MICROBIOLOGY AND FOOD SAFETY

Risk perceptions of public health and food safety hazards in poultry husbandry by citizens, poultry farmers and poultry veterinarians

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ABSTRACT Differences in risk perceptions of public health and food safety hazards in various poultry husbandry systems by various stakeholder groups, may affect the acceptability of those husbandry systems. Therefore, the objective was to gain insight into risk perceptions of citizens, poultry farmers, and poultry veterinarians regarding food safety and public health hazards in poultry husbandry systems, and into factors explaining these risk perceptions. We surveyed risk perceptions of *Campylobacter* contamination of broiler meat, avian influenza introduction in laying hens, and altered dioxin levels in eggs for the most commonly used broiler and laying hen husbandry systems in Dutch citizens (n = 2,259), poultry farmers (n = 100), and poultry veterinarians (n = 41). Citizens perceived the risks of the three hazards in the indoor systems higher and in the outdoor systems lower than did the professionals. Citizens reported higher concerns regarding aspects reflecting underlying psychological factors of risk perception compared to professionals. Professionals indicated a relatively low level of personal control, which might imply risk denial. Of the socio-demographic characteristics, gender and childhood residence were associated with risk perceptions. The influence of other factors of risks perception are discussed. It is suggested that risk perceptions of all stakeholder groups are influenced by affect, stigma, and underlying values. To adapt current or new husbandry systems that can count on societal support, views of key stakeholders and multiple aspects such as animal welfare, public health, food safety, and underlying values should be considered integrally. When trade-offs, such as between animal welfare and public health have to be made, insight into underlying values might help to find consensus among stakeholders.

Key words: poultry husbandry, risk perception, stakeholder perception, public health, food safety

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INTRODUCTION

In the Netherlands poultry husbandry is characterized by intensive husbandry systems with high numbers of animals kept at high stocking densities, mostly without access to an outdoor run. From 2000 to 2015, the total number of chickens increased from 104 million to 107 million, while the number of farms that keep chickens—laying hens or broilers—decreased from 3,860 to 2,049 (CBS StatLine, 2016). Over the last decade, the media has covered multiple crises related to poultry husbandry, such as compromised welfare of fast growing broilers and laying hens in cage systems, disease outbreaks such as avian influenza (bird flu), and food safety scandals, such as the dioxin affair. Also, nongovernmental organization (NGOs) and citizens have expressed their concerns about how animals are kept, about the public health risks of livestock production and about the safety of food (Hansen et al., 2003; Bergstra et al., 2016).

As a result, new legislation has come into force in the European Union, such as a ban on the conventional battery cages for laying hens since January 2012 (European Commission, 1999). Today, the most applied husbandry systems are indoor colony cages or indoor non-cage systems (for laying hens), and conventional indoor

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systems (for broilers). Only a minor part of the husbandry systems offers outdoor access to poultry, but the number of outdoor systems and the consumption of outdoor eggs and meat is growing (Bejaei et al., 2011). Which husbandry system people prefer depends on how they perceive variegated issues such as animal welfare, price of eggs or meat, or public health and food safety risks, and which issues they weigh most heavily. For example, professionals, such as farmers and veterinarians, perceive good care to animals and an economically viable system important (Vanhonacker et al., 2008; Bergstra et al., 2016), and they prefer indoor systems (Van Asselt et al., 2015; Gocsik et al., 2016). Quite in contrast, citizens perceive naturalness, outdoor access, public health and food safety important (Vanhonacker et al., 2008; Bergstra et al., 2016), and they prefer free-range systems that provide to chickens outdoor access (Van Asselt et al., 2015).

Existing literature on public health hazards in poultry husbandry indicated that, compared to chickens in indoor systems, keeping chickens in free-range systems with outdoor access is associated with higher public health and food safety risks for certain hazards, such as *Campylobacter* contamination, avian influenza, and dioxin (Kijlstra et al., 2009). Although sample methods and results differ, meat from broilers kept in outdoor systems, such as free-range and organic systems, is more likely to be contaminated with *Campylobacter* than meat from indoor kept broilers (Heuer et al., 2001; van der Zee et al., 2005; Rosenquist et al., 2013). In a study of Rosenquist et al. (2013) meat from organic broilers was about two times more likely to be contaminated than meat from conventional kept broilers (54% vs. 20%). With regard to laying hens, two hazards are associated with keeping hens in outdoor systems: elevated dioxin levels in eggs and avian influenza. Studies indicated that dioxin levels are higher in eggs from hens that have outdoor access, and in particular in eggs from organic hens from private owners, than in eggs from hens that are kept indoors (Pussemier et al., 2004; Schoeters and Hoogenboom, 2006; Van Overmeire et al., 2006; Kijlstra et al., 2007; Van Overmeire et al., 2009a,b; EFSA, 2012). Outdoor access to laying hens was a risk factor for avian influenza (Koch and Elbers, 2006; Gonzales et al., 2013). A Dutch study reported that the introduction rate of the low pathogen avian influenza virus on farms that offer outdoor access to hens was 11 times higher compared to farms that do not offer outdoor access (Gonzales et al., 2013). Considering these studies, one may argue that from a public health point of view indoor husbandry systems are preferable above outdoor systems.

The general public seems not aware that these risks may be higher when chickens are kept in systems with outdoor access than when chickens are kept in indoor systems. NGO's such as the Dutch Society for the Protection of Animals (Dierenbescherming) and the Alert Animal Foundation (Wakker dier), who both favor organic production, do not communicate about these risks (Kijlstra et al., 2009). Professionals involved in poultry husbandry, such as farmers and veterinarians, may be more knowledgeable and experienced regarding public health and food safety hazards related to poultry husbandry than are citizens. Literature on risk perceptions indicate that in case people lack knowledge or when the risk assessment is complex, they will make a more intuitive risk assessment, in which other aspects, such as feelings and trust levels may play a role (Finucane et al., 2000a; Slovic et al., 2007). Consequently, the general public may view food safety and public health hazards in various poultry husbandry systems differently from professionals such as poultry farmers and poultry veterinarians. Studies on risk perceptions of the general public compared to experts in the context of, for example, new technologies and food production, have shown that knowledge and experience, psychological factors and socio-demographic characteristics, could explain differences between risks perceptions of lay people and experts (Fischhoff, 1978; Slovic, 1987; Fife-Schaw and Rowe, 1996; Sjöberg, 2000; Hansen et al., 2003). Differences in risk perceptions among the general public and professionals, such as farmers and veterinarians regarding public health and food safety hazards may have consequences for the acceptability of poultry husbandry systems and especially for the acceptability of outdoor systems. To co-design socially acceptable husbandry systems, the perceptions of different stakeholders should be understood and considered (Groot Koerkamp and Bos, 2008; Spoelstra et al., 2013). A better understanding of risks perceptions of food safety and public health hazards by stakeholder groups may contribute to the co-design of poultry husbandry systems that address societal concerns.

The objective of this study is twofold: 1) to gain insight into risk perceptions of food safety and public health hazards in different poultry husbandry systems from the general public as compared to professionals involved in poultry husbandry, and 2) exploring the reasons why these risk perceptions differ. This study will survey the perceptions of three potential public health hazards that may appear more often in outdoor poultry husbandry systems than in indoor husbandry systems: *Campylobacter* contamination of broiler meat (Heuer et al., 2001; Van Overbeke et al., 2006; Rosenquist et al., 2013), avian influenza introduction in laying hens (Koch and Elbers, 2006; Gonzales et al., 2013) and altered dioxin levels in eggs (Schoeters and Hoogenboom, 2006; Van Overmeire et al., 2006; EFSA, 2012). The risks perceptions of these three hazards will be surveyed for the most common used broiler husbandry systems—conventional, conventional plus, free-range, and organic—and in laying husbandry systems—colony cages, indoor non-cage, free-range, and organic. We will now give a concise overview of relevant risk perception research that will guide the analysis of the current study.

Theoretical Background

Risk Perception. Risk perceptions are complex and are affected by several factors. First of all, the "real" or "objectified" risk, a result of technical estimate of risks, influences the perception of risk (Sjöberg, 2000). In some contexts, when people have experience with and hazard-related knowledge—such as experts on the field of topic—the perceived risk may converge more or less with objective risk estimates (Sjöberg, 2000). In most contexts, however, as is in the context of poultry husbandry, risk perceptions of people who are non-experts is open to the influence of other subjective factors (Slovic et al., 2007). Instead of an objective risks assessment of the hazards related to poultry husbandry, people assess the risks more intuitively, whereby risks and benefits are not perceived independently from each other (Finucane et al., 2000a; Ueland et al., 2012). A variety of theories have identified factors that explain risk perceptions, such as knowledge and experience, underlying psychological factors, and self-protection (for example see Fischhoff, 1978; Slovic, 1987; Fife-Schaw and Rowe, 1996; Sjöberg, 2000; Hansen et al., 2003; Krewski et al., 2012).

Knowledge and Experience. In order to accurately assess the riskiness of public health hazards in poultry husbandry some knowledge of the probability and consequences of the hazards, and also about poultry husbandry in general, is necessary. Experts tend to assess risks more in accordance with objectified standards than lay people (Slovic, 1987). Therefore, differences in risk perception between experts and the general public were attributed to the knowledge deficit of lay people (Hansen et al., 2003). Regarding public health hazards related to poultry husbandry, most citizens are lay people, while professionals—such as poultry veterinarians—have received extensive training and experience, are thus more knowledgeable on these hazards and can be considered as experts. However, it has been questioned whether experts are "right" and lay people "wrong" and it has been strongly argued that risk perception is affected by other factors rather than just knowledge (Rowe and Wright, 2001; Hansen et al., 2003).

Underlying Psychological Factors. In many studies devoted to risk perceptions in general or regarding food hazards more specifically, the psychometric approach is used to explain differences in risk perceptions (Slovic, 1987; Sparks and Shepherd, 1994; Fife-Schaw and Rowe, 1996). Psychometric studies demonstrated that risk perceptions are influenced by specific perceptual factors, such as perceptions with respect to the degree of control, severity of the consequences, fatality of consequences, voluntariness, trust in experts, and unknownness by the people exposed (Fischhoff, 1978; Slovic, 1987; Slovic, 1993; Sparks and Shepherd, 1994; Fife-Schaw and Rowe, 1996). Later studies suggested additional factors that should be included in the psychometric model. For example, the naturalness of hazards influences risk perceptions (Fife-Schaw and Rowe, 1996; Siegrist et al., 2006) and chemical hazards are perceived as more risky than are microbial hazards (Siegrist et al., 2006; Kher et al., 2013). Therefore, the type of hazard should be considered as well. Furthermore, it was shown that the degree of perceived personal control over the hazard is an important factor of risk perception. Risks that are perceived to be under control, are judged less severe than when they are not (Weinstein, 1982; Sparks and Shepherd, 1994; Sjöberg, 2000; Hansen et al., 2003; Leikas et al., 2009).

Self-protection. To explain fear appeals and to change self-protective behavior in risk contexts, the Protection Motivation Theory is used (Rogers, 1975; Maddux and Rogers, 1983). According to this theory, perceived risk and perceived self-efficacy are relevant aspects in risk attitudes (Rogers, 1975; Maddux and Rogers, 1983). Self-efficacy is the level of confidence in one's ability to undertake protective behavior. In the context of risk perception in poultry husbandry it refers to a person's ability to protect himself against a hazard related to poultry husbandry systems and will be referred to as self-protection.

Based on the literature above, we hypothesize the following in the context of public health hazards in poultry husbandry. Given their diverging background in knowledge and expertise, 1) risk perceptions of citizens will differ from professionals such as poultry farmers and poultry veterinarians; 2) these differences in risk perceptions may be attributed to differences in underlying psychological factors held by citizens vis-à-vis professionals; 3) the perceived ability to protect themselves against hazards related to poultry husbandry will differ between citizens and professionals.

MATERIALS AND METHODS

Survey

To gain insight into risk perceptions of public health hazards related to poultry husbandry by different stakeholder groups and factors that may explain these risks perceptions, a quantitative survey was done by means of an online questionnaire among three key stakeholder groups in March and April 2014. The general public, poultry farmers, and poultry veterinarians were considered relevant stakeholder groups. The opinions of the general public concerning adaptation of current or development of new husbandry systems, most notably through NGO's, has become important (Boogaard et al., 2011). The general public was investigated in their role as citizens, because citizens, without being necessarily consumers, participate in the public debate about poultry husbandry (Harvey and Hubbard, 2013). Poultry famers' opinions were considered relevant because they are most directly involved in choosing husbandry systems. Poultry veterinarians are the farmers' key

Table 1. Statements regarding three hazards with correct answers.

	Statement	Correct answer
1.	*Campylobacter*, an intestinal bacterium present in chicken, is the most important cause of intestinal infections in humans.	True
2.	All bird flu viruses are a threat to public health.	False
3.	Prolonged intake of dioxin may cause cancer.	True

advisors on disease prevention which makes their risk perceptions of interest.

Participants

The questionnaire was filled out by representatives of Dutch citizens, poultry farmers, and poultry veterinarians. CentERdata (www.centerdata.nl), a research institute specialized in online survey research by means of the CentERpanel, approached the citizens. The CentERpanel is a representative sample of the Dutch population. CentERdata approached 3,344 CentERpanel participants, of whom 2,373 (71.0%) begun the questionnaire and 2,259 respondents (67.6%) completed the questionnaire. We invited poultry farmers to participate in the questionnaire by a digital newsletter of the Dutch organization of poultry farmers (NOP), which was sent to about 3,000 people interested in poultry husbandry. Moreover, we posted several articles on websites regarding poultry husbandry, such as the Dutch poultry magazine (Pluimveehouderij[2]), and on a website regarding agriculture in general. The newsletter and websites were all free available. Out of the 2,046 professional poultry farmers in the Netherlands, 100 farmers (4.9%) completed the questionnaire. Veterinarians registered with the Section Poultry Health of the Royal Veterinary Association of the Netherlands (n = 144) were invited in an e-mail from CentERdata to participate in the survey. Of this registered group 51 (35.4%) completed the questionnaire and of them, 40 met our definition of poultry veterinarian—someone working more than 30% of their time as a veterinarian in the poultry sector—and were included for analysis.

Questionnaire

The questionnaire was developed using literature review and input from a consulting group consisting of experts and representatives of several stakeholder groups, citizens, poultry farmers, and poultry veterinarians. Prior to data collection, the survey was pilot tested for clarity and comprehensibility of the questions by representatives of the three stakeholder groups. Based on these comments the questionnaire was then further revised and subsequently executed. Because the survey was part of a larger research that was designed to explore perceptions of poultry husbandry, only questions relevant for the study of risk perception are reported here. The questionnaire consisted of different parts: 1) statements to assess knowledge, 2) degree of self-protection, 3) underlying psychological factors of risk perception, 4) risk perceptions of three public health hazards in four different husbandry systems, and 5) questions regarding socio-demographic characteristics.

Measures

Knowledge. As a first check to verify whether the knowledge of the three stakeholder groups differs regarding the three public health hazards, the question was asked before any additional information about the hazards or husbandry systems was provided. To assess the knowledge a statement was included regarding the disease caused by each of the respective hazards (Table 1). The respondents were asked to indicate for each statement whether it was true or false. They could also choose for the option “I do not know”.

Self-protection. To measure the ability of self-protection we asked respondents to rate to what extent they are able to protect themselves against the three public health hazards. Because the respondents might not know the specific hazards, the questionnaire did not present the names of the hazards, but wordings that reflect the hazards, namely: “chicken pathogens spread through the air”, “pathogens on broiler meat”, and “chemical substances in eggs”. Respondents could rate the degree of self-protection against these hazards on a five-point Likert scale ranging from “absolutely not” to “absolutely yes”.

Underlying Psychological Factors. Based on the literature we selected underlying psychological factors of risk perception that were relevant for this research. To research these underlying psychological factors of risk perception, 11 statements were formulated, which reflect the following factors: unknown by the people exposed, trust in experts, severity of the consequences, voluntariness, the type of the hazard (bacteria vs. chemicals), and personal control (Table 2). Respondents were asked to what extent they perceived the situation as being risky: “To what extent are you concerned to get ill from chickens, broiler meat or eggs in the following situations?” They could rate their concern on a five-point Likert scale ranging from “absolutely not” to “absolutely yes”. Because people tend to perceive personal risks lower than risks for other

[2]Poultry production: a professional journal for the poultry production sector.

Table 2. Psychological factors of risk perception and statements based on these factors of risk perception.

Psychological factors of risk perception	Statement reflecting psychological factors of risk perception
Unknown	There is no information about the health consequences
Trust in experts	Experts state that health consequences are little
Severity (mild)	People may get an eye infection from it
Severity (medium)	People may get diarrhea from it
Severity (severe)	A few people will get cancer from it
Severity (fatal)	Someone may die from it
Voluntariness	People may get ill when being around a poultry farm
Voluntariness	People may get ill when eating chicken that is not cooked well enough
Type of hazard	Bacteria are present on chicken meat
Type of hazard	Chemicals are present in eggs
Personal control	People themselves may take measures to prevent the risk

Table 3. Descriptions of the four broiler and laying hen husbandry systems.

Husbandry system	Description
Broilers	
Conventional	free-range on litter, age at slaughter 42 days
Conventional plus	free-range on litter, a little more space, enrichment, age at slaughter 56 days
Free-range outdoor	free-range on litter, more space, enrichment, outdoor access, age at slaughter 56 days
Organic	free-range on litter, more space, enrichment, outdoor access, organic feed, age at slaughter 70 days
Laying hens	
Colony cages	cages for groups of 80 hens, littered area, nests, perches
Indoor non-cage	free-range on litter and/or multi-tiered, with nests, perches, a little more space
Free-range outdoor	free-range on litter and/or multi-tiered, with nests, perches, more space, outdoor access
Organic	free-range on litter and/or multi-tiered with nests, perches, more space, outdoor access, beaks are not treated, organic feed

people (Weinstein, 1982), we asked explicitly to rate the risks for themselves.

Risk Perceptions. To gain insight into risk perceptions, participants were asked to score the public health risks of 1) *Campylobacter* on broiler meat for broilers kept in a respectively conventional, a conventional plus, a free-range system with outdoor access and in an organic system, 2) the public health risk of bird flu, and 3) of dioxin in eggs for laying hens kept in respectively colony cages, an indoor non-cage system, a free-range system with outdoor access and in an organic system. A short description of the husbandry systems was provided as is shown in Table 3. Also for each hazard the following additional info was given:

- *Campylobacter* is an intestinal bacterium from chicken. A *Campylobacter* contamination may cause an intestinal infection in humans.
- Bird flu viruses are transmissible between different bird species and are usually not contagious to humans. Bird flu viruses are changing constantly and in future, bird flu might cause infection and disease in humans.
- Dioxin is a chemical substance, which is present in various products from animal origin. In humans, prolonged intake of dioxin may cause cancer.

The respondents could score the public health risk of three hazards in the four different husbandry systems on a five-point Likert scale ranging from "very low" to "very high". They could also opt for the answer option "I do not know".

Socio-demographic Characteristics. Socio-demo graphic characteristics have been shown to be associated with perceptions of risk (Slovic, 1999; Finucane et al., 2000b) and perceptions of animals and animal welfare (Knight et al., 2004; Kendall et al., 2006; Vanhonacker et al., 2007; Cohen et al., 2012). Therefore, the last part of the questionnaire contained questions regarding socio-demographic characteristics of the respondents: gender, age, educational level, urbanization level of current residence childhood residence, having children (yes or no), household income, pet ownership (yes or no), frequency of meat consumption, and whether they donate to a nature or animal welfare organization. The main socio-demographic features of the respondents are presented in Table 4. Compared to the data from the Central Bureau of Statistics in the Netherlands the citizens' sample was slightly overrepresented with older people, and higher educated people. Poultry farmers and poultry veterinarians were predominantly male, which was representative for these professional groups.

Data Analyzes

To process and analyze data SPSS 22.0 was used. To compute mean scores ± standard errors for the risk perceptions of the three hazards in the four different husbandry systems, the answer "I do not know" was recoded into missing. For each risk, the percentage of "I do not know" scores was calculated. The association between 1) mean scores for risk perceptions of the individual hazards within a husbandry system, and 2) the stakeholder groups was explored by analysis of

Table 4. Socio-demographic characteristics of the respondents.

	Citizens (n = 2,259)	Poultry farmers (n = 100)	Poultry veterinarians (n = 41)	CBS[1]
Gender (%)				
Male	52.2	88.0	80.5	49.2
Female	47.8	12.0	19.5	50.8
Age (%)				
15 to 34 years	16.6	11.0	12.2	29.3
35 to 54 years	36.8	73.0	51.2	34.2
>55 years	46.6	16.0	36.6	36.5
Education (%)				
Low	26.7	28.0	0.0	30.9
Intermediate	29.3	43.0	0.0	41.0
High (Bachelor/Master)	44.0	29.0	100.0	28.1

[1]CBS Data from the Central Bureau of Statistics in the Netherlands dated 01–03-2014.

Table 5. Knowledge regarding public health hazards in citizens (n = 2,259), poultry farmers (n = 100), and poultry veterinarians (n = 41).

Statement		Citizens	Poultry farmers	Poultry veterinarians
Campylobacter	Correct (%)	20.8	40.0	63.4
	Incorrect (%)	10.0	45.0	29.3
	I do not know (%)	69.1	15.0	7.3
Avian influenza	Correct (%)	33.2	78.0	80.5
	Incorrect (%)	36.7	17.0	17.1
	I do not know (%)	30.1	5.0	2.4
Dioxin	Correct (%)	59.4	90.0	90.2
	Incorrect (%)	2.3	2.0	0
	I do not know (%)	38.3	8.0	9.8

variances. ANOVA was done if variances were homogeneous according to Levene's test. If variances were not homogeneous, the Welch test was used instead. If the effect of the stakeholder groups on the mean risk perception scores was significant ($P < 0.05$) using ANOVA F-test, the post-hoc Games-Howell test for multiple comparisons was done to analyze differences between individual stakeholder groups. The effect of socio-demographic characteristics of citizens on the risk perceptions of the three hazards in four different husbandry systems was analyzed by calculating Person's chi-square.

RESULTS

Knowledge Regarding Hazards

The assessment of knowledge regarding the disease caused by *Campylobacter*, avian influenza and dioxin confirmed that the context-specific knowledge of the stakeholder groups differed between citizens and the professional groups (Table 5). From the stakeholder groups, poultry veterinarians answered the most statements correctly, and citizens were the least accurate. As could also be expected, citizens responded more often than the farmers and veterinarians "I do not know", which indicates a higher level of experienced uncertainty concerning these topics. Compared to the other statements, the statement regarding *Campylobacter* was most often answered with "I do not know". The statement regarding dioxin in eggs was answered most often correctly as compared to the other statements.

Risk Perceptions

To gain insight into the risk perceptions of public health hazards related to poultry husbandry, perceived risks were surveyed in the three stakeholder groups. The perceived risk of 1) *Campylobacter* contamination of broiler meat, of 2) avian influenza, and of 3) dioxin in eggs, from broiler or hens, kept in four different husbandry systems are presented in Table 6. The mean risk scores of the citizens showed a different pattern from the mean risk scores of the two professional groups. Citizens expressed higher risk perceptions of the three hazards when poultry is kept in the indoor systems (conventional, conventional plus, colony cages, or indoor non-cage systems) relative to farmers and veterinarians ($P < 0.05$). Farmers, however, perceived the risks of the three hazards in the outdoor systems (free-range and organic systems) higher ($P < 0.05$) than did citizens. Also veterinarians scored the risks of *Campylobacter* and avian influenza in organic systems, and of dioxin in eggs from hens kept in both free-range outdoor and organic systems higher ($P < 0.05$) compared to citizens. The largest differences we observed between the scores from the citizens and the farmers. Farmers perceived the risks in indoor systems lower than did veterinarians, but this difference was significant ($P < 0.05$) only for the perceived risk of *Campylobacter* in the indoor systems. Citizens perceived risk of dioxin in eggs from

Table 6. Mean perceived public health risks in citizens (n = 2,259), poultry farmers (n = 100), and poultry veterinarians (n = 41) (1 = very low; 5 = very high risk).

	Citizens		Poultry farmers		Poultry veterinarians		Test statistics	*P* value
	Mean	% dnk*	Mean	% dnk	Mean	% dnk		
Public health risk of *Campylobacter* in broilers kept in:								
Conventional system	$3.49^a \pm 1.145$	41.4	$2.02^b \pm 1.079$	8.0	$2.88^c \pm 1.122$	0.0	F(2, 1454) = 75.82	<0.001
Conventional plus	$3.23^a \pm 0.957$	40.4	$2.35^b \pm 1.042$	8.0	$3.02^a \pm 1.129$	0.0	F(2, 1477) = 36.29	<0.001
Free-range outdoor	$2.96^a \pm 0.973$	39.8	$3.80^b \pm 1.328$	8.0	3.33 ± 1.207	2.4	F(2, 76.27) = 19.06	<0.001
Organic system	$2.74^a \pm 1.191$	38.8	$4.02^b \pm 1.305$	11.0	$3.55^b \pm 1.176$	2.4	F(2, 1487) = 55.19	<0.001
Public health risk of avian influenza in laying hens kept in:								
Colony cages	$3.46^a \pm 0.033$	31.7	$1.38^b \pm 0.082$	1.0	$1.50^b \pm 0.129$	2.4	F(2, 86.93) = 351.19	<0.001
Indoor non-cage	$3.17^a \pm 0.027$	31.9	$1.47^b \pm 0.076$	1.0	$1.60^b \pm 0.133$	2.4	F(2, 83.09) = 270.69	<0.001
Free-range outdoor	$3.25^a \pm 0.026$	31.2	$4.13^b \pm 0.115$	2.0	3.72 ± 0.220	4.9	F(2, 76.24) = 29.49	<0.001
Organic system	$3.04^a \pm 0.032$	32.2	$4.22^b \pm 0.117$	3.0	$3.87^b \pm 0.198$	4.9	F(2, 1665) = 49.07	<0.001
Public health risk of dioxin in eggs from laying hens kept in:								
Colony cages	$3.33^a \pm 1.250$	39.2	$1.28^b \pm 0.706$	4.0	$1.38^b \pm 0.667$	2.4	F(2, 91.31) = 434.29	<0.001
Indoor non-cage	$3.07^a \pm 1.063$	39.2	$1.33^b \pm 0.691$	5.0	$1.43^b \pm 0.675$	2.4	F(2, 86.67) = 339.08	<0.001
Free-range outdoor	$2.92^a \pm 1.038$	39.1	$3.67^b \pm 1.370$	7.0	$3.49^b \pm 1.227$	0.0	F(2, 78.21) = 17.25	<0.001
Organic system	$2.61^a \pm 1.191$	38.9	$3.95^b \pm 1.363$	5.0	$3.76^b \pm 1.090$	0.0	F(2, 1513) = 70.39	<0.001

*% dnk: % respondents of the stakeholder group who answered "I do not know".
[a–c]Means within a row with different superscripts differ significantly ($P < 0.05$, Post-hoc Games Howell multiple comparisons test).

Table 7. Mean self-protection ability (±SE) against public health hazards in citizens, poultry farmers, and poultry veterinarians (1 = absolutely not; 5 = absolutely yes).

	Citizens	Poultry farmers	Poultry veterinarians	Test statistics	*P* value
Pathogens on chicken meat	$3.65^a \pm 0.024$	$4.35^b \pm 0.121$	$4.56^b \pm 0.202$	F(2,83.04) = 53.67	<0.001
Chicken pathogens spread through air	2.71 ± 0.024	2.87 ± 0.091	2.85 ± 0.116	F(2, 2379) = 1.12	0.327
Chemicals in eggs	$2.66^a \pm 0.027$	$2.60^a \pm 0.141$	$1.78^b \pm 0.146$	F(2, 81.44) = 17.34	<0.001

[a,b]Means within a row with different superscripts differ significantly ($P < 0.05$, Post-hoc Games Howell multiple comparisons test).

chickens kept in an organic system lowest from the three public health hazards. It is interesting to notice that the range in mean scores from citizens is lower than the range in mean scores from the professionals.

Self-protection

To understand why the risk perceptions of public health hazards in poultry husbandry differ between the three stakeholder groups, the degree of self-protection against three hazards was surveyed. The mean scores for the extent to which participants think to be able to protect themselves against three hazards are presented in Table 7. All three stakeholder groups scored their ability to protect themselves against the hazard "pathogens on chicken meat" as highest of the three hazards. However, for "pathogens on chicken meat" the mean score from citizens was lower ($P < 0.001$) than the mean scores from farmers and veterinarians. The mean scores for the hazard "chicken pathogens that spread through air" did not differ among the three groups. Veterinarians scored the ability to protect themselves against "chemicals in eggs" lower ($P < 0.05$) than did citizens and farmers. Compared to farmers and citizens, veterinarians showed the largest range in mean scores for self-protection against all three hazards.

Underlying Psychological Factors

The means scores for statements reflecting underlying psychological factors of risk perception—concern to get ill from chicken, chicken meat, or eggs—given by citizens, poultry farmers, and poultry veterinarians, are presented in Table 8. The range of the mean scores from farmers and veterinarians was larger than the range of mean scores from citizens. Citizens were more concerned ($P < 0.05$) for 9 out of 11 statements than were farmers and for 7 out of 11 statements than were veterinarians. Farmers only scored the statement reflecting the factor personal control, "people themselves can take measures to prevent the risk", higher ($P < 0.05$) than citizens did. The concern for "people may get ill when being around a poultry farm", a statement which reflects voluntariness, shows a considerable difference ($F(2, 2397) = 102.15$; $P < 0.001$) among the three stakeholder groups. Farmers scored this latter statement, "people may get ill when being around a poultry farm" lower ($P < 0.05$) than veterinarians, whereas farmers scored all other statements not did differently from the veterinarians. The three groups scored the other statement reflecting voluntariness, "people could become ill when eating chicken that is not cooked well enough" not differently. The structure of the ratings did not differ much among the stakeholder group. However, citizens scored the concern for "people may get ill when eating chicken that is not cooked well enough" as highest, followed by "bacteria are present on chicken meat", whereas farmers and veterinarians scored the concern for personal control, "people themselves can take measures to prevent the risk", as highest.

Table 8. Mean concern (±SE) for situations reflecting psychological factors of risk perception in citizens, poultry farmers, and poultry veterinarians (1 = absolutely not concerned; 5 = absolutely concerned).

Psychological factor	Statement	Citizens	Poultry farmers	Poultry veterinarians	Test statistics	*P* value
Unknown	There is no information about the health consequences	$3.28^{a} \pm 0.002$	$2.45^{b} \pm 0.127$	$2.54^{b} \pm 0.224$	F(2, 78.27) = 25.62	<0.001
Trust in experts	Experts state that health hazards are little	$2.90^{a} \pm 0.020$	$2.42^{b} \pm 0.124$	2.59 ± 0.212	F(2, 77.96) = 8.22	0.001
Severity (mild)	People may get an eye infection from it	$3.05^{a} \pm 0.020$	$2.28^{b} \pm 0.115$	$2.41^{b} \pm 0.204$	F(2, 78.34) = 26.10	<0.001
Severity (medium)	People may get diarrhea from it	$3.43^{a} \pm 0.021$	$2.64^{b} \pm 0.128$	3.02 ± 0.196	F(2, 78.32) = 20.44	<0.001
Severity (severe)	A few people will get cancer from it someday	$3.08^{a} \pm 0.022$	$2.26^{b} \pm 0.116$	$1.90^{b} \pm 0.187$	F(2, 2,397) = 53.57	<0.001
Severity (fatal)	Someone may die from it	$3.25^{a} \pm 0.024$	$2.23^{b} \pm 0.116$	$2.66^{b} \pm 0.241$	F(2, 78.82) = 39.38	<0.001
Voluntariness	People may get ill when being around a poultry farm	$2.98^{a} \pm 0.023$	$1.52^{b} \pm 0.086$	$2.10^{c} \pm 0.170$	F(2, 2,397) = 102.15	<0.001
Voluntariness	People may get ill when eating chicken that is not cooked well enough	3.81 ± 0.024	3.56 ± 0.127	3.39 ± 0.223	F(2, 78.80) = 3.40	0.039
Type of hazard	Bacteria are present on chicken meat	$3.64^{a} \pm 0.23$	$2.92^{b} \pm 0.130$	$2.88^{b} \pm 0.252$	F(2, 78.27) = 18.88	<0.001
Type of hazard	Chemicals are present in eggs	$3.43^{a} \pm 0.020$	$2.33^{b} \pm 0.135$	$2.80^{b} \pm 0.186$	F(2, 78.22) = 37.11	<0.001
Personal control	People themselves can take measures to prevent the risk	$3.39^{a} \pm 0.023$	$3.76^{b} \pm 0.149$	3.59 ± 0.207	F(2, 78.33) = 3.35	0.04

[a–c]Means within a row with different superscripts differ significantly ($P < 0.05$, Post-hoc Games Howell multiple comparisons test).

Socio-demographic Characteristics

The potential effect of socio-demographic characteristics on risks perception scores from citizens was analyzed. Gender and childhood residence were related to the risk perception scores for the three risks in the four different husbandry systems (Chi-square test; $P < 0.05$ and $P < 0.001$). Compared to male respondents, female respondents perceived the risks of the three hazards for indoor systems higher ($P < 0.05$) and for outdoor systems lower ($P < 0.01$), and females answered more often "I do not know". Respondents who grew up on a farm more often scored the risks of indoor systems lower ($P < 0.01$), and for outdoor systems higher ($P < 0.01$) than respondents who did not grew up on a farm. Respondents who eat meat one time a week or less perceived the risks in the indoor systems higher ($P < 0.001$) than respondents who eat meat more often. Age, educational level, household income, children (yes or no), pet owner (yes or no), and donate to a nature or animal welfare organization had a significant effect ($P < 0.05$) on one or more risk perceptions, but these effects did not point into one clear direction and were difficult to interpret. Risk perceptions were not significantly associated with social class, and urbanization level of current residence.

DISCUSSION

Last decades society has increasingly expressed concerns regarding livestock husbandry and especially regarding intensive animal husbandry (Hansen et al., 2003; Bergstra et al., 2016). Citizens prefer husbandry systems that offer outdoor access to chickens, but these outdoor systems may have negative consequences for public health and food safety risks. Insight into stakeholder views on risk perceptions provides crucial input for adaptation of current or development of new husbandry systems, which can count on societal support. Therefore, the objective of this research was firstly to gain insight into risk perceptions of three public health hazards related to keeping poultry in various husbandry systems, and secondly to explore how these risk perceptions of the stakeholder groups may be explained. The present investigation is the first study that reports risk perceptions of public health hazards in different poultry husbandry systems by three key stakeholder groups: Dutch citizens, poultry farmers, and poultry veterinarians. Regarding the Dutch citizens, a representative panel was used in our study. However, only 4.9% of the total number of Dutch poultry farmers was included in this research, and these participated because they were invited by announcement in magazines and newsletters targeted at poultry farmers. Although the educational level of the farmers ranged from lower education to higher education and shows a variegated distribution, it should be noted that the selection method of poultry farmers could be biased, for example towards more knowledgeable farmers.

Risk Perceptions Poultry Husbandry Systems

Our results indicate that the stakeholder groups assess the public health risks related to poultry husbandry differently. Citizens perceived the public health risks of *Campylobacter* contamination of broiler meat, altered dioxin levels in eggs, and of avian influenza in chickens kept in indoor systems higher than they perceived these risks in chickens kept in outdoor systems. Farmers and veterinarians, however, perceived these risks higher when chickens are kept in a system with outdoor access than when they are kept in an indoor system. According to literature the "real" risks of these hazards, avian influenza, *Campylobacter,* and dioxin in eggs, are higher in outdoor than in indoor poultry husbandry systems (Bouwknegt et al., 2004; Koch and Elbers, 2006; Schoeters and Hoogenboom, 2006; Kijlstra et al., 2009; Gonzales et al., 2013; Sommer et al., 2013). However, it is not clear what the "real" risks for consumers' health are, and to what extent these hazards imply a higher public health risk when chickens are kept in outdoor instead of indoor systems.

Literature describes the risks for introduction of avian influenza, for contamination of eggs with dioxin, or for contamination of meat with *Campylobacter*, and not the "real" risks for citizens or for consumers of eggs or broiler meat. To what extent a hazard is a risk to public health depends also on several aspects, such as prevention measures and consumer behavior. For example, meat from broilers kept in outdoor systems is more often contaminated with *Campylobacter*, but meat from all broiler husbandry systems may be contaminated with *Campylobacter* and meat may get contaminated during slaughter (EFSA Panel on Biological Hazards, 2011; Wagenaar et al., 2013). Thus, independent from the origin of the broiler meat, human infections can occur and depend on hygienic handling and preparation of chicken meat (Bell and Kyriakides, 2009; EFSA Panel on Biological Hazards, 2011). With regard to dioxin in eggs, it appears that eggs have only a small impact on the total dietary dioxin intake (Kiviranta et al., 2004; De Vries et al., 2006; EFSA, 2012) and dioxin levels in eggs from outdoor chickens can be monitored not to exceed a certain level. Outdoor access is a risk factor for avian influenza, but indoor poultry was also infected with avian influenza. In high risk periods, avian influenza transmission from wild bird to chickens may be prevented by keeping outdoor poultry temporarily indoors. Avian influenza transmission from birds to humans is rare (Wildoner, 2016) and if a flock is infected, the flock is culled as soon as possible, so the infection risk for the general public is small. Although the "real" risks of *Campylobacter*, dioxins and avian influenza for the public health are not clear, it seems that professionals perceive these risks in different husbandry systems better in accordance with literature than do citizens. The professionals and especially the farmers, however, may have an optimistic bias of the public health risks related to the indoor systems and they may overestimate the risks related to the outdoor systems.

Role of Knowledge

The observed differences between risk perceptions of the stakeholder groups are in line with earlier studies, which describe that lay people perceive risks differently from experts (Slovic, 1987; Hansen et al., 2003; Jensen et al., 2005; Zingg and Siegrist, 2012). The general public expresses more concerns regarding modern methods of food production than experts do (Hansen et al., 2003; Ueland et al., 2012). As explanatory factor of these differences put forward in the literature is the knowledge deficit of lay people, which implies that their lack of knowledge and understanding of the modern production methods causes these concerns. The present study confirms that citizens were less knowledgeable than were farmers and veterinarians regarding disease caused by the hazards *Campylobacter*, avian influenza, and dioxin. Citizens may be considered as lay people and poultry veterinarians may be considered as experts on public health hazards related to poultry husbandry. However, it is less certain whether poultry farmers can be considered per se as experts regarding public health hazards. Thus, the difference between citizens and professionals might not be caused by just knowledge differences. Also, in the literature, the knowledge discrepancy as sole cause of the lay-expert differences in risk perception has been questioned (Sjoberg, 1999; Rowe and Wright, 2001; Hansen et al., 2003). That is, differences in risk perceptions may also be caused by differences in views on the degree of self-protection, underlying psychological factors, and socio-demographic characteristics.

Self-protection

Based on the knowledge and experience of the professionals it was expected that they would rate their capacity of self-protection higher than citizens. Indeed, farmers and veterinarians considered their ability to protect themselves against "pathogens on chicken meat" higher than did citizens. Based on the professionals' higher ability of self-protection, one might think that the professionals might perceive the public health risk due to *Campylobacter* on broiler meat and dioxin in eggs lower than do citizens. The professionals scored the risks for *Campylobacter* and dioxin in eggs in the indoor systems lower than citizens, but they scored these risks in outdoor systems higher then did citizens. These higher risk perceptions related to outdoor systems in professionals seem not to correspond with the professionals' higher self-protection. So, the ability to protect themselves could not explain the differences in risk perceptions between citizens and the professionals.

Underlying Psychological Factors

Previous studies on underlying psychological factors of risk perceptions revealed that risk perception is influenced by severity of the consequences, unknown by the people exposed, voluntariness, trust in experts, type of hazard, and personal control. In our study, we asked participant to indicate their degree of concern for statements reflecting these factors in the context of poultry husbandry and the three public health hazards. Citizens were more concerned for 9 out of 11 factors than were farmers and for 7 out of 11 factors than were veterinarians. The scores for the statement "people may get ill when being around a poultry farm", which reflects personal control, differed most between the farmers and citizens. The farmers did not perceive being around a farm as a risk, while literature indicates that being around a poultry farm is a risk to get ill from *Campylobacter* or avian influenza (Koopmans et al., 2004; Havelaar et al., 2009). As this statement reflects personal control, farmers may feel that they have control in this situation. Control is an important factor of risk denial (Sjöberg, 2000), which may cause an optimistic bias of public health risks related to poultry farms by these professionals. However, it does not explain why the professionals perceive the risks of the indoor systems lower and of the outdoor systems higher than do citizens. Other risk factors based on the psychometric model could not explain clearly the differences in risks perceptions between the stakeholder groups.

Socio-demographic Characteristics

The socio-demographic characteristics of citizens, gender and childhood residence, were associated with risk perceptions. Female citizens perceived the risks in indoor systems higher and in outdoor systems lower than did males. This is in line with earlier studies on risk perceptions, which report that women assess risks as more problematic than do men (Slovic, 1999; Finucane et al., 2000b; Zingg and Siegrist, 2012). The professional groups in this study were predominantly male and this might have influenced the risk perception of these professional groups. Also, the childhood residence of citizens was of influence and as most farmers are spent their childhood on a farm, this period of childhood may be of influence on risk perception. This implies that the perceptions of females and people who did not spend their childhood on a farm should be considered when designing new husbandry systems in order to gauge the social acceptability of the system.

Affect

Citizens. In the specific context of poultry husbandry, factors that we did not survey may have influenced risk perceptions. Two concepts that may be helpful in this regard, affect and stigmatization, will be discussed here. The risk assessment of public health hazards in poultry husbandry is complex and requires some knowledge regarding both poultry husbandry systems and the hazards. When risk judgement is complex or when people lack knowledge, they make a more intuitive and holistic judgement and refer to more general knowledge, instead of making a deliberate judgement (Slovic et al., 2007; Van Den Heuvel et al., 2008). In this intuitive judgement, affect plays an important role (Finucane et al., 2000a; Slovic et al., 2007). "Affect" refers to an emotional state, and is defined a positive (like) or negative (dislike) evaluative feeling towards a stimulus. It means that positive or negative feelings towards a husbandry system (i.e., the stimulus), may influence risk perceptions related to that system. This would mean that people will use their positive or negative feelings regarding, for example poultry husbandry systems, hen welfare, or healthiness of the poultry products, to assess the public health risks. Citizens perceived outdoor systems as the most desirable husbandry systems for broilers (Van Asselt et al., 2015). They also view naturalness and outdoor access important for animal welfare (Vanhonacker et al., 2008; Bergstra et al., 2015), and consider organic food healthier and safer than conventional food (Harper and Makatouni, 2002; Aertsens et al., 2009). Citizens' positive attitudes towards outdoor and especially towards organic husbandry systems, could therefore influence the assessment public health risk related to the poultry husbandry systems.

Professionals. Affect may have also influenced the risk perception of professional stakeholders—farmers and veterinarians. It has been shown that conventional farmers often have negative attitudes towards outdoor husbandry systems (Van Asselt et al., 2015; Gocsik et al., 2016; Stadig et al., 2016a). Several reasons may underlie this negative attitude. First of all, farmers may worry about the risk of disease spread of among others, avian influenza (Gocsik et al., 2015), most notably because in case of an outbreak of avian influenza in a flock, all chickens have to be culled. Also, *Campylobacter* contamination of meat or altered dioxin levels in eggs may have negative consequences, e.g., financial impact, for the farmers. Secondly, the negative attitude of famers may be caused by their current farm characteristics that might not be suitable to convert to an outdoor system (Gocsik et al., 2015). The professionals and especially the poultry farmers, may have extended their negative attitudes towards the outdoor systems to the perceptions of public health risks in the outdoor systems. This may explain why the famers assessed the risk for the three hazards in the outdoor systems ranging from high to very high.

Stigma

Another mechanism that may be of influence on the observed risk perceptions is stigmatization. A stigma is a lasting and negative affective response that may dominate the perception of a certain issue (Lofstedt, 2010; Walker, 2013), and often originates from media images. Citizens' knowledge concerning risks in poultry husbandry derives mainly from media, which regards mainly portrayals of problems of intensive livestock husbandry, such as food scandals, animal disease outbreaks, and the dioxin affair (Te Velde et al., 2002). These media portrayals may have led to stigmatization of intensive production systems, and poultry husbandry in particular. Citizens' negative attitudes towards intensive husbandry may have negatively influenced their perception of public health risks of the more intensive indoor systems.

Underlying Values

The results might suggest that differences between stakeholder groups can be explained by differences in knowledge and experience, which resulted in a more holistic and intuitive risk assessment. Hence, one might conclude that providing information may bring the perceptions of the stakeholder groups more in accordance with each other. However, there are several reasons why information provision may fail. First of all, also in the professional groups affect seems to play a role. Secondly, in the current post-trust society top down communication from experts to lay public does not work (Lofstedt, 2010). And even if people have the same knowledge level, still the acceptable level of risk may differ among people (Hansen et al., 2003). The acceptable level of risk may depend on involved values (Hansen et al., 2003) and perceived benefits (Ueland et al., 2012). For example, in case people perceive a more ethical production method important, they may accept greater public health risks (Jensen et al., 2005). Also, other aspects, such as a better taste of meat from free-range broilers (Stadig et al., 2016b) may be weighed against the public health risks. So, in the context of poultry husbandry systems, trade-offs, such as between risks for human health and benefits for poultry welfare, may be based on underlying values (Hayenhjelm and Wolff, 2012).

Implications

Differences in risk perceptions among and within stakeholder groups will have consequences for the acceptability of the various husbandry systems. Citizens perceive outdoor systems as better for public health and food safety, while most professionals tend to have negative attitudes towards outdoor systems. The public health and food safety risks may be higher in outdoor systems than in indoor systems, but these risks related to outdoor systems may be controlled. Thus, outdoor systems could be social acceptable poultry husbandry systems.

To adapt current or new husbandry systems that can count on societal support, views of relevant stakeholder groups and multiple aspects such as animal welfare, public health risks, and underlying values should be considered integrally. Co-design (e.g., Groot Koerkamp and Bos, 2008; Spoelstra et al., 2013) has proven to be a successful design process that involves successfully multiple stakeholders and their opinions. When trade-offs, such as between animal welfare and public health risks have to be made, insight into underlying values might help to find consensus among stakeholders.

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