, but that instead the measures included in the national control programme must be implemented in order to prevent *Salmonella* infection on the farm.

In *Salmonella* originating from broilers, resistance to fluoroquinolones is the most significant of all sources, being even greater than human origin and from poultry feed (Veldman et al., 2016). The latter is an indication that this resistance is developing as a result of the administration of fluoroquinolones at the farm. Chicken meat imported from Brazil contains a great deal of ESBL carriers, similar to the meat originating from the Netherlands and other EU Member States. *Campylobacter* on broilers and originating from chicken meat is often resistant to multiple types of antibiotics.

Within the poultry sector, a higher percentage of the indicator organism *E. coli* is resistant to virtually all antibiotics than the isolates from the pig, dairy cattle and fattening veal sectors (Veldman et al., 2016). From the point of view of human health care, it is the ESBLs that are the most problematic at this moment in time. For that reason, exposure to beta-lactam antibiotics should be reduced where possible. In 2015, resistance to colistin, a last-resort antibiotic used to combat infections in humans, had not yet occurred, with this likewise being the case for meropenem, a carbapenem that is often used as a last resort in human intensive care. In the Dutch poultry sector, colistin is only used if no other agent is effective, after which an analysis is conducted to preclude the need for the use of the antibiotic in the future. This policy should certainly be continued. Carbapenem-Resistant *Enterobacteriaceae* (CRE) are opportunistic human pathogens that are difficult to treat and which are occasionally found in the veterinary sector abroad, despite the fact that carbapenems are not used for veterinary purposes. Transmission of CREs from humans to the veterinary sectors is distinct possibility. Thereafter, selection may occur due to exposure to other beta-lactam antibiotics, which need not necessarily be carbapenems. At this stage, no specific measures are as yet required, however it is vital that carbapenem resistance in the veterinary sector should be monitored, despite the absence thereof at this point in time.

The trends of the resistances measured in recent years can best be tracked for the commonly used indicator organism, *E. coli*. Nevertheless, a break with the trend in the case of resistances of isolates of broilers can be observed. After many years of continuous increase in the resistance rates to virtually all types of antibiotics, there has been a visible decrease since 2011. It would seem that the reduction of the use of antibiotics in the agricultural sector since 2007 has begun to bear fruit. It is therefore of the utmost importance that the highly restrictive

[4] http://ec.europa.eu/health/antimicrobial_resistance/docs/2015_prudent_use_guidelines_nl.pdf

veterinary prescription policy be pursued with vigour. The veterinary sector has arguably and demonstrably taken responsibility with regard to this matter. The use of agents other than the first choice has been limited to situations that are unavoidable. In recent years, the use of third-choice agents has been reduced to practically zero and the application of second-choice antibiotics has been significantly reduced. It is paramount that the various stakeholders build on the results that have been achieved. Wageningen UR has developed a feather test for the NVWA that allows the use of antibiotics to be detected, for which purpose the NVWA collects feathers at slaughterhouses. Based on the site of the antibiotic in the feather, it can be determined at which stage of life of the poultry the antibiotic presumably was administered to the animals. The NVWA uses the test to carry out random checks at slaughterhouses to verify that the FCI forms have been completed truthfully. In 2016, the NVWA verified some 400 samples, which yielded that twelve broiler farms had not reported use of antibiotics.

The WLR has qualified various health effects as a result of infectious diseases as serious impact, including respiratory and gastro-intestinal conditions. The mortality rate in poultry farming has not decreased in recent years and there is still a relatively high degree of use of antibiotics to treat health problems. The initial reduction target of 50% was achieved, however a further reduction has been complicated by the presence of chiefly (secondary) bacterial infections.

Despite the availability of vaccines, a great many antibiotics are still used in broilers and parent flocks to treat yolk sac inflammation, airsacculitis, skin inflammation, fallopian tube inflammation and peritoneal inflammation caused by E. coli. In addition, a large amount of antibiotic is also used to control necrotic enteritis caused by C. perfringens type A. Infections with coccidian predispose animals for secondary bacterial infections in addition to viral infections, such as infectious bronchitis and infectious bursitis (Gumboro Disease).

The debate surrounding preventive vaccination or post-development treatment with antibiotics in the poultry farming sector is also taking place on an international level. A special OIE working group (OIE, 2015) identified which conditions would require further control (for the reduction of antibiotic use), in relation to which new or improved vaccines could provide a solution within the foreseeable future. The working group concluded that within the poultry farming sector, new or improved vaccines were required for E. coli and C. perfringens in particular, however also for certain strains of infectious bronchitis.

Simply reducing dosages would be a very disadvantageous way of achieving a reduction of the amount of antibiotics used, given that it is the low dosages in particular that most frequently select for resistance (Feng et al., 2016; Ter Kuile et al., (2016). Therapeutic objectives can be achieved with minimal development of resistance by treating the animal with the highest dosage that can be administered to the animal without damage, until the immune system is able to gain control of the infection itself. Once this is the case, the treatment can be terminated. Laboratory data suggests that administering an insufficiently high dose entails a significantly higher risk of resistance development than premature termination of treatment. In addition, the method that the antibiotics are administered is crucial. For broilers, the antibiotic is usually added to the drinking water. If a system with single pipelines is used, there is a high likelihood that the drugs which precipitate in the pipes will dissolve at a later time. This results in low concentrations ending up in the normal drinking water, thus allowing resistance to develop (Andersson and Hughes, 2014). All dosing protocols should limit the emergence of dose gradients as much as possible to ensure that there is as little exposure of bacteria to sub-therapeutic concentrations. In case where there is no double pipeline system, the remnants of the antibiotics should be removed from the pipes before they can be used for the animals' normal water supply. For that reason, the Health Centre for Poultry (*Gezondheidscentrum voor Pluimvee*, GvP) recommends that drinking water lines, tanks or medicine mixers should be cleaned and disinfected after each flock using an agent on a hydrogen peroxide / peracetic acid basis (which is permitted for this type of application).

Risk assessment for chemicals
Unlike exposure to microbiological agents, exposure to chemical contaminants in food does not result in an identifiable burden of disease (Van Kreijl & Knaap, 2004). Any long-term effects of chemical contaminants, in general, are difficult to relate to specific substances and/or attributable to certain foodstuffs. For the substances referred to here, it is not possible to attribute a disease burden in the risk assessment of chemicals in food products. In most cases, no direct link can be demonstrated between the exposure to substances and cases of disease in the population.

EFSA (2012) concludes that it is highly unlikely that chemicals in poultry would lead to acute or immediate health effects. The explanation for this is that acute effects brought on by chemicals are mostly caused by relatively high concentrations that are not easily achieved through the food chain. EFSA recommends that the analysis for residues and contaminants in poultry meat (products) should be closely linked to food chain information and feed and that there should be careful adjustments with regard to new and emerging chemicals.

Dioxins and polychlorinated biphenyls
The most significant contributor to the presence of PCBs and dioxins in poultry meat is animal feed. Based on recent calculations by the RIVM (Boon et al., 2016), the intake of dioxins through feed in the Netherlands is not cause for public health concerns. Non-dioxin like polychlorinated biphenyls (NDL-PCBs[5]) have the same sources as PCBs, however, these PCBs do not have the specific toxicological effects of dioxins and are less dangerous. The concentrations identified in the poultry meat supply chain for these substances do not give rise to public health concerns.

Similarly, in the case of other environmental contaminants, such as perfluorooctanoic acid and brominated flame retardants, the food intake calculations show that no toxicological threshold values are being exceeded in poultry. Although poultry meat products do contain environmental contaminants, they generally only contribute a small portion of the total contaminant uptake via food.

Pesticides and biocides
Pesticides consist of active ingredients and in their formulation will also often contain agents that themselves may be toxic. Pesticides or their residues (including metabolites and impurities) may find their way into animal feed and, subsequently, into the poultry supply chain. In addition, biocides are used, for example, in the housing units or pens of poultry, such as acaricides against spiders.

The KAP database shows that between 2009 and 2011 no significant residues of pesticides or biocides were measured in any of the 65 samples tested. As such, the risks of these agents are considered to be negligible.

[5] NDL-PCBs = Non-Dioxin Like PolyChlorinated Biphenyls

Heavy metals
Animal feed is the main source of heavy metals, such as cadmium and lead. For that reason, the levels of cadmium, arsenic and lead in feed are strictly regulated. The KAP database of 2009-2011 shows that the Maximum Levels (MLs) for heavy metals were exceeded in 20 of the 54 samples: two cases relating to cadmium (in turkey meat and pigeon meat) and 18 cases for lead (13 in duck meat and 5 in pigeon meat). The source of these high concentrations is unknown, as is whether this contamination lead to – prolonged – intake in humans. Although there are few samples, the percentage of cases exceeding the MLs is high. The information, however, is insufficient to be able to carry out a risk assessment.

Residues of veterinary drugs
There are various types of veterinary drugs, such as antibiotics, worming agents (anthelmintics), drugs against parasites (anticoccidial agents) and anti-inflammatory drugs that are intentionally used within the poultry sector (see Annex 3). The use of these drugs can lead to residues in meat or in other products of animal origin. Some veterinary drugs and their metabolites are currently banned, such as chloramphenicol, nitroimidazole, nitrofurans and semicarbazide, due to the significant risks they pose to public health. The KAP database shows that between 2009-2011, twelve of the 1201 samples showed concentrations of antimicrobial agents above the Maximum Residue Levels (MRLs). The samples related to four cases of nitrofurans, one case of nitrofurazone in broiler meat and three cases of furazolidone in chicken meat. The MRL for doxycycline had also been exceeded in seven broiler meat samples. The MRLs for enrofloxacin (sum of enrofloxacin and ciprofloxacin) and of ciprofloxacin had also been exceeded in one broiler meat sample. In 2011, only 12 chicken meat samples were analysed for growth regulators (with metaproterenol in particular), all of which yielded negative results. Non-steroidal anti-inflammatory drugs (NSAIDs) were found in 2 of the 192 samples. No sympathomimetic drugs (such as the beta-agonist cimaterol in particular) were found in any of the 12 chicken meat samples in 2011.

The report for the EU National Residue Monitoring Plans shows that between 2002 and 2013, 214 nitrofurans or metabolites thereof were found in broiler meat on a number of occasions. The EFSA has calculated that it is unlikely that health risks should occur below concentrations of 1,0 µg/kg nitrofurans or SEM in foodstuffs (EFSA CONTAM Panel, 2015). In the monitoring of the presence of nitrofurans in carrier pigeons in the Netherlands, the NVWA found a significant non-compliance percentage in which the nitrofuran metabolite AMOZ was found. For that reason, BuRO made the recommendation in 2014 that carrier pigeons should not be consumed (BuRO, 2014).

Cleaning agents and disinfectants
Cleaning agents and disinfectants (biocides) are used at various instances in all links of the poultry and egg supply chain, such as in the disinfection tubs when entering the housing unit, mandatory cleaning and disinfection of the pens, transport trolleys and crates in which live poultry is transported. Biocides may only be put on the market following authorisation by the Dutch Board for the Authorisation of Plant Protection Products and Biocides (Ctgb).

There is no insight into the use of cleaning agents, disinfectants (and other biocides) due to the lack of systematic records in the chain and the lack of insights into turnover figures of disinfectants and biocides.

The food safety and health risks of disinfectants cannot be assessed due to the lack of insight into both the use and the potential residues in animal products.

Banned agents: fipronil
In the summer of 2017, it was revealed that a significant number of professional laying hen farms had made use of the agent known as fipronil, which is a banned agent used against red poultry mite in poultry sheds (BuRO 2017a; 2017b; 2017c; 2017d). This illegal use resulted in the contamination of roughly 20% of the eggs at that time. The acute and semi-chronic public health risks to consumers were low, however the large-scale contamination undermined the system of laws and regulations intended to safeguard food safety.

As a result of this incident, a review was carried out of the potential use and the associated risks of banned agents used against pests or diseases, such as for red poultry mite and histomonas in particular, in the poultry sector. A selection of banned agents of which it was estimated that they could be used as an illegal alternative to red poultry mite yielded 35 active ingredients. For histomonas this resulted in a list of 4 active ingredients (see Annex 3).

At the end of August 2017, EFSA requested that the Member States carry out a voluntary, additional screening for the presence of residues of illegal agents during the months of September and October. They were asked to analyse a representative number of samples without further instructions.

In addition to the professional poultry farm sector, there are also private poultry farms (less than 250 chickens and/or breeders of special poultry, and the petting zoos and care farms). There is a realistic chance that these poultry farmers may use agents that would normally be used to prevent fleas and ticks in dogs, cats and other companion animals against red poultry mite in their poultry. This admission does not take into account the possible consumption of the companion animals and, as such, no waiting period was derived for food safety reasons. This implies that the used of these drugs in the private poultry farming sector may potentially result in elevated health risks for (regular) customers of poultry meat and eggs from this sector.

Control of chemical risks
Chemical risks can be avoided and controlled through the application of quality assurance programmes, such as GLOBAL GAP (Good Agricultural Practices) on the farm and HACCP (Hazard Analysis Critical Control Points) at poultry processing plants. In addition, most poultry farmers are certified for the IKB system (Integrated Chain Quality) in the Netherlands. These types of quality assurance systems must nevertheless be adaptable to future developments.

The ‘washing’ of slaughtered poultry is a frequent method used worldwide to further reduce microbiological contamination. EFSA previously issued an opinion in 2005 on the use of chlorine in the disinfection of chicken carcasses. EFSA concluded that the use of chlorine dioxide or acidified sodium chlorite would not lead to the formation of halomethanes or other organic chlorinated by-products. This also applied to the use of peracetic acid. For that reason, EFSA concluded that there were no risks to public health, while it does note that Good Hygiene Practices should still be in force, even when using disinfectants (EFSA, 2005).

In the Netherlands, the number of poultry farms is on the decrease, whereas the size of the companies is growing. This is resulting in a further intensification of the production chain for poultry meat. This may have a positive impact on food safety, given that if farmers invest in making improvement to their business operations they are likely to become more aware of food safety. Larger numbers of poultry, however, will also affect the feed market, which in turn may affect the quality and the safety of these products. There is currently a trend of an increasing number of farmers mixing feed ingredients themselves at their own farm. Further globalisation may adversely affect the transparency of the chain, primarily in the animal feed sector.

Risk assessment for physical materials
Physical hazards may arise from various types of external materials, particles or objects that may end up in poultry meat products, particularly during the processing phases. Sources of physical hazards include contaminated raw materials, poorly designed housing and materials, errors in processing stages and poorly trained staff. Physical hazards relate to the introduction of glass, metal, stones, plastic, rubber, wood bone, shot, needles and lubricants. Within the poultry chain specifically, fragments of bone and feathers are occasionally observed in products. Given the increasing degree of automation in slaughterhouses, these are the key areas of focus. The consumption of bone fragments can lead to health hazards, such as blockage of the oesophagus or perforation of the gastrointestinal tract. In children, bone fragments appear to account for 12% of all blockages caused by foreign bodies (Arana et al., 2001). New techniques are being developed to allow for the detection of bone fragments, however, at present they are expensive and are not widely used. Nonetheless, the physical risks seem to be very limited and effectively manageable.

Food Safety Risk Assessment: Summary
Within the poultry meat supply chain, we can identify a correlation between the introduction of pathogenic micro-organisms at the farm and food safety for the consumer. Micro-organisms introduced at the farm are able to traverse all links of the production chain and threaten public health if the meat has not been properly heated for consumption. These micro-organisms chiefly relate to *Campylobacter* and *Salmonella*. The fact that contaminations from the farm can be passed on to the subsequent stages in the chain could be used to make further improvements to food safety. In doing so, the chain could be tracked back from the consumer to the farm. Infections that are identified in retail should be able to be traced back to the cutting plant, the slaughterhouse, the transport company and the farm easily. Virtually all these links record infection rates, however at present the information is not easily accessible or transposable, given that registrations take place in various databases and is used for various different purposes. Systematic records at flock level could significantly improve risk estimates and could also improve compliance if companies were to share and apply this information between one another, in part, to implement the recommendations of the Dutch Safety Board to ensure that:

‘*binding agreements are made with private parties in order to achieve structural improvement of the level of food safety*’

‘*companies [call] each other to account regarding high-risk behaviour, such as unsanitary slaughtering or illegal practices. Companies should inform one another, and the NVWA, of any high-risk behaviour taking place at other companies*’

‘*the traceability of products should improve and the performance of individual companies in the field of food safety should become more transparent to consumers.*’

During processing, storage or consumption, the meat may subsequently become contaminated with Listeria monocytogenes and other pathogenic micro-organisms.

Failure to comply with the duty to report *Salmonella* infection during the ‘meat production’ phase increases the risk posed to public health. The discrepancy in *Salmonella* infection rates during the primary phase and the slaughter phase (0.5% vs 8.6%) is potentially an indication of insufficient reporting in the primary phase.

Poultry slaughterhouses succeed to complying with the Process Hygiene Criterion for *Campylobacter* to varying degrees. If all slaughterhouses were to perform at the same high level of success, this would result in greater health benefits. As of 2018, a *Campylobacter* PHC is required by law for the production of all poultry meat in the EU.

The rise of *Salmonella* Infantis is worrying, given that this serotype results in human infections. *Salmonella* and *Campylobacter* infection and animal diseases at the farm may be controlled using a great deal of preventive measures. At present, the use of antibiotics in the poultry sector is still high, resulting in a serious risk of antimicrobial resistance of pathogens. Both the legal and illegal use of second and third-choice antibiotics in the primary phase in particular remain a serious threat to antimicrobial resistance in poultry and the transmission thereof to humans. A key example is the elevated percentage of fluoroquinolone resistance in *Salmonella*.

The administration of antibiotics via drinking water systems may cause long-term exposures to low concentrations. This is certainly the case if such drinking water systems are not adequately cleaned. This contributes to the risk of development of antimicrobial resistance.

The risks of chemicals in the poultry meat chain are very low. Poultry meat does not significantly contribute (< 1%) to the uptake of dioxins and dioxin-like PCBs from foodstuffs. There is little information available on the presence of brominated flame retardants and a number of other contaminants in animal feed and poultry meat.

Occasionally, substances have been found in eggs, including substances that are banned for laying hens. The risk assessment of the exposure of consumers to these chemicals indicates that the toxicological threshold (Acceptable Daily Intake, ADI) is not exceeded.

The results of the chemical research conducted in the poultry meat chain have been concentrated at various government and private sector organisations and, as such, the data is not easily accessible or useable for risk assessment and reports. In addition, information is lost during the storage of the results of measurements of chemicals, such as quantitative information on levels exceeding the detection threshold but below the standard.

The very minor risks of physical hazards occurring in the poultry meat supply chain are entirely controlled by the measures of the various companies.

The present assessment of the chain shows that the entire system of food safety assurance (as well as that for animal health and animal welfare), at present, still depends on the delegation of critical phases in the food safety and quality assurance process to the private sector, meaning the owners themselves, and as such is still vulnerable. As regards food safety, for example, large sections of the *Salmonella* monitoring programme or carried out by or on behalf of the farmers.

B Animal welfare risk assessment

Ad 1 + 2 Hazards: identification and characterisation for animal welfare

Throughout their lives, animals experience distress as a result of exposure to a large number of hazards, which can broadly be categorised into hazards as a result of the hereditary characteristics of the animal (as a result of breeding policy), housing and care in the broadest sense of the word (management, stockman ship, appropriate handling), external facilities, means of transport and environmental conditions (such as weather conditions and pathogens). The distress that they experience as a result is discussed in terms of the animals' key needs: a sufficient and appropriate diet, adequate housing and the ability to express other normal behaviours (Welfare Quality criteria).

This risk assessment will also make use of foreign data to indicate where improvements can be made in the Netherlands in terms of animal welfare issues. BuRO, however, wishes to emphasise that this does not mean that the risks to animal welfare are greater in the Netherlands than abroad. On the contrary: BuRO is aware that in a great many countries were poultry is reared and kept the risks to animal welfare are often far greater than in the Netherlands.[6]

In order to be able to assess the welfare of chickens or other poultry, their natural, physiological needs should be known. The chicken and other poultry are omnivorous by nature (feeding on both vegetable and animal materials by nature) and will spend over 80 - 90% of their time during the day scratching / foraging. The chicken and its conspecifics naturally inhabit wooded areas where they are able to find shelter and protection against any natural predators and where they are able to withdraw to the safety of a branch at night to rest. In addition, the birds will have a dust bath every other day, lasting roughly half an hour.

If these animals are unable to fulfil their natural needs, they will often develop deviant and/or stereotypical behaviour, such as the picking of other objects or those who share their pen (feather pecking), which may progress into forms of cannibalism. Feather picking, in essence, is an adjusted type of foraging behaviour.

Table 3.
Pillars of welfare based on Welfare Quality.

Pillars of welfare based on Welfare Quality			
Appropriate nutrition	**Suitable housing**	**Optimal health**	**Normal behaviour**
• Absence of prolonged hunger • Absence of prolonged thirst	• Comfort when resting • Temperature comfort • Ease of movement	• Absence of injuries • Absence of disease • Absence of pain due to stock management procedures	• Expression of social behaviour • Expression of other species-specific behaviour • Quality of human-animal relationship • Positive emotional state

[6] This risk assessment will not address the animal welfare risks for animals that are kept in domestic, non-professional settings. The threshold for domestic, non-professional poultry keepers is 250 animals or less. This number is chiefly determined by the regulations for manure, possible claims to poultry rights and temporary larger numbers of animals during the breeding season for hobby breeders. The same threshold of 250 animals is used in the European approach to the control of *Salmonella* and Campylobacter.

Various types of animal welfare risks are recorded at the farm. Other findings come from the inspections at the slaughterhouse (Annex 4). The WLR had identified more than 30 potential animal welfare concerns during the fattening phase of chickens kept for meat production (Annex 5). A number of those concerns have a limited impact, such as the vaccination of animals, fear of humans, weak animals and hypothermia, which occurs primarily in very young animals in the first week of life.

Of the welfare concerns that have a moderate impact, it is chiefly distress caused by reduced feed or water intake, the reduced quality of the plumage and limitations in terms of activity/poor locomotion that occur most frequently.

Animal welfare concerns with a serious or significant impact on the animals include: deformed skeletal structure, breast blisters, hock burn, footpad lesions, (endo)parasitic infestations, (non-)infectious, mild and severe respiratory diseases, (non-)infectious gastrointestinal diseases, hopeless suffering, beak trimming, feather picking, limited behaviour repertoire, disturbed rest and overweight animals.

The possible severity of harm to animal welfare is not easy to determine. In addition, the threats and the resulting effects are highly varied in nature. BuRO has asked experts to estimate the severity of each threat on a scale of 1 (low harm) to 7 (severe harm). The animal welfare concerns identified in the poultry meat chain with an estimated impact of (combination of severity and duration) of 4 and above have been listed in Table 4.

These animal welfare concerns are manifestations of the animal as a response to exposure to one or more hazards. Often the issues will be multifactorial in nature and can affect one another or even reinforce one another in various ways.

The hazards to the welfare of poultry in the primary phase are largely microbiological in nature, relating to the various germs that may affect the animals' health, such as bacteria, viruses and parasites. In addition, there are a great many threats to the welfare of animals' through the lack of physical capabilities for animals to express their natural behaviour. These physical threats to animal welfare are caused by various factors, such as housing, climate control, the design of the pens, the quality of the litter and feed. (Surgical) procedures on and injuries to the animal will also affect and threaten animal welfare.

The administration of veterinary drugs, or lack thereof, and the use of vaccines may also lead to animal welfare harm. During transport from the farm and during the slaughter phase, key hazards consist of the catching process, the quality of the means of transport, climate conditions, the absence of water and feed and the facilities at the slaughterhouse.

Ad 3 + 4 The presence of animal welfare hazards and risk assessment
The same types of threats can be present in various links of the poultry meat chain, however the estimated severity of the threat may vary per stage of the chain. Thirst due to the (temporary) lack of provision of water is a well-known threat, however footpad lesions and death occur in all links of the chain.

Table 4.
Overview of animal welfare problems in the poultry meat supply chain with an estimated severity of 4 or above.

Animal welfare problems per phase of the chain: Impact > 3 on a scale of 1 (absent) to 7 (very severe)						
Welfare problem	**(Grand)parent flocks**	**(Grand)parent layers**	**Hatchery**	**Broiler farm**	**Transport of broilers**	**Slaughter of broilers**
Reduced feed intake	5	5	5	4	5	
Reduced water intake	5	5	5	4	5	
Reduced plumage quality		4		4	4	
Damage to plumage	4	5		4		
Hyperthermia			5	4	4	5
Hypothermia			4			
Limited activity/locomotion	4	4		4		
Abnormalities in skeletal development	6	6		6		
Small wounds or scratches				4	5	
Major injuries	4	4		4	6	6
Bone fractures, muscle schisms, dislocations	4	4		4	6	
Breast blisters	5	5		5		
Hock burn	5	5		5		
Footpad lesions	6	6		6		
Endoparasitic infections	6	6				
Non-infectious gastrointestinal problems	4	4		5		
Non-infectious respiratory problems	4	4		5		
Mild respiratory problems	4	4		5		
Sever respiratory problems	6	6		7		
Infectious gastrointestinal problems	5	5		6		
Weak animals					6	
Hopeless suffering	6	6		6		
Killing at farm	4	4	4	4		
Beak trimming (procedure)						
Beak trimming (after procedure)	5	5				
Interaction with dominant cockerels		5				
Feather pecking	6	6		6		
Limited behavioural repertoire	5	5	5	5		
Disturbed rest	5	5		5		
Clipping of rear toe (procedure)	4					
Clipping of rear toe (after procedure)	5					
Obesity				6	6	
Fear of the environment					5	5
Shackling						5
Cutting when conscious						4

General animal welfare concerns throughout the entire live phase of poultry

Footpad lesions as an animal welfare indicator
The European Council Directive laying down minimum rules for the protection of chickens kept for meat production (2007/43/EC), which is implemented in the Animals Act, Animal Keepers Decrees and Regulation on Animal Keepers, sets out restrictions to the maximum number of animals (in kg live weight) per m2 of housing. Exceptions are permitted, provided that additional rules in the field of housing, care and management are met. The additional requirements include a restricted mortality rate (based on a fixed calculation formula) and the monitoring of footpad lesions. Following the example of Sweden and Denmark, the Netherlands, as the third European country, has implemented the mandatory monitoring of footpad lesions as an additional requirement in addition to maximum stock density, albeit with other, less stringent criteria than in Sweden and Denmark. Other European countries make use of optional monitoring. Where Sweden and Denmark use a threshold value (average annual score) 40, the Netherlands has introduced a system (see Annex 6) that uses thresholds of 80 - 120.[7]

Footpad lesions are a multifactorial disorder affecting the footpads, which is chiefly caused by damp litter, but which also entails a number of other factors such as heredity, nutrition, the origin of the animals and animal health. There is no unique relationship between the prevention of footpad lesions and high stock density, despite there being a significant correlation between the two. Nevertheless, the absence of footpad lesions is regarded as a crucial indicator of (good) animal welfare and as an indicator of the stockman ship of the poultry farmer.

In the Netherlands, data published by the Netherlands Enterprise Agency (RVO) shows that there is a gradual improvement underway in the average scores for footpad lesions per month (RVO website). The value of this observation to the animal welfare of broiler chickens is limited. Roughly 20% of poultry housing units still has an annual average score of > 80 for footpad lesions. This means that within that unit, the majority of the flocks that were produced that year suffered from footpad lesions to a severe degree.

The mandatory monitoring of footpad lesions is primarily used in the context of the regulation of maximum stock density, but can also be used as an intermediate indicator at the level of the (individual) flock in conjunction with the cumulative daily mortality rate. Elevated mortality and / or severe harm due to footpad lesions occurring in one or more consecutive flocks is a strong indication of insufficient control of animal welfare at the relevant farm.

Mortality and death on arrival as animal welfare indicators
Mortality is referred to as an ‘iceberg’ indicator, as it is the result of a collection of health and welfare concerns. Frequently identified concerns include daily mortality, mortality in the first week of life and cumulative mortality, which relate to animals dying as a result of animal health and animal welfare concerns, and to animals that are (or must be) selected for culling on a daily basis by the farmer in order to prevent any further discomfort (killing at the farm). Any unforeseeable increase in daily, weekly, cumulative mortality, selection and

[7] Broadly speaking, an average annual score of 40 means that in virtually each flock of broilers that was produced that year, the majority of the animals suffer from minor to moderate harm as a result of footpad lesions, with minor to moderate harm to animal welfare as a consequence. An average annual score of 80 or above means that in virtually each flock of broilers the majority of the animals suffered from severe harm to their footpads, which is painful and can be considered as severe harm to the welfare of the animals / severe discomfort.

disease may reflect a problem with regard to animal welfare (OIE, 2016). The converse is not necessarily the case: in flocks (or at farms) with low mortality, serious animal welfare issues may still occur, such as mental concerns in the form of fear, stress and disturbed rest or insufficient ability to express natural behaviours or normal behaviour such as foraging and scratching.
In the literature, mortality in broilers ranges from 1 to 14% (EFSA, 2012). The same report indicates that in a major European study (Welfare Quality), the cumulative mortality at slaughter for regular broilers was 2.9% (at an average age of 38 days), whereas for the breeds that mature slower mortality amounted to 3.1% (measured at an average age of 54 days).

The average cumulative daily mortality (loss) in broilers in the Netherlands saw a drop over the past 10 years from nearly 4% to approx. 3.2%, with a stagnation in the last 3 years (Agrimatie; bedrijvennet). This is in line with the loss of 3.12% reported in the Animal Keepers Decree database on 2015 (NVWA). The average loss in 2015 for the group of farms in Cat 1 is lower (avg. 2.5%) than for the farms in Cat 2 and Cat 3 (avg. 3.14%). The variance in group of Cat 3 farms is high. This relates to an average annual score. At the level of the flock, the standard loss is exceeded by more than 20% per category.

The high distribution in loss between flocks and categories means that health and welfare gains can be achieved, first and foremost, by gaining insight into the loss figures (benchmarking), so that they can be more actively applied to provide risk-based monitoring, for example, in the event the standard is exceeded (verbal communication NVWA). The government could set long-term targets by linking the reduction of losses to the categorisation of the housing (maximum stock density) and by supporting any international initiatives in the field of vaccine development for animal diseases (as recommended by the OEI working group).

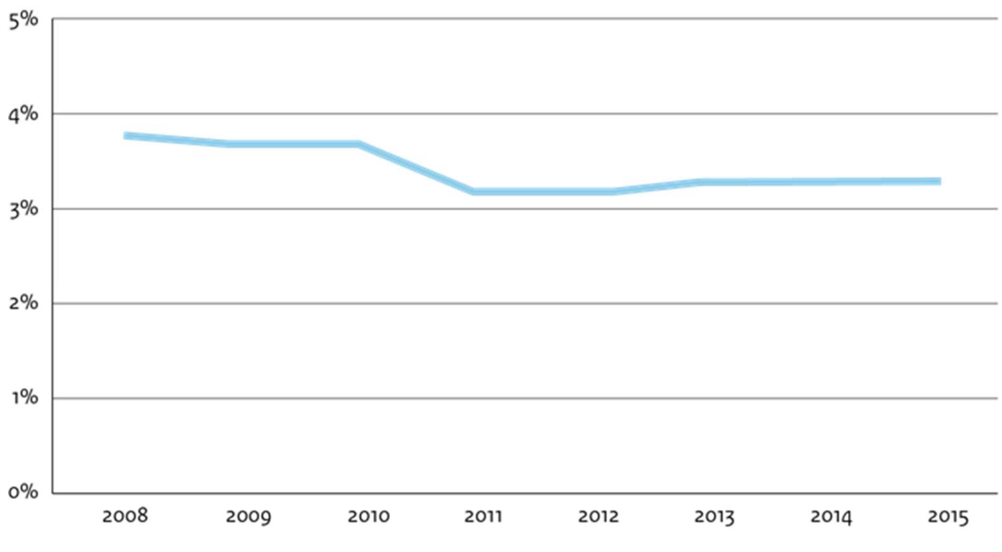


Figure 2.
Cumulative daily mortality (loss) of broilers (Agrimatie) for the period of 2008-2015.

Poultry that is slaughtered in the Netherlands chiefly originates from the Netherlands, supplemented with large numbers of animals from Germany, Belgium and Denmark, and from France (spent laying hens) and Poland (broilers) to a lesser extent. There is also a reverse flow of Dutch broilers to chiefly Belgian and German slaughterhouses. There is no slaughterhouse for turkeys in the Netherlands, with virtually all those birds being slaughtered in Germany. The majority of spent Dutch laying hens are mostly slaughtered abroad, with a relatively small percentage being slaughtered in Poland. These animals will often be on the road for over 10 - 12 hours and run a greater risk of discomfort as a result of insufficient water and feed supply during transport, in conjunction with deprivation prior to the catching, the duration of both the loading and unloading and the waiting time at the destination (slaughterhouse).

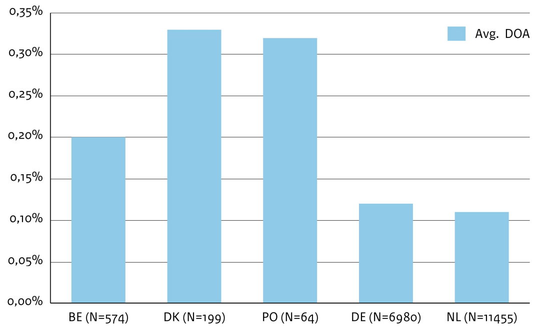
The hazards of transport process are chiefly related to the heredity of the animal (such as overweight animals that cannot roll back from a supine position), inappropriate handling by various actors such as the catching crew (rough handling, injuries, dislocations and fractures) and the health and fitness of the animal (flock health status; poor plumage of chiefly spent laying hens, weaker animals at the end of the laying cycle with an elevated risk of fractures). Furthermore, the hazards of transport relate to the drivers and the means of transport (including the covering of the vehicle and climate control during transport), the effects of overcrowding during extreme weather conditions and the use of unsuitable, poorly maintained crates and containers. In addition, the conditions at the slaughterhouse also play a key role (including the loading process, prolonged waiting times before slaughter, possible period without water and /or feed in conjunction with a lengthy journey or poor location of waiting area).

Crucial and available indicators with regard to physical discomfort during transport include death on arrival (DOA) and injury. Death on arrival as an indicator is currently available in the form of average mortality per slaughterhouse (per year), including as the percentage of flocks that exceed the signalling standard of 0.5% DOA (figure 3). In international terms (EFSA, 2011), average death on arrival varies considerably with outliers of 0.85% chiefly relating to spent laying hens.

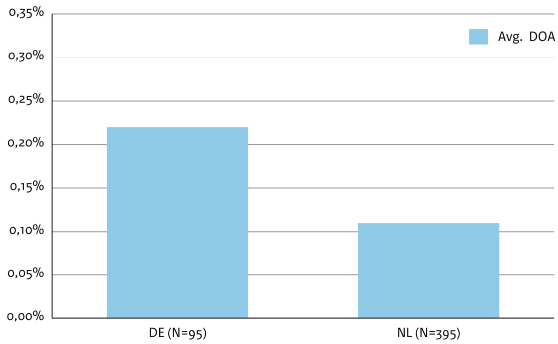
Average death on arrival at the slaughterhouse in the Netherlands for 2014 - 2016 (NVWA data, Pladmin) sits at roughly 0.14% for both broilers as ducks. For spent laying hens and parent flocks that are slaughtered in the Netherlands, this figure is slightly higher, namely between 0.15% and 0.17%. The latter only relates to animals that are slaughtered in the Netherlands (approximately 20%). Given that over 600 million poultry birds in total are slaughtered in the Netherlands, this figure relates to over 800,000 birds that are arrive at their destination dead and depending on the cause of death potentially experienced prolonged discomfort to a greater or lesser extent. There is no data regarding the spent laying hens that are slaughtered in slaughterhouses abroad and sometimes have spent a considerable amount of time in transport.

In addition to the average death on arrival, a record is also made of whether a flock falls within the established signalling standard of 0.5% DOA. Analysis of the NVWA data for 2014 - 2016 shows that there are significant discrepancies between flocks in terms of exceeding the signalling standard per slaughterhouse (figure 4).

Average DOA for broilers per country of origin (NVWA-2016-1)



Average DOA for ducks per country of origin (NVWA-2016-1)



Average DOA for laying hens per country of origin (NVWA-2016-1)

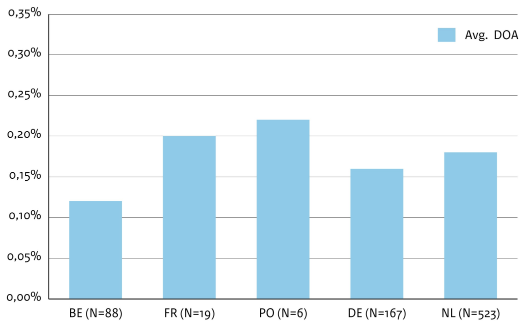


Figure 3.
Data with regard to death on arrival (DOA) at slaughterhouse; the differences between average death on arrival per country of origin (NVWA data, 2016, 1st half-year Pladmin).

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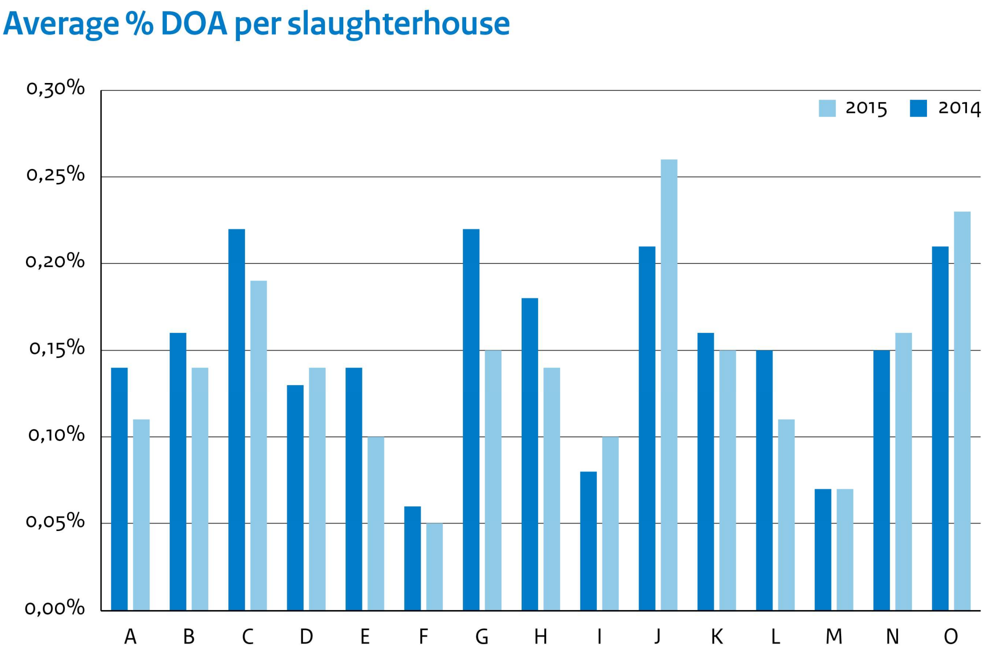


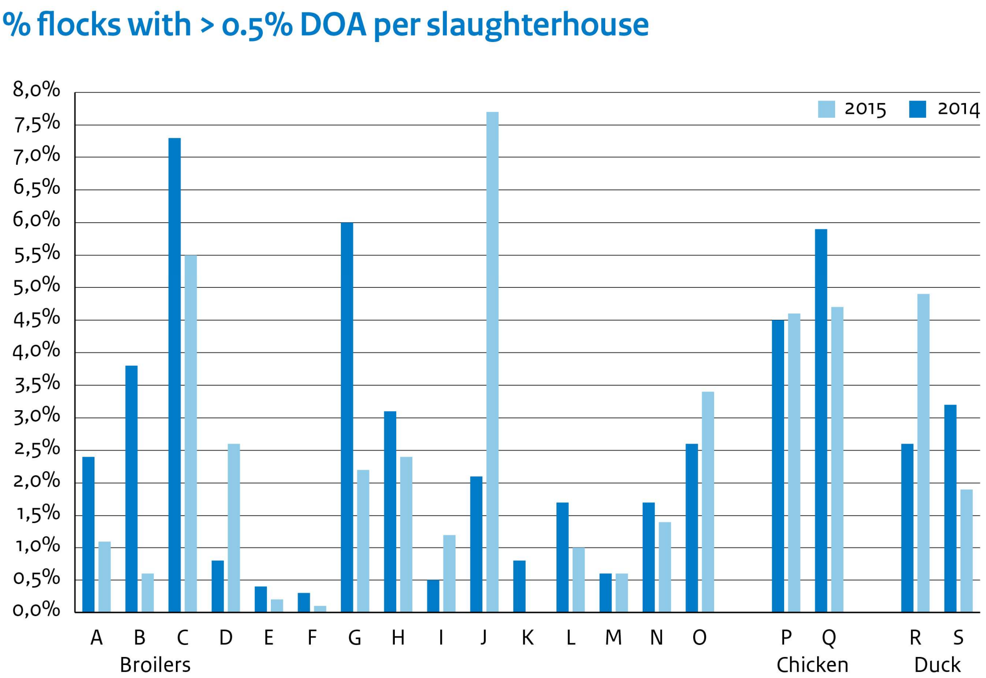


Figure 4.
Differences between the major poultry slaughterhouses with regard to death on arrival (years 2014 and 2015). Top / left variation in annual average DOA per slaughterhouse; bottom / right variation in slaughterhouse with regard to exceeding of threshold of 0.5% DOA per flock.

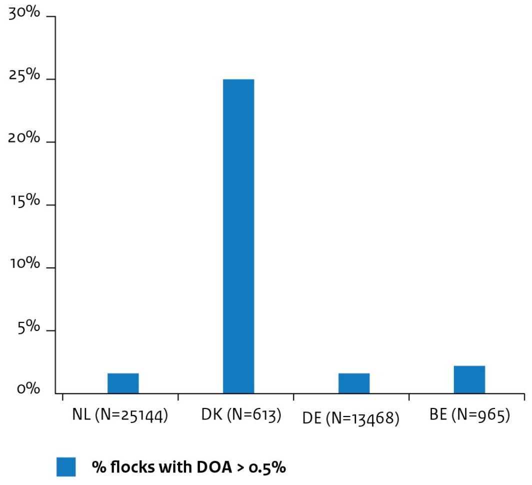
The differences in DOA at the slaughterhouse vary significantly between the various countries of origin of the animals. The most extreme instance is that of the spent laying hens from France (FR) and broilers from Denmark (DK) (figure 5). For spent laying hens that were delivered from France in 2015 and slaughtered in the Netherlands, an excess figure was measured in more than 25% of the flocks, compared to an average of 3.8% for Dutch flocks. For broilers from Denmark, the excess amounts to over 10% in 2015 compared to an average of 2% for the remaining countries of origin including the Netherlands.

Thirst in relation to animal welfare
The Animal Keepers Decree of 2014 requires that animals should be able to satisfy their need for water. There are varying interpretations of this requirement in the broiler sector in the primary phase. In 2017, BuRO carried out a separate risk assessment of water provision to parent flocks. Water is not always permanently made available to poultry: limited access, such as only during certain hours a day around feeding times, is an existing practice. These feeding times (and consequently watering times) are limited to prevent broiler parent flocks from gaining too much weight too quickly, developing joint problems and subsequently having difficulties moving around. At 90% of broiler breeders, water is provided in a restricted manner alongside feed up to 2 - 4 hours after the feed has been finished; in addition, a fixed water-feed ratio is applied. This results in an estimated 4 - 8 hour period during the light period during which the water supply is cut off to the animals. At 10% of broiler breeders, the water supply is not cut off but is regulated by a decreasing of the water pressure. Studies conducted among chickens (laying hens, broilers and broiler parents) show that water deprivation of 6 and 8 hours leads to situations in which the animals are no longer able to maintain the physiological equilibrium in their fluid balance. This result in animal welfare problems such as stress, frustration and thirst.

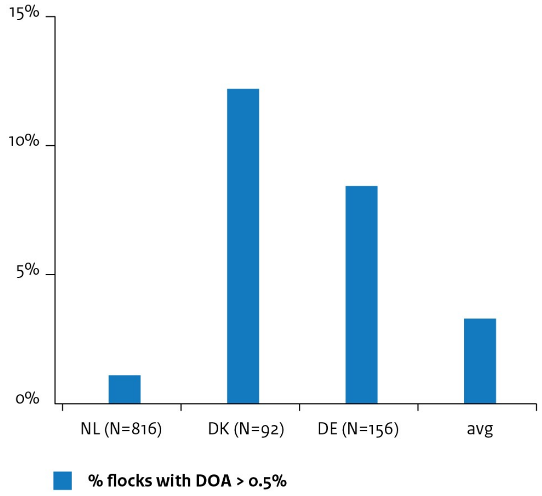
Excessive water supply, however, can also result in animal welfare hazards. Wet litter increases the probability of the occurrence of contact dermatitis, respiratory problems and impairment of scratching and dust bathing behaviour.

The regulations in the field of water provision to animals to allow them to satisfy their need for water cannot be enforced by the NVWA in a uniform manner. In part, this is the result of the absence of clear regulations in respect of temporary water deprivation. It is partly for that reason that prevalence data is virtually absent and that the scope of the animal welfare risk cannot be estimated accurately. Continuous water supply with systems that use a reduced water pressure may reduce or eliminate these animal welfare risks.

Broilers 2015 – death on arrival



Ducks 2015 – death on arrival



Laying hens 2015 – death on arrival

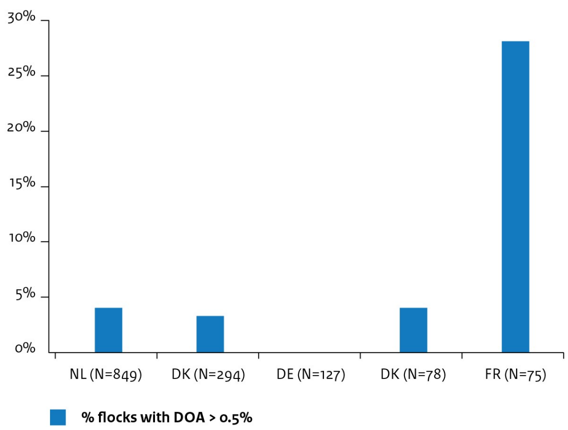


Figure 5.
The various DOAs at the slaughterhouse between the various countries of origin of the animals.

Other animal welfare risks throughout the live phase of poultry
Risk is determined by the severity of the impact and the probability of the harmful effect actually occurring. In addition to the assessment of severity and duration of the welfare concerns, Visser (2015) also described the degree of occurrence (prevalence) based on the scientific literature, which is represented as follows for the various links of the poultry meat supply chain.

These animal welfare problems are outlined in the literature, which, in this case, is often based on data from a limited number of companies. The poultry farming sector retains a great deal of management data, whether or not pursuant to a requirement under the Animals Act, the Animal Keepers Decree and the Broiler Decree. In respect of broilers specifically, all incomings and outgoings must be recorded, with the cumulative daily mortality rate being recorded in the Broiler Decree database (VKB databank). The mandatory footpad lesions score must also be logged in the database for the maximum stock density category permitted (cat. 1, 2 or 3).

The Food Chain Information form must be completed for the meat inspection during the slaughter process, which list mortality in the first week of life and the cumulative daily mortality. Slaughter findings during the inspection are recorded in the Poultry administration database of the NVWA (also known as Pladmin) and may contribute to gaining an idea of the health situations at the holding of origin.

Table 5.
Key animal welfare problems based on impact and prevalence in the successive phases of the broiler chain.

Parent flocks	Parent layers	Hatchery	Broilers	Transport	Slaughterhouse
Water-feed intake	Water-feed intake	Reduced feed-water	Abnormal skeletal development	Reduced water-feed	Fear of the environment
Clipping of rear toe	Damaged plumage	Killing at farm	Limited locomotion	Major injuries	Bone fractures
Beak trimming (after procedure)	Abnormal skeletal development	Disturbed rest	Footpad lesions	Bone fractures, injuries	Shackling
Limited behavioural repertoire	Footpad lesions		Inf and non-inf diseases	Obesity	
Disturbed rest	Ectoparasitic infections		Limited behavioural repertoire	Mortality	
	Interaction with dominant cockerels		Disturbed rest	Fear of the environment	
	Limited behavioural repertoire		Obesity	Reduced quality plumage	
	Disturbed rest		Mortality		

Given that data on each flock must be registered in the Broiler Decree database (VKB), a FCI form must be completed for the slaughter and an inspection takes place at the slaughterhouse or an export certification takes place for transport abroad, various sources of data are available on broilers that may contribute to an exposure assessment of animal welfare hazards.

Specifically, for the assessment of the welfare of broilers, in addition to mortality and footpad lesions, this assessment will make use of the available data on wing fractures and injuries between the time of catching and slaughter. This risk of injuries and fractures is also crucial in other links in the chain, however it is most critical in this stage. Infections and other animal diseases are likewise not unique to a specific link in the chain – these types of hazards play a role at all farms –

however they are most salient in relation to the rearing farms for parent flocks and the broiler poultry farms. This also applies to the use of antibiotics and other veterinary drugs or vaccinations.

Broiler parent stock, rearing and breeding
In relation to broiler parent stock, many animal welfare problems occur that to a large extent coincide with the animal welfare problems in the meat production phase, as well as that of ducks and turkeys. The key welfare problems are: animals becoming overweight, abnormal skeletal development and microbial infections of which parasitic infections are the main concern; there are effective vaccines available for many viral and bacterial diseases. During the rearing period of approximately 21 weeks, the animals are vaccinated approximately 20 times.

The key additional hazards to broiler parent stock are caused by the genetic predisposition as a result of the breeding policy that is geared toward rapid growth, low feed conversion and meat growth and the aforementioned parasitic infections, including through a limited number of veterinary drugs and vaccines. The remaining hazards for a large part consist of the inability to be able to exhibit natural behaviour due to insufficient housing facilities and care, the quality of the litter and interaction caused by dominant cockerels. Beak trimming as well as the clipping of the rear toe may cause pain. Not treating the animals may also have adverse effects, given that feather pecking and damage to the plumage may arise if the animal density becomes too great.

Hatchery
The key hazards at the hatchery are the duration of the hatching itself and the handling and movement of the chicks. Hatching eggs are incubated under strictly conditioned circumstances whereby the hatching eggs are moved to hatching cabinets or drawers (hatchers) after approx. 18 days. The chicks hatch at an age of approx. 20 days within a period of up to 18 hours with a relatively large time difference. Only after virtually all eggs have hatched are the chicks removed from the incubator, sorted, packed and transported to the rearing or fattening farm. Only upon arrival at the relevant farm will the chicks be given access to water and feed. As such, the chicks that have hatched first will have had no access to water or feed for a long period of time, which results in their having to use the yolk sac nutrients to stay alive, resulting in fewer nutrients becoming available to build up an effective immune system. In order to avoid this problem, new so-called on-farm hatching techniques have been developed (RDA, 2016). Chicks that have hatched through on-farm hatching appear to have lower mortality during the first week of life and appear to be of better quality, in relation to which the rapid access to water and feed seem to be the most critical factor (RDA, 2016). After roughly 18 hours, any eggs that have not hatched or have partially hatched are removed. The hatched chicks are sorted into first and second-choice chicks, where the lower quality chicks (second choice) are killed with CO_2 depending on the demand for the hatchery. Factors such as hygiene during the hatching process, laying of floor eggs and the use of formalin to disinfect hatching eggs, have a negative impact on the quality of day-old chicks and, as such, have a possibly negative effect of the health and welfare of the broiler farm (Visser, 2015).

During all the various operations, such as the debeaking, inoculation and sexing and movements at the hatchery, the chicks will experience discomfort such as fear, pain and /or disturbed rest. Both the inoculation of the animals at the hatchery, the debeaking itself and the sexing of the chicks are brief steps with minor impact. In the system used, these steps score low on the impact scale and will not be addressed further in this risk assessment. A limited number of

animals will suffer from the after effects of debeaking for a long period of time, which is reflected as a moderate welfare risk among (broiler) parent stock.
On average, day-old chicks will be sorted, packed in boxes and shipped out for transport within 12 hours of the last animals hatching at the hatchery. This happens under properly conditioned circumstances, resulting in relatively little discomfort even during relatively long journeys. During these types of journeys, however, the lack of provision of water may be a threat. During transport from the rearing farm to the end company, there will probably by minor discomfort during catching, loading, transport and unloading of the animals. There is hardly any monitoring in respect of this phase and there is very little data available. For that reason, the risks to animal welfare during this transport phase are difficult to estimate.

More generally, there are few key data available at BuRO to allow a comprehensive assessment, quantification and comparison of the animal welfare risks. Making the key data available in a uniform fashion per hatchery and per breed would contribute to increasing quality awareness at hatcheries and to better choices for customers and for the regulator. The key figures that are crucial for the assessment of animal welfare at the hatchery are: the hatching rate of the egg, the average weight of chicks at a certain age, the ratio of first and second-choice chicks, the percentage of chicks killed at the hatchery, and the mortality rate in the first week of life. In order to facilitate a chain-oriented assessment and to safeguard animal welfare, it is essential that this information be available at the level of the flock, so that it can be aggregated to the level of the chain.

Broilers during farm phase
The hazards to animal welfare on the farm are caused by factors including the housing (pens, layout, facilities, litter, climate control, light regime), the access to and quality of water and feed, in addition to an 'insufficient environment' that does not allow animals to satisfy their natural needs. On the farm, poultry can be exposed to microbiological hazards such as bacteria, viruses and parasites. The extent to which this occurs is partly related to the housing and living conditions listed above. Hygiene at the farm, however, is also a crucial factor affecting the development of microbiological infections.

In addition to discomfort as a result of insufficient access to food, such as occurs during the hatchery phase, during the rearing of parent stock and around transport times, the quality of the animal feed is also a key risk factor to animal health. Animal feed of poorer quality, including as a result of inferior raw materials, will often manifest itself in poor digestibility for the animal, leading to non-infectious gastrointestinal disorders such as diarrhoea. For that reason, animal feed is a key risk factor for the occurrence of footpad lesions in animals.

In relation to broilers in particular, health problems in the first week of life (major cause: provision of antibiotics) are related to the appropriate and timely feeding of the chicks, both in the final phase of the hatching process and the first few days of life. Recent initiatives such as on-farm hatching, where the chicks hatch at the farm instead of at the hatchery, play a key role with regard to this problem (RDA, 2016). There are also indications that as a result of the breeding policy applied in recent decades, the nutrition in the hatching is no longer sufficient to ensure the optimum health of day-old chicks. A project was recently launched within agri-food top sector called '*Healthy broilers for Healthy humans*', which specifically focuses on '*identifying factors in the early phase of life of chicks that are vital to ensuring optimum animal health and animal welfare throughout the entire production process, in order to preclude the use of antimicrobial agents and to ensure the optimum quality of the end product*'

(WUR, 2016). A second project called '*Healthy bones*' focuses on the issue of '*the extent to which the development of bone and wing quality is positively affected by factors as such i) the nutrition of parent animals, ii) the nutrition of young broilers, and iii) the origin of the sources of phosphorus in the feed*'.

In broilers, bacterial infections are a key cause of disease, an indication for use of antibiotics and a cause of death. Within the context of reducing the use of antibiotics, in recent years veterinarians have been required to report any visits to farms at which an antimicrobial agent was prescribed, as well as the indication for its use (IKB-CRA database). Other veterinarian visits may be reported on a voluntarily basis. Of the 3,711 flocks that are registered, 3,099 flocks were reported, for which approx. 30% a diagnosis of an animal disease was reported as an indication for treatment of the flock. Key 'clusters' of reasons for treatment with antibiotics (data 1st quarter 2017) are mortality in the first week of life (8% of flocks), locomotion problems (9%), digestive problems (6%), respiratory problems (6%) and miscellaneous problems (9%). The number of flocks for which there were no indications for treatment with antibiotics was approx. 68% (Note: multiple indications may be reported simultaneously).

Key diagnoses included yolk sac inflammation, collapse of the femoral head, joint inflammation, pericarditis, air sacculitis, inflammation of the upper respiratory areas, intestinal disorder/dysbacteriosis, coccidiosis, necrotic enteritis, peritonitis and symptoms of bacterial infection. (*GD basismonitoring 2017 Q1*). Given that broilers live relatively short lives and are given additional protection from the parent animal during the first weeks of life (through the yolk), they are given few vaccinations.

The key animal welfare problems in broilers are related to the genetic selection for rapid growth, weight and physique, which are limited locomotion, or the activity of the animals, abnormal skeletal development, the occurrence of footpad lesions, various infectious and non-infectious respiratory and gastrointestinal disorders, disturbed rest, limited behavioural repertoire and obesity.

Wet litter will result in disorders including contact dermatitis, with footpad lesions being the key concern. Animals suffering from footpad lesions will experience pain and are less active. Wet litter is associated with a number of different risk factors such as the spillage of drinking water, ventilation, stock density, litter quality and the quality of feed. Although all poultry species are sensitive to footpad lesions, there is a significant difference in sensitivity between the various types (brands) of broilers. Within the fast-growing broiler breeds, the Cobb and Ross broiler brands are far more sensitive than the Hubbard flex brand. Other animal welfare problems in broilers on the farm are determined by the genetic background or brand choice to a significant extent. The so-called slow-growing breeds (the 'intermediate' segment, which reach the carcass weight of 2.5 kg by 49 days or more) are less likely to experience discomfort due to a number of problems than the so-called regular or 'fast-growing' broilers that will achieve a carcass weight of 2.5 kg in roughly 35 days time. As a result, any estimation of the prevalence will have a broad bandwidth. Specifically, the following welfare problems are concerned: abnormalities in the skeletal development, limited behavioural repertoire, limited activity/locomotion, disturbed rest, injuries (small cuts/scratches, breast blisters, hock burn, footpad disorders), obesity, reduced plumage quality, and hyperthermia.

In recent years, abnormalities in the breast and back muscles have been identified specifically in fast-growing, heavy broilers. This is a degenerative disorder of the muscles with white striping, which in extreme cases will harden

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into what is known as *wooden breast*. This primarily occurs in fast-growing broilers, where it is chiefly the broiler brands that are bred for the largest possible breast muscles that are the most sensitive. Feed restriction during the fattening period seems to be a risk factor for the occurrence of wooden breast (Trocino, 2015). It is both an animal welfare problem for the animals and a quality problem for the slaughterhouse. Based on expected body weight > 2.2 kg, at-risk flocks are checked for the presence of wooden breast for 5 minutes at the beginning of the slaughter process. If more than 1% of the animals exhibits wooden breast, an additional belt inspector is deployed for the entire flock (oral information NVWA). If over 3% of the flock shows signs of wooden breast, a welfare report is submitted. In the first half of 2016, exceeding 1% wooden breast was identified in 18% of the flocks, with very large discrepancies between the various slaughterhouses.

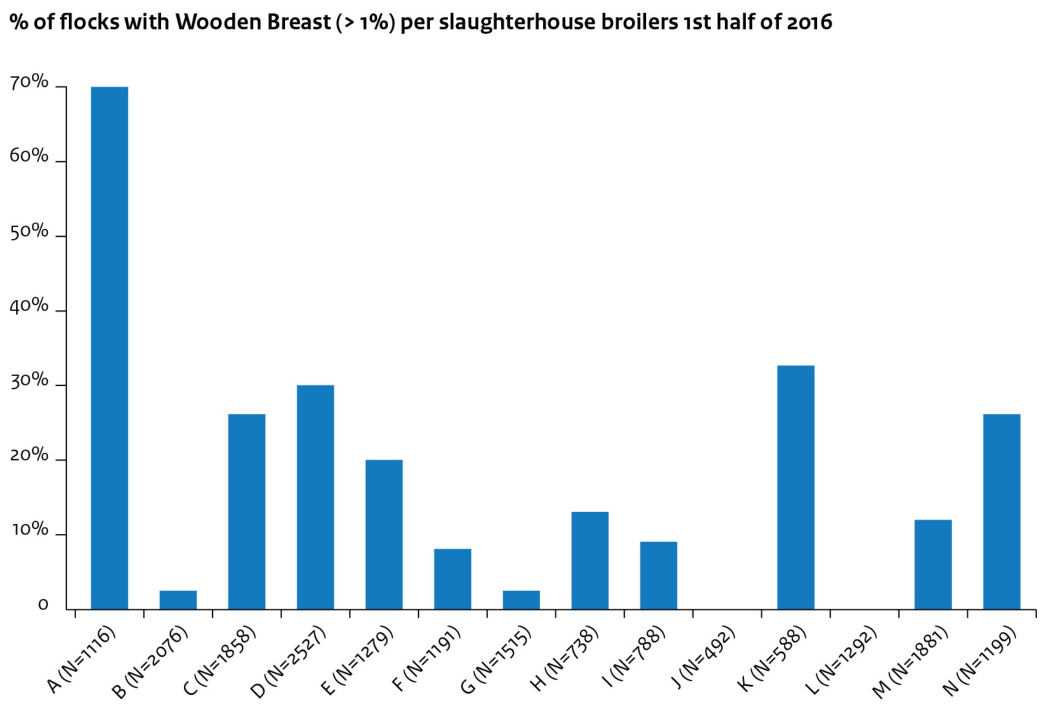


Figure 6.
Percentage of flocks per slaughterhouse where over 1% of animals exhibited wooden breast.

There is comprehensive overview of the key figures within the broiler farm (or poultry meat supply chain), which inhibits broad-spectrum risk-oriented monitoring. Further digital unlocking of data by the NVWA, systematic data analysis, specific inclusion of the 'intermediate segment breed' in the databases, linking external data such as IKB and improvement of the inspection process for potential animal welfare indicators at the slaughterhouse are all key factors and will contribute to improved transparency in the supply chain

Transport to slaughterhouse
The hundreds of millions of poultry birds that are slaughtered in the Netherlands are first caught and placed in crates and loaded up, after which they are transported to a slaughterhouse. Once they have arrived, they are stunned, removed from the crates (often through a tilting process) and subsequently shackled for the slaughter line. The order of these last three steps may vary, which means there will be differences in the nature and magnitude of the risks.

If birds are caught using mechanic catching, by certified professional catching crews or the farm's own employees, animals may be crushed and may suffer dislocations and fractures due to rough handling. When being placed into the containers or crates, birds may be injured as a result of damaged crates or containers or overly dense packing. Based on an international exploratory study, EFSA (2012) reported that there was relatively little difference in terms of discomfort between professional catching crews and mechanic catching, provided the catching process was carried out with care (EFSA, 2012). There are indications that in poultry flocks caught by the farm's own catching crews there is an elevated risk of injury to the animals.

As outlined previously, thirst and death are factors that play a role in animals' transportation to the slaughterhouse. In addition, injuries may be sustained during transport, including to the birds' plumage.

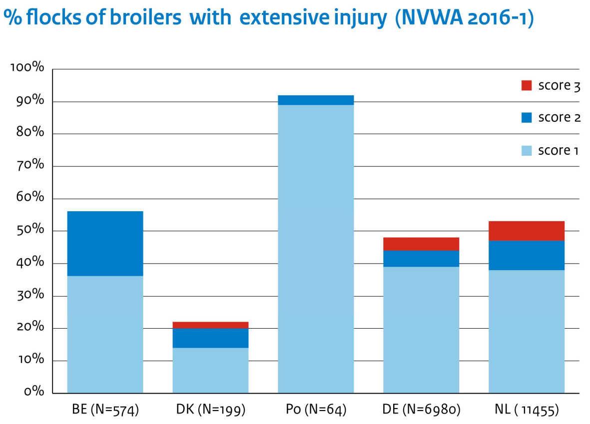
At the slaughterhouse, injury is primarily assessed at the inspection following slaughter and is recorded as a wing fracture and extensive injury. Both these types of injury are checked through a brief sampling process and are recorded in semi-quantitative terms, resulting in the data being less robust.

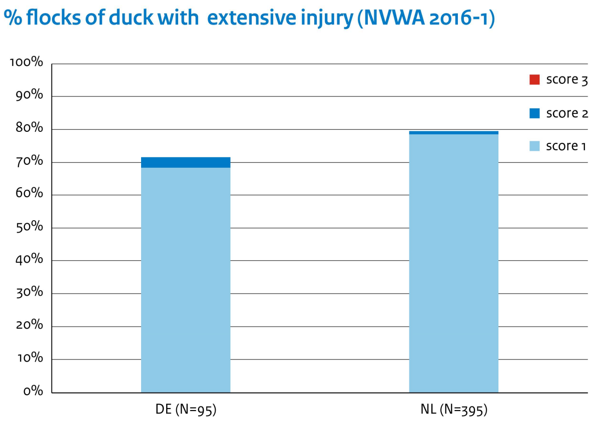
Based on an NVWA project carried out in 2014, wing injury is estimated in 3% of the animals (Visser, 2015). Other international data is also based on a project-based approach, involving animals being tracked and checked intensively for a short period of time. Systematically recorded data, potentially based on ad random samples, however, is absent. In recent years, there have been a number of studies on the animal welfare of broilers in relation to transport to slaughter (Jacobs, 2016; Jacobs, et al., 2016). In this project, damage during catching was measured as 1.27% wing injury, with an average of 3.5% wing injury after transport (cumulative damage of catching and transport).

Routinely it is the case that in Dutch slaughterhouses, exceeding of the signalling values (such as > 2% wing injury) is only recorded as a remark and expressed in a score of 0, 1, 2 or 3. During the first half of 2016, 5% of slaughter records contained remarks on excessively high rates of wing injury, meaning a score of 1 or above.

Given that poultry is slaughtered in the Netherlands that originated from multiple countries and the data has been systematically recorded since 2014, it is possible to demonstrate the combined effect of the country of origin of the flock and the nature and duration of transport.

There are clear differences between the major slaughterhouses, between animal species and between country of origin and provenance. In ducks there are more flocks that exceed the signalling standard in terms of extensive injury and open fractures than in broilers. It is chiefly ducks from France that often display the most serious injuries. Flocks of both ducks and broilers from Poland also frequently display injuries.





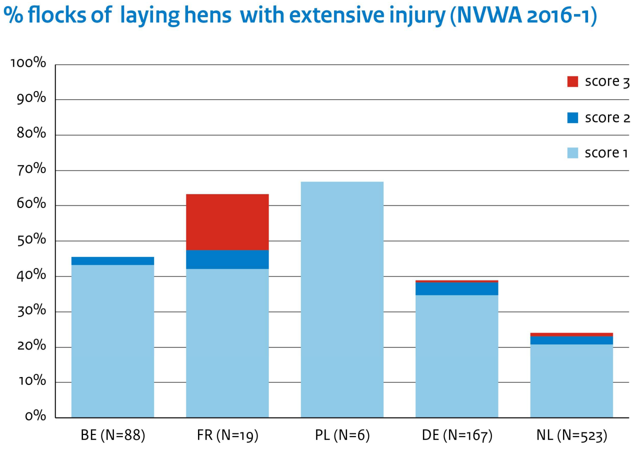
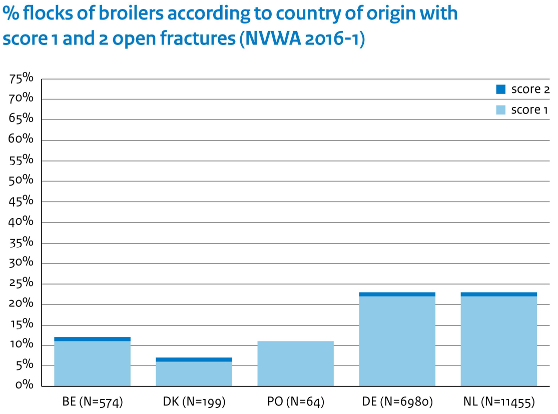
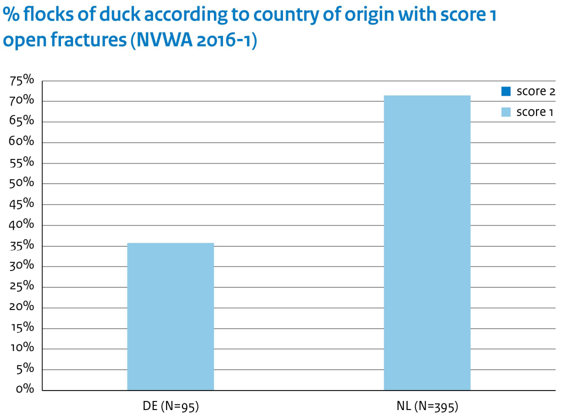


Figure 7.
Differences in the prevalence (exceeding of signalling standard) of extensive injury per country of origin (1st half of 2016; data NVWA Pladmin).





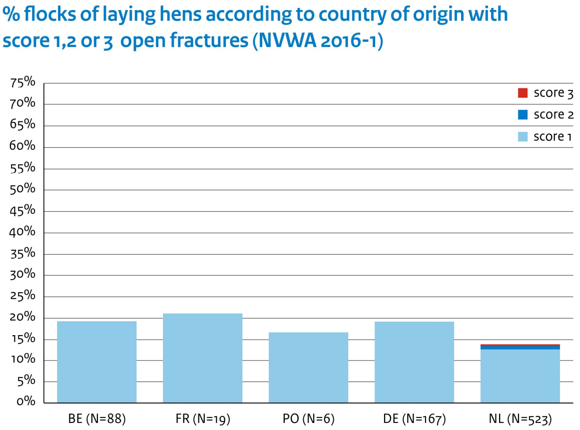
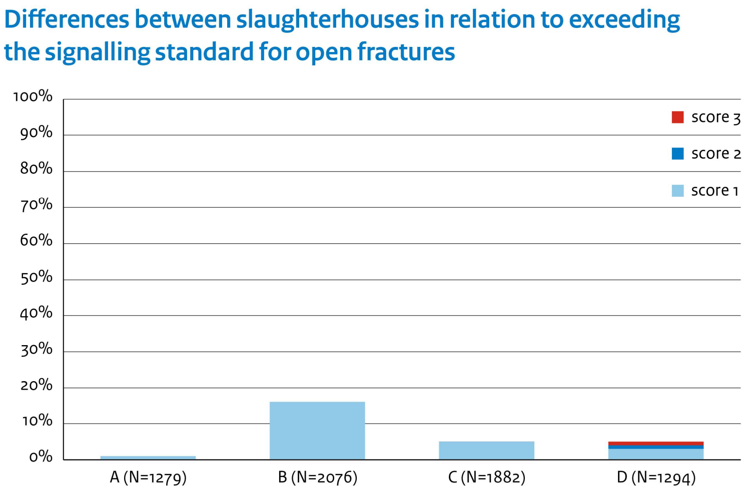


Figure 8.
Differences in the prevalence of open fractures (percentage of flocks above signalling standard) by country of origin (1st half of 2016; NVWA Pladmin data).



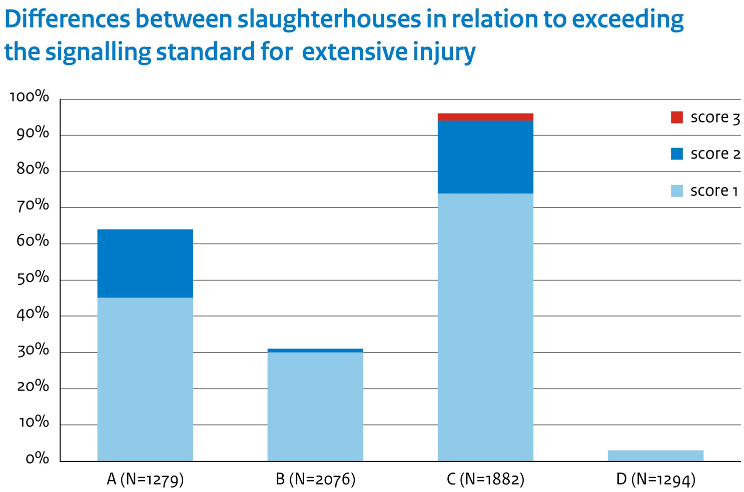


Figure 9.
Differences between slaughterhouses in relation to exceeding the signalling standard for injury. The top graph relates to open fractures, with the bottom graph showing extensive injury (1st half of 2016, NVWA Pladmin data).

The percentage of broiler flocks from the Netherlands and Germany that exceed the standard for open fractures is higher than the percentage of flocks from Denmark and Belgium.

Fractures and injuries can be caused on several occasions during the relocation from the farm to slaughter: during the catching process, getting crushed in crates or containers, during transport, but equally at the slaughterhouse during the unloading process, including during the tilting before being stunned.

Given that there is no uniform body of records from catching crews and transporters, at present data analysis cannot be used to trace this type of injury back to risk factors such as the farm of origin, the catching crew, the transport company or the effects of handling at the slaughterhouse. In this area, substantial welfare gains could be made, given that current data available shows that there are significant differences between slaughterhouses (figure 9). By systematically linking records of slaughterhouses at flock level with CFI information, DOA, footpad lesions, and other abnormalities identified during the meat inspection, a more effective quantitative risk assessment can be drafted within each link of the poultry meat supply chain. This may then serve as a benchmark for the safeguarding of animal welfare by individual companies. The responsibilities with regard to animal welfare in the transport phase, however, are distributed across multiple actors. Due to the fact that mortality and injury can take place at various instances (during catching, transport, as well as at the slaughterhouse, including during the tilting process), the comprehensive registration of catching crews, transporters, FCI information and inspection findings may contribute to tracing potential risk factors and may form a basis for risk-oriented monitoring. The data, however, should be recorded with a sufficient level of detail and should align with data from other companies/farms in other segments of the supply chain.

Slaughterhouse

The key hazards and risks at the slaughterhouse include the waiting times (insufficient protection against adverse weather conditions, insufficient access to water and/or feed), the unloading of the animals, including internal transportation within the slaughterhouse to the stunning facilities (disturbed rest, fear, crushing within facilities, tilting when not stunned) and the actual slaughter process (stunning, cutting and slaughter, during which insufficient stunning, unstunned slaughter and live shackling of animals may occur).

Stunning of animals

At slaughterhouses that still make use of electric water bath stunning, non-uniform flocks run a higher risk of incomplete stunning and, as such, of slaughter whilst the animals are alive and still conscious. There are three main systems for the stunning of animals, namely Controlled Atmosferic Stunning (abbreviated to CAS, known as '*gasbedwelming*' in Dutch, primarily with CO2 gas), electric water bath stunning and hand-held electrical stunning. In global terms, the first 2 systems (CO2 and water bath) are the most widely used methods in the major slaughterhouses. In 2004, EFSA concluded that water bath bore larger risks of unstunned slaughter or cutting of animals while conscious; EFSA recommended that water bath stunning should be phased out. This, however, was not included as policy in European Directive No. 1099/2009, based on economic considerations. Nevertheless, most major Dutch slaughterhouses have switched to CO2 stunning.

The system of CO2 stunning and that of water bath stunning, in addition to the increased risk of unstunned killing, also entail the discomfort of live shackling and unstunned cutting referred to in the above. In CO2 stunning this may occur through factors such as insufficient gas concentration or inadequate inhalation by the animals. Incorrect stunning by water bath systems may be the result of insufficient contact with the water or the incorrect settings of the equipment.

Each stunning technique has its advantages and disadvantages, however, similarly to EFSA, the Humane Slaughter Association (HSA, 2015) has indicated that water bath stunning should not be the preferred method of stunning due to the following reasons.

- Live shackling.
- The difficulty of controlling the effectiveness of individual stunning due to factors such as the contact between the animals themselves, insufficient contact with the water or avoidance of the water by the animals.
- The large-scale equipment operates using a constant voltage for multiple animals simultaneously, resulting in not every animal being optimally stunned.

- Water bath stunning often results in bleeding within the body, leading to poorer carcass quality. This may also indicate that the electricity does not only pass through the head using a correctly applied stunning method, but primarily passes through the body, leading to incomplete stunning.

The WUR cites the following risks in relation to unstunned (conscious) cutting (Visser, 2015):

- Animals pull their head up for the knife, which results in their running the risk of not be cut (killed) correctly. The discomfort consists of pain during the cutting and delayed or absent onset of unconsciousness. The discomfort consists of pain during the cutting and delayed or absent onset of unconsciousness.
- Animals who are cut incorrectly may end up in the scalding tank still conscious.

Unstunned tilting
Unstunned tilting is a specific problem. At the behest of the NVWA, the Office for Risk Assessment & Research (BuRO) conducted a separate risk assessment (2017) for the unstunned tilting of poultry. In the Netherlands, many broilers are unloaded at the slaughterhouse alive and still conscious, meaning unstunned, on arrival. Occasionally this takes place with the mechanic tilting of the container in which they have been transported. In the case of optimum tilting procedures (referred to as regular tilting), the broilers slide from the container onto the belt, as it were. In the case of rough tilting, the animals fall down and may end up falling onto and crushing one another depending on the belt speed. On estimate, tilting takes place in 2/3 of all slaughtered animals (Enforcement department of the NVWA). The monitoring conducted by the NVWA has revealed that rough tilting occurs are various slaughterhouses and it is estimated that each year at least 13 million animals may be subjected to this treatment.

Tilting (of unstunned animals) is currently not specifically banned by the regulations in force, however general rules state that the killing of animals and any associated activities should prevent all avoidable forms of pain, stress or suffering for the animals. The current monitoring and registration process at slaughterhouses and by the NVWA yields insufficient insight into the prevention of this type of discomfort. Registrations of injuries and fractures are only recorded semi-quantitatively and make no distinction between recent (having occurred in the slaughterhouse) or older injury (catching or crushing during transport).

As of 2016, the NVWA has implemented a uniform welfare monitoring system for slaughterhouses, in which compliance with the rules in the field of animal welfare is reported. These reports chiefly relate to compliance with rules and regulations and at present do not provide sufficient insight into the welfare problems identified in the animals.

Over the past year, the NVWA has launched its intervention policy wither regard to rough tilting practices and various slaughterhouses have already made modifications to their tilting facilities or have prepared improvement plans. The risk assessment conducted by BuRO referred to above endorses the policy currently being pursued, however at the same time concludes that discomfort is caused to large numbers of animals through regular, careful tilting practices. Effective alternatives are available for unstunned tilting practices that would allow these animal welfare risks to be prevented virtually entirely.

Ducks and turkeys

Ducks

Many of the welfare problems and concerns that apply to broilers, also apply to ducks, such as abnormal skeletal development, overly fast-growing breeds that become overweight, the prevalence of footpad lesions, etc. A specific welfare problem for ducks is the lack of open water or any alternatives. As such, ducks are unable to express their natural grooming behaviour, which requires at least a measure of deeper water. This results in secondary welfare problems such as uncleaned noses and eyes. Recently, a newly developed drinking water system for ducks was introduced (the 'Pekino deep drawn cup system'), which partially meets the needs of ducks (Klambeck, 2014). It is not known to what extent this new system has penetrated existing practices.

Turkeys

The majority of welfare problems that occur for broilers also apply to turkeys. Key areas of consideration include a breeding policy which focuses on (overly) fast-growing animals that become overweight, have moderate to poor mobility and overly meaty. The excess weight of animals is considered a serious animal welfare issue, both during the live phase as well as during transport to the slaughterhouse (Visser, 2015, interview with CEO Hendrix Genetics). Turkeys are more sensitive to severe respiratory infections. Mortality among turkeys is higher than for broilers, as is the rate of use of antimicrobial agents. An additional risk factor is the multi-age system at turkey farms, which results in infections being able to persist for longer once present. As with broilers (and ducks), footpad lesions are a major problem, for which, however, there is no required monitoring. The extent to which the stock density (no. of birds permitted per kg/m2, higher than for broilers) plays a role in this regard is not known.

Feather pecking is a particular concern at turkey farms: the severity and the impact of which being greater than for broilers, given that in turkeys this may cumulate into cannibalism.

Technological developments (precision) livestock farming

One of the major challenges facing (the poultry farming sector and) the regulators is obtaining an accurate set of transparent, robust data of preferably animal-specific indicators in order to be able to supervise and regulate compliance with animal welfare requirements as efficiently as possible (the same applied to animal health, hygiene and biosecurity). Where possible, these indicators should be able to register objectively and made available digitally. In recent years, there have been rapid developments in the field of ICT, GPS systems and sensor technology that are gradually being implemented in the agriculture and animal husbandry sectors. (Rathenau, 2016). Methods that are already available include automated video registration systems for the footpad lesion scores at the slaughter line (de Jong, 2011) and camera systems in broiler housing units (Rathenau, 2016; EU-PLF project website www.eu-plf.eu). The later relates to an automatic behaviour monitor that uses camera images and registers factors such as the activity and spatial distribution of broiler chickens. Inactivity or uneven distribution will consequently be indicators of lack of well-being. In a practical test carried out under the EU-Precision Livestock Farming project, it was revealed that use of this behaviour monitoring system could forecast the development of footpad lesions during the fattening phase.

In the most recent EFSA opinion on animal welfare during the transport of animals (EFSA, 2011), the use of better and more GPS systems during transport was argued and recommended. RFID devices could be used to monitor body temperature, so too could thermal imaging techniques.

Processes that are eligible for 'precision livestock farming' (Rathenau, 2016) include the monitoring of animals' growth and aspects of animal behaviour, signally and monitoring or animal diseases, such as avian flu and physical processes in the animal's environment (such as temperature and ventilation in the housing unit).

Summary of animal welfare risk assessment
Throughout their lives, animals are exposed to a multitude of hazards that can reinforce one another, which is chiefly the case for feather pecking and footpad lesions. Premature death is also a serious and common effect of multifactorial threats to animal welfare.

The most significant threats to animal welfare lie in the farm phase, immediately followed by threats during transport to slaughter. Heredity, housing, management, health, catching, loading and transportation cause a great many (severe) welfare problems for broilers, turkeys and ducks both in the primary and secondary phase. A number of serious welfare problems that are very common are: abnormal skeletal development, footpad lesions, obesity, disturbed rest and a restricted behavioural repertoire. A number of other serious welfare problems that occur in fewer animals or of which the prevalence is as yet unclear are: feather pecking, breast blisters, hyperthermia and various (non-)infectious respiratory and gastrointestinal disorders.

The European and national rules and regulations for the keeping of broiler chickens requires that data should be recorded on aspects including mortality and footpad lesions. Solid data is available in this regard for the primary phase. Where animals are slaughtered in the Netherlands, data, which is recorded at the 'inspection' at the slaughterhouse, is also available and relates to death on arrival and injury. The specific 'meat' inspection information that is primarily assessed in the context of food safety and product quality can also be used to gain insight into the health of animals during the life on the farm.

Mortality rate is referred to as an iceberg indicator and is the result of a collection of health and welfare problems. The mortality rate relates to animals that die as a result of animal health and welfare issues, as well as to animals that are (or must be) culled on a daily basis in order to prevent any further discomfort (death on the farm). In addition to the mortality rate, footpad lesions are also an indicator of impaired animal welfare at the level of the flock, which may have a variety of causes. Daily, weekly, and cumulative mortality and prevalence of footpad lesions are expressions of animal welfare problems for flocks of animals. The converse is not necessarily that case as in flocks (or at farms) with a low mortality rate or limited prevalence of footpad lesions, serious animal welfare problems may still occur, for example in the form of mental problems such as fear, stress, and disturbed rest or the inability to sufficiently satisfy natural needs or being able to exhibit natural behaviour such as foraging and scratching. Nevertheless, footpad lesions and mortality at the level of the flock are very suitable indicators to use when monitoring animal welfare at farm/company level in all phases of the live phase of poultry. These flock-level indicators are also useful for farms/companies interacting with one another, in order for them to address concerns with regard to animal welfare care. In order to continue the improvement of animal welfare, the standards of mortality and footpad lesions could be lowered further and supplemented with other indicators relating to specific animal welfare aspects.

The forthcoming ban on beak trimming was impelled from an animal welfare point of view, however, it may potentially result in an increase in feather pecking. This may lead to an increase in cannibalism practices and a higher mortality rate, chiefly in turkeys. The envisaged welfare gains (avoiding surgical procedures) will depend entirely on the extent to which poultry farmers are able to adapt their management (as well as other factors, such as housing) to the new circumstances.

Restricted supply of water to broiler parent stock, primarily during the rearing period, in the form of water deprivation causes welfare issues such as thirst.

The mechanical tilting of crates, in which the animals are transported, containing still conscious broilers at the slaughterhouse causes avoidable stress, pain and suffering (such as fear, bruising, fractures and amputations) in comparison to absence of tilting prior to stunning. This results in a moderate risk to animal welfare.

Incorrect stunning of poultry at the slaughterhouse through the use of an electric water bath and/or CO2 gassing results in insufficient unconsciousness, leading to discomfort such as pain when the animals are killed.

The information on the food safety and animal welfare risks in the poultry meat supply chain virtually exclusively relates to chickens, to duck and turkeys to a very limited extent and is practically absent in relation to other types of poultry.

The present assessment of the chain shows that the entire system of animal health and welfare assurance (as well as that for food safety), at present, still depends on the delegation of critical stages in the food safety and quality assurance process to the private sector, meaning the owners themselves, and as such is still vulnerable. The results of footpad lesions (including those that are monitored at the slaughterhouse), for example, are submitted by the owners to the database and the FCI for, with this also being the case for data such as mortality in the first week of life and the cumulative mortality rate.

Findings of the risk assessment for the poultry meat supply chain

1
Hazards to animals and humans are primarily introduced at the beginning of the poultry meat supply chain, with their effects having an impact in later phases of the chain. In this regard, there is a correlation between animal welfare and food safety.

2
Pathogenic micro-organisms may be present in poultry meat that may threaten public health if the meat is not properly heated prior to consumption. These micro-organisms chiefly related to *Campylobacter* and *Salmonella*, of which introduction takes place primarily during the farm phase. During processing, storage or consumption, the meat may subsequently become contaminated with *Listeria monocytogenes* and other pathogenic micro-organisms. Raw poultry meat that is infected with pathogenic bacteria is a key source of subsequent contamination of other foodstuffs.

3
Salmonella is frequently found in all phases and stages of the broiler chain. Failure to comply with the duty to report *Salmonella* during the meat production phase increases the risk to public health.

4
Poultry slaughterhouses succeed to complying with the Process Hygiene Criterion for *Campylobacter* to varying degrees. If all slaughterhouses were to perform at the same high level of success, this would result in greater health benefits.

5
The rise of *Salmonella* Infantis is worrying, given that this serotype also causes human infections. *Salmonella* Infantis is included in the European control programme for *Salmonella* for the breeding phase, however is not included for the meat production phase.

6
The level of contamination of *Salmonella* and *Campylobacter* in all links of the poultry meat supply chain (from the egg to the farm, the slaughterhouse, the cutting plant, and finally to the plate) provides a reference point for chain-oriented food safety monitoring throughout the entire chain, provided that the information is recorded in sufficient detail and can be linked to successive links in the chain.

7
Both the legal and illegal use of second and third-choice antibiotics in the primary phase in particular remain a serious threat to antimicrobial resistance in poultry and the transmission thereof to humans. One example is the elevated percentage of fluoroquinolone resistance for *Salmonella* that is found in poultry.

8
The administration of antibiotics via drinking water systems may cause long-term exposures to low concentrations. This contributes to the risk of development of antimicrobial resistance.

9
There is chance that banned agents are being used to combat red poultry mite, given the widespread problem of this pest among laying hens, in conjunction with the limited availability of effective drugs for the prevention and treatment thereof.
The likelihood that the banned drugs are also used to combat histomonas is lower, despite there also being no available drugs for that purpose, given that histomonas outbreaks in the primary sector occur infrequently.
The use of these banned drugs goes to undermine the system which guarantees food safety and results in a potentially increased food safety risk.

10
Results of chemical research conducted within the poultry meat supply chain are concentrated and retained by various government and private sector organisations, with the data being poorly accessible and useable to the NVWA. As such, reporting to EFSA is not up to standard. In addition, information is lost during the storage of the results of measurements of chemicals, such as quantitative information on levels exceeding the detection threshold but below the standard.
The National Residue Monitoring Plan largely consists of random sampling.

11
The risks of chemicals in the poultry meat chain are very low. Poultry meat, for example, does not significantly contribute (< 1%) to the uptake of dioxins and dioxin-like PCBs from foodstuffs. The incidental presence of regularly measured chemical contaminants in poultry meat to date has virtually never resulted in an increased risk to public health.

12
The very low risk of physical hazards in the poultry meat chain are adequately controlled by the measures of the private sector.

13
The most significant threats to animal welfare lie in the primary phase, followed, to a lesser extent, by threats during transport to slaughter. Heredity, housing, management, health, catching, loading and transportation cause a great many (severe) welfare problems for broilers, turkeys and ducks both in the primary and secondary phase. A number of serious welfare problems that are very common are: abnormal skeletal development, footpad lesions, obesity, disturbed rest and a restricted behavioural repertoire. A number of other serious welfare problems that occur in fewer animals or of which the prevalence is as yet unclear are: feather pecking, breast blisters, hyperthermia and various (non-)infectious respiratory and gastrointestinal disorders.

14
Footpad lesions, cumulative mortality in the primary phase and death on arrival at the slaughterhouse are indicators of animal welfare issues. The highest percentages of 'death on arrival' exceeding the standard were identified for flocks of animals from other countries.

15
The compulsory monitoring process of footpad lesions for broilers in the category with the maximum stock density assumes an average annual score per housing pen. This leaves too much room for serious animal welfare risks at the level of the individual animal and the flock. In addition, the current Dutch standard for footpad lesions offers insufficient protection for the welfare of broilers.

16
The average cumulative mortality rate of broilers in the primary phase is relatively high, yet lies within the range of the EU standard, but nevertheless relates to a large number of animals (approx. 10 million per year). The average mortality (death on arrival) at the slaughterhouse is at a low level (0.14% approx. 800,000 per year). There is no relevant EU standard in force and there are significant differences between slaughterhouses.

17
The footpad lesion score and the average cumulative mortality rate both provide reference points for chain-oriented monitoring of animal welfare throughout the chain, provided that the data can be linked between the various links in the chain.

18
There are no mandatory registrations available regarding footpad lesions for poultry other than fast-growing broilers at maximum stock density. Nonetheless, footpad lesions also constitute a serious problem to these other types of poultry, yet no adequate regulations as yet exist.

19
The forthcoming ban on beak trimming was impelled from an animal welfare point of view, however, it may potentially result in an increase in feather pecking. This may lead to an increase in cannibalism practices and a higher mortality rate, chiefly in turkeys. The envisaged welfare gains (avoiding surgical procedures) will depend entirely on the extent to which poultry farmers are able to adapt their management (as well as other factors, such as housing) to the new circumstances.

20
Limited supply of water to broiler parent stock, dictated by a breeding-related animal welfare problem, in the form of water deprivation causes other welfare problems such as thirst.

21
The shift to slow-growing broilers, the 'intermediate segment', is a key current trend. This cannot be discerned as a separate segment in the data of the NVWA, resulting in the effects of this shift on animal welfare and animal health as yet going unmonitored.

22
The regular registrations of injury at the slaughter line are not adequate enough to determine in which (previous) link in the chain this injury was caused.
As such, risk-oriented monitoring earlier on in the chain cannot be achieved. Nevertheless, there are significant discrepancies in the figures with regard to mortality and injury between major Dutch slaughterhouses and between types of poultry and the various origin of the animals.

23
In a segment of poultry slaughterhouses, the crates in which the animals are transported are tilted whilst the animals are still conscious. This causes avoidable stress, pain and suffering (such as fear, bruising, fractures and amputations). This moderate risk to animal welfare may be prevented by tilting the animals when already stunned, as takes places in many other slaughterhouses.
EU countries have different legal interpretations in their approach to unstunned mechanical tilting.

24
Incorrect stunning of poultry at the slaughterhouse leads to insufficient unconsciousness, resulting in pain when the animals are killed (cutting).

25
Many welfare and health problems are multifactorial in nature, where the factors that are vital to the risks to animals and humans may also affect one another. This illustrates the complexity and rigour of the (entire) production system.

26
Information (data) on factors that affect the risks is not systematically collected or recorded in a risk-oriented way and is not, or not readily, available to the NVWA.

27
The information on the food safety and animal welfare risks in the poultry meat supply chain virtually exclusively relates to chickens, to duck and turkeys to a very limited extent and is practically absent in relation to other types of poultry.

Advice following the risk assessment for the poultry meat supply chain

1
Businesses should be encouraged to implement at least a limited set of food safety indicators (*Salmonella* and *Campylobacter*) as well as for animal welfare at flock level (mortality, death on arrival and footpad lesions) in order to initiate improvements in previous links in the chain.
The NVWA should also use this set of indicators in order to provide risk-based monitoring of the chain.

2
In order to increase the food safety standards further, the monitoring of the minimisation of contamination of poultry carcasses, initiated under the improvement programme for poultry, should be continued. This supervision should centre on the performance of individual slaughterhouses to achieve the targets of the statutory *Salmonella* Process Hygiene Criterion and the *Campylobacter* Process Hygiene Criterion.
In partnership with the Dutch poultry sector (laying birds and meat), a coordinated *Campylobacter* approach should be implemented that focuses on achieving lower levels of prevalence and contamination in the entire primary phase.

3
Compliance of the duty of report *Salmonella* contamination in the meat production phase should be promoted and advanced, taking into account the probable negative financial impact on the reporting parties.

4
At the European level, the NVWA should advocate in favour of an expansion of the *Salmonella* approach for poultry by declaring the measures for *Salmonella* Infantis applicable in the rearing and breeding phase similarly applicable to the meat production phase.

5
At the national level, the NVWA should advocate in favour of the continuation of the restrictive policy in force in recent years regarding the use of antibiotics in poultry. The monitoring practices with regard to the correct application of antimicrobial agents and the management of drinking water systems and other methods to administer antibiotics should be continued and stepped up.

6
Poultry meat should regularly be tested for use of banned drugs or substances that may be used for the prevention or treatment of red poultry mite or histomonas. These substances should be defined and selected based on the food safety risk assessment of those substances; this assessment should be updated periodically.

7
The NVWA should take steps to ensure the National Residue Monitoring Plan become more risk oriented, with the intensity of the chemical measurements for dioxins and PCBs being reduced and the intensity of the chemical measurements for veterinary drugs being increased.

8
The NVWA should ensure that the data of microbiological and chemical analyses in poultry meat, for which there is a basis by law, is effectively and transparently organised, including Dutch data distribution to EFSA. This should be executed in way that makes the data accessible to risk assessors and regulators, preferably in a centralised, managed database.

9
The NVWA should ensure better use of all available digital government data resources and FCI information. Furthermore, efforts should be made to ensure that data resources are aligned for the collection of prevalence data for optimising risk-oriented, information-driven monitoring of the primary phase.

10
Within the European Union, more stringent welfare standards should be advocated for the keeping of poultry, focusing on a lower cumulative mortality rate and breeding-related aspects. At the national level, the NVWA should advocate in favour of more stringent requirements aimed at limiting footpad lesions in broilers, as well as in favour of the drafting of requirements for footpad lesions in other poultry.

11
The monitoring of animal welfare in the primary phase should at least be reorganised to focus on the key indicators, such as cumulative mortality and footpad lesions, monitoring of transport practices and death on arrival. The data that is used should not be limited to information on the averages of various flocks, but should include data at flock level. Where possible, this monitoring should be supplemented with information from robust animal-based welfare indicators such as open fractures and other injuries.

12
At a national and EU level, the NVWA should advocate in favour of reducing long-distance transport of poultry. More stringent requirements should be put in place for conditions during transport, in relation to climate control and restricted water intake in particular to reduce stress.

13
While unstunned mechanical tilting is still permitted, the NVWA should carefully monitor and ensure that rough tilting, as currently defined, no longer takes place.

14
The use of water bath stunning for the stunning of poultry should be prevented. While this method is still permitted, ensure strict compliance with the correct stunning and killing practices at poultry slaughterhouses.

15
A survey should be conducted of whether the information that can be obtained using new precision livestock farming methods can be used to improve monitoring and enforcement.

16
A communication strategy should be designed with regard to the animal welfare risks for poultry, taking into account the social sensitivity of the subject and based on the NVWA risk communication strategy.

17
The NVWA should advocate in favour of there being sufficient focus on information provision and knowledge sharing regarding the correlation between animal welfare, food safety and sound economic business management in order to achieve improvements in all these areas. The key areas of focus should be hygiene on the farm, the reduction and highly selective use of antibiotics in animals and the use of more robust animals that are less susceptible to disease. This should preferably be implemented in partnerships with all sections of the sector: farmers, catching crews, transporters and slaughterhouses.

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