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PUBLIC PERCEPTION OF HEALTH- AND FOOD-RELATED RISKS

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Chapter I

General introduction

1 Introduction

Each year, tens of thousands of people die from seasonal influenza. However, no one in the Western world has died because of the avian influenza. People worry about the avian flu, yet they are reluctant to be vaccinated against the seasonal flu. People are troubled by thoughts of BSE (Bovine Spongiform Encephalopathy), but worry far less about the cholesterol that contributes to heart disease, which kills several hundreds of thousands of people annually. These examples illustrate what has been found in many scientific studies investigating public risk perception over the last decades; this list could be easily arbitrarily extended. In 2006, one issue of TIME magazine dedicated its cover story, entitled 'Why We Worry About the Wrong Things', to this research area of public risk perception, pointing to the fact that human beings 'have a confounding habit of worrying about mere possibilities while ignoring probabilities, building barricades against perceived dangers while leaving [themselves] exposed to real ones'.

The aim of the present work is to examine the variables that are associated with people's risk perception, and further, to investigate how risk perception affects people's decisions. In this thesis, we primarily examine people's risk perceptions in a public health risk related context. Initially, we investigated people's risk perception ratings of different animal treatments, such as vaccinations, antibiotics and hormones, concerning their affect on human health through the consumption of animal products. Then, we specifically examined whether people consume meat from animals vaccinated against epidemics. We differentiated between pure animal epidemics (e.g. foot and mouth disease) and zoonoses, which are animal epidemics that can still be very dangerous to people (e.g. avian flu). The avian influenza example at the beginning of this introduction nicely illustrates that people's risk perception is probably higher than the actual posed risk. Therefore, this subject is appropriate for lay people versus expert comparisons, as experts are supposed to possess more knowledge about their own domain this is said to be an important factor influencing risk perception (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Slovic, 1987). Therefore, secondly, the present work compares veterinarians' and the public's risk perceptions of different animal treatments concerning their affect on human health through the consumption of animal products and their acceptance of different strategies to fight zoonoses, respectively. To directly investigate the hypothesis, based on a psychological theory postulating that gender differences in risk perception are due to the fact that men are more likely to be more knowledgeable about risk-related issues than women and that persons who are better informed will be less concerned about risks to health and the envi-

ronment (Davidson & Freudenburg, 1996), we also performed gender comparisons using lay people and expert samples. As knowledge is said to be a relevant aspect of people's risk perceptions, meaning that a better understanding helps people to come to more adequate decisions (Kuklinski, Metlay, & Kay, 1982), in the third part of the thesis, we investigated the influence of knowledge about vaccination on people's decisions to vaccinate. People have changed their decision-making behaviour concerning vaccinations; they do not vaccinate themselves and their children as readily as they did in the past (Muscat, et al., 2009; Poland & Jacobson, 2011). From a public health perspective, the impact of that change is significant, such that diseases that had been exterminated on whole continents have re-emerged (e.g. poliomyelitis outbreak in the Netherlands in 1992/93). Associated with the initial subject of people's risk perceptions of animal treatments for human health through the consumption of animal products, the last part of the thesis deals with people's food safety perceptions. For this study, we investigated people's risk perceptions of every step in the meat supply chain—from animal feed to the use of leftovers at home.

The first section will introduce the reader to the most influential research that has already been conducted on risk perception. This section describes how research is applied to the given context and also describes several works done on the subject that will not be discussed in detail in the main chapters of the present thesis. The subsequent section relates to the first, as it outlines research on the differences between lay people's and experts' risk perceptions, concluding with some thoughts regarding the knowledgeable support hypothesis (Davidson & Freudenburg, 1996). The third section is dedicated to people's knowledge about vaccination and how that knowledge influences their choices to vaccinate themselves and their children. The fourth section discusses the subjective food safety perceptions of the public during non-scary food situations. Non-scary food situations are those where no major food scares, such as BSE or the avian flu, are present. The introduction section concludes with an overview of the subsequent chapters.

2 Public risk perception

2.1 Risk perception of health- and food-related hazards

In the formal quantitative risk assessment literature, risk is most commonly defined as a weighted combination of uncertainty and severity of loss, which is often interpreted

as the product of probability and loss (PxC) (Pidgeon & Beattie, 1998). However, people's risk perception is based on more than just probability and outcome (Oglethorpe & Monroe, 1994). Risk perception is influenced by various kinds of attitudes and judgments, also called characterization of risk (Fischhoff, et al., 1978; Slovic, 1987). A distinct set of risk characteristics attributed to people's perception of risk have been identified by various researchers (Fischhoff, et al., 1978; Starr, 1969). Research following this work, and tested across groups of consumers and a diverse set of hazards, has led to two principal dimensions strongly correlating with risk perceptions: the degree to which the risk is unknown or unobservable to the consumer and the degree to which the risk creates apprehension or a feeling of dread (Slovic, 1987). Therefore, the more involuntary the risk exposure, the greater the likelihood of perceived risk, e.g. toward meat from animals vaccinated against a zoonosis. A lack of familiarity with the hazard, e.g. avian flu, increases consumer uncertainty. This unfamiliarity might increase consumer apprehension towards the use of vaccination for food-producing animals. Several studies have used the psychometric paradigm to investigate lay people's perceptions of hazards (Fife-Schaw & Rowe, 1996; Kirk, Greenwood, Cade, & Pearman, 2002; Siegrist, Keller, & Kiers, 2006; Sparks & Shepherd, 1994).

Stampfli, Siegrist and Kastenholz (2010) suggest that it might be possible that consumers will not seek information about the methods used in the production of food products. As a result, they may consume food products made using production methods, which, if they were prompted to think about them, would cause them some concern. This might be the case for meat from animals vaccinated against an epidemic. There are a number of recent examples of interventions within animal production systems that have offended the sensibilities of consumers, including genetic modification of animals and crops (McEachern & Schroder, 2002). Other major food scandals, such as BSE in the U.K. and other European countries, have also increased the consumer and political focus on food safety (Engelstad, 2005). Prior incidents have demonstrated the importance of public perceptions in risk management (Frewer, Miles, & Marsh, 2002). Although many food safety hazards are well defined, differences in opinions and a lack of understanding about the degree of risk posed by specific situations, such as emergency vaccination, especially those related to new and advanced vaccines, remain (Scudamore, 2007). A study using focus groups was conducted in England to investigate consumers' attitudes against animal vaccination against foot and mouth disease (Breakwell, 2003). The study showed that there are great differences in perceptions and knowledge among lay people. As there are no representative data available for the focus group discussion methods, no statements can be made about how prevalent the

acceptance or rejection of animal vaccinations are in the general population. Data from a Eurobarometer study showed that more than 50% of consumers would hesitate to consume meat from vaccinated animals (Scudamore, 2007), believing that doing so is related to risk.

2.2 Important variables influencing health- and food-related risk perception

Several authors (Fessenden-Raden, Fitchen, & Heath, 1987; Lee, 1989) have emphasized the importance of knowledge about a potential hazard in determining risk perception, and a number of studies have highlighted the importance of knowledge on the acceptability of risk (Kuklinski, et al., 1982; Maharik & Fischhoff, 1993). Thus, questions about the general knowledge of human vaccination were incorporated in our own questionnaire (see Chapter II), as people interpret issues concerning animal vaccination in terms of human vaccination (Breakwell, 2003).

People use heuristics, such as trust, to assess the risks and benefits of a new technology when knowledge is missing (Siegrist & Cvetkovich, 2000). Trust has generally been found to be strongly linked to risk perception (Slovic, 1993) and also, specifically, to food safety risks (Siegrist, 2000). Trust especially plays a role for the assessment of risk when people cannot make assessments based on their own experiences (Siegrist & Cvetkovich, 2000; Siegrist, Cvetkovich, & Roth, 2000). Siegrist, Cvetkovich and Roth (2000) believe that it is generally true that being able to determine who to trust is most important in situations where the individual lacks the interest, time abilities, knowledge or other sources to personally make decisions and take actions.

Further, the influence of culturally coined moral values on risk perception has been broadly discussed in the past (Dake, 1991; Finucane, 2002; Marris, Langford, & O'Riordan, 1998; Sjöberg, 1996). Values are defined by culturally defined standards that people use to decide what is desirable, good, beautiful and that serve as broad guidelines for social living (Macionis, 2010). Cultural values not only colour how we perceive our environments, but also shape the core of our moral world view (Macionis & Plummer, 2005). Moral values can be simplified as a subset of values that concern the needs of others, such as animals, as well as the individual (McEachern & Schroder, 2002). Consumers view high animal welfare standards at the production stage as an indicator that the resulting food is safe, healthy and of high quality (Fallon & Earley, 2008). Another concept closely related to animal welfare is people's perceptions of nature.

Nature and naturalness are generally positively valued concepts that are often linked to food products through advertising (Siegrist, 2008). People who consider the naturalness of food to be important perceive food risks differently from people who do *not* consider the naturalness of food to be important (Siegrist, et al., 2006). Less known, so far, are consumers' perceived risks related to the consumption of a specific product, such as meat from vaccinated animals. One study, investigating milk, found animal vaccinations to present consumers with the knowledge of an artificial 'additive' in the milk production process, and to some, involuntary exposure to a perceived product risk (Grobe & Douthitt, 1995). A similar consumer scepticism about animal vaccinations was observed for fish (Engelstad, 2005). Vaccination seemed to be perceived as a foreign substance. Consumers, therefore, had the impression that vaccination changed the product.

A study by Fischhoff and colleagues (1978) using the psychometric paradigm to investigate the perception of several risks, determined that vaccination, in general, was perceived as not very severe but slightly unfamiliar. Therefore, on the two dimensions of the psychometric paradigm, vaccination is perceived as less risky than antibiotics in meat, BSE and hormones. The public generally regards vaccination in a favourable manner due to its benefits to human health (Scudamore, 2007). Vaccination is seen as ethically and morally acceptable and people interpret issues concerning animal vaccination in terms of human vaccination (Breakwell, 2003). However, so far, there have been no studies investigating people's perceptions of animal vaccinations directly by comparing it with other animal treatments that might affect human health through the consumption of animal products. Using a qualitative method, we identified the animal treatments that are most important for the public regarding human health considerations through the consumption of animal products (see next paragraph).

2.3 Qualitative studies to relate public risk perception to expert risk assessment

To investigate our research questions, we used a combination of qualitative and quantitative methods, similar to those proposed by the 'Mental Models Approach' (Morgan, Fischhoff, Bostrom, & Atman, 2002). This approach uses a multi-stage approach to design generally understandable information that makes concessions to the reader's needs and fills possible important knowledge gaps. The 'Mental Models Approach' helps to identify and filter this central information. Therefore, the experts' views are taken into account as well as the public's needs. This approach includes the following

stages: 1) Interviews with experts are conducted. All aspects that the experts consider relevant for the understanding of the problem area are gathered and arranged. 2) This information is then complemented by interviews with lay people. The aim of the first two stages is to receive a global picture of the problem area, yielding an extensive compilation of knowledge, misconceptions, comprehension problems, views and attitudes. As only a limited number of people can be interviewed, no conclusions can be drawn about the significance and relevance of those single elements. 3) The third step, using a representative survey, carves out the centrality of the topic areas and their aspects. 4) The aim of the fourth stage is to develop information based on the findings of the first three stages. 5) In the last stage of the approach, the developed information materials are assessed by interested persons. This approach has been successfully applied in diverse areas (Bostrom, Morgan, Fischhoff, & Read, 1994; Cousin & Siegrist, 2010; Jungermann, Schutz, & Thuring, 1988; Niewohner, Cox, Gerrard, & Pidgeon, 2004). For the present research, a modified version of the 'Mental Models Approach' will be used to reveal lay people's beliefs about strategies to fight animal epidemics as well as their willingness to eat meat from animals vaccinated against an epidemic and also, to assess their attitudes towards vaccination.

For our research, we conducted open interviews with experts ($N = 21$) and lay people ($N = 12$) to construct and evaluate mental models for both groups. Differences in knowledge were detected between the two groups. Moreover, we were able to identify misconceptions and information requirements among the lay people. Additionally, we found that lay people felt a lack of trust for responsible actors, such as the pharmacy and food distributors. The results of those qualitative studies were used to develop the subsequent quantitative studies (see Chapters II, III, IV and V).

3 Lay people and expert comparisons

3.1 Public risk perception versus expert risk assessment

Bolger and Wright's (1994) definition of a real expert includes two key factors affecting the expert's performance: ecological validity and learnability. They define *ecological validity* as the degree to which experts are required to make judgments inside or outside the domain of their professional experience and/or express their judgments in unfamiliar metrics. There are two conditions to be fulfilled for ecological validity: 1) the risk domain should be familiar to the expert, and it should be one in which they con-

duct practical risk assessment; 2) the response mode in the task should approximate the one used in a typical risk assessment. *Learnability* is defined as the degree to which good judgment can be learned in the task domain. Good performance results if both dimensions are high; if one or both dimensions are low, performance will be poor.

For the effective fighting of highly contagious animal diseases, the perceptions and needs of all stakeholders need to be taken into account, as the understanding of stakeholder responses to risk remains one of the weakest elements in risk governance and a continuing cause of failure (Briggs & Stern, 2007), as could be shown for BSE (Millstone & Van Zwanenberg, 2007). Millstone and van Zwanenberg (2007) describe the ways in which inappropriate early responses can skew the perceptions of stakeholders, exacerbate conflicts between different interest groups and constrain the government's options for effective action. Insight into stakeholders' perceptions cannot be obtained swiftly, as the event plays out, but requires preparation and planning (Briggs & Stern, 2007). Thus, stakeholders' behaviours, both in advance of and during the risk event, depend, in part, on their perceptions of the hazard per se, i.e. how it might affect them and their own role within the complex system of response. Therefore, prior knowledge about the risk perception of all stakeholders in an epidemic situation is essential.

Higher risk perceptions are expected from lay people compared to farmers and veterinarians, as experts tend to rate risks within their own domain as lower compared to ratings by the public (Sjöberg, Frewer, Prades, & Truedsson, 2000). In the literature, we find evidence that experts use probabilities and outcomes for their risk perception measurements, whereas lay people use more qualitative measures (Fischhoff, et al., 1978; Slovic, 1987). The common explanation for this is that more competence or knowledge lessens one's worries about a situation; therefore, scientifically knowledgeable people perceive less risk than the general population.

3.2 Gender comparisons in expert and lay people samples

Differences between men and women regarding risk perception have been observed in many studies (Davidson & Freudenburg, 1996), which find that women perceive more or higher risks as compared to men. One hypothesis is the *knowledgeable support hypothesis*, which states that men are more likely to be knowledgeable about risk-related issues than women and that persons who are better informed will be less concerned about risks to health and the environment. More recently, this view has been challenged by several studies (Kraus, Malmfors, & Slovic, 1992; Slovic, et al., 1995; Slovic,

Malmfors, Mertz, Neil, & Purchase, 1997). However, none of the studies so far has actually investigated this hypothesis using a sufficiently large female expert population and compared it to a female lay people sample.

A meta-analysis on gender differences in risk taking examined 150 studies and compared the tendencies of male and female participants; this analysis clearly supports the idea that male participants are more likely to take risks than female participants (Byrnes, Miller, & Schafer, 1999). In his discussion, Eccles (1987) suggests that gender differences arise whenever males and females hold different expectations and values. Shifting from risk taking to risk perception, one aim of a study by Finucane, Slovic, Mertz, Flynn and Satterfield (2000) was to provide data about how people of different genders perceive risks. It asked about different health and food risks. In this study, white men rated a wide range of hazards as lower in risk than white and non-white women, as well as non-white males. According to Slovic (1999), risk conflict goes beyond science, as it is deeply rooted in the social and political fabric of our society; therefore, questioning the common explanation, scientifically knowledgeable people perceive less risk than the general population. This so-called *white male effect* (Finucane, et al., 2000) proposes that white males perceive less risk in the world because, more so than other groups, they create, manage, control and benefit from many of the major technologies and activities (Slovic, 1999).

The purpose of a study by Barke, Jenkins-Smith and Slovic (1997) was to analyse differences in the ways that men and women scientists perceive nuclear risk. They compared life scientists' and physical scientists' risk attitudes and perceptions, finding that gender differences and field of research had an additive effect on risk perceptions, with women scientists and life scientists perceiving greater risks. Following this line of research, another study (Walker, Mertz, Kaltén, & Flynn, 2003) compared personal risk perceptions for developing diabetes among practicing physicians. It found that women reported greater perception of risks than men. Overall, only a few studies have examined gender differences in expert samples.

Comparing expert samples and lay people samples, Kraus, Malmfors and Slovic (1992) investigated basic toxicological concepts, assumptions and interpretations among toxicologists and the general population. The results showed that, although gender differences were less evident in the sample of toxicologists, perhaps because the number of women was too small ($n = 26$) to measure them reliably. Therefore, female toxicologists did appear to be more concerned about chemical risks and were less favourably impressed by the benefits of chemicals than their male counterparts. However, the differences were smaller for the toxicologists than for the public. Applying

similar questions as Kraus and colleagues (1992), Slovic, Malmfors, Krewski, Mertz, Neil and Bartlett (1995) surveyed members of the Canadian Society of Toxicology and Slovic, Malmfors, Mertz, Neil and Purchase (1997) surveyed members of the British Toxicological Society; both studies found that female toxicologists' risk ratings were considerably higher than those of their male counterparts.

4 The role of knowledge in influencing vaccination decisions

4.1 Current state-of-the-art in vaccination

In Switzerland, vaccination against childhood diseases, such as MMR (measles, mumps, rubella), DTP (diphtheria, tetanus, pertussis), poliomyelitis, hepatitis B, varicella and HPV (human papillomavirus) are recommended. However, none of these vaccinations are mandatory; parents are left to make personal decisions regarding the vaccination of their own children. Whereas this decision was mainly made by the doctor some decades ago, today, informed decision is the public strategy of choice and parents are especially dependant on reliable information sources. There has also been research on the question of whether parents receive enough information from their physicians during consultation to answer all their questions concerning vaccinations; it seems this is not the case (McMurray, et al., 2004). Therefore, the use of the Internet to answer questions concerning health information (Hufken, Deutschmann, Baehring, & Scherbaum, 2004; Kummervold, et al., 2008) is a logical consequence. The fact that anyone can publish his or her uncensored opinions on the Internet (Clements, Evans, Dittman, & Reeler, 1999) makes the current state of affairs however very alarming.

Another circumstance that has changed the current situation concerning vaccinations is the fact that vaccines have largely eliminated the threat of serious infectious childhood diseases, possibly undervaluing the significance of immunization (Gellin, Maibach, & Marcuse, 2000). Thus, concern about vaccine safety has increased, as the incidence of vaccine-preventable diseases has declined. Therefore, by virtue of their absence, the diseases that vaccines prevent no longer serve as a reminder of the need for immunization. The circumstance of fewer vaccinations has made herd immunity impossible for certain vaccinations, which has resulted in the re-emergence of diseases that were meant to be exterminated in certain regions (e.g. poliomyelitis outbreak in the Netherlands in 1992/93). However, the decision to vaccinate oneself and one's own

children should still be voluntary and pro- and contra-arguments need to be carefully weighed against each other.

Vaccination has sparked a huge public debate. Proponents consider vaccinations to be important to fight, and ultimately eradicate, existing severe illnesses, as happened with smallpox in the past. For these people, the importance of vaccination is without question. Opponents, however, consider vaccinations unnecessary, and feel that the human body is strong enough to fight those illnesses; they perceive the intervention of a medical application as an invasion of the body's natural defences. Debate over the two perspectives and the emergence of new media, such as the Internet, have disseminated a vast amount of information to the general population (Kata, 2010; Lewis, et al., 1988; Robert Koch Institut & Paul Ehrlich Institut, 2007). Coping with the jungle of often contradictory information is almost impossible for the average person.

4.2 The influence of knowledge on decisions to vaccinate

Although many scientific studies on knowledge about vaccination exist (Apisarnthanarak, Apisarnthanarak, & Mundy, 2008; Das, et al., 2010; Davis, Dickman, Ferris, & Dias, 2004; Gazmararian, et al., 2010; Hild-Mosley, Patel, Markwell, & Massad, 2009; Holcomb, Bailey, Crawford, & Ruffin, 2004; Lewis, et al., 1988; Maayan-Metzger, Kedem-Friedrich, & Kuint, 2005; Yudin, Slalaripour, & Sgro, 2009; Zimet, Liddon, Rosenthal, Lazcano-Ponce, & Allen, 2006), there is not a general vaccination knowledge scale that has good psychometric properties. There is only one scale measuring knowledge about vaccination in general rather than knowledge of one vaccine in particular (Wu, et al., 2008). There are several further problems associated with this lack of a general knowledge scale in the literature. Many studies investigate knowledge about vaccination with one single item (Pavia, Foresta, Carbone, & Angelillo, 2003; Ritvo, et al., 2003; Weir, Brunton, Jennings, Smith, & Litt, 2004) and only a few measured knowledge with multiple single items (Gaglia, Cook, Kraemer, & Rothberg, 2007; Ridda, et al., 2008). Such investigations cannot make any clear statements about people's general knowledge regarding vaccination.

Ambiguous statements are spread, arising from misconceptions about the functionality of the immune system and over misconceptions about the effects and consequences of vaccination (Downs, de Bruin, & Fischhoff, 2008). Those misconceptions could be illustrated through the use of an extended mental model study (Downs, et al., 2008). However, to date, there has been no research quantifying those results or statis-

tically measuring their underlying structure in terms of uni- or multidimensionality. The problem with limited understanding of vaccinations is that it makes people potentially vulnerable to misinformation (or disinformation) (Downs, et al., 2008). Although how a community's welfare depends on individuals' decisions has been discussed, the term 'herd immunity' is not actively present in people's minds. The wish to eradicate diseases is well expressed; however, the steps needed to reduce exposure are rarely mentioned. People are equipped with the perception of incompleteness concerning vaccination information and many have reported seeking additional information and a preference for the use of the Internet rather than consulting their doctor for information. Moreover, past research already found evidence that when people use vaccination-related web sites it does influence their risk perception as well as their vaccination decisions (Betsch, Renkewitz, Betsch, & Ulshofer, 2010). The problem related to such a search strategy is that the simplest search terms most likely reach anti-vaccine sites (Downs, et al., 2008). This circumstance underlines the need to inform people about vaccination and illustrates the need for a tool that enables governmental institutions to pursue people's changes concerning knowledge over time, as new media sources will probably influence this subject.

Knowledge is proposed to be important for people's decisions to vaccinate (Downs, et al., 2008). However, knowledge is not the only factor that influences people's vaccination decisions. Therefore, the education of the public should not be the sole solution to help people make informed decisions concerning vaccination. However, a certain understanding prevents feelings of insecurity, which is insofar important as insecurity might lead to inaction. For vaccinations, the omission versus action bias plays an important role, as side effects from the act of vaccinating influence people's concerns about vaccinations (Meszaros, et al., 1996; Wroe, Bhan, Salkovskis, & Bedford, 2005). Therefore, vaccination decisions should be based on complete informed consent. This term is especially valuable, as most vaccination decisions that people make are not for themselves but for their own children.

In sum, public understanding of vaccination-related aspects have been examined in a number of studies (Apisarnthanarak, et al., 2008; Das, et al., 2010; Davis, et al., 2004; Gazmararian, et al., 2010; Hild-Mosley, et al., 2009; Holcomb, et al., 2004; Lewis, et al., 1988; Maayan-Metzger, et al., 2005; Yudin, et al., 2009; Zimet, et al., 2006). However, to date, no methodological scale has been properly developed to investigate people's understanding of vaccination. Therefore, direct comparisons between countries and different samples are difficult. Moreover, the development of people's understanding over time is not traceable. Consumers seem to have an incomplete understanding

of the immunization process and of the effects and consequences of vaccination (Downs, et al., 2008). As knowledge about vaccination appears to be necessary for people to make informed decisions for themselves and their children, a closer examination of people's knowledge and/or misconceptions seems worthwhile.

5 Food risk perception

5.1 How food safety perceptions have developed over the last decade

Over the last 10 years, a variety of food scares have directed public attention to food safety issues and have made the issue of food safety highly topical (Grunert, 2005). Among the food industries, the meat sector is the one facing the most public negativity. This is due to the association of meat consumption with certain risks to human health (Krystallis, Chryssochoidis, & Scholderer, 2007). Resulting from our qualitative studies (see above), the most often spontaneously named food scare was the BSE scandal. In 1990, the first case in Switzerland was confirmed and five years later, a peak level of 68 cases were detected; a second peak level of 50 cases was reached in 1999 (BSE Unit of Switzerland, 2006). Although measures to control the disease were quickly applied and there have been no cases of Creutzfeldt–Jakob disease in Switzerland to this day, the disease is still very present in people's minds.

Due to recent food crises in Europe, food safety has become a hot topic in the mass media (Raspor, 2008; Rohr, Luddecke, Drusch, Muller, & von Alvensleben, 2005) and consumer concern about threats associated with food is growing (Raspor, 2008). The medial bagging of those food crises was probably additionally responsible for segments of the general public to not only become interested in, but also critical of, certain food production methods—both at the farm and the processing levels (Grunert, 2005). Accordingly, the topic of animal welfare has been widely investigated in the past (Issanchou, 1996; Vanhonacker, Van Poucke, Tuyttens, & Verbeke, 2010; Worsley & Skrzypiec, 1998) and is said to be a critical aspect for people's purchasing behaviour in the future (Issanchou, 1996; Verbeke & Viaene, 1999; Verbeke & Viaene, 2000). Issanchou (1996) mentions that increasing doubt related to animal welfare could be a sign of a possible future behavioural change in some consumer groups.

Food safety scares are defined as people's perceptions of major food crises, such as BSE and the avian influenza and are influenced by people's perceptions of technological production methods, such as food irradiation and GMOs (Grunert, 2005). More

generally, food safety can also be defined as people's expectations that their food is not related to any risk during consumption (Raspor, 2008).

5.2 The importance of investigating subjective risk perception

Steenkamp (1997) proposed three types of factors affecting the classification of food acceptance and behaviour: environmental factors (e.g. situational influence), person-related factors (e.g. demographic, psychological and biological characteristics) and properties of the food (e.g. physical, credence and sensory properties). Food safety is a property of the food. A very important aspect for the investigation of consumers' food risk perceptions is the fact that studies are based on people's subjective risk perception, although they might be completely overestimated compared to experts' ratings (Issanchou, 1996). There is often little relationship between the perceived hazard of a food safety concern and its actual hazard (Verbeke, Scholderer, & Frewer, 2006). Consumer perception of safety deals with the question of how safety is perceived by consumers and how these perceptions influence consumer decision-making (Grunert, 2005). Consumers are the ultimate user of the products and, therefore, quality improvement must be driven by the consumer's expectations and perceptions (Issanchou, 1996). It is therefore important to understand how consumers use the concept of food safety in judgments about food (van Rijswijk & Frewer, 2008).

Illness resulting from food-borne disease has become one of the most widespread public health problems in today's world (Motarjemi & Kaferstein, 1997). Over the last decade, up to 87% of reported food-borne disease outbreaks in the United Kingdom, Europe, Australia, New Zealand, the United States and Canada have been associated with food prepared or consumed in the home (Redmond & Griffith, 2003). This circumstance might be explained by previous research (Fife-Schaw & Rowe, 2000) implying that, in general, people are more likely to worry about risks caused by external factors over which they feel they have no control, while being much less concerned about personal factors or factors linked to their own behaviour. Therefore, people perceive more risk in the production stage. Technological risks that are shaped by beliefs that the risks are out of control are unnatural or artificial and are somehow adding to the existing risk environment, all of which contribute to explaining their greater perceived harmfulness and seriousness (Verbeke, Frewer, Scholderer, & De Brabander, 2007). Consequently, fright increases when the problem is perceived as inevitable, e.g.

it cannot be avoided or eliminated through personal precautions like careful cooking, which is the case with BSE, for example.

5.3 The total food supply chain

Meat-related consumer research can be roughly categorized into three areas (Krystallis, et al., 2007): 1) analysis of the way consumers perceive the quality of meat, mainly in terms of intrinsic cues such as colour, fat content, etc.; 2) investigation of consumer attitudes towards meat safety and the way these affect meat-purchasing preferences; and, resulting from the previous two, 3) consequences of the mandatory and/or voluntary adoption of quality and safety certification schemes for the meat supply chain (extrinsic meat quality cues). Consumers started to be particularly attentive to such extrinsic meat quality cues after food scares in which meat played a central role. Research described (organic) labels, special butcher shops and sales at farm gate next to the much less common HACCP (Hazard Analysis and Critical Control Points) and/or ISO14000-certified foods as extrinsic signs of meat quality (Arvanitoyannis, Krystallis, & Kapirti, 2003; Verbeke, Demey, Bosmans, & Viaene, 2005). This long list should make it clear that the assurance of food safety is the responsibility of the stakeholders at all stages of the total meat supply chain, as food-borne outbreaks are not contained within a single link (Vanderlinde, 2000). A total integrated food chain approach is necessary 1) to establish specifications for those in the manufacturing sector, 2) to identify the food safety systems' critical control points, and 3) to be able to maintain traceability (Stringer, Hall, & The Breakdowns Food Safety Group, 2007).

In sum, safety is an important element in consumer food perceptions and decision making associated with food choice (Grunert, 2005; Rohr, et al., 2005), as most European countries have witnessed growing public unease about the health and safety of modern methods of food production over recent decades (Hansen, Holm, Frewer, Robinson, & Sandoe, 2003). There is an extensive range of food-related issues about which European consumers now worry, such as salmonella, BSE/vCJD, the use of agrochemicals in farming, genetic modification and food additives, to list but a few examples. Overall, consumer confidence was probably most damaged during the last decade because of risks pertaining mainly to livestock and meat production, i.e. the agricultural sector (Verbeke, et al., 2007). However, little is known about the influence of food safety without food scares being present; risk communication facilitators would profit from these insights.

6 Chapter overview

In this thesis, we present research done on the subject of health- and food-related risk perceptions. First, we examine the factors that are associated with risk perception and, further investigate how risk perception is related to people's decisions. Second, the present research aims to compare the public's risk perceptions with those of the experts.

The first part of this thesis concentrates on people's risk perceptions. More precisely, Chapter II presents the results of a questionnaire designed to measure people's risk perceptions of different animal treatments, such as vaccinations and antibiotics. Additionally, people's willingness to eat meat from animals vaccinated against epidemics and the variables influencing their decisions were investigated. The next chapter (Chapter III) compares the findings of Chapter II concerning public risk perception to experts' risk assessments, i.e. farmers and veterinarians. This study additionally investigates gender differences in lay people and expert samples.

Exploring people's decisions in a slightly different risk-related health field, Chapter IV investigates the influence of knowledge about vaccination on people's decisions to vaccinate themselves and their children. Finally, in Chapter V, people were asked to rate their food safety perceptions separately for the total meat supply chain. The study addresses the question whether food safety is an important factor influencing people's meat consumption decisions next to other important variables, such as quality importance and subjective knowledge. Subsequent chapters are described in greater detail below.

6.1 Chapter II

The first study in this thesis addresses people's risk perception and their acceptance of different animal treatments concerning their affect on human health through the consumption of animal products. Chapter II also examines consumers' willingness to eat meat from animals vaccinated against animal epidemics and zoonoses. There is a substantial economic loss associated with the reduction of meat consumption in animal epidemic situations. Whereas in zoonotic situations, this reduction is comprehensible despite food safety assurances, the reduction in meat consumption for animal epidemics is not entirely rational from an expert's point of view.

The study used an extensive questionnaire to firstly measure differences in people's risk perception and their acceptance of different animal treatments concerning their affect on human health through the consumption of animal products and, secondly, to pursue the matter of which factors influence people's meat consumption decisions in animal epidemic situations. Using binomial regression analysis, several scales and sociodemographic variables were investigated to determine their relevance for people's willingness to eat meat from animals vaccinated against zoonoses.

People had lower risk perception ratings and higher acceptance ratings for vaccination than for most of the other animal treatments, such as antibiotics and hormones. However, few people were willing to eat meat from animals vaccinated against an animal epidemic and even fewer were willing to eat meat from animals vaccinated against a zoonosis. This result can be well explained by a theory by Grunert (2006) arguing that people act differently depending on their roles as citizens or consumers.

6.2 Chapter III

The second part of the studies about risk perception regarding animal epidemics and animal treatments focuses on comparisons between lay people and experts. When it comes to differences between lay people and experts in risk perception, most research on the topic has found that, because lay people use different cues for building risk perception than experts, they generally perceive more risk (Fischhoff, et al., 1978; Slovic, 1987). Moreover, the 'knowledgeable support hypothesis' states that because men are generally more knowledgeable about risk-related issues, men perceive less risk than women (Davidson & Freudenburg, 1996). However, subsequent research has since challenged this view (Kraus, et al., 1992; Slovic, et al., 1995; Slovic, et al., 1997). We will contribute to the existing literature by investigating a sufficiently large female expert sample.

The aim of this study was two-fold: the first goal was to compare risk perceptions of the general public with those of two different kinds of experts—farmers and veterinarians. The second aim was to examine whether we could find gender effects in our data. We conducted a large-scale questionnaire, presenting all stakeholders with the same questions concerning risk perception of different animal treatments and acceptance of different kinds of strategies to fight animal epidemics. Unfortunately, there were too few female farmers; therefore, we could only compare the general public and the veterinarians in the gender analyses.

We found that the public substantially differed in its risk perception compared to the experts. Having two experts groups, we found the farmers to be more similar to the public in their response patterns than to the experts, which was somewhat surprising. Comparing the experts, i.e. the veterinarians, to the public, we found substantial gender effects not only for the public but also for the experts. Therefore, the 'knowledgeable support hypothesis' cannot be supported with our data.

6.3 Chapter IV

Chapter IV investigates people's knowledge about vaccination. Many studies indicate that knowledge about vaccination might influence people's decisions to vaccinate themselves and their children. However, the literature does not indicate any general knowledge scales about vaccinations, but rather questions about specific vaccinations. Moreover, those scales have never been explicitly methodologically tested.

Using Mokken scale analysis, the present work developed an extensive knowledge scale to measure people's knowledge about vaccination. Using two different methods of collecting data and performing a test-retest analysis, we developed a stable scale with good psychometric properties.

The results indicate that the general public holds several significant misconceptions regarding vaccinations. We found that more knowledge and less misconceptions about vaccination were not only associated with people's decisions to rather vaccinate themselves but we also found that knowledgeable parents rather had their children vaccinated against various childhood diseases.

6.4 Chapter V

Chapter V investigates the public's food risk perception in a normal food situation, i.e. when no major food scandal is present. As discussed above, past research either measured food safety concerns and its relation to other variables, or focused on what variables influence meat consumption in general. This study combines those two approaches by investigating whether food safety perceptions influence people's meat consumption next to other important variables that were identified in the past as important for people's meat consumption decisions. Additionally, we not only looked at people's general food safety perceptions, but we also asked them to indicate their risk

perception for any single step in the food chain, as this approach was stated to be more useful for the implementation of strategies to maintain food safety.

Using a large-scale mail survey, in the first part of the questionnaire, respondents were asked to rate their risk perception at 18 single steps, starting with animal feed and ending with the use of leftovers at home. In the next step, people were asked to state their opinion on a variety of constructs that were stated as important for people's meat consumption decisions in the past.

A principal component analysis yielded two very distinct factors for the total meat supply chain that can be well described with 'risk perception at the production stage' and 'risk perception at home'. Moreover, those two constructs differed in that risk perception at home was much lower compared to risk perception at the production stage. The inclusion of those two constructs separately into a multiple regression analysis next to the other important variables for people's meat consumption, confirmed that food safety perceptions are not crucial in determining people's meat consumption decisions without the presence of a major food crisis.

6.5 Chapter VI

In the last chapter of this thesis, a general discussion summarizes and integrates the main findings of the studies. Furthermore, methodological issues and limitations are discussed. The thesis concludes with implications for research and practice, especially with recommendations for communication strategies.

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Chapter II

People's willingness to eat meat from animals vaccinated against epidemics

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Abstract

Animal epidemics are associated with significant economic damage and they negatively influence consumers' meat consumption. Vaccination can be used as a strategy to prevent the outbreak of animal epidemics. The current study examines people's willingness to eat meat from animals vaccinated against an animal epidemic. We asked people separately about their willingness to eat meat from animals vaccinated against both animal epidemics and against zoonoses. Zoonoses are also animal epidemics, but they might affect human health. A questionnaire was sent out to a representative sample of Swiss people and yielded $N = 1033$ completed datasets. Although animal vaccinations were highly accepted among those surveyed, compared to a wide range of other animal applications such as antibiotics, only about a quarter of those surveyed indicated that they would eat meat from animals vaccinated against a zoonosis. Some 60% indicated they would eat meat from animals vaccinated against an animal epidemic. We found attitudes about animal vaccination, knowledge about human vaccination, misunderstanding of animal treatments, and average meat consumption to significantly influence people's willingness to eat meat from animals vaccinated against a zoonosis. Therefore, it is necessary that regulatory bodies provide information on both the safety of meat for human consumption and ways to minimize any potential health risks from the handling or consumption of meat products that might be infected in cases of zoonotic outbreaks.

1. Introduction

Food scandals, accidents, and product safety incidents have depressed fresh meat consumption in Europe (Verbeke, Van Oeckel, Warnants, Viaene, & Boucque, 1999). Consumers' perception of meat and meat consumption has also been negatively influenced by animal epidemics. Infection of cows with bovine spongiform encephalopathy (BSE) resulted in a sustained loss in the beef market in Great Britain (Burton & Young, 1997). The British foot and mouth disease crisis in 2001 fueled consumers' concern about the possible impacts of this disease on human health (Poortinga, Bickerstaff, Langford, Niewohner, & Pidgeon, 2004). The outbreak of the avian influenza epidemic (bird flu) in Thailand is another example of an animal epidemic that had severe economic effects for meat producers (Tangtaweewipat, Cheva-Isarakul, Tonsoa, Paipisai, & Suna, 2006). Vaccinations are available for a number of animal diseases, such as blue-tongue disease or rabies. Vaccination is a common strategy to prevent the outbreak of animal epidemics. For an evaluation of a vaccination strategy, cost-benefit aspects as well as public acceptance of the strategy are important. Little is known, however, about people's perception of animal vaccination and about the willingness of individuals to eat meat from animals vaccinated against an epidemic. A question of particular relevance is whether people's willingness to eat meat from animals vaccinated against an animal epidemic differs from people's willingness to eat meat from animals vaccinated against a zoonosis. A zoonosis is a contagious disease that can be transmitted from animals to humans, such as the avian flu. Zoonoses are of particular relevance, as they might affect human health. An example of an animal epidemic would be foot and mouth disease, a disease that is dangerous for animals but not transmittable, i.e., dangerous to humans. We examined people's willingness to eat meat from animals vaccinated against an animal epidemic and against a zoonosis. Additionally, we investigated the factors that influence the same willingness to eat meat from animals vaccinated against a zoonosis.

1.1 Risk perception of animal diseases and animal vaccinations

Consumers' attitudes toward animal vaccinations against foot and mouth disease were examined in England (Breakwell, 2003). Focus group discussions showed that there are large differences in perception and knowledge among laypeople. Breakwell's qualitative study did not provide any information about the percentages of acceptance

or rejection of animal vaccinations in the population. Data from a Eurobarometer study showed that a large portion of consumers would hesitate to consume meat from vaccinated animals (European Commission, 2006). More than 50% of the respondents believed that the consumption of meat from vaccinated animals is related to some health risk. So far, no study has investigated in detail people's risk perception or willingness to eat meat from animals vaccinated against an animal epidemic and/or a zoonosis.

1.2 Factors influencing people's willingness to eat meat from vaccinated animals

Animal vaccination is a topic most consumers are most likely not familiar with. Asked about their willingness to eat meat from vaccinated animals, respondents will likely rely on some general knowledge and attitudes. Results of qualitative research suggest that people interpret issues concerning animal vaccination in terms of human vaccination (Breakwell, 2003). In a recent study, we found that people hold not only little knowledge but also many misconceptions about vaccination knowledge (Zingg and Siegrist, 2012). Concerning food safety knowledge, experts were found to believe that people were acceptably knowledgeable about e.g. BSE, but had only little knowledge about e.g. GMOs (Shaw, 2003). This view is in line with a consumer study where the public's perceived knowledge of food risk issues differed according to risk type (Sparks & Shepherd, 1994). When knowledge is missing, people use cues such as trust to assess the risks and benefits of a new technology (Siegrist & Cvetkovich, 2000). Siegrist et al. (2000) showed that it is generally true that being able to determine whom to trust is most important in those situations where the individual lacks knowledge to personally make decisions and take actions. In a study about genetically modified (GM) food, attitudes towards genetic modification were the best predictors of participants' intention to buy genetically modified products (Lähteenmäki, et al., 2002). It has been suggested that consumers may also view high animal welfare standards as an indicator that food is safe, healthier, and of high quality (Fallon & Earley, 2008). Another concept closely related to animal welfare is people's perception of nature. In advertisements, food products are often associated with nature (Siegrist, 2008). Nature and naturalness are generally positively valued concepts. People for whom the naturalness of food is important perceive food risks differently from people for whom the naturalness of food is not important (Siegrist, Keller, & Kiers, 2006). Skepticism against vaccination has also been observed in a case where fish were the food species (Engelstad, 2005). Vaccination seemed to be perceived as a foreign substance. Consumers therefore had the impres-

sion that the vaccination changed the product. It is also reasonable to assume that consumers' responses to risk are affected by their demographic characteristics, such as gender (Kirk, Greenwood, Cade, & Pearman, 2002), age (Kirk et al., (2002), education (Grobe, Douthitt, & Zepeda, 1999), and income.

1.3 Rationale of the present study

In the present study, we examined the degree of risk that laypeople perceive in various applications for animal treatment compared to animal vaccination. Participants assessed their perceived risks and their acceptance of those applications. These assessments may identify those applications for which public debates or opposition will be more likely than others. This will allow us to better estimate the dimension of a public debate about food safety concerning vaccination against animal epidemics and zoonoses.

Vaccinating animals against an animal epidemic has a different relevance for humans than vaccinating animals against a zoonosis, as zoonoses might affect human health. We therefore asked people separately about their willingness to eat meat from animals vaccinated against animal epidemics and against zoonoses. For a better understanding of how people's willingness to eat meat from animals vaccinated against epidemics is formed, we additionally examined several factors that may have an influence.

2 Method

2.1 Survey development

Between May and September 2009, we conducted qualitative interviews with experts ($N = 21$) and lay people ($N = 12$) to detect possible concerns, false beliefs, and relevant knowledge in connection with animal vaccinations and highly contagious animal epidemics. Based on these qualitative studies and the literature, knowledge questions and attitude questions were developed for a fully standardized questionnaire. The questionnaire was designed to measure people's willingness to eat meat from animals vaccinated against an animal epidemic versus meat from animals vaccinated against a zoonosis, and additionally to measure the variables influencing this willingness. In a

questionnaire, only relative, not absolute, attitudes can be measured. Therefore, we considered investigating other risks associated with meat consumption as important for a better understanding of the public opposition to meat from animals vaccinated against an epidemic (see Table 2). For people's willingness to eat meat from animals vaccinated against an animal epidemic and against a zoonosis, we identified the following variables as important predictors according to the literature and our own qualitative research: trust in key stakeholders, attitudes about the vaccination of animals against an epidemic, misunderstanding of animal treatments, knowledge about the impact of human vaccination, concerns about animal welfare, and naturalness. Table 1 shows the items of the six scales, including Cronbach's α . In addition to the scales, the following sociodemographic variables were used in the analyses: age, gender, education, and income. Additionally, participants were asked how much meat they consume on average.

Table 1. Scales related to people's willingness to eat meat from animals vaccinated against zoonoses, including Cronbach's α

Scale, items and Cronbach's alpha	Item-total correlation
Trust in people and institutions involved in animal epidemic situations	
$\alpha = .75$ ($M = 3.53$, $SD = .92$, $N = 1033$)	
A. Farmers	.38
B. Veterinarians	.43
C. Food industry	.62
D. Large distributors	.57
E. Pharmacy	.58
Attitudes about vaccination of animals against an epidemic	
$\alpha = .85$ ($M = 4.14$, $SD = 1.02$, $N = 1033$)	
A. Animal vaccinations cannot be seriously harmful; otherwise, authorities would ban them.	.72
B. There is a good reason why certain animal vaccinations are recommended.	.75
C. Overall, animal vaccinations deliver more benefits than harm.	.73
D. We live in such a hygienic environment that animal vaccinations are redundant.*	.65
E. The composition of a vaccine forms its proof of authority.	.64
F. For dangerous animal diseases, a vaccination duty should be applied.	.53
G. Vaccination is a better strategy than culling the affected animals.	.34
H. Animal vaccinations are another important factor that is upsetting the environment.*	.44
Misunderstanding of animal treatments	
$\alpha = .55$ ($M = .23$, $SD = .24$, $N = 1023$)	
A. Consuming meat from vaccinated animals can result in my becoming immune to the illness.	.26
B. My own hormonal balance will not become interrupted due to the consumption of meat from animals treated with hormones.	.26

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|--|-----|
| C. The consumption of meat from animals treated with antibiotics can result in some antibiotics not being effective anymore. | .38 |
| D. Human beings can become overweight due to hormones consumed through meat. | .39 |
| E. The consumption of antibiotics and hormones through meat can cause illnesses. | .31 |

Knowledge about the impact of human vaccination $\alpha = .65$ ($M = .75$, $SD = .33$, $N = 1021$)

- | | |
|---|-----|
| A. Vaccinations are redundant, as the illnesses can be treated, e.g., with antibiotics. | .43 |
| B. Without broadly applied vaccination programs, we would still have smallpox. | .48 |
| C. The effectiveness of vaccinations has been proved. | .48 |

Concerns about animal welfare $\alpha = .73$ ($M = 4.24$, $SD = .93$, $N = 1033$)

- | | |
|---|-----|
| A. I think feeding animals with industrially produced animal feeds is critical. | .44 |
| B. In Switzerland, animal protection arrangements are disproportionate.* | .39 |
| C. Today's large-scale livestock farming negatively influences the environment. | .55 |
| D. Too little attention is given to the application of medicine to animals. | .42 |
| E. Livestock transport is proportional in Switzerland.* | .34 |
| F. Discussions about the dignity of animals go too far.* | .44 |
| G. I am not willing to support large-scale livestock farming. | .53 |

Naturalness $\alpha = .86$ ($M = 4.86$, $SD = .86$, $N = 1033$)

- | | |
|--|-----|
| A. I prize naturalness very highly. | .53 |
| B. I feel good when eating natural food. | .64 |
| C. When I purchase food, I pay attention to its naturalness. | .67 |
| D. I am willing to pay a higher price for natural food. | .57 |
| E. Natural food is better for my health. | .70 |
| F. Natural food tastes better than other food. | .66 |
| G. The more natural a product, the more qualitatively better nutrients and vitamins it contains. | .61 |
| H. The application of fertilizers and pesticides negatively influences the quality of food. | .49 |
| I. Every processing step negatively influences the quality of food. | .49 |

Note. Items marked with an asterisk were reversed. Next to Cronbach's α , means, standard deviations, and sample sizes are given.

2.2 Participants

We asked randomly selected households in Switzerland to participate in a mail survey that was conducted between October and December 2009. About one-third of the questionnaires were sent out to the French-speaking part of Switzerland and about two-thirds of the questionnaires were sent out to the German-speaking part of Switzerland for an accurate coverage of the overall Swiss population. The household member older than 18 years of age whose birthday was next was asked to complete the questionnaire. This procedure was an attempt to quasi-randomly assign the questionnaire within a household. Two reminders were sent out to non-responders; the second

reminder enclosed another copy of the questionnaire. An overall response rate of 41% ($N = 1123$) was achieved.

Concerning missing values, each scale (see Table 1) was analyzed separately, and participants with more than 50% of the values missing in at least one of the scales were deleted for the final sample. For participants with fewer missing values for the scales with consisting of quantitative variables, the missing values were estimated using the expectation-maximization procedure in SPSS's missing value analysis, using all other quantitative variables for the estimation. Scales with categorical variables were not replaced. We additionally excluded all participants who indicated that they were vegetarians ($n = 40$), leaving a final sample size of $N = 1033$ for the scales with quantitative variables, and $N = 1023$ and $N = 1021$, respectively, for the scales with categorical variables. Forty-seven percent ($n = 482$) of the participants who reported their gender were female, and 53% ($n = 542$) were male. Nine participants did not report their gender. The mean age of the sample was 53 years ($SD = 16$), with a range from 18 to 99 years. Compared with Swiss census data (48 years), the mean age in the present sample was slightly higher (BFS, 2009). For the data analyses in Table 2 we included the 1033 participants that remained after the exclusion of vegetarians and after the deletion of participants with more than 50% missing values in one of the scales, as described above. For the analysis in Table 3 only 1011 participants were included, because some did not answer the "willingness to eat"-questions and therefore had to be deleted. For the analyses in Table 4 we had to delete additional 39 and 89 participants, respectively, as they did not indicate responses to the sociodemographic questions.

3 Results

3.2 Risk perception and acceptance of vaccination compared to other treatments

An overall test indicated significant differences between the different treatments for *risk perception* ($F(6, 6192) = 1006.31, p < .001, \eta_p^2 = .49$) and for *acceptance* ($F(6, 6192) = 1501.60, p < .001, \eta_p^2 = .59$). Seven dependent *t*-tests were performed to compare, on the one hand, the *risk perception*, and, on the other hand, the *acceptance* of vaccinations with the six remaining treatments (see Table 2). Overall, lower risk and higher acceptance were perceived for vaccinations compared to almost all other treatments.

Table 2. Post-hoc t-tests for pairwise comparisons between the risk perception of animal vaccinations and other applications and post-hoc t-tests for pairwise comparisons between the acceptance of animal vaccinations and other applications

	Risk perception		Acceptance	
	Mean	SD	Mean	SD
Homeopathy for disease treatment	1.89*	1.37	5.04*	1.49
Additional vitamins for strengthening the immune system	2.61*	1.45	4.24	1.49
<i>Vaccinations for disease treatment</i>	3.05	1.44	4.35	1.52
Antipsychotic drugs to, e.g., calm animals before transportation	3.52*	1.53	3.30*	1.61
Antibiotics for disease treatment	3.87*	1.41	4.13*	1.44
Hormones for growth promotion and/or behavioral manipulation	4.98*	1.37	1.46*	0.94
Antibiotics for growth promotion	5.07*	1.32	1.40*	0.92

Note. Before the questions concerning risk perception and acceptance were asked, we introduced the following text: “The following is about different treatments that are used with animals that later on enter the meat food chain.” Risk perception: For the post-hoc t-tests for risk perception, the question was “How risky do you rate the following animal treatments for the Swiss population?” and the answering scale was coded with 1 = no risk at all to 6 = very high risk; $N = 1,033$. * indicates a significant difference from vaccinations for disease treatment: $p < .05$ (Bonferroni corrected). All the significant comparisons had a t -value greater than $t = 8.74$. Acceptance: For the post-hoc t-tests for acceptance, the question was “How acceptable do you rate the following animal treatments?” and the answering scale was coded with 1 = absolutely not acceptable to 6 = highly acceptable; $N = 1,033$. * indicates a significant difference from vaccinations for disease treatment: $p < .05$ (Bonferroni corrected). All the significant comparisons had a t -value greater than $t = 4.64$.

3.3 People’s willingness to eat meat from animals vaccinated against an animal epidemic versus a zoonosis

Cross tabulations were performed for the two dependent variables: “Would you eat meat from animals vaccinated against an animal epidemic that is not dangerous for people (e.g., foot and mouth disease)?” and “Would you eat meat from animals vaccinated against an animal epidemic that might be dangerous for people (e.g., avian flu)?” The answer options were “yes”, “no”, and “do not know”. Results are displayed in Table 3. The Pearson chi-square result was significant ($\chi^2(4, N = 1011) = 325.57, p < .001, \gamma = .62$). As expected, more people indicated a willingness to eat meat from animals vaccinated against an animal epidemic than against a zoonosis.

Table 3. Cross tabulations for people's willingness to eat meat from animals vaccinated against an animal epidemic versus a zoonosis^a

		B. People's willingness to eat meat from animals vaccinated against a zoonosis		
		Yes	Do not know	No
A. People's willingness to eat meat from animals vaccinated against an animal epidemic	Yes	95% (<i>n</i> = 260)	51% (<i>n</i> = 84)	45% (<i>n</i> = 255)
	Do not know	3% (<i>n</i> = 8)	47% (<i>n</i> = 77)	18% (<i>n</i> = 106)
	No	2% (<i>n</i> = 5)	2% (<i>n</i> = 4)	37% (<i>n</i> = 212)

^a Column percentages and absolute values are shown.

Note. $\chi^2(4, N = 1011) = 325.57, p < .001, \gamma = .62$

3.5 Factors influencing people's willingness to eat meat from animals vaccinated against a zoonosis

We performed logistic regression analyses to investigate the factors that influence people's willingness to eat meat from animals vaccinated against a zoonosis, as people are much more unwilling to eat meat from animals vaccinated against a zoonosis than against an animal epidemic. We were primarily interested in the factors that influence people's decisions to either consume or not consume meat from vaccinated animals, because animal vaccinations are not dangerous for humans through meat consumption. Therefore, two binomial logistic regressions were performed, with the measurement of people's willingness to eat meat from animals vaccinated against a zoonosis as a dependent variable. One binomial logistic regression was performed using the answer options "yes" and "no" of the dependant variable, which we were primarily interested in. We additionally performed another binomial logistic regression using the answer options "yes" and "do not know" of the dependant variable. Thereby, we can clearly see what the predictors are that differ between people who are willing to consume meat from animals vaccinated against a zoonosis and people who are not willing or are unsure about it. For both analyses we entered the variables described in Table 1, sociodemographic variables, and the question about a person's average meat con-

sumption into the regression model. After the model chi-square statistic was calculated, overall the model predicts the acceptance of the consumption of meat from animals vaccinated against a zoonosis significantly better than when only the constant was included for the regression model with the answer options “yes” and “do not know” ($\chi^2(12, N = 399) = 71.24, p < .001$) and for the regression model with the answer options “yes” and “no” ($\chi^2(12, N = 757) = 181.98, p < .001$). Table 4 shows the results of the binomial regression analyses. A negative sign for B means that people with a high value on the according scale are more willing to eat meat from vaccinated animals.

Table 4. Binomial logistic regression analyses for variables predicting people's willingness to eat meat from animals vaccinated against a zoonosis

Variable	Yes (= 0) vs. Do not know (= 1)			Yes (= 0) vs. No (= 1)		
	B	SE B	Exp (B)	B	SE B	Exp (B)
Constant	-.06			-1.82		
Trust in people and institutions involved in animal epidemic situations	.09	.14	1.09	.13	.11	1.14
Attitudes about vaccination of animals against an epidemic	-.39**	.14	.68	-.51***	.11	.60
Misunderstanding of animal treatments	-1.27*	.50	.28	-.73*	.37	.48
Knowledge about the impact of human vaccination	-1.32**	.43	.27	-1.17**	.34	.31
Concerns about animal welfare	.18	.15	1.20	.15	.12	1.16
Naturalness	.03	.15	1.04	.46***	.12	1.58
Meat consumption	.30*	.14	1.35	.33**	.11	1.40
Gender	.72**	.25	2.05	-.03	.19	.97
Age	.01	.01	1.01	.02***	.01	1.02
Education (low. vs. high)	.13	.29	1.14	.82***	.23	2.27
Education (middle vs. high)	-.55	.36	.58	.22	.26	1.24
Income	-.05	.11	.95	.00	.08	1.00

Note. Trust was measured on a six-point scale ranging from 1 = "no trust at all" to 6 = "a lot of trust." Attitudes, concerns, and naturalness were measured on a six-point scale ranging from 1 = "totally disagree" to 6 = "totally agree." Knowledge and misunderstanding, respectively, were coded with 0 = "incorrect" and "did not know" and 1 = "correct." Gender was coded with 0 = female and 1 = male. Meat consumption was measured on a six-point scale ranging from several times a day over once a day, several times a week, once a week, several times a month to less than once in a month. For the binomial logistic regression analysis with the answer categories "yes" and "do not know," the dependent variable was coded with 0 = yes and 1 = do not know. $R^2 = .22$ (Nagelkerke); $N = 399$; $p < .05$; $**p < .01$. For the binomial logistic regression analysis with the answer categories "yes" and "no," the dependent variable was coded with 0 = yes and 1 = no. $R^2 = .30$ (Nagelkerke); $N = 757$; $p < .05$; $**p < .01$; $***p < .001$. A negative sign for B means that people with a high value on the according scale are more willing to eat meat from vaccinated animals.

4 Discussion

Compared with other applications, animal vaccinations were perceived in general as rather low in risk. Only homeopathy and additional vitamins were perceived as less risky than animal vaccination. Therefore, in comparison to the tested animal applications, a vaccination to prevent animal diseases seems not to be perceived as the biggest hazard for human health. Asking for the acceptance of the same animal applications, vaccination also seems to be more accepted than most of the other applications. Overall, animal vaccination was widely accepted by the public. Therefore, regulatory bodies can expect fewer public debates and less opposition to vaccinations compared to other applications such as antibiotics and hormones.

We found a very different tendency in people's willingness to eat meat from animals vaccinated against an animal epidemic versus a zoonosis. Only about a quarter of the participants indicated that they would eat meat from animals vaccinated against a zoonosis. Almost 60% of the participants indicated that they would eat meat from animals vaccinated against an animal epidemic. Therefore, regulatory bodies need to be aware that there is a difference between perceptions of animal epidemics and zoonoses. Whereas for animal epidemics there is no risk to human health concerning the transmission of the disease, the situation is different for zoonoses. This possible health risk might be reflected in the lower rate of people's willingness to eat meat from animals vaccinated against a zoonosis, e.g. consumers are concerned that the vaccination does not fully remove the potential for the transmission of the disease. As the public perceives various animal vaccinations differently, it is not enough to simply inform people about the fact that animals already are and will be vaccinated, as different animal vaccinations produce different public reactions. However, we cannot clearly conclude that people's unwillingness is a reaction to the vaccination itself or to the consumption of meat from an animal that has been seen to need a vaccination to protect itself. Nevertheless, the conclusion that people rather reacted to the vaccination is more likely, as there is a difference between the results of their responses to the animal epidemic versus the zoonosis. If people had reacted to the consumption of an animal that has been seen to need a vaccination to protect itself, we would not expect such a large difference between the animal epidemic and the zoonosis.

A reasonable explanation for the difference between risk perception and acceptance of animal vaccinations versus people's willingness to eat meat from animals vaccinated against an animal epidemic and against a zoonosis can be found in a theory presented by Grunert (2006). He formulated a distinction between people's role as con-

sumers and people's role as citizens. People might have attitudes towards meat production in their role as citizens that may not affect their purchase behavior as consumers. For example, people can be critical about the consumption of meat from vaccinated animals but still highly value the usage of vaccinations as a useful strategy for preventing animal diseases. Consumers may buy food products that were made by using production methods that, if the consumers were prompted to think about, would cause them some concern (Stampfli, Siegrist, & Kastenholz, 2010). When asked explicitly about the food and agricultural system, consumers argue for a transformation, because current practices seem to be too detrimental to the environment and unable to address health and equity goals (Macfarlane, 2002). Although vaccination was accepted in the abstract in this study, many participants indicated that they would not eat meat from animals vaccinated against an epidemic. We therefore suggest that people do not link their considerations about the acceptance of vaccinating animals with the fact that the meat of vaccinated animals might enter the food chain in the future. Regulatory bodies should take into account that citizens generally accept vaccinations to prevent further spreading of an epidemic disease but are at the same time unwilling to eat meat from animals vaccinated against an animal epidemic.

The current research analyzed the predictive power of twelve variables in terms of consumer willingness to eat meat from animals vaccinated against a zoonosis. Two binomial logistic regression analyses were performed. Four of the twelve predictors were significant in both regression analyses, namely positive attitudes about animal vaccinations, knowledge about human vaccination, misunderstanding of animal treatments, and meat consumption. Therefore, people with more knowledge and less misunderstanding, more positive attitudes concerning vaccinations and a higher meat consumption were more willing to eat meat from vaccinated animals than people who were unwilling or unsure. As knowledge about human vaccination was an important factor for people's willingness to eat meat from vaccinated animals, knowledge about human vaccination is important for issues concerning animal vaccinations. Additionally, misunderstanding of animal treatments was significant. This information should serve to advise regulatory bodies to not only assure people about food safety, but also to give them information about how one might be personally affected by a zoonotic disease and, perhaps additionally, how one can cope with meat to exclude all eventualities of being infected if possible (e.g., sufficient cooking, as in the case of avian influenza). The result showing that people who eat little meat are more unwilling or unsure might be a consequence of the fact that they are already more skeptical concerning meat safety issues. For the regression model with the answer options "yes" and "do not

know,” gender became significant, meaning that women were more likely to be unsure about their decision to eat meat from vaccinated animals than men. This result is consistent with conclusions from other studies indicating that men generally tend to express less concern for food and environmental safety issues than women (Veeman & Li, 2006). This tendency was explained by the fact that women are more likely to be primary grocery shoppers and the main meal makers in a household. However, it was also presumed that the result could reflect different perceptions of risk. This difference between men and women concerning risk perception has been found in many studies before (Davidson & Freudenburg, 1996). This feature is important for institutions responsible for risk communication, because it would be a good way to tailor their campaigns to women. For the regression model with the “yes” and “no” answers, the three additional predictors of naturalness, age, and education became significant. People who care more about naturalness are more unwilling to consume meat from vaccinated animals than people who do not. As the naturalness of food plays an important role in people’s willingness to eat meat from vaccinated animals, it is important for regulatory bodies to keep in mind that people base their judgments and decisions on their personal conception about naturalness. Younger people, for example, are more willing to eat meat from vaccinated animals. This result is in line with an other study that found that older people perceived more risks than younger people in food safety issues such as food additives and agricultural waste disposal (Veeman & Li, 2006). We also found that people with lower education levels were more willing to consume meat from vaccinated animals than people with higher education levels.

Also, in line with most of the past research, we examined self-reported behavior and not actual behavior. People are often not aware of the situational factors influencing their decisions, especially in this case, as we conducted our study when the risk issues studied were not particularly salient in the public debate. Although there is some evidence from opinion polling, the present study was not conducted during a major risk crisis. Especially as regards some of the questions we asked, our participants probably constructed their attitudes and decisions ad hoc, because they had never thought about these questions before. We therefore also expected trust to be an important factor in people’s willingness to eat meat from vaccinated animals, as people rely on trust if they do not have much knowledge (Siegrist, et al., 2000). We did not find a significant effect, though. We suggest that in the case of vaccinations against animal epidemics trust may not be a useful cue. Farmers, veterinarians, and people from the industry tend to be for or against a vaccination depending on the specific case. For a general

statement, it therefore becomes difficult for people to assess whether the stakeholder holds a position for or against it.

Consumers do not possess much knowledge about food production processes. This makes risk communication very challenging, as people may not be interested in such information. However, for zoonotic situations, i.e., situations that might become dangerous for human health, it is important for the regulatory bodies to not only secure food safety but to additionally provide information about how individuals might be personally affected by a zoonotic disease and how they can protect themselves from being affected.

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Chapter III

Lay people's and experts' risk perception and acceptance of vaccination and culling strategies to fight animal epidemics

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Abstract

To fight highly infectious animal diseases, there are almost exclusively two possible strategies that can be undergone: vaccination and culling. For effective risk communication and management strategies during a crisis, the risk perception and beliefs of the different stakeholders are essential. Risk perception and acceptance of various strategies to fight such animal epidemics are examined for the population, farmers, and veterinarians. Data were gathered from questionnaires sent out to three stakeholder groups. All stakeholders clearly preferred a vaccination strategy to a culling strategy. We found that farmers, although they were expected somehow to be experts, had response patterns more similar to the population than to the veterinarians. As expected, veterinarians perceived less risk and had higher acceptance ratings than the population. We equally found gender differences for lay people and for experts. Therefore, the explanation of differences in risk perception between men and women according to knowledge could clearly be ruled out. We detected differences between men and women concerning their attitudes and moral values, which were the same for lay people and for experts.

1 Introduction

In an animal epidemic situation, farmers are highly affected by the threat of possible losses not only concerning their animals, but also their maintenance. Veterinarians are largely involved in the prevention and fight of possible animal epidemics. On the one hand, they are involved in decisions about the most reasonable strategies to fight such epidemics; on the other hand, they are affected by the realization of the according strategies. In a broader sense, the population is influenced by animal epidemics as it might affect their risk perception and, hence, their consumption behavior. In Great Britain, the infections of cows with bovine spongiform encephalopathy (BSE) resulted in sustained losses in the beef market (Burton & Young, 1997). In addition, Germany and France have been faced with dramatic economic consequences in the beef market due to the perceived risk associated with this zoonosis (Setbon, Raude, Fischler, & Flahault, 2005; Weitkunat, et al., 2003). The avian influenza epidemic in Thailand is another example of an animal epidemic that had severe economic effects for meat producers (Tangtaweewipat, Cheva-Isarakul, Tonsoa, Paipisai, & Suna, 2006).

For many animal epidemics, there are two methods that are most often used to fight them. One method is to vaccinate the animals to prevent the further spread of the disease. Another method is to cull the infected animals, again, to prevent the further spread of the disease. To prevent losses for meat producers on one hand and to fight animal epidemics effectively on the other hand, it is important to know the acceptance of different strategies not only of the population, but also of the farmers and the veterinarians. The farmers need to accept the strategy to cooperate effectively with the veterinarians, but also the veterinarians need to accept a strategy to act accordingly. For the effective fighting of animal epidemics, the perceptions and needs of all stakeholders need to be taken into account, as the understanding of stakeholder responses to risk remains one of the weakest elements in risk governance, and a continuing cause of failure (Briggs & Stern, 2007), as shown with BSE (Millstone & Van Zwanenberg, 2007; Leiss & Powell, 2004). Millstone and van Zwanenberg (2007) describe how inappropriate early responses can skew the perceptions of stakeholders, exacerbate conflicts between different interest groups, and constrain the government's options for effective action. The insight into stakeholders' perceptions cannot be gained swiftly, as the event plays out, but requires preparation and planning (Briggs & Stern, 2007). The goal of the present study is, therefore, to better understand the acceptance of different ways to fight animal epidemics by various stakeholder groups.

We examined risk perception and acceptance of the three groups: the population, farmers and veterinarians.

1.1 Public perception of animal epidemics

Relatively few studies have examined how the public perceives different strategies to fight animal epidemics. A focus group discussion in England showed that there are large differences across consumers regarding perception and knowledge toward animal vaccinations against the foot and mouth disease (Breakwell, 2003). This qualitative study did not provide any information about the percentages of acceptance or rejection of animal vaccinations in the population, however. A Eurobarometer study indicated that more than 50 percent of the respondents believed that the consumption of meat from vaccinated animals was associated with some risk (European Commission, 2006). One reason for that risk perception might be that consumers consider vaccination as an unnatural or artificial measure. Such skepticism against vaccination was observed for fish (Engelstad, 2005). Consumers had the impression that the vaccination changed the product, because it was perceived as a foreign substance. Some studies examined people's risk perception of animal applications other than vaccination. Those studies found hormone residues in the meat to be perceived as risky (Sparks & Shepherd, 1994) as well as BSE and growth hormones (Kirk, Greenwood, Cade, & Pearman, 2002). Another study also found that BSE and antibiotics in the meat were perceived as more risky compared with other food hazards (Siegrist, Keller, & Kiers, 2006).

In this research we wanted to know how the population, the farmers, and the veterinarians accept different strategies to fight animal epidemics. We asked people exclusively about animal epidemics that could affect human beings, such as the avian flu. Therefore, we did not ask people about animal epidemics that are solely affecting animals and not human beings, such as foot and mouth disease. Common strategies to fight an animal epidemic are a vaccination strategy to prevent the further spread of a disease, a culling strategy where all animals in the same cot will be culled, and a culling strategy where additionally all animals from cots that might have had contact with an infected cot will be culled. Additionally, we asked people to state their acceptance of a culling strategy where only the affected animals would be culled. This strategy is not a realistic one, but we were interested in the acceptance of a culling strategy, when no healthy animals are culled. We measured, therefore, lay people's perceptions of other possible hazards associated with animal production (e. g. hormones for growth promo-

tion, antibiotics for treatment of diseases) and compared it with animal vaccination. We therefore gain a better understanding of the acceptance rating of a vaccination strategy.

The population differs from farmers and veterinarians in that they are lay people concerning animal epidemics. We expect, therefore, a higher risk perception for the population compared with farmers and veterinarians. Past research suggests that experts tend to rate risks within their own domain as lower compared to ratings by the public (Sjöberg, Frewer, Prades, & Truedsson, 2000). There is evidence that experts use probabilities and outcomes for their risk perception measurements, whereas lay people use more qualitative measures (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Slovic, 1987). Lay people might be more influenced by affect than experts. Because the outcome of animal epidemics is associated with very negative feelings, this could influence the population's reactions toward actions related to animal epidemics. Experts can rely on their knowledge for assessing measures related to animal epidemics. As a result, they might rely less on affect and may perceive fewer risks associated with animal vaccination as compared with lay people.

1.2 Gender differences in risk perception

In many studies, differences in risk perception between males and females have been observed (Davidson & Freudenburg, 1996). Females typically perceive more risks compared with males. Different explanations for these gender differences have been proposed (Davidson & Freudenburg, 1996). One prominent explanation has been labeled as white male effect (Finucane, Slovic, Mertz, Flynn, & Satterfield, 2000). In this study, white males perceived fewer risks compared with non-white males and white or non-white females. The white male effect states that white males see less risk in the world because they create, manage, control, and benefit from many of the major technologies and activities, more than the other groups (Slovic, 1999).

An important question is whether gender differences can only be observed in samples of lay people, or whether such differences also exist in expert samples. Kraus, Malmfors, and Slovic (1992) found that female toxicologists were more concerned about chemical risks and were less impressed with the benefits of chemicals than male toxicologists. It should be noted, however, that the gender differences in the expert sample were smaller than in the sample of lay people. Surveys with members of the Canadian Society of Toxicology (Slovic, et al., 1995) and surveys with members of the

British Toxicological Society (Slovic, Malmfors, Mertz, Neil, & Purchase, 1997) replicated the effect that female toxicologists' perceive higher risks associated with chemicals than male toxicologists.

The purpose of a study by Barke, Jenkins-Smith, and Slovic (1997) was to analyze differences in the ways that male and female scientists perceive nuclear risk. They compared life scientists' and physical scientists' risk attitudes and perceptions, and found that gender differences and field of research have an additive effect on risk perception with female scientists and life scientists perceiving greater risks. Another study (Walker, Mertz, Kalten, & Flynn, 2003) compared personal risk perception for developing diabetes among practicing physicians. They found that women reported greater risk perception than men. In the domain of health and food-related hazards, Raude and colleagues (2005) also found that female medical scientists expressed more worries about the risks than their male counterparts.

1.3 Rationale of the present study

We examined how the population, farmers, and veterinarians differ concerning their risk perception related to different hazards in animal production. Given that farmers may have more expertise related to animal epidemics, as they are responsible for the welfare of their animals, we expected them to be more similar in their response pattern to the veterinarians than to the lay people. Overall, we expected the lay people to perceive most risk, as they are not very familiar with different animal applications.

Vaccination and culling strategies are possible measures for fighting animal epidemics. All stakeholders must accept the chosen strategy in order to be promising. Culling strategies differ in their extent, going from culling animals in a single cot to culling animals in a broader environment. We examined how various stakeholder groups rated their acceptance of three different culling strategies and a vaccination strategy.

Another goal of the present study was to examine gender differences in the lay people sample and the expert sample. Additionally, we looked at several questions concerning people's attitudes and moral values concerning animal epidemic situations, animal vaccinations and animal welfare.

2 Method

2.1 Participants

2.1.1 Population

A mail survey was conducted between October and December 2009. Randomly selected households in Switzerland were contacted. About one third of the questionnaires were sent out to the French-speaking part of Switzerland and about two thirds of the questionnaires were sent out to the German-speaking part of Switzerland for an accurate coverage of the overall Swiss population. The household member over 18 years of age whose birthday was next was asked to complete the questionnaire. This procedure was an attempt to quasi-randomly assign the questionnaire within a household. Two reminders were sent out to non-responders; the second reminder enclosed another copy of the questionnaire. An overall response rate of 41 percent ($N = 1123$) was achieved. We excluded three persons from the analyses, as they almost only fell out some socio-demographic variables, leaving finally 1120 persons in total.

Forty-eight percent ($n = 528$) of the participants who reported their gender were female, 52 percent ($n = 581$) were male. Eleven participants did not report their gender. The mean age of the sample was 53 ($SD = 16$) years with a range from 18 to 99 years. Compared with Swiss census data (48 years), the mean age in the present sample was slightly higher (BFS, 2009).

2.1.2 Farmers

The farmers were randomly selected from a full database that registers all Swiss farmers. One third of the questionnaires were sent out to the French-speaking part of Switzerland and two thirds of the questionnaires were sent out to the German-speaking part of Switzerland. We only selected farmers who raise cattle, calves, pigs, or fowl. The questionnaire was sent out between February and March 2010. The reminder enclosed another copy of the questionnaire. An overall response rate of 53% ($N = 451$) was achieved. We excluded three farmers from the analyses, as they only stated some socio-demographic information but did not answer any of the questions, leaving finally 448 farmers in total. Ninety percent ($n = 396$) of the farmers who reported their gender were male, 10 percent ($n = 45$) were female. Seven farmers did not report their gender.

2.1.3 Veterinarians

The veterinarians were randomly selected from a full database that registers all Swiss veterinarians. One third of the questionnaires were sent out to the French-speaking part of Switzerland and two thirds of the questionnaires were sent out to the German-speaking part of Switzerland. The questionnaire was sent out to them concurrent to the farmers' mail survey. We selected only veterinarians for farm animals. The reminder enclosed another copy of the questionnaire. A response rate of 67 percent ($N = 504$) was achieved. We excluded three veterinarians from the analyses, as they only stated some socio-demographic information but did not answer any of the questions, leaving 501 veterinarians in total. Seventy-one percent ($n = 356$) of the veterinarians were male and 29 percent ($n = 145$) were female.

2.2 Questionnaire

In our questionnaire, we measured not only perceived risks related to animal vaccination, but also other hazards related to animal production. Therefore, we are able to compare risk perception of animal vaccinations with other related risks. In a qualitative study between May and September 2009, we accomplished open interviews with lay-people, detecting the following risks as important for the subject in question: antibiotics for growth promotion; antibiotics for disease treatment; hormones for growth promotion and/or behavioral manipulation; antipsychotic drugs (e.g. calm animals before transportation); homeopathy for disease treatment; and additional vitamins for strengthening the immune system. In our questionnaire, risk perception was measured on a six-point scale ranging from 1 = 'no risk at all' to 6 = 'very high risk'.

In a second step, we compared the acceptance of different strategies to fight animal epidemics. We asked the stakeholders to rate their acceptance on a six-point scale ranging from 1 = 'absolutely not acceptable' to 6 = 'highly acceptable'. The four strategies were: culling only the diseased animals; culling additionally all animals in the same cot; culling additionally all animals in cots in the nearer environment that might also be affected; and vaccination. All strategies were meant to prevent further spreading of the disease. To receive a deeper understanding of the different acceptance between the stakeholders, we moreover asked all three groups the same six attitude and value questions concerning animal epidemics on a six-point scale ranging from 1 = 'totally disagree' to 6 = 'totally agree' (see Table 5).

3 Results

3.1 Risk perception

For each of the seven treatments we performed a one-way ANOVA to compare the three groups (see Table 1). Additionally, we performed post hoc tests to investigate the differences between the groups in more detail (see Table 1). For all seven variables, significant group differences were observed. The lay people always perceived the highest level of risk, followed by the farmers who perceived a bit less risk, and the veterinarians who perceived the lowest level of risk. For ‘antibiotics for growth promotion’ and for ‘antipsychotic drugs’ the farmers did not differ from the population concerning risk perception, for ‘homeopathy for disease treatment’ the farmers did not differ from the veterinarians. Looking at the means, one can conclude that all three groups perceived most risks for ‘antibiotics for growth promotion’ and for ‘hormones for growth promotion and/or behavioral manipulation’. For the population and the farmers, the least risk was perceived for ‘homeopathy for disease treatment’ followed by ‘additional vitamins for strengthening the immune system’ and followed by ‘vaccinations for disease treatment’. Therefore, one can say that vaccinations –although being perceived at a moderate risk level - lie at the lower end of a risk perception comparison with the investigated treatments. Interestingly, veterinarians perceived vaccinations and additional vitamins as similarly risky, and they perceived risk associated with homeopathy as higher than risk associated with vitamins and vaccinations. For vaccinations, the largest difference between farmers and veterinarians was observed.

Table 1. One-way ANOVAs for measuring the risk perception of the different treatments and *post hoc* comparisons among the population, farmers, and veterinarians

	Population	Farmers	Veterinarians	F-values
Antibiotics for growth promotion	5.07 (1.32)a	4.94 (1.32)a	4.25 (1.56)b	$F(2, 2042) = 62.10$, $p < .001$
Antibiotics for disease treatment	3.88 (1.41)a	2.72 (1.40)b	2.19 (1.00)c	$F(2, 2044) = 323.12$, $p < .001$
Hormones for growth promotion and/or behavioral manipulation	4.98 (1.38)a	4.64 (1.54)b	4.36 (1.56)c	$F(2, 2034) = 32.05$, $p < .001$
Antipsychotic drugs to, e.g., calm animals before transportation	3.52 (1.54)a	3.35 (1.65)a	3.03 (1.58)b	$F(2, 2029) = 16.56$, $p < .001$
Vaccinations for disease treatment	3.06 (1.46)a	2.45 (1.46)b	1.38 (.77)c	$F(2, 2034) = 276.71$, $p < .001$
Homeopathy for disease treatment	1.91 (1.39)a	1.55 (1.15)b	1.54 (1.14)b	$F(2, 2043) = 20.86$, $p < .001$
Additional vitamins for strengthening the immune system	2.61 (1.46)a	1.79 (1.20)b	1.38 (.72)c	$F(2, 2040) = 184.89$, $p < .001$

Note. The rating scale went from 1 = 'no risk at all' to 6 = 'very high risk'. Sample sizes are $N = 1094$ - 1106 for the population, $N = 440$ - 443 for the farmers, and $N = 496$ - 500 for the veterinarians. Different letters indicate significant mean differences between the population, farmers and veterinarians, $p < .05$, using the Games-Howell post-hoc test.

3.2 Gender differences in risk perception

For the gender comparison, we included only veterinarians and the population into the further analyses, as only about ten percent of the farmers were women. We used t-tests for comparing males and females in the lay group as well as in the expert group. Results of the t-tests, means, and standard deviations are shown in Table 2. For 'antibiotics for growth promotion', 'antibiotics for disease treatment', and 'homeopathy for disease treatment' we found gender effects for the population as well as for the veterinarians. Interestingly, for homeopathy, this effect was reversed; therefore, males perceived more risks for this treatment than women. This was true for lay people as well as for experts. For 'hormones for growth promotion' and for 'antipsychotic drugs' we found a gender effect for the population but not for the veterinarians. Surprisingly, for 'vaccinations for disease treatment' we found a gender effect for the veterinarians but not for the population. In summary, we found significant gender effects for experts and

for lay people. Female experts perceived overall more risks than male experts. Gender differences for both groups were found for very highly risky perceived treatments (i.e. antibiotics for growth promotion) and for treatments with rather low perceived risks (i.e. homeopathy for disease treatment). Differences in the means between men and women were about equal in both groups, meaning that the gender effect is as strong for experts as it is for lay people.

Table 2. Gender differences examined with *t*-tests for the risk perception of the different treatments within the population and within the veterinarians

		Females	Males	<i>t</i> -values
Antibiotics for growth promotion	Population	5.26 (1.19)	4.90 (1.40)	$t(1092) = 4.54,$ $p < .001$
	Veterinarians	4.51 (1.48)	4.14 (1.58)	$t(496) = 2.38,$ $p = .018$
Antibiotics for disease treatment	Population	4.02 (1.36)	3.75 (1.44)	$t(1093) = 3.16,$ $p = .002$
	Veterinarians	2.46 (1.09)	2.07 (.94)	$t(496) = 4.01,$ $p < .001$
Hormones for growth promotion and/or behavioral manipulation	Population	5.22 (1.24)	4.77 (1.45)	$t(1088) = 5.41,$ $p < .001$
	Veterinarians	4.38 (1.50)	4.36 (1.59)	$t(494) = .12,$ $p = .908$
Antipsychotic drugs to, e.g., calm animals before transportation	Population	3.65 (1.50)	3.41 (1.57)	$t(1081) = 2.55,$ $p = .011$
	Veterinarians	3.02 (1.52)	3.04 (1.60)	$t(494) = -.12,$ $p = .904$
Vaccinations for disease treatment	Population	3.11 (1.45)	3.01 (1.46)	$t(1085) = 1.23,$ $p = .218$
	Veterinarians	1.50 (.84)	1.34 (.74)	$t(498) = 2.22,$ $p = .027$
Homeopathy for disease treatment	Population	1.73 (1.25)	2.08 (1.48)	$t(1092) = -4.30,$ $p < .001$
	Veterinarians	1.34 (.80)	1.62 (1.24)	$t(497) = -2.51,$ $p = .012$
Additional vitamins for strengthening the immune system	Population	2.54 (1.44)	2.68 (1.48)	$t(1090) = -1.53,$ $p = .125$
	Veterinarians	1.34 (.66)	1.39 (.75)	$t(498) = -.79,$ $p = .430$

Note. The rating scale went from 1 = 'no risk at all' to 6 = 'very high risk'. Sample sizes are $N = 515$ -522 for the female population, $N = 568$ -575 for the male population, $N = 143$ -145 for the female veterinarians, and $N = 352$ -355 for the male veterinarians.

3.3 Acceptance of strategies to fight epidemics

We performed a 3(group) x 4(strategy)-mixed design ANOVA with the four strategies as a within subject factor and the three groups as a between subject factor. The main effect for the between subject factor group, $F(2, 2011) = 15.32, p < .001$, the main effect for the within subject factor strategy, $F(3, 6033) = 458.65, p < .001$, and the interaction effect group x strategy, $F(6, 6033) = 31.04, p < .001$, were significant. As can be seen in Table 3, the farmers were much more similar in their response pattern to the population than to the veterinarians. For the strategy where all animals from cots in the environment of an affected cot will also be culled, farmers showed even less acceptance than the public, $t(1539) = 5.18, p < .001$. The strategy where only the diseased animals will be culled is not a practical strategy in an epidemic situation, which might also be reflected by the low acceptance of the veterinarians for this strategy. We, therefore, did not include this strategy in our further analyses. We were mainly interested in the differences between the acceptances for a culling strategy versus a vaccination strategy. As all three groups accepted the vaccination strategy more than the two culling strategies, the vaccination strategy was compared with the culling strategy where the diseased animals and additionally all animals in the same cot would be culled. If we could find significant differences for this culling strategy, we could also find significant differences for the second realistic culling strategy. We performed three t-tests to investigate the differences within each of the three groups. The population, $t(1100) = -10.04, p < .001$, the farmers, $t(437) = -5.64, p < .001$, and the veterinarians, $t(482) = -3.01, p = .003$, all accepted vaccination more than culling in an epidemic situation. Results suggest, therefore, that all three stakeholder groups showed higher levels of acceptance for the vaccination strategy compared with the two realistic culling strategies.

Table 3. Means and standard deviations for the acceptance of different strategies to fight animal epidemics among the population, the farmers, and the veterinarians

	Population	Farmers	Veterinarians
Culling only the diseased animals	4.84 (1.76)	4.77 (1.89)	4.19 (2.12)
Culling the diseased animals and additionally all animals in the same cot	4.10 (1.78)	4.22 (1.93)	4.88 (1.48)
Culling all animals on an affected cot and all animals from the cots in the environment that might also be affected by the disease	3.01 (1.69)	2.52 (1.71)	3.48 (1.76)
Vaccination of all animals	4.77 (1.56)	4.91 (1.56)	5.17 (1.51)

Note. The rating scale went from 1 = 'absolutely not acceptable' to 6 = 'highly acceptable'. Sample sizes are $N = 1099$ for the population, $N = 436$ for the farmers, and $N = 479$ for the veterinarians.

3.4 Gender differences for the acceptance of strategies to fight epidemics

Again, we performed analyses to investigate possible gender effects in our data. Due to the low number of female farmers ($n = 45$), we only included the population and the veterinarians. We performed a 2(group) x 2(gender) x 4(strategy)-mixed design ANOVA with the four strategies as a within subject factor and the group (experts versus lay people) and gender as between subject factors. The three-way interaction was significant, $F(3, 4689) = 3.51, p = .015$. The strategy x group interaction was significant, $F(3, 4689) = 31.81, p < .001$, and the strategy x gender interaction was also significant, $F(3, 4689) = 11.88, p < .001$. The group x gender interaction was not significant, $F(1, 1563) = 3.82, p = .051$. There was a significant main effect for gender indicating that males had higher acceptance ratings than females, $F(1, 1563) = 9.21, p = .002$. There was also a significant main effect for group indicating that lay people had lower acceptance ratings than experts, $F(1, 1563) = 10.38, p = .001$. Finally, there was a significant main effect for strategy, $F(3, 4689) = 263.30, p < .001$, indicating that the vaccination strategy was accepted most, followed by the culling strategy where only the diseased animals will be culled, followed by the culling strategy where additionally all animals in the same cot will be culled and followed by the culling strategy where additionally all animals in cots in the nearer environment that might also be affected will be culled. Planned t-tests were used to examine gender differences in the population and the veterinarians for all four strategies (see Table 4). There were no significant gender effects for the vaccina-

tion strategy and the culling strategy where only the diseased animals will be culled. For the two other (realistic) culling strategies, males had higher acceptance ratings than females. This was true for experts and for lay people. Interestingly, those effects were much stronger for the experts than the lay people.

Table 4. Gender differences examined with *t*-tests for the acceptance of the different strategies to fight animal epidemics within the population and within the veterinarians

		Females	Males	<i>t</i> -values
Culling only the diseased animals	Population	4.85 (1.78)	4.82 (1.74)	$t(1094) = .26,$ $p = .794$
	Veterinarians	4.40 (1.84)	4.09 (2.22)	$t(481) = 1.46,$ $p = .145$
Culling the diseased animals and additionally all animals in the same cot	Population	4.00 (1.78)	4.21 (1.77)	$t(1089) = -$ $2.00, p = .045$
	Veterinarians	4.31 (1.55)	5.11 (1.39)	$t(484) = -5.58,$ $p < .001$
Culling all animals on an affected cot and all animals from the cots in the environment that might also be affected by the disease	Population	2.91 (1.66)	3.12 (1.71)	$t(1089) = -$ $1.98, p = .048$
	Veterinarians	3.07 (1.67)	3.63 (1.78)	$t(485) = -3.20,$ $p = .001$
Vaccination of all animals	Population	4.85 (1.51)	4.71 (1.61)	$t(1092) = 1.47,$ $p = .141$
	Veterinarians	5.11 (1.46)	5.19 (1.53)	$t(483) = -.52,$ $p = .604$

Note. The rating scale went from 1 = 'absolutely not acceptable' to 6 = 'highly acceptable'. Sample sizes are $N = 518$ - 521 for the female population, $N = 572$ - 575 for the male population, $N = 140$ - 141 for the female veterinarians, and $N = 343$ - 346 for the male veterinarians.

3.5 Gender differences in attitudes and values concerning epidemics

Additionally, we conducted gender comparisons for lay people's and experts' attitudes and values in epidemic situations. We performed *t*-tests for the population and the veterinarians on each of our six attitude and value questions (see Table 5). Women in both groups generally care more about the manner of how animals will be culled than the fact that they will be culled. Secondly, women care more about the higher detriments

ments for little farms compared to large factories. Thirdly, women agree more than men to the statement that animals have the same right to live as human beings. Looking at the other three questions in the table, one can see that overall, lay people and experts have positive attitudes toward animal vaccination. In the comparisons of those three questions about people's attitudes toward animal vaccination, there is also only one significant comparison, namely, that male rather than female veterinarians agree with the statement that a vaccination duty should be applied in Switzerland for dangerous animal diseases.

Table 5. Gender differences examined with *t*-tests for the manifestation of attitudes and values within the population and within the veterinarians

		Females	Males	<i>t</i> -values
Overall, animal vaccinations deliver more benefits than harm.	Population	4.10 (1.38)	4.21 (1.39)	$t(1087) = -1.34,$ $p = .179$
	Veterinarians	5.47 (1.14)	5.64 (.97)	$t(495) = -1.74,$ $p = .083$
For dangerous animal diseases, a vaccination duty should be applied in Switzerland.	Population	4.05 (1.65)	4.12 (1.68)	$t(1085) = -.66,$ $p = .508$
	Veterinarians	4.89 (1.39)	5.41 (1.21)	$t(487) = -4.11,$ $p < .001$
Vaccination is a better strategy than culling the affected animals.	Population	4.30 (1.49)	4.19 (1.53)	$t(1087) = 1.26,$ $p = .207$
	Veterinarians	4.97 (1.30)	5.20 (1.24)	$t(486) = -1.81,$ $p = .071$
The method of how animals will be culled in animal epidemic situations is worse than the fact that they will be culled at all.	Population	4.11 (1.62)	3.23 (1.63)	$t(1068) = 8.80,$ $p < .001$
	Veterinarians	2.88 (1.59)	2.53 (1.66)	$t(483) = 2.16,$ $p = .032$
Little farms are more strongly affected than large factories in animal epidemic situations.	Population	4.66 (1.56)	4.22 (1.59)	$t(1082) = 4.58,$ $p < .001$
	Veterinarians	3.18 (1.53)	2.56 (1.63)	$t(491) = 3.93,$ $p < .001$
Animals have the same right as humans to live.	Population	5.15 (1.32)	4.75 (1.57)	$t(1088) = 4.58,$ $p < .001$
	Veterinarians	4.78 (1.31)	4.08 (1.75)	$t(489) = 4.29,$ $p < .001$

Note. The rating scale went from 1 = 'totally disagree' to 6 = 'totally agree'. Sample sizes are $N = 506-518$ for the female population, $N = 564-572$ for the male population, $N = 141-144$ for the female veterinarians, and $N = 343-354$ for the male veterinarians.

4 Discussion

The aim of the present study was to compare different stakeholders' acceptance of various strategies to fight animal epidemics. From our result we can conclude that all stakeholders accept a vaccination strategy much more than a culling strategy. For our research we firstly compared vaccination against a wide range of animal applications. Interestingly, vaccination was perceived as rather unriskey compared to most of the other applications. The risk perception ratings for vaccinations were even at the lower side of the rating scale. In a second step, we compared a vaccination strategy to different culling strategies. Here, we clearly found all stakeholders to accept a vaccination

strategy much more than realistic culling strategies. The practical implications of those results are clear-cut. The very often-practiced strategy to cull animals should be reduced, as the acceptance of the population, farmers, and veterinarians is rather low compared to a vaccination strategy. Therefore, future strategies should go more into the direction of a vaccination strategy, as on one side vaccinations are perceived as less risky compared with various other applications and a vaccination strategy is very accepted compared to culling strategies.

For a full picture of the above conclusions it is important to additionally discuss the differences between the investigated stakeholders. For the various animal applications, the farmers perceived overall more risk than the veterinarians but less risk than the population. For vaccinations, this difference was very strong. For the strategies to fight animal epidemics, farmers did again lie in between the veterinarians and the population, but were more similar in their acceptance ratings to the population than to the veterinarians. Veterinarians had the highest acceptance ratings overall, followed by the farmers and followed by the population. This result was surprising, as we expected farmers if at all to be more similar to the veterinarians as they are experts on the present subject, too. One explanation for this unexpected difference between farmers and veterinarians might be the different degree of involvement. Whereas veterinarians do not depend financially on an epidemic outbreak, the farmers' maintenance depends on such occurrences, as they will be paid for the losses of the animals but not for the indirect production losses. Moreover, farmers have a more emotionally close relationship with their animals than the veterinarians in case of a culling strategy. Especially, when also all animals from cots that might have had contact with one of the infected cots will be culled, too. For this strategy, farmers had even lower acceptance ratings than the population. This effect might be explained by the fact that farmers thereby had to cull their animals although they never had an infected animal in their own cot. This might happen if a neighbored farmer has infected animals and a preventative-culling radius is defined that might include their cots.

Veterinarians are often involved in decision-making strategies and they need to be aware of the fact that farmers and the population accept (despite their high acceptance ratings) vaccination less than they do, on one hand. On the other hand, risks associated with vaccinations are still on a moderate level for the population and for the farmers, although compared to other applications they are perceived as less risky. These differences should be incorporated into risk management considerations and into risk communication strategies.

Bolger and Wright (1994) mention ecological validity and learnability as key factors for expert performances. Ecological validity is the degree to which experts are required to make judgments inside or outside the domain of their professional experience and/or express their judgments in unfamiliar metrics. Learnability is the degree to which good judgment can be learned in the task domain. If both dimensions are high, good performance will be apparent, but if one or both are low then performance will be poor. For ecological validity, firstly, the risk domain should be familiar to the expert, and it should be one in which they conduct practical risk assessment. For our research we can say that our experts made statements in their risk domain, as we only included veterinarians that also work with farm animals. Secondly, for ecological validity, the response mode in the task should approximate that used in typical risk assessment. The response mode in the task was a rating scale, which probably is not used in real life decisions. We do not, however, consider this as a problem, as the population had to rate the same questions with the same rating scale. Therefore, we think this problem is cancelled out by the comparison of experts and lay people. Concerning learnability, our experts are more or less experienced with epidemics depending on their age. Certainly, they all know about the strategies and the according consequences from epidemics that occurred abroad, such as the avian flu. Past studies examining experts' risk perception often lack the above conditions as they only indicate to have investigated scientists (e. g. Barke, et al., 1997; Raude, et al., 2005) whereby it is not clear what kind of scientists those are. Especially if the authors ask them about a wide range of risks (e. g. Barke, et al., 1997), it is difficult to know whether they are genuine experts on the asked tasks. We can, therefore, clearly add to the existing literature by not asking experts about a wide range of risks but exclusively about their own domain which makes them genuine experts according to the definition of Bolger and Wright (1994).

For examining gender differences, we could only include the population and the veterinarians in our gender analyses, as there were not enough female farmers. For the different strategies to fight animal epidemics that might affect humans, there were gender differences for the two practical culling strategies, i.e. for the strategy where all animals in a cot will be culled and for the strategy where additionally all animals from cots in the environment that might be affected by the disease will be culled. Gender differences were observed in the lay people sample as well as in the expert sample. The fact that men accept those two strategies more than women might be explained by the different results in the moral value questions between men and women; however, this is only one possible explanation among others.

In our study, we not only asked experts about their personal risk perception, as Walker et al. (2003) did, but we asked the experts to state their professional opinion. Therefore, the *knowledgeable support hypothesis* (Davidson & Freudenburg, 1996) can clearly be ruled out as an explanation for gender differences in risk perception, as we found the same differences for lay people and for experts. Therefore, more knowledge cannot explain the differences between male and female experts. Gender differences remain even in areas where men and women have the very same knowledge, competencies and involvement. This result implies that incorporating female experts into risk communication strategies is worthwhile, as –holding expertise constant- they probably are more similar to female lay people than to male experts concerning risk perception. Women perceive more risk than men; therefore, women are the ones to whom risk communication campaigns should be tailored.

Further studies should examine the basis of those gender differences in more detail. Slovic (1999) mentions that not only the public but also scientists are influenced by emotion and affect. In addition, the public as well as experts are influenced by worldviews, ideologies and values (Dake, 1991; Wildavsky & Dake, 1990). Another important factor for risk perception is social trust. Results by Siegrist and Cvetkovich (2000) suggest that the lay public relies on social trust when making judgments of risks and benefits when personal knowledge about a hazard is lacking. Future research should examine how experts and lay people as well as men and women differ with respect to those variables.

The beliefs, opinions, and perceptions of risk assessment by experts can be assumed to play a significant role in decision-making on risk policies in society (Fromm, 2006). Therefore, it is not only of interest to know more about experts' risk perception (Fromm, 2006) but also for practical implications that we would highly recommend involving female experts in the decision-making processes about the strategies to fight animal epidemics that might affect humans. From our results, we can conclude that women obviously differ from men regarding risk perception and acceptance ratings. This is true not only for the broad population but also for experts concerning their professional judgments. Half of the population are women, and especially as women often are responsible for the purchasing in a household, it would be of high interest to governments to elect strategies that also match female moral values. Thereby, the decrease in meat consumption in food scandal situations might be lowered.

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Chapter IV

Measuring people's knowledge about vaccination: Developing a one-dimensional scale

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Abstract

We propose a new scale to measure people's general knowledge about vaccinations. The scale's psychometric properties and its relationship with people's willingness to vaccinate were examined in two studies. In Study 1, a representative sample of the German- and French-speaking populations in Switzerland ($N = 1123$) responded to a mail survey. In Study 2, members of an online panel answered the same questions ($N = 233$). The results of both studies suggest that people differ considerably in their ability to correctly answer questions related to vaccinations. Mokken scale analyses and a test-retest analysis showed that nine items form a one-dimensional scale with good psychometric properties. In both studies, a substantial correlation between knowledge and willingness to vaccinate was observed. The scale proposed in this study is well suited for research examining group differences. In a time when new media such as the Internet is highly accessible to most people, misconceptions can easily be spread. A good knowledge scale is important for measuring possible knowledge changes.

1 Introduction

Nowadays, the decision about immunization may be undervalued because vaccines have largely eliminated the threat of serious infectious diseases in childhood (Gellin, Maibach, & Marcuse, 2000). Thus, as the incidence of vaccine-preventable diseases has declined, concern about vaccine safety has increased. The same might be true for refreshing immunizations in adulthood, such as those for diphtheria and tetanus. From a public health perspective, it is important to know which factors influence people's willingness to vaccinate. Knowledge has been proposed as an important factor shaping parent's decisions about the vaccination of their children (Downs, de Bruin, & Fischhoff, 2008). Parents had many misconceptions about the effect of vaccinations and the consequences of vaccinations as well as the immunization process itself (Downs, et al., 2008). As we will point out in our review of the literature, there is a lack of a general knowledge scale about vaccinations that has good psychometric properties. Our research proposes a general knowledge scale and examines the impact knowledge has on people's decision to vaccinate not only their children but also themselves.

The findings about the importance of knowledge for people's willingness to vaccinate are mixed. In some studies, only single items were used to measure knowledge (Pavia, Foresta, Carbone, & Angelillo, 2003; Ritvo, et al., 2003; Weir, Brunton, Jennings, Smith, & Litt, 2004); the psychometric properties of these measures are therefore unclear. There are a few studies that used multiple single items to measure knowledge (Gaglia, Cook, Kraemer, & Rothberg, 2007; Ridda, et al., 2008). It is unclear, however, whether the items form a one-dimensional scale. In many studies, no clear distinction between knowledge and attitude has been made (Akan, et al., 2010; Johnson, Nichol, & Lipczynski, 2008; Nichol, MacDonald, & Hauge, 1996). Therefore, the importance of knowledge in people's willingness to vaccinate remains ambiguous. We will use the term *knowledge* for items we can clearly classify as either correct or incorrect, based on scientific evidence (e.g.: "Vaccinations increase the occurrence of allergies."). We clearly distinguish the term *attitudes* from this definition, as attitudes describe items that measure how positively or negatively vaccines are perceived, as well as items that have no correct or incorrect answer (e.g. "I am afraid to suffer from side effects after a vaccination.").

Several scales measure parents' knowledge about children's vaccinations (Apisarnthanarak, Apisarnthanarak, & Mundy, 2008; Gazmararian, et al., 2010; Lewis, et al., 1988; Maayan-Metzger, Kedem-Friedrich, & Kuint, 2005; Yudin, Slalaripour, & Sgro, 2009), especially about the human papillomavirus (HPV) vaccine (Das, et al., 2010;

Davis, Dickman, Ferris, & Dias, 2004; Hild-Mosley, Patel, Markwell, & Massad, 2009; Holcomb, Bailey, Crawford, & Ruffin, 2004; Zimet, Liddon, Rosenthal, Lazcano-Ponce, & Allen, 2006). To the best of our knowledge, only one study used a scale that measured parents' knowledge of vaccinations in general rather than knowledge of one vaccine in particular (Wu, et al., 2008). This knowledge scale measured whether respondents were able to match diseases with the right vaccines (e.g. chicken pox with varicella).

Over the last decades, people have more and more used new media forms such as the Internet to answer questions concerning health information (Hufken, Deutschmann, Baehring, & Scherbaum, 2004; Kummervold, et al., 2008). On the Internet, anyone can upload their opinion on a specific subject uncontrolled by authority (Clements, Evans, Dittman, & Reeler, 1999). Consequently, people searching for information are overloaded with vast quantities of information and different opinions about vaccinating (Kata, 2010; Robert Koch Institut & Paul Ehrlich Institut, 2007). Moreover, people often express to have limited time to ask their physicians questions during their visits (Petts & Niemeyer, 2004). Taken together, this is a precarious development.

The aim of this study was to develop a knowledge scale about vaccinations that includes knowledge questions that are relevant to decisions about vaccination in general, and not only for one single vaccine. Therefore, in our scale we included questions about the immunization process related to vaccination, the impact of vaccination, and the consequences of vaccination. In two studies, we examined the psychometric proportion of the knowledge scale and its relationship to people's decisions about whether to vaccinate themselves and their children.

2 Study 1

The aim of Study 1 was to formulate relevant knowledge items related to whether people decide to vaccinate themselves or their children. The knowledge items covered most of the questions that people are interested in when it comes to vaccinations. Instead of conducting a mental model study (Downs, et al., 2008), we relied on the information in a document published by the Robert Koch institute, which is provided for the general public who use the Internet (Robert Koch Institut & Paul Ehrlich Institut, 2007). It lists and comments on the most prevalent misconceptions about vaccinations. A second aim of Study 1 was to examine how people's knowledge of vaccination is associated with their decisions about whether or not to vaccinate themselves and their children.

2.1 Method

2.1.1 Participants

A mail survey was conducted from October to December 2009. Randomly selected households in the German- and French-speaking parts of Switzerland were contacted. The household member who was 18 years or older and whose birthday was next was asked to complete the questionnaire. Thus, we quasi-randomly assigned the questionnaire within each household. Non-responders received two reminders, the second of which contained another copy of the questionnaire. Overall, 1123 persons sent back completed questionnaires. This corresponds to a response rate of 40.8%. Of the participants who reported their gender, 47.7% ($N = 530$) were female and 52.3% ($N = 581$) were male; 14 participants did not disclose their gender. The mean age was 53 years ($SD = 16$). Compared with Swiss census data (BFS, 2009), the sample was slightly older and was comprised of more males than the general Swiss population. In our sample, 9.8% (13.2%, census data) attended primary school; 40.2% (51.7%, census data) attended vocational school; 16.2% (10.3%, census data) attended higher secondary school; 28.6% (24.8%, census data) attended college or university; and 5.3% chose the category “other”. The average net household income of the Swiss census data is CHF 6465 (BFS, 2009), whereas the average net household income of our sample was CHF 6548.

2.1.2 Questionnaire

The questionnaire included eleven knowledge items. These items were formulated based on the information given by the Robert Koch institute in Germany, addressing the most prevalent misconceptions about vaccination (Robert Koch Institut & Paul Ehrlich Institut, 2007). The Robert Koch institute has the legal duty to prepare scientific findings for health-related political decisions. The institute provides answers to often-posed questions, and it attempts to correct common misconceptions. There is no reason to assume that these misconceptions are specific to Germany, because mental model studies conducted in other countries unveiled very similar knowledge gaps at least for parents concerning the vaccination decisions for their children (Downs, et al., 2008).

The response categories for the knowledge items were “correct,” “incorrect,” and “do not know.” We included only items for which a correct or incorrect answer could be

clearly determined based on available scientific evidence. Additionally, we asked people whether they had opted for the seasonal influenza vaccination at least once during the past five years. We also asked them to state whether they vaccinated their children against various children's diseases. Participants with children too young for certain vaccinations were asked to imagine how they would decide if their children were old enough; participants without children were asked to imagine how they would decide if they had children.

2.1.3 Data analysis

We used the Mokken scale analysis to construct a one-dimensional knowledge scale. Data was analyzed using MSP5 (Version 5.0, Iec ProGAMMA, Groningen, The Netherlands). The Mokken scale analysis is a nonparametric, probabilistic version of the Guttman scaling procedure (van Schuur, 2003). A respondent's probability of solving an item depends on two factors: 1) on his or her latent trait (e.g. knowledge) and 2) on the characteristic of the item (e.g. level of difficulty) (Molenaar & Sijtsma, 2000). Therefore, the Mokken scale analysis ranks respondents according to their probability of a positive response (i.e. their latent trait, such as ability or knowledge), and it orders items according to their probability of being answered positively. Thus, unlike measurements such as reliability or factor analysis, the Mokken scale analysis explicitly allows items to differ with regard to their distribution or difficulty. The Mokken scale analysis is a much stronger test of unidimensionality of a scale than Cronbach's α or principal component analysis (PCA).

An important assumption of the Mokken scale analysis is double monotonicity, stating that both rank orders should be monotone (Molenaar & Sijtsma, 2000). First, the item response function should be monotonically nondecreasing, meaning that the item order for all respondents is similar. Thus, if person A has a higher solving probability than person B for item x, person A's probability of solving item y should also be higher than person B's. Second, the item order, according to difficulty, should be identical for each person. For example, if person A had a higher probability of solving item x compared to item y, then person B should also show a higher solving probability for item x than for item y. A respondent's total score therefore gives an indication of which items have been solved. If, for example, a person has a total score of four, it is very probable that he or she has solved the four easiest items.

The Loevinger's scalability coefficient H indicates the degree to which

respondents can be accurately ordered by the set of items (Molenaar & Sijtsma, 2000). A scale with $.3 \leq H < .4$ is a weak scale, a scale with $.4 \leq H < .5$ is an average scale, and a scale with $.5 \leq H \leq 1.0$ is a strong scale (Mokken, 1971). Additionally, the scalability coefficients for all individual items should be $H_i > .3$.

Knowledge items were recoded into dichotomous variables for data analysis (1 = “correct answer”, 0 = “incorrect answer” and “do not know”). In other words, we scored the items as is usual in multiple-choice tests.

2.2 Results

2.2.1 Knowledge scale about vaccination

Table 1 displays the response distributions of all items. It shows that most respondents had little knowledge and many misconceptions about vaccinations. The Mokken scale analysis yielded a scale consisting of nine items with a Loevinger’s scalability coefficient of $H = .45$. Thus, the knowledge scale is of moderate scalability with a rather high reliability of $r = .79$ (Mokken, 1971). With $H_i \geq .39$, the scalability coefficients for all individual items are satisfactory. The means of correct responses indicate that the scale included items with various levels of difficulty ($.24 \leq M_s \leq .75$). We checked for double monotonicity by visually checking the P-matrices, and we did not find substantial violation of this assumption. As the Mokken scale analysis resulted in the exclusion of two of the eleven items, our final knowledge scale consisted of items 1-9 shown in Table 1.

We computed several correlations and one point-biserial correlation (gender), respectively, to see how knowledge about vaccination is associated with sociodemographic variables. The sociodemographic variables were: gender (female = 0; male = 1), age, education and income. Education level ($r = .10, p = .002, N = 1026$) and income ($r = .11, p = .001, N = 1026$) were significantly associated with knowledge about vaccination: people with higher education levels and people with more income had more knowledge about vaccination. There were no such differences for age ($r = -.02, p = .632, N = 1058$) and gender ($r = -.01, p = .779, N = 1064$).

Table 1. Response distributions of knowledge items

Items	Response distribution	Item scalability	
1. Vaccines are superfluous, as diseases can be treated e.g. with antibiotics.(-)	Study 1	75 8 17	$H_i = .44$
	Study 2	84 6 10	$H_i = .50$
2. Without broadly applied vaccine programs, smallpox would still exist.	Study 1	75 7 18	$H_i = .48$
	Study 2	85 5 10	$H_i = .41$
3. The efficacy of vaccines has been proven.	Study 1	73 12 15	$H_i = .53$
	Study 2	77 9 14	$H_i = .49$
4. Children would be more resistant if they were not always vaccinated against all diseases.(-)	Study 1	43 36 21	$H_i = .46$
	Study 2	46 35 19	$H_i = .48$
5. Diseases like autism, multiple sclerosis and diabetes might be triggered through vaccinations.(-)	Study 1	35 16 50	$H_i = .39$
	Study 2	44 12 44	$H_i = .42$
6. The immune system of children is not overloaded through the many vaccinations.	Study 1	30 30 40	$H_i = .44$
	Study 2	36 23 42	$H_i = .53$
7. Many vaccinations are administered too early, so that the body's own immune system has no possibility to develop.(-)	Study 1	24 40 37	$H_i = .48$
	Study 2	29 34 36	$H_i = .54$
8. The doses of the chemicals used in vaccines are not dangerous for humans.	Study 1	24 37 39	$H_i = .42$
	Study 2	26 44 29	$H_i = .37$
9. Vaccinations increase the occurrence of allergies.(-)	Study 1	24 35 41	$H_i = .41$
	Study 2	33 31 36	$H_i = .53$
10. By means of gene technology, vaccinations that feature less side effects can be produced.*	Study 1	31 13 56	
	Study 2	43 9 48	
11. Vaccinations can not generate the diseases they are meant to prevent of.*	Study 1	30 41 28	
	Study 2	27 48 25	

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

■ correct ■ incorrect ■ do not know

Note. Study 1: $N = 1075$; Study 2: $N = 221$. (-) denotes items with an incorrect statement. Accordingly, responses were reversed to indicate correct and incorrect answers. For the Mokken scale the items were changed into a dichotomous response format of 0 (incorrect or did not know) and 1 (correct). Items marked with * were not included in the Mokken scale as they reduced the scale's quality.

2.2.2 Children's vaccines

We calculated correlations for the responses to questions about vaccinating against various children's diseases¹ with the respondent's knowledge about vaccination. We used a point-biserial correlation with the 2 answer options: "yes" (0) and "no" (1). We left out the answer option "do not know" (out of 1075 respondents, between 61 and 190 answered with "do not know"). A negative correlation means that more knowledge is associated with higher vaccination rates. We found significant negative correlations between people's knowledge about vaccinations and their self-reported or hypothetical decisions to vaccinate their children (see Table 2). We did not ask participants whether they were answering based on actually having children or based on a hypothetical question. As a result, we cannot compare hypothetical with self-reported decisions.

Table 2. Point-biserial correlations between people's knowledge about vaccination and their decision to vaccinate their children against various diseases (0 = yes, 1 = no)

	Study 1				Study 2			
	r	N	"Yes"	"No"	r	N	"Yes"	"No"
Diphtheria, tetanus, pertussis (DTP)	-.19**	963	94% (N = 908)	6% (N = 55)	-.17*	150	94% (N = 141)	6% (N = 9)
Poliomyelitis	-.18**	956	96% (N = 914)	4% (N = 42)	-.20*	150	97% (N = 145)	3% (N = 5)
Measles, mumps, rubella (MMR)	-.32**	912	77% (N = 699)	23% (N = 213)	-.25**	151	77% (N = 116)	23% (N = 35)
Hepatitis B	-.20**	806	49% (N = 391)	51% (N = 415)	-.31**	130	38% (N = 50)	62% (N = 80)
Varicella	-.24**	863	40% (N = 343)	60% (N = 520)	-.26**	133	35% (N = 46)	65% (N = 87)
Human papillomavirus (HPV)	-.20**	799	27% (N = 218)	73% (N = 581)	-.10	128	11% (N = 14)	89% (N = 114)

Note. * $p < .05$; ** $p < .01$. People who answered with "do not know" in Study 1, and "do not know" or "children too young" in Study 2 were not included in the computation of the correlation coefficients.

¹ The full text of the question read: Have you vaccinated your children against the following diseases? If you do not have children yourself or your children are too young for certain of the following diseases, imagine that you had to decide now whether to vaccinate your children.

2.2.3 Seasonal influenza vaccine

Participants answered the question, “Have you been vaccinated against seasonal influenza at least once during the last five years?” (yes = 0; no = 1). Twenty-nine percent ($N = 305$) of the participants answered with “yes” and 71% ($N = 758$) answered with “no”. Only four participants answered with “do not know” and were therefore not included in the analysis. We calculated a point-biserial correlation for the self-reported behavior of vaccinating against seasonal influenza and knowledge about vaccination. We found a significant correlation coefficient of $r = -.23$ ($p < .01$, $N = 1063$). The results show that more knowledge about vaccination correlates with higher vaccination rates for oneself.

A binomial logistic regression analysis was performed with people’s decision to vaccinate themselves against seasonal influenza as the dependent variable. We were primarily interested in whether knowledge about vaccination was a significant predictor for the decision to vaccinate oneself against seasonal influenza, controlling for sociodemographic variables. The predictor variables were significantly associated with people’s decisions ($\chi^2(5, N = 956) = 169.26$, $p < .001$). Table 3 shows the results of the binomial logistic regression analysis. Knowledge about vaccination was a very important variable to be associated with whether someone would decide to vaccinate against seasonal influenza. The more people knew about vaccination, the more likely they were to vaccinate themselves against seasonal influenza. Another significant predictor was age, with older people being more likely to vaccinate themselves against seasonal influenza than younger people.

Table 3. Binomial logistic regression analysis for variables predicting people's decision to vaccinate themselves against influenza (0 = yes, 1 = no)

	B	SE B	Exp (B)	95% CI
Study 1: past behavior				
Constant	5.17	.54		
Age	-.05***	.01	.95	.94 - .96
Knowledge about vaccination	-2.43***	.31	.09	.05 - .16
Education	-.06	.09	.94	.79 - 1.12
Income	.00	.08	1.00	.86 - 1.16
Gender	.12	.16	1.12	.82 - 1.54
Study 2: past behavior				
Constant	8.11	1.61		
Age	-.06***	.02	.94	.91 - .97
Knowledge about vaccination	-2.02**	.76	.13	.03 - .59
Education	-.49	.41	.61	.27 - 1.37
Income	-.79	.44	.45	.19 - 1.08
Gender	.10	.44	1.11	.47 - 2.63
Study 2: future behavior				
Constant	7.47	1.57		
Age	-.07***	.02	.94	.90 - .97
Knowledge about vaccination	-2.50**	.78	.08	.02 - .38
Education	-.47	.43	.63	.27 - 1.45
Income	-.30	.44	.74	.32 - 1.75
Gender	.02	.44	1.02	.43 - 2.38

Note. Study 1: past behavior: $R^2 = .23$ (Nagelkerke); *** $p < .001$; $N = 956$; coding for gender: 0 = female, 1 = male. Study 2: past behavior: $R^2 = .25$ (Nagelkerke); *** $p < .001$; ** $p < .01$; $N = 214$; coding for gender: 0 = female, 1 = male. Study 2: future behavior: $R^2 = .28$ (Nagelkerke); *** $p < .001$; ** $p < .01$; $N = 194$; coding for gender: 0 = female, 1 = male.

2.3 Discussion

In Study 1, we constructed a one-dimensional scale measuring knowledge about vaccination. Furthermore, we found that knowledge about vaccination correlated with people's willingness to vaccinate against seasonal influenza and with people's willingness to vaccinate their children. We did not differentiate between people's hypothetical or self-reported behavior concerning their decisions to vaccinate their children. Hence, one aim of Study 2 was to measure only the parents' self-reported behavior about whether to vaccinate their children.

3 Study 2

The aim of Study 2 was to replicate the findings of Study 1. We examined the scalability of the nine items selected in Study 1. We also examined the relationship between knowledge and people's self-reported vaccination behavior. Additionally, in Study 2 we asked people to include where they get information about vaccinations. We were interested in examining whether the use of the Internet was positively or negatively related to participants' knowledge.

3.1 Method

3.1.1 Participants

We invited 277 persons to participate in an online study in spring 2011. The participants were members of an Internet panel consisting of persons who agreed to participate in scientific studies. One reminder was sent out two weeks after the first delivery. Overall, 233 persons responded. Of the participants who reported their gender, 35.7% ($N = 87$) were female and 59.8% ($N = 146$) were male. The mean age was 53 years ($SD = 14$). Compared with Swiss census data (BFS, 2009), the sample was slightly older and was comprised of more males than the general Swiss population. In our sample, 5.1% (13.2%, census data) attended primary school; 28.3% (51.7%, census data) attended vocational school; 36.1% (10.3%, census data) attended higher secondary school; 30.5% (24.8%, census data) attended college or university; and 5.3% chose the category "other." The average net household income of the Swiss census data is CHF 6465 (BFS, 2009), whereas the average net household income of our sample was CHF 7665.

3.1.2 Questionnaire

We asked people to answer the same eleven knowledge items about vaccination as in Study 1. We further asked them to give information about their past decisions to vaccinate their children. This time, we only asked people with children to answer this question to rule out discrepancy between hypothetical vs. self-reported behavior. Then, we asked all participants to give information about their personal vaccination behaviors. First, we asked them to state whether they had received the seasonal influenza vaccination in the past winter (2010/2011). Then, we asked if they intended to get the seasonal influenza vaccination in the upcoming winter (2011/2012). We further asked them whether they had ever renewed their tetanus and diphtheria vaccinations in adulthood and whether they intended to renew their tetanus and diphtheria vaccinations in the future. At the end of the questionnaire, people indicated how often they used the following sources for gaining information about vaccinations: physicians, natural health practitioners, the Internet, and discussion forums in the Internet. Possible answers ranged from never (1) to very often (6).

3.1.3 Test-retest reliability

Two weeks after the last participant responded, we sent out another online survey to the same participants, with the same eleven knowledge items to calculate the test-retest reliability for the knowledge scale. Participants were asked to provide an individual code in both surveys, which allowed us to match the two responses. Forty-four point six percent ($N = 104$) of the participants also responded to the second online survey.

3.2 Results

3.2.1 Knowledge scale about vaccination

The Mokken scale analysis yielded a scale consisting of the same nine items as in Study 1 (see Table 1). Items were recoded (correct = 1, incorrect = 0 and do not know = 0). The Loevinger's scalability coefficient was good ($H = .48$), and the reliability was high ($r = .80$) (Mokken, 1971). With $H_i \geq .37$, the scalability coefficients for all individual items

were satisfactory. The means of correct responses indicate that the scale included items with various levels of difficulty ($.26 \leq Ms \leq .85$). We tested for double monotonicity by visually checking the P-matrices, and we did not find substantial violation of this assumption. The test-retest reliability for the knowledge scale with the nine items was $r = .70$ ($p < .01$, $N = 104$).

We computed several correlations and one point-biserial correlation (gender), respectively, to see how knowledge about vaccination is associated with sociodemographic variables. The sociodemographic variables were: gender (female = 0; male = 1), age, education and income. Neither education level ($r = .08$, $p = .265$, $N = 221$), income ($r = .13$, $p = .054$, $N = 221$), age ($r = .07$, $p = .272$, $N = 221$), nor gender ($r = -.04$, $p = .531$, $N = 221$) were significantly associated with knowledge about vaccination. Further, we conducted a t-test to see whether people with children ($M = .53$, $SD = .27$, $N = 156$) scored differently on the knowledge scale than people without children ($M = .47$, $SD = .26$, $N = 65$). This was not the case: $t(219) = 1.72$, $p = .088$.

3.2.2 Children's vaccines

We correlated people's knowledge about vaccination with their decisions about whether to vaccinate their children ("Have you vaccinated your children against the following diseases?"; yes = 0 and no = 1). Between 5 and 28 out of 156 people responded with "do not know" and were therefore excluded from the analyses. One person (varicella) and another 13 persons (HPV) answered with "children too young" and were therefore additionally excluded from the analyses. Correlations are reported in Table 2. We found significant correlations between people's decisions to vaccinate their children and their knowledge about vaccinations for almost all diseases.

3.2.3 Seasonal influenza vaccine and tetanus and diphtheria vaccine

Participants answered the question, "Have you been vaccinated against seasonal influenza in the past winter 2010/2011?" and "Will you vaccinate against seasonal influenza in the upcoming winter 2011/2012?" (yes = 0; no = 1). Twenty percent ($N = 43$) of the participants answered with "yes" and 80% ($N = 177$) answered with "no". Participants who answered with "do not know" ($N = 4$) were not included in the analysis. For future behavior, 22% ($N = 43$) of the participants answered this question

with “yes” and 78% ($N = 156$) answered with “no”. Again, participants who answered with “do not know” ($N = 22$) were not included in the analysis. We calculated point-biserial correlation coefficients for people’s self-reported behavior/behavioral intention to vaccinate against seasonal influenza and knowledge about vaccination. We found significant correlations for past behavior, $r = -.27$ ($p < .01$, $N = 220$), and for future behavior, $r = -.30$ ($p < .01$, $N = 199$).

In regard to renewing tetanus and diphtheria vaccinations in adulthood (“Have you ever refreshed the tetanus and diphtheria vaccination in adulthood?” and “Will you refresh the tetanus and diphtheria vaccinations in the future?”), 76% ($N = 155$) of the participants answered with “yes” and 24% ($N = 50$) answered with “no”. Participants who answered with “do not know” ($N = 16$) were not included in the analysis. For future behavior, 75% ($N = 123$) of the participants answered this question with “yes” and 25% ($N = 40$) answered with “no”. Participants who answered with “do not know” ($N = 56$) or “not yet applicable” ($N = 2$) were not included in the analysis. We found significant correlation coefficients for past behavior, $r = -.24$ ($p < .01$, $N = 205$), and for future behavior, $r = -.42$ ($p < .01$, $N = 163$).

We conducted a binomial logistic regression analysis to examine factors influencing people’s decision to vaccinate against seasonal influenza in the past winter of 2010/2011 (see Table 3). The predictor variables significantly improved the model (χ^2 (5, $N = 214$) = 37.29, $p < .001$). Controlling for sociodemographic variables, knowledge about vaccinations was significantly associated with the decision to vaccinate against seasonal influenza. The logistic regression analysis with future behavior as a dependent variable provided similar results (χ^2 (5, $N = 194$) = 39.06, $p < .001$). The results are shown in Table 3.

3.2.4 Correlations between vaccination knowledge and information sources

Participants with more vaccination knowledge about vaccination more often asked a physician ($r = .25$, $p < .01$, $N = 220$) for information about vaccinations. People with less knowledge about vaccination more often asked a natural health practitioner ($r = -.30$, $p < .01$, $N = 220$) for information about vaccinations. We neither found an association between Internet use for vaccination information and knowledge about vaccination ($r = .00$, $p = .977$, $N = 220$), nor did we find an association between the use of discussion forums in the Internet and knowledge about vaccination ($r = -.07$, $p = .296$, $N = 220$).

4 General discussion

Several studies have measured general knowledge about vaccinations. Ad hoc measures were used in most of these studies; therefore, little is known about the psychometric properties of these measurements. Furthermore, in various studies no clear distinction between attitudes and knowledge has been made (Akan, et al., 2010; Johnson, et al., 2008; Nichol, et al., 1996). The aim of the present study was therefore to develop a one-dimensional knowledge scale with good psychometric properties.

The results of both studies suggest associations between general vaccination knowledge and people's decision to vaccinate. People with a higher level of general knowledge are more likely to vaccinate compared with people having a lower level of general knowledge. It seems plausible that not only general knowledge, but also specific knowledge, influence vaccination decisions. The goal of the present study was to develop a general knowledge scale; therefore, questions that are specific to certain vaccinations were not included.

The research results of this study show that people differ considerably in their ability to correctly answer questions related to vaccinations. Some misconceptions seem to be widespread, whereas others are held only by a minority. The research suggests that a one-dimensional Mokken scale can be constructed. The finding that there seems to be one latent variable influencing people's responses is important. Unlike PCA or classical test theory, the Mokken scale allows items to differ with regard to their difficulty. This makes the suggested scale especially promising for cross-cultural research or for group comparisons when the items could be very easy or very difficult to answer for such groups. The test-retest coefficient further shows that the scale has good reliability.

For the knowledge scale, items were formulated that cover important knowledge or misconceptions that affect people's decisions about whether to vaccinate. A past study using qualitative measures has detected knowledge on one side and misconceptions on the other side as important for parents' vaccination decisions for their children (Downs, et al., 2008). Our study could show that the same is true for the general public; there was no difference between people with and without children concerning their score in the knowledge scale. Therefore, our results could not only quantify but also generalize those findings to the public at large. In two studies, we found substantial correlations between knowledge and people's willingness to vaccinate their children or themselves. One conclusion of this study is that people's knowledge should be increased. One must not forget, however, that this may not be as

easy as it sounds. The public needs not only to be interested in the topic of vaccination, but they also need to trust the information given by public health agencies.

The Internet and Web 2.0 have changed information search behavior. The Internet is a source in which everyone can upload his or her opinions on a specific subject, and it is not controlled by an authority or by experts (Clements, et al., 1999). Therefore, people searching for information can be overloaded with a huge amount of information and different opinions about vaccination (Kata, 2010; Robert Koch Institut & Paul Ehrlich Institut, 2007). However, our results suggest that to date, there is no relationship between vaccination knowledge and the use of the Internet for gaining information about vaccinations. Nevertheless, it would be useful to track this relationship in the future, as people's use of the Internet for gaining health information is still a developing subject. Some limitations of this study need to be addressed. The knowledge items of the present questionnaire were formulated based on misconceptions often expressed in Germany. These misconceptions are very similar to the ones described in other studies (Downs, et al., 2008). We cannot rule out, however, that other misconceptions may be more prevalent in non-industrialized countries. Further, no logistic regression analyses were conducted for the decision to vaccinate children, because the present age and income of the respondents is not the relevant variable, but rather the respondent's age and income at the time of the vaccination decision. This information was not available; therefore, these analyses could not be conducted.

Another limitation is the fact that we have measured self-reported behavior and not actual behavior. Further studies should therefore examine how the knowledge scale about vaccination is associated with people's actual behavior. As knowledge might not be the only significant variable associated with behavior, future research could evaluate its association with other factors. One such factor might be social pressure, as vaccinations are only efficient if there are a high percentage of people who are vaccinated. So, those people who do not vaccinate their children might be considered "freeriders". Trust in medical or pharmaceutical institutions could also be decisive for people to have or to show a pro- or anti-vaccination attitude or behavior. Based on the results of studies about those aspects, it will be possible to finally conclude whether a focus on knowledge acquisition would be useful for the development of vaccination campaigns or information material about vaccination. It will also be important to investigate the causal relationship between all the variables we investigated in the present studies, as we primarily calculated correlations. Study 1 was conducted during the swine flu pandemic of 2009, which might have influenced

the results. Nonetheless, we replicated the results with Study 2, which was conducted in spring of 2011.

Knowledge about vaccinations is associated with people's self-reported behavior about vaccinating themselves and their children. Over the last decades, new media forms have developed that codetermine our daily lives. It will be important to examine how these new information forms are associated with people's knowledge about vaccination. The scale proposed in this study could be a valuable tool for such research because it possesses the important characteristics of a one-dimensional scale that is suitable for measuring knowledge changes.

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Chapter V

Public risk perception in the total meat supply chain

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Abstract

Due to past major food scares, food-safety perceptions have become a widely investigated topic. The aim of the present study was to examine food-safety perceptions separately for every step of the total meat supply chain, as such a detailed approach yields more promising strategies to ensure food safety in the future. Using a large-scale survey, we examined people's risk perceptions of 18 steps describing the total meat supply chain. The results revealed a clear distinction between risk perception at the production stage and risk perception at home in the total meat supply chain, in that people perceived significantly less risk at home. However, people's risk perceptions of the single stages in the total meat supply chain were overall slightly above average. Additionally, there were individual differences, as risk perception at the production stage was highly correlated with risk perception at home, meaning that some people perceived more risk than others overall. Using a multiple regression analysis, we found food-safety perceptions to be barely significant next to other important variables affecting people's meat-consumption decisions. For those analyses, we asked participants to assess several constructs previously found to be associated with meat consumption. The goal was to determine how food-safety perceptions influence people's meat consumption next to other important constructs in situations in which no major food scandal is present. The present paper concludes by discussing possible marketing and policy strategies to overcome people's inaccurate safety perceptions of the stages of the total food chain.

1 Introduction

Over the last few decades, so-called food scares have increased people's concerns about food safety. Bovine Spongiform Encephalopathy (BSE) in Europe, the avian flu (H5N1) in several countries across the globe and just recently the *Escherichia coli* (EHEC) outbreak in Germany are all examples of food scares that even today influence consumers' food decisions. Such food scares have substantially increased consumers' concerns about food consumption and potential health risks (Krystallis, Chryssochoidis, & Scholderer, 2007; Verbeke, Scholderer, & Frewer, 2006). Among the food industries, the meat sector is the one facing the most public negativity due to the association of meat consumption with certain risks to human health (Krystallis, et al., 2007). Therefore, the safety of meat has been at the forefront of societal concerns (Grunert, 2005; Sofos, 2008), and evidence exists that challenges to meat safety will continue in the future (Raspor, 2008; Sofos, 2008). These challenges become more and more distinguished due to changes in animal production, product processing and distribution, increased international trade, changing consumer needs and increased preferences for minimally processed products (Sofos, 2008).

Food-safety incidents can have substantial negative consequences for the food industry as well as for regulatory institutions and the development of policy in the area of consumer protection (de Jonge, van Trijp, Renes, & Frewer, 2007). In the past, food-safety incidents have led to decreased consumption of products (Burton & Young, 1997; Verbeke, Van Oeckel, Warnants, Viaene, & Boucque, 1999) and an impairment to the image of the particular industry perceived to be responsible for the incident (Verbeke, 2001). In modern societies, we know less and less of how foods are produced, and the perceived control about what we eat thus decreases (Issanchou, 1996). Moreover, there is less and less consensus about what is good and what is bad to eat, causing uncertainty to increase (Issanchou, 1996; Seward, 2003). Therefore, for the majority of consumers, a certain fear is always present in a latent state concerning product safety (Issanchou, 1996). Thus, the present study investigates public food-risk perceptions and their influence on meat consumption *in the absence* of any major food scare.

1.1 Food supply chain

The term “food safety” has several meanings, and it is important to distinguish between the following usages: 1) Food safety can describe situations in which major safety problems are perceived (Grunert, 2005), such as BSE (Burton & Young, 1997; Setbon, Raude, Fischler, & Flahault, 2005) or the dioxin problem in Belgium (Verbeke, 2001) and Ireland (Kennedy, Delaney, Hudson, McGloin, & Wall, 2010). During such so-called food scares, risk perceptions can dominate all other considerations in food choice and lead consumers to avoid certain categories or brands for some time until the situation returns to normal (Grunert, 2005). 2) Consumers apply food-safety considerations to certain production technologies, such as food irradiation and GMOs (genetically modified organisms) (Grunert, 2005). 3) For the present study, we use the term food safety in a much broader sense, defining it as an assurance that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use (Raspor, 2008).

With this definition as a basis, in our study, we asked people to rate the single stages of the meat supply chain concerning their personal risk perception with regard to the meat-production process. Therefore, we did not simply ask them to rate their risk perception of meat safety in general but in a more complete manner. This detailed approach to measuring food-safety perceptions was used, because past studies have mentioned the increasing importance of studying and managing the aspects of food production in relation to the total food chain rather than one stage in isolation (Scroggins, 1993; Stringer, Hall, & The Breakdowns Food Safety Group, 2007), as it yields more meaningful policy and marketing implications. The term “food chain” refers to the total supply process from agricultural production, harvest/slaughter and primary production and/or manufacturing to storage and distribution, retail sale or use in catering and consumer practice (Stringer, et al., 2007). According to this definition, we developed a meat supply chain that was, on the one hand, very detailed to fulfil the former request and, on the other hand, dispersed into stages that were still distinguishable and meaningful for the average consumer. Therefore, we finally came up with 18 single stages (see Table 2).

1.2 The importance of subjective food safety

The food supply has never been safer and better controlled than it is today (Nayga, 1996; Verbeke, Frewer, Scholderer, & De Brabander, 2007). It seems, however, that consumers are generally uncertain about the safety and quality of their food. Both social and political observers share a common belief that society is becoming more risk aware (Kirk, Greenwood, Cade, & Pearman, 2002). Social science research has supported this belief over the last 30 years by constantly finding a gap between experts' risk assessments and lay people's risk perceptions (Verbeke, et al., 2007; Zingg & Siegrist, 2012). Therefore, public risk perceptions need to be taken into account (Kirk, et al., 2002) even when the fear appears inconsistent with the views of food scientists (Issanchou, 1996). What is more, there is often a weak relationship between the perceived and actual danger of a food-safety concern (Verbeke, et al., 2006). Therefore, the aim of the present study is to investigate consumers' *personal* risk perceptions of meat safety. We therefore add to the current claim that methodologies developed in consumer science will have to become more widely used than they are today, as the meat industry is changing from a traditional production-led industry to a consumer-driven industry (Issanchou, 1996). A recent article reviewing and evaluating different food-risk prioritisation and management frameworks concludes that consumer risk perceptions are currently not integrated in the formal and traditional food-risk analysis process (Anders & Schmidt, 2011). However, their analysis concludes that a more integrated and broader science-based system approach including the consumer perspective is needed to reduce the incidence of food-borne pathogens in the international food supply (Anders & Schmidt, 2011). The British government's BSE policy is one past example that was not consistent with the policies favoured by either producers or consumers and did not serve the long-term interests of either of these two groups (Millstone & Van Zwanenberg, 2007; Poortinga, Bickerstaff, Langford, Niewohner, & Pidgeon, 2004).

1.3 The Role of Food Safety in Meat-consumption Decisions

A large body of research has examined the influence of various variables on people's meat consumption. A combination of attitudinal and demographic variables were found to account for almost one third of the variance in reported red-meat consumption (Worsley & Skrzypiec, 1998). Among others, attitude components include concerns about animal welfare and health restraint. Several other studies find sociodemographic

factors (Guenther, Jensen, Batres-Marquez, & Chen, 2005; Yen, Lin, & Davis, 2008), animal welfare (Issanchou, 1996; Vanhonacker, Van Poucke, Tuyttens, & Verbeke, 2010) and health-related attitudes (McCarthy, O'Reilly, Cotter, & de Boer, 2004; Richardson, Shepherd, & Elliman, 1993) to have a significant effect on meat consumption. Moreover, meat is described as an important component of the diet (Verbeke, Perez-Cueto, de Barcellos, Krystallis, & Grunert, 2010) and as nutritionally beneficial for consumers (Allen & Ng, 2003). Additional factors associated with meat consumption include value for money (Richardson, et al., 1993), eating enjoyment (McCarthy, et al., 2004) and knowledge (Guenther, et al., 2005). As we are primarily interested in people's subjective perceptions, we only measure subjective knowledge in our survey.

While a vast amount of studies examined the influence of different variables on meat consumption, none of those studies has examined the influence of food-safety perceptions conjointly with those other variables, although food safety is proposed as an important factor affecting people's meat-consumption decisions (McCarthy, et al., 2004). Various researchers have studied temporary changes in meat-consumption behaviour, while others have examined more long-lasting meat-consumption changes in eating habits, also due to past food scandals (Burton & Young, 1997; Verbeke, et al., 1999). Therefore, our research question asks whether food-safety concerns are still a significant predictor next to the other important variables that influence meat consumption.

1.4 The present study

The main aim of the present study is to detect people's meat-safety perceptions independently for every single step of the meat supply chain (see Table 2). To the best of our knowledge, no study to date has examined people's subjective food-safety perceptions separately for every single step of the meat supply chain. An additional aim of the present study is to obtain food-safety ratings that are unaffected by major food scares, as this enables us to measure whether people consider meat-safety perceptions important factors in their general meat-consumption decisions. Thus, the next step of the present study is to filter out the importance of food-safety perceptions on meat consumption controlling for some of the most significant constructs that normally influence people's meat consumption.

As discussed above, we identified the following constructs (see Table 1) as crucial for people's meat consumption next to sociodemographic variables: importance of ori-

gin, concerns about animal welfare, subjective knowledge, quality importance and benefits. This last construct consists of health/nutritional benefit perceptions and eating enjoyment considerations. Consequently, the purpose of the present work is to determine the relative importance of subjective food-safety perceptions and additionally, by means of a regression analysis, explore whether food safety is still considered important by the public next to the above-mentioned key variables. Most researchers in the past have mainly included variables other than food-safety concerns regarding meat consumption (Allen & Ng, 2003; Guenther, et al., 2005; Issanchou, 1996; McCarthy, et al., 2004; Richardson, et al., 1993; Vanhonacker, et al., 2010; Verbeke, et al., 2010; Worsley & Skrzypiec, 1998; Yen, et al., 2008). Regarding food-safety concerns, most research looked at how this construct was built (Hwang, Roe, & Teisl, 2005; Nayga, 1996; Yeung & Morris, 2001). Therefore, another aim of the present study is to combine those two research areas and investigate the effect of people's food-safety perceptions on meat consumption, controlling for some of the most important variables influencing meat consumption in a *non-scare food situation*.

2 Method

2.1 Participants

Data were collected using a mail survey distributed in the German-speaking part of Switzerland between the end of August and mid-December 2009. Participants were randomly selected from the Swiss electronic telephone directory. The questionnaire was accompanied by a cover letter describing the aim of the study and ensuring complete anonymity. As an attempt to assign the questionnaire within a household quasi-randomly, a meat-consuming member of the household aged 18 or older and whose birthday was next was asked to fill in the questionnaire. Approximately a month later, each household received a reminder and was asked to participate in the study. After another month, they received another reminder, this time together again with the questionnaire. The questionnaire consisted of 16 pages. In total, 1,002 questionnaires were returned by the end of the data-collection period, which corresponded to a response rate of 45.2%.

Our sample consisted of 47.9% males, and the average age was 53.5 years ($SD = 15.4$). Self-reported education level ranged from primary school (9.2%), vocational school (43.1%) and higher secondary school (19.5%) to college or university (22.7%) (another

5.5% could not be classified under one of these categories). According to Swiss census data (BFS, 2009), males were slightly underrepresented, whereas age and education level were slightly higher than the Swiss average.

2.2 Questionnaire

The questionnaire was designed to investigate people's safety perceptions separately for the single steps in the total meat supply chain. Therefore, people were asked to indicate how risky they perceived each single step of the described 18 steps (see Table 2) of the meat supply chain on a six-point scale ranging from 1 ("no risk at all") to 6 ("very high risk"). Meat consumption was measured on a five-point scale. The scale was labeled as 1 = "less than once a week", 2 = "about once a week", 3 = "several times a week", 4 = "about once a day", and 5 = "several times a day". Based on a literature review, we identified some of the most important underlying constructs related to meat consumption. Therefore, for the present study, variables measuring the following five constructs were used (see Table 1):

Benefits of meat consumption were measured using a scale consisting of nine items (see Table 1). Participants responded on a six-point scale ranging from 1 ("totally disagree") to 6 ("totally agree"). In our sample, the mean of the scale was 4.05 ($SD = .98$), indicating that participants generally saw meat consumption as rather beneficial for their health and their well-being. Reliability analysis yielded a Cronbach's α of .86.

Quality importance considerations of meat were assessed using a scale consisting of three items (see Table 1). Participants responded on a six-point scale ranging from 1 ("totally disagree") to 6 ("totally agree"). The mean of the scale for our sample was 3.48 ($SD = 1.23$), demonstrating that participants were slightly sensitive to quality aspects concerning meat products. Reliability analysis yielded a Cronbach's α of .55.

Subjective knowledge about aspects of the food chain was measured using a scale consisting of six items (see Table 1). Participants responded on a six-point scale ranging from 1 ("completely uninformed") to 6 ("very well-informed"). In our sample, the mean of the scale was 3.33 ($SD = 1.11$), indicating that participants assessed themselves as having average knowledge of the total food supply chain. Reliability analysis yielded a Cronbach's α of .88.

Concerns about animal welfare were assessed using a scale consisting of seven items (see Table 1). Participants responded on a six-point scale ranging from 1 ("totally disagree") to 6 ("totally agree"). The mean of the scale for our sample was 4.17 ($SD =$

.90), demonstrating that participants cared about animal welfare. Reliability analysis yielded a Cronbach's α of .72.

We measured *importance of origin* using a scale consisting of four items (see Table 1). Participants responded on a six-point scale ranging from 1 ("totally disagree") to 6 ("totally agree"). The mean of the scale for our sample was 4.49 ($SD = 1.31$), demonstrating that participants paid a great deal of attention to the origin of their meat. Reliability analysis yielded a Cronbach's α of .89.

Table 1. Scales related to people's meat consumption including Cronbach's α

Scale, items and Cronbach's α	Item-total correlation
Benefits	
$\alpha = .86$ ($M = 4.05$, $SD = .98$, $N = 968$)	
A. Eating meat is important for my health.	.72
B. Eating meat adds to my well-being.	.76
C. Eating meat gives me energy and strength.	.77
D. Red meat is an important iron source for me.	.57
E. Meat is an important protein source for me.	.66
F. Eating meat is important, as it provides vitamins and mineral nutrients.	.63
G. If I eat too little meat, I feel somewhat unhappy.	.49
H. I feel happy while consuming meat.	.31
I. I like to eat meat.	.35
Quality importance	
$\alpha = .55$ ($M = 3.48$, $SD = 1.23$, $N = 967$)	
A. When purchasing meat, a high price is a reliable indication of a high-quality meat product.	.49
B. I never buy meat products from discount brands or discount stores.	.36
C. I rarely eat meat, but I consciously pay attention to the quality of the meat.	.46
Subjective knowledge	
$\alpha = .88$ ($M = 3.33$, $SD = 1.11$, $N = 961$)	
We are interested in how well informed you feel you are on the following subjects:	
A. Animal husbandry (feed, husbandry methods, hygiene)	.62
B. Legal determining factors/approval for application of drugs and vaccinations for production animals	.77
C. Instructions for animal transportation	.80
D. Instructions for slaughtering (hygiene, type of slaughtering)	.79
E. Legal determining factors/approval procedures for meat processing	.75
F. Handling of meat products at home (hygiene, cooking, storage, use of leftovers)	.37

Concerns about animal welfare $\alpha = .72$ ($M = 4.17$, $SD = .90$, $N = 961$)

A. I think feeding animals with industrially produced animal feeds is critical.	.42
B. In Switzerland, animal-protection arrangements are disproportionate.*	.45
C. Today's large-scale livestock farming negatively influences the environment.	.50
D. Too little attention is given to the application of medicine to animals.	.45
E. Livestock transport is proportional in Switzerland.*	.22
F. Discussions about the dignity of animals go too far.*	.49
G. I am not willing to support large-scale livestock farming.	.46

Importance of origin $\alpha = .89$ ($M = 4.49$, $SD = 1.31$, $N = 980$)

A. When purchasing meat, I prefer organic products.	.60
B. When purchasing meat, I prefer products coming from ethical husbandry.	.78
C. I gladly pay a higher price if I know that the animal has been kept in a species-appropriate manner.	.87
D. I gladly pay a higher price if I know that the meat comes from an environmentally friendly production facility.	.81

Note. Items marked with an asterisk were reversed. Next to Cronbach's α , means, standard deviations and sample sizes are given.

3 Results

3.1 Risk Perception of the Meat Supply Chain

Table 2 displays the psychometric properties of the meat supply stages. A principal component analysis running over all 18 meat-supply stages resulted in two separate factors explaining together 67.22% of the total variance: *risk perception at the production stage* and *risk perception at home* (see Table 2). For the construction of the two separate scales, we first calculated Cronbach's α and then calculated the means by including the items A to M for *risk perception at the production stage* and the items N to R for *risk perception at home*. Overall, people's risk perception at home was lower ($M = 2.82$, $SD = 1.26$) compared to people's risk perception at the production stage ($M = 3.42$, $SD = 1.10$). We performed a dependent t-test to compare the two means ($t(990) = 17.17$, $p < .001$). Calculating the effect size, we concluded that a strong effect was observed ($d = .77$). Although we found two separate factors that diverged highly from each other, we also observed mean differences between the separate stages within the two scales. For example, within the *risk perception at the production stage* scale, we found the stages *animal feed* (composition, fertilizer, pesticide, antibiotics) and *addition of supplements* (dyestuffs, flavour enhancers) to be perceived as most risky. Within the *risk perception at home* scale, we found *processing* (hygiene, cooking, heating) to be perceived as least risky.

Table 2. Psychometric properties of the food chain variables

	F1	F2	N	M	SD	Item-total correlation
Risk perception at the production stage						
$\alpha = .95$ ($M = 3.42$, $SD = 1.10$, $N = 951$)						
A. Animal feed (composition, fertilizer, pesticide, antibiotics)	.69		983	3.86	1.42	.62
B. Type of livestock breeding (number of animals per m ² , run for animals, building grounds)	.74		983	3.43	1.35	.68
C. Hygiene (disinfection of building, cleanliness of animals)	.76		987	3.58	1.41	.73
D. Veterinary care (drugs, vaccinations)	.73		990	3.25	1.44	.72
E. Livestock transport (transport between farms, transport to slaughterhouse)	.71		988	3.45	1.41	.66
F. Slaughtering (hygiene, refrigeration)	.79	.36	985	3.30	1.53	.84
G. Manufacture (hygiene, refrigeration, butchering)	.79	.38	987	3.28	1.52	.84
H. Preserving (blanching, curing)	.75	.32	983	3.16	1.39	.78
I. Addition of supplements (dyestuffs, flavour enhancers)	.72		987	3.84	1.36	.64
J. Manufacturing of products, merging of meat (minced meat, sausages)	.73		986	3.53	1.33	.73
K. Packaging (hygiene, refrigeration, fusing, packing in tin)	.72	.43	988	3.19	1.44	.80
L. Transport to selling point (hygiene, refrigeration)	.66	.51	989	3.15	1.40	.78
M. Storage at selling point (hygiene, refrigeration)	.59	.56	989	3.30	1.40	.72
Risk perception at home						
$\alpha = .94$ ($M = 2.82$, $SD = 1.26$, $N = 980$)						
N. Transport home (hygiene, refrigeration)		.80	988	2.86	1.37	.77
O. Storage home (hygiene, refrigeration)		.89	991	2.67	1.40	.85
P. Processing (hygiene, cooking, heating)		.86	985	2.46	1.36	.84
Q. Storage of leftovers (hygiene, refrigeration)		.88	992	3.06	1.46	.87
R. Use of leftovers (hygiene, cooking, heating)		.86	992	3.05	1.46	.84

Note. People were asked to indicate how risky they perceived each single step of the meat supply chain to be on a six-point scale ranging from 1 = "no risk at all" to 6 = "very high risk". A principal component analysis using varimax rotation resulted in the reported two factors F1 and F2 (factor loadings >.30 are reported in the table above) explaining together 67.22% of the total variance.

3.2 Correlations Between Safety Perceptions and Other Variables

We calculated correlations (see Table 3) between *risk perception at home*, *risk perception at the production stage*, *meat consumption*, *age*, *gender* and the constructs described in the method section (see Table 1). All of these variables with *meat consumption* as the dependent variable were later used to perform a multiple regression analysis to measure their predictive influence, as described in the introduction section. *Risk perception at the production stage* was highly correlated with *risk perception at home* ($r = .60, p < .001$), meaning that some people always perceive more risk and some people always perceive less risk for both stages. *Risk perception at the production stage* was correlated with *concerns about animal welfare* ($r = .35, p < .001$), meaning that people's animal welfare considerations are associated with risk perception at the production stage. Both *risk perception at the production stage* and *risk perception at home* were associated with *benefits* ($r = -.26, p < .001$ and $r = -.18, p < .001$, respectively), meaning that people's benefits and pleasure perceptions through meat consumption are associated with less risk perception in the total meat supply chain.

Table 3. Correlation matrix for all variables included in the multiple regression analysis

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Meat consumption	-									
2. Gender	.22***	-								
3. Age	-.04	.16***	-							
4. Risk perception at the production stage	-.22***	-.09**	.01	-						
5. Risk perception at home	-.08**	-.03	-.08**	.60***	-					
6. Benefits	.34***	.11***	.03	-.26***	-.18***	-				
7. Quality importance	-.35***	-.17***	.09**	.12***	.07*	-.11**	-			
8. Subjective knowledge	.10**	.02	.13***	-.19***	-.13***	.23***	.10**	-		
9. Concerns about animal welfare	-.31***	-.19***	.02	.35***	.11**	-.24***	.32***	-.09**	-	
10. Importance of origin	-.25***	-.19***	.05	.17***	.04	.02	.54***	.17***	.47***	-

Note. = 931. *** $p < .001$. ** $p < .01$. * $p < .05$. Coding for gender: 0 = female, 1 = male.

3.3 The Influence of Safety Perception on Meat Consumption

A multiple regression analysis was performed with people's meat consumption as the dependant variable. We included safety perception as two separate constructs in our analyses, as the principal component analysis yielded two separate factors for food-safety perception (i.e. risk perception at the production stage and risk perception at home) (see Table 2). We were primarily interested in whether risk perception at the production stage and risk perception at home, separately, were important predictors of people's meat consumption next to sociodemographic variables and other important variables that were associated with meat consumption in the past during no major food scares. The analysis showed that the predictor variables were significantly associated with people's meat consumption ($F(9, 921) = 35.99, p < .001$). Table 4 shows the results of the multiple regression analysis. Including all variables in the multiple regression analysis, "benefit perceptions" was the most important predictor of people's meat consumption. The more people were convinced about the importance of meat to their health and well-being, the more they actually consumed meat. "Quality importance" was another important construct for people's meat consumption; the more people cared about quality, the less meat they consumed. Gender was also significant, in that men consumed more meat than women. "Subjective knowledge" and "concerns about animal welfare" were additional significant constructs, in that people with more subjective knowledge consumed more meat, and people that were more concerned about animal welfare consumed less meat. Finally, "risk perception at the production stage" was a significant predictor of people's meat consumption, whereas people's "risk perception at home" was not. Therefore, people who perceived more risk at the production stage consumed less meat than people who perceived less risk at the production stage. However, although significant, risk perception at the production stage only explained a small part of the overall variance. In total, the included variables explained 26% of the total variance.

Table 4. Predictors of self-reported meat-consumption behaviour

	B	SE B	β
Constant	3.51	.21	
Benefits	.21	.03	.25***
Quality importance	-.16	.02	-.24***
Gender ^a	.20	.05	.12***
Risk perception at the production stage	-.07	.03	-.09*
Concerns about animal welfare	-.08	.03	-.09*
Subjective knowledge	.05	.02	.06*
Risk perception at home	.04	.02	.06
Importance of origin	-.03	.03	-.05
Age	-.00	.00	-.04

^a Coding for gender: 0 = female, 1 = male.

Note. $R^2 = .26$. $N = 931$. *** $p < .001$. * $p < .05$.

4 Discussion

We found people to perceive risk in all single stages of the total meat supply chain to a greater or lesser extent. However, we found a clear separation of people's risk perception at home and people's risk perception at the production stage, such that people perceive more risk at the production stage than at home. This result provides several implications for strategies aimed at ensuring food safety. First, it highlights that this difference between people's risk perception at home versus people's risk perception at the production stage is a very stable effect, as it has been repeatedly found in previous research (Fife-Schaw & Rowe, 2000; Verbeke, et al., 2006) and it could be replicated even in the non-scare food situation of the present study. Additionally, it is also a very strong effect, as shown by the rather high effect size calculated in the present study. This difference between risk perception at home and risk perception at the production stage has been explained in the past by the fact that fright increases when the problem is perceived as uncontrollable (i.e. it cannot be avoided or eliminated through personal precautions like careful cooking, which is the case with BSE or dioxin though not with most microbiological contaminants such as Salmonella and Campylobacter) (Verbeke, et al., 2006). Looking at the factor loadings in Table 2, one can see that the last item of

the *risk perception at the production stage* scale, item M, although loading higher on this first factor, is also loading high on the second factor, i.e. *risk perception at home*. This can be explained by the fact that this stage is closest to the *risk perception at home* scale, therefore being very close to one's personal control stages. Furthermore, people think that information about risk reduction is directed towards other people who they believe are at a higher risk of being exposed to the hazard, who have less control over their personal exposure to the associated risks and who possess less knowledge regarding self-protective behaviours (Verbeke, et al., 2006). This phenomenon, known as "optimistic bias", was found for risk perception with respect to food-related hazards (Sparks & Shepherd, 1994). Such optimistic biases in personal risk perceptions are crucial as they might inhibit risk-reducing behaviours (Weinstein, 1989). Unfortunately, optimistic bias is also fully resistant to health education and risk communication (Verbeke, et al., 2006), as people who believe they are not or less prone than others, might be less convincible to adopt precautionary measures (Weinstein, 1989). This is additionally emphasised through the fact that consumers consider themselves informed about food safety (Bruhn & Schutz, 1999). These results are especially alarming, as most foodborne illnesses are due to the obvious mishandling of foods (Sofos, 2008). Experts on foodborne diseases estimate that most cases of foodborne illness originate from foods prepared at home (Fein, Lin, & Levy, 1995; Redmond & Griffith, 2003). Moreover, foodborne diseases are one of the most widespread health problems (Motarjemi & Kaferstein, 1997). A review of food-safety studies (Redmond & Griffith, 2003) found inadequate food-handling practices observed during consumer meal-preparation sessions for 1) undercooking, 2) improper cooling, 3) room temperature storage for leftovers, 4) inadequate hand washing and drying and 5) actions that increased cross-contamination in several studies performed in the UK, in Australia and in the USA. Therefore, consumer education should be a major target to improve meat and food safety (Sofos, 2008), as people perceive too little risk in an area in which they should perceive more risk. However, we also found individual differences, as we found a strong correlation between *risk perception at home* and *risk perception at the production stage*, meaning that some people generally perceive more risk in the total meat supply chain than others.

Another finding of the present study provides insight into the effect of food-safety perceptions on people's meat consumption in a non-scary food situation. Results show that next to previously detected important variables influencing meat consumption, risk perception of food safety is not a crucial variable affecting people's decisions about meat consumption. Although *risk perception at the production stage* was found

to be significant, meaning that people perceiving more risk related to food safety at the production stage consumed less meat than people perceiving less risk related to food safety at the production stage, the effect does not explain a relevant part of the variance. *Benefits* and *quality importance* play the most critical role concerning people's meat consumption. People who clearly perceive more benefits for their health and garner more eating enjoyment through the consumption of meat also consume more meat. The finding that *risk perception* was not a very significant factor for people's meat consumption behaviour, whereas *benefits* was a very significant predictor of people's meat consumption could be explained by past research done on nanotechnology food and genetically modified (GM) food. Those findings indicate that people's willingness to buy nanotechnology food and packaging products is strongly influenced by perceived benefits and weakly influenced by perceived risks (Stampfli, Siegrist, & Kastenholz, 2010). Moreover, for the acceptance of GM food technology, perceived benefits were more important than perceived risks (Siegrist, 2000). This interpretation is further supported by the strong correlations found between *risk perception at the production stage* and *benefits* and *risk perception at home* and *benefits*. In the regression analysis, we found that men consumed more meat than women, which is also in line with past research (Yen, et al., 2008). Subjective knowledge was another significant variable in our model. Thus, people who think that they possess enough knowledge about meat in general eat more meat than people who perceive that they know little about the subject. However, we have to be aware that this is a pure self-estimation and not an objective measurement.

Our finding that *concerns about animal welfare* affect people's meat consumption goes along with the suggestion that increased doubt related to animal welfare could be a sign of possible future behavioural changes in consumers (Issanchou, 1996; Verbeke & Viaene, 2000). Following this line of argumentation, the association of *quality importance* with low meat consumption could be another sign of the proposed future trend that meat quality is increasingly inferred from information about the meat and not only the meat itself (Grunert, 2006). Subsequently, we found *concerns about animal welfare* to correlate with *quality importance* and *importance of origin* and found *quality importance* to correlate with *importance of origin*. These correlations could be interpreted as additional confirmation of the aforementioned proposed future trend (Grunert, 2006) that people use not only the meat itself for their quality judgments, but also information about the origin of the meat and the fair treatment of the animals. Additionally, *concerns about animal welfare* were correlated with *risk perception at the production stage*, *risk perception at home* and with meat consumption.

Therefore, people with more concerns about animal welfare also had higher food safety perceptions and consumed less meat. This result should encourage producers to incorporate high animal welfare standards in their production processes, label them accordingly and make them traceable for the public.

4.1 Marketing and Policy Implications

Traceability, labelling and public involvement in risk management decision-making are selected noteworthy examples of strategies aimed at restoring consumer confidence (Verbeke, et al., 2007). Altogether, effective communication about food risks and safety is influenced by the extent to which people perceive the source to be trustworthy (Rohr, Luddecke, Drusch, Muller, & von Alvensleben, 2005). Therefore, measures of trust in institutions associated with the regulation and marketing of food influence individuals' risk assessments associated with food and agriculture (Kjaernes, 2006; Veeman & Li, 2006). In the current era of information overload, consumers receive inconsistent signals concerning the nutritional qualities and safety characteristics of food (Verbeke & Viaene, 2000). Therefore, it is important that not only producers, but also retailers and regulatory bodies communicate their food-safety efforts (e.g. through the use of labels) (Verbeke, et al., 2007), as food-safety issues affect all stages of the food chain. Vanderlinde (2000) states that foodborne outbreaks are not contained within a single link in the food supply chain. Thus, food safety has become the responsibility of all sections within this continuum (Attenborough & Matthews, 2000). Therefore, management of meat-safety risks should rely on a holistic approach that applies to all sectors, from the producer through to the processor, distributor, packer, retailer, food-service worker and consumer (Sofos, 2008). An integrated approach allows 1) the establishment of specifications for those in the manufacturing sector, 2) the identification of critical control points in the food-safety systems and 3) the establishment of traceability (Stringer, et al., 2007). Looking at the means of the different stages within the factor *risk perception at the production stage* of the total meat supply chain, we can see that people perceive the most risks related to *animal feed* and the *addition of supplements*. Therefore, people responsible for those stages of the food chain should pay particular attention to ensuring (and, accordingly, communicating) food safety.

Our study found that food-safety perceptions do not significantly affect people's meat consumption in normal food situations (i.e. when no major food scare is present). In the past, people were found to change their meat-consumption behaviours during

major food scares, and some of them even changed them in the longer term (Burton & Young, 1997; Verbeke, et al., 1999). However, people do not use food-safety considerations for their daily meat-consumption decisions. As has been demonstrated in the past, this situation can change in an instant, as almost without exception, former real or perceived food-safety problems reached into food scares after substantial mass media coverage (Verbeke, et al., 2006). Moreover, all stakeholders associated with the meat supply chain need to be aware that food safety has become a hot topic in the mass media due to past food crises (Raspor, 2008; Rohr, et al., 2005). Media coverage plays an important role in people's food-risk perceptions following a major food scare, as media perspectives on the safety of the food supply might have an impact on those of the general public (Seward, 2003). Consequently, a food perceived or reported to be unsafe, the story can be amplified in the press and then validated in the public mind. This process is called the social amplification of risk (Kasperson, et al., 1988). Media triggers can cause food-safety risks to evolve from a problem into a crisis, which is why it is important to investigate subjective food-safety perception and not objective risk perception (Verbeke, et al., 2006), as has been done in the present research.

4.2 Limitations and Future Research

This study aimed to explore the effect of food-risk perceptions in the total meat supply chain by investigating a randomly selected sample from the general population. Therefore, the sample was limited to people who were presumably moderately interested and involved in the topic. Additionally, people only indicated their self-reported behaviour, which reflects their perceptions of their own behaviour rather than actual behaviour. However, as we were also especially interested in people's subjective assessments, we believe that the present research produced meaningful results. Another limitation is that we only investigated cross-sectional data. However, it is important to employ long-term research, as a limitation of cross-sectional research in general is that no inferences can be made with respect to the generalizability of the results (MacCallum & Austin, 2000). Therefore, a deeper understanding of the causality of the relationships might be provided by studying changes in consumer confidence in the safety of food and its determinants over time (de Jonge, et al., 2007). Change occurs for a person upon experience and, for a given population, over time (Issanchou, 1996). Holm and Kildevang (1996) point out that concerns about food are based on worries not only about health but also about agriculture, ecology and food culture. This relation of food quality

to wider political and societal perspectives induce that such broader issues should be included in a realistic contemporary concept of food quality. However, such developing trends can only be observed using a longitudinal framework. Additionally, it might be interesting to investigate the present research in an experimental setting. An experiment could shed more light on the question of how much and what kind of information is needed in order to enable citizens to come to more appropriate risk-perception ratings at home. Additionally, it is important that those experiments investigate actual behaviour and not only self-reported behaviour. Observational studies obtain a more realistic indication of the food-hygiene actions effectively utilised in domestic food preparation (Redmond & Griffith, 2003). Moreover, environmental factors (e.g. economic, cultural and marketing factors) have been proposed to be important for affecting food acceptance and behaviour next to person-related factors (e.g. biological, psychological and sociodemographic factors) and the properties of the food (e.g. physiological and sensory effects) (Steenkamp, 1997). Such environmental factors can be better investigated in experimental settings. Another variable that might have increased the explained variance of the present regression model, is people's meat consumption habits, as they have been found to play a crucial role in people's meat-consumption decisions (Saba & Di Natale, 1999).

4.3 Conclusion

Overall, our findings suggest that people differ significantly in their risk perception depending on the specific stages of the meat supply chain, meaning that people differ in their risk perception at home versus their risk perception at the production stage. Past literature suggests that this difference is produced by subjective consumer perceptions (Verbeke, et al., 2006). Using consumer-perspective approaches is important, as understanding consumer behaviour is essential to accomplishing the appropriate managerial and marketing decisions, including strategic choices regarding risk management, risk assessment and risk communication (Verbeke, et al., 2006). Moreover, there are also differences between people, in that some people perceive more risk over all stages of the total meat supply chain than other people. Although people's considerations about food-safety perceptions did not affect their decisions to consume meat, they indicated that they perceived risk to a greater or lesser extent in the total food chain. Consequently, the assurance of food safety should be a continuous request of regulatory bodies and all other affected stakeholders.

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Chapter VI

General discussion

1 Introduction

The present research investigated people's perceptions of health- and food-related risks. The majority of the hazards examined in the current work are not constantly present. Animal epidemics and zoonoses emerge irregularly; the same is true for major food safety crises. This situation is slightly different for vaccinations. Although there is always the possibility that the diseases vaccinations prevent could occur, most of those diseases have not recently occurred in Switzerland—some even for decades (e.g. poliomyelitis, diphtheria). Therefore, they are not currently on the minds of the general population. Previous research showed that the public tends to perceive risks differently from experts (Slovic, 1987). Moreover, various dynamic social processes lead the public to worry about risks that are assessed as low by experts (risk amplification), but make them disregard risks that experts judge as more serious (risk attenuation) (Kasperson, Kasperson, Pidgeon, & Slovic, 2003). As people's perceptions of hazards play an important role in the implementation of strategies in crisis situations, it is important to identify the factors that are associated with these perceptions, and it is essential to investigate how those perceptions are related to people's decisions. If a vast proportion of the Swiss population refused to consume meat, a grave crisis for the whole agricultural industry could ensue, as happened with the BSE crisis in Great Britain (Burton & Young, 1997). From a public health perspective, if people refused vaccinations and, therefore, endangered herd immunity (Bundesamt für Gesundheit, 2010), devastating effects for the public health of a whole nation could result.

Therefore, the aim of the present thesis was to investigate the factors that are associated with people's risk perceptions and to examine how risk perception is related to people's decisions. Moreover, the results of the studies done with the public were related to those done with experts' assessments to see how they diverged. In this thesis, we used a multi-method approach to assess people's intuitive understanding of epidemic and food crisis situations as well as their understanding of vaccination. First, qualitative interviews identified the prevalent mental concepts and related them to the experts' situation descriptions (see General introduction). Subsequently, quantitative studies (Chapter II, Chapter IV and Chapter V) were performed in order to investigate a representative sample so that generalizable results could be drawn. Accordingly, in the end, all public perceptions were directly related to experts' risk assessments, either by a direct comparison of statements by experts and lay people (Chapter III) or through the use of scientific literature comparing the two groups (Chapter IV and Chapter V).

The discussion sections of the particular chapters or research papers already provide the reader with interpretations of the main results. However, to be able to holistically discuss the results of all four studies, the aim of this general discussion section is, initially, to give an overview of the central findings, which simplifies an integration of the discussion sections of all chapters. Further, limitations of the present studies and implications for future research will be addressed. Consequences for risk communication and implementations for decision-making strategies from the present research will then allow general conclusions to be drawn from the thesis as a whole.

2 Central findings

2.1 People draw different conclusions, depending on their assigned role

People's risk perceptions and acceptances concerning animal epidemics were measured using a variety of approaches. On one side, we asked people to indicate their acceptance of different strategies to fight highly contagious animal diseases that are possibly hazardous for human beings, such as the avian flu (Chapter III). On the other side, we asked them to indicate their risk perceptions and their acceptance of various animal treatments for human health through the consumption of animal products, such as antibiotics and hormones, next to vaccinations, to be able to estimate future public debates concerning animal vaccinations (Chapter II). Additionally, we asked people to indicate their willingness to consume meat from animals vaccinated against pure animal epidemics and zoonoses (Chapter II). A vaccination strategy was much more accepted than culling strategies to fight zoonoses. Also, we found that animal vaccinations were much more accepted and had much lower risk perception ratings than most of the other animal treatments. However, we found that only about a quarter of all people indicated that they would consume meat from animals vaccinated against a pure animal epidemic or a zoonosis. To get a deeper understanding of why people would refuse to consume meat from animals vaccinated against a zoonosis, we performed two regression analyses yielding that 'attitudes about animal vaccination', 'knowledge about human vaccination', 'misconceptions about animal treatments' and 'average meat consumption' significantly influenced people's willingness to consume meat from vaccinated animals. As 'knowledge about human vaccination' and 'misconceptions about animal treatments' were important factors for people's willingness to consume meat from vaccinated animals, knowledge seems to be an important factor.

Taken together, the above results suggest that people draw different conclusions depending on the framing of the hazard. This distinction between the roles of individuals as consumers and as citizens was formulated by Grunert (2006). He stated that people might hold views about various forms of meat production as citizens. However, these views may be only faintly reflected in their behaviour as consumers. Therefore, people can be critical about the consumption of meat from vaccinated animals but still highly value the use of vaccinations as a strategy for preventing animal diseases. To make an informed decision, people need to be aware of the fact that a vaccinating strategy to prevent an animal epidemic or a zoonosis later on means that meat from those vaccinated animals will end up in grocery stores. Depending on the specific animal vaccination, i.e. against an animal epidemic or a zoonosis, people vary in their willingness to consume meat from those animals. The public perceives different animal vaccinations unequally, as was shown for vaccinations against pure animal epidemics versus zoonoses. For zoonotic situations, i.e. situations that might adversely affect human health, it is important for regulatory bodies to not only secure food safety but to additionally provide consumers with information about how one might prevent oneself from being affected by a zoonotic disease.

2.2 There is no support for the ‘knowledgeable support hypothesis’

Chapter III demonstrates that veterinarians, farmers and the general population differ in their acceptance ratings of different strategies to fight zoonoses, and in their risk perception ratings of different animal treatments concerning their affect on human health through meat consumption. Although farmers were considered to be experts on the present subject, we found farmers’ response patterns to be more closely related to those of the general population than to those of veterinarians. Overall, the public perceived the most risks and had the lowest acceptance ratings, which is in line with previous research (Sjöberg, Frewer, Prades, & Truedsson, 2000).

In the past, men were often described to be more knowledgeable concerning risk-related issues, which is why they were often found to be less concerned about risk in general (Davidson & Freudenburg, 1996). As we found the same differences among lay people and experts, i.e. veterinarians, the ‘knowledgeable support hypothesis’ (Davidson & Freudenburg, 1996) can be disregarded. More knowledge cannot explain the differences between male and female experts. There remain gender differences

even in areas where men and women have the very same knowledge, competencies and involvement.

Eccles (1987) suggests gender differences whenever men and women hold different expectations and values. Therefore, we conducted gender comparisons for lay people and experts' attitudes and values in zoonotic situations. Women in both the lay people and expert groups generally cared more about the manner in which animals would be culled than the fact that they would be culled. Secondly, women cared more about the higher detriments for little farms compared to large factories. Thirdly, women agreed more than men to the statement that animals have the same right to live as human beings. This difference between men and women might explain the fact that women accepted the two culling strategies less readily than men, as they obviously have low agreement on the manner in which animals are culled in epidemic situations. Examining the three attitude questions, one can see that, overall, both lay people and experts have positive attitudes toward animal vaccination. This might reflect the low risk perception for animal vaccinations compared to the other animal treatments and the very high acceptance ratings of the vaccinating strategy to fight animal epidemics in both groups. A strategy to fight animal epidemics should, therefore, not only include considerations about the most effective strategy, but also ethical aspects about the handling of animals during an outbreak and animal welfare in general, as those aspects are especially important to the female population. Those aspects should not only be incorporated into the decision-making processes but also communicated to the public.

2.3 People have little knowledge and many misconceptions about vaccinations

People with knowledge about the impact and consequences of vaccinating, as well as a certain understanding about the relationship between vaccinating and the immune system, decide more often to vaccinate themselves and their children against recommended diseases than people without such knowledge and people with misconceptions about those mechanisms. We can conclude from our results that misconceptions are widespread among the public, which could be seen on the results showing that people not giving the right answer to a knowledge question sometimes answered with 'do not know' but also very often with 'no' or 'yes', therefore, often convincingly giving an incorrect answer.

This deficit, found in Chapter IV, might be a consequence of the fact that many people think that vaccinating is not important because a disease is no longer prevalent (Gellin, Maibach, & Marcuse, 2000) and they have never experienced it. Additionally, there are new media forms, such as the Internet, that people may use to search for information. On the Internet, anyone can upload his or her opinion on a specific subject, uncontrolled by authority (Clements, Evans, Dittman, & Reeler, 1999). Therefore, people searching for information are overloaded with vast quantities of information and different opinions about vaccinating (Kata, 2010; Lewis, et al., 1988; Robert Koch Institut & Paul Ehrlich Institut, 2007). Linked with the often expressed statement that people have limited time to ask their physicians questions during their visits (Petts & Niemeyer, 2004), this is a precarious development.

We think that relevant knowledge, which also includes the possible side effects of vaccinations, would assist parents with 'informed decision making'. A study by Downs, de Bruin and Fischhoff (2008) found that knowledge about vaccination is important for informed decision making; however, they only conducted qualitative interviews. Our studies allowed us to quantify those results. Informed decision making was not only influenced by people's knowledge but also by the detection and correction of people's misconceptions (Downs, et al., 2008). One conclusion that could not be drawn from our studies is whether knowledge transfer changes people's decisions concerning vaccination for themselves and their children. This means that we do not know if people who become more knowledgeable about vaccination, and whose misconceptions are resolved, will change their decisions to vaccinate themselves and/or their children. There are several other factors that might be important for people's vaccination decisions, such as trust (Serpell & Green, 2006) and affect (Betsch, Renkewitz, Betsch, & Ulshofer, 2010). However, the advantages of a universal knowledge scale can be used not only among different vaccinations but also among people's decisions concerning vaccinating themselves and their children. Another advantage of the present knowledge scale is the fact that it is much more efficient to provide the public with general knowledge instead of specific knowledge about every single vaccination to help them make informed decisions. Moreover, a general knowledge scale will help track the changes in people's knowledge and misconceptions over time and under the influence of different information sources and new media forms.

2.4 People perceive too little risk in areas where they should perceive more

There was a strong difference between people's risk perceptions at home, e.g. processing (hygiene, cooking, heating), and people's risk perception at the production stage, e.g. addition of supplements (dyestuffs, flavour enhancers), although we also found differences within those two separate factors. This result can be explained by the fact that fright increases when the problem is perceived as inevitable (Verbeke, Scholderer, & Frewer, 2006). Previous research results (FifeSchaw & Rowe, 2000) imply that people generally are more likely to worry about risks caused by external factors over which they have no control, while being much less concerned about personal factors or factors linked to their own behaviour. This result related to food was already found for technology-based risk, as self-imposed risk was found to be more acceptable to consumers than technology-based risk (Grunert, 2005). Thus, although meal preparation at home is objectively much riskier than meal production in a factory, consumers perceive ready-made meals as more dangerous than meals they cook themselves. Moreover, this perceived risk is amplified when new and unknown technologies are used. Furthermore, although consumers usually appreciate risks associated with their own handling of food, they believe that the probability of being affected themselves by a problem is lower than the probability of the average consumer being hit by the same problem. This phenomenon is known as 'optimistic bias' (Weinstein, 1989). Overall, in the food risks area, optimistic biases are much greater for food poisoning contracted in the home, for example, compared to technologies applied to food production (Verbeke, Frewer, Scholderer, & De Brabander, 2007).

Experts estimate that most cases of food-borne illness originate from foods prepared at home (Fein, Lin, & Levy, 1995; Redmond & Griffith, 2003). Epidemiological data from Europe, North America, Australia, and New Zealand indicate that a substantial proportion of food-borne diseases are ascribable to improper food preparation practices in consumers' homes (Redmond & Griffith, 2003). Over the last decade, up to 87% of reported food-borne disease outbreaks in the United Kingdom, Europe, Australia, New Zealand, the United States and Canada have been associated with food prepared or consumed in the home. Those findings illustrate how the public perceives little risk in areas where it should perceive more risk. Additionally, the results of the present study are in line with the results of Chapter III, stating that the general public perceives risks differently than the experts.

3 Limitations and future research

The present research investigated the influence of many factors that are associated with risk perception and the interaction of risk perception with people's decisions. As stated at the very beginning of the General discussion, for the hazards in Chapter II, Chapter III and Chapter V, we performed the studies when those risks were *not* present. Therefore, our results provide an important insight into what could be possible factors for major hazards; certain decision tendencies of various population groups could be detected. However, this does not provide a final estimation of how people would behave in an acute hazard situation. Past research has often pointed to this divergence in self-reported and actual behaviour (Redmond & Griffith, 2003). Self-reported behaviour can also lead to over- or underreporting, which is partly due to social desirability. Moreover, our participants were forced to make decisions that they might never have had to think about before, which is why they had to build some of their preferences. Although it would be useful to have data on how people react in such major crises, let us hope there is no such incident in the near future.

This absence of disease was detected as one of the major problems of why people are reluctant to get themselves and their children vaccinated (Gellin, et al., 2000). This circumstance was followed by a shift toward more concern about the vaccination and its side effects than fear of the actual disease. Herd immunity cannot be provided if too few people are vaccinated against a certain disease and the risk of exterminated diseases to re-emerge will become an actual hazard. This is why more knowledge and fewer misconceptions seem to be important for people to base their decisions on complete fundamentals. Therefore, future research should directly investigate how more knowledge influences people's decisions to vaccinate. Here, one should add that it will be useful for future studies to differentiate between knowledge and attitude, as past research has also found educated people to be against vaccination (Maayan-Metzger, Kedem-Friedrich, & Kuint, 2005), which might indicate that for the present topic both constructs are very influential. Therefore, it might be useful to see how both attitudes and knowledge influence people's decisions and how those three factors interact. Another interesting approach would also be to see whether parents actively opt in or out of the decisions, and to look at the current state of the art in practices, as the omission versus action bias is very important for vaccination decisions (Meszaros, et al., 1996; Wroe, Bhan, Salkovskis, & Bedford, 2005). The omission bias was also found to be associated with regret (Ritov & Baron, 1995). Therefore, the inclusion of specific emotions (Chapman & Coups, 2006) or affect (Betsch, et al., 2010; Loewenstein, Weber, Hsee, &

Welch, 2001) should be included into further research, to investigate the interrelationship between risk perception, knowledge, attitudes, affect and the actual behaviour. Although our study in Chapter IV was very closely to actual behaviour, future studies should give even more priority to the recent claim that social psychological studies lack the investigation of actual behaviour (Baumeister, Vohs, & Funder, 2007). Moreover, for risk communication to be effective, future research should also track people's perceptions and decisions, as they might change over time. Therefore, long-term data should be another approach to be followed by future studies. The development of a general knowledge scale is a useful tool for this requirement, especially in light of the recent appearance of new media forms.

In Chapter III, we found gender differences in the lay people and expert samples. Therefore, future research in the risk perception area should not only focus on differences between lay people and experts but also on the differences within these groups. More research is needed to explain gender effects. Although research has been conducted (Eccles, 1987; Finucane, Slovic, Mertz, Flynn, & Satterfield, 2000), none of the studies experimentally investigated that relationship. Here, one could manipulate the values and investigate the effects. We do consider that value differences are responsible; however, social desirability could also explain part of the variance. Additionally, it would be useful to examine inter-individual differences, as we also found differences within the samples for the study in Chapter V, i.e. a high correlation between risk perception at the production stage and risk perceptions at home—meaning that there were people within the sample that perceived more risk overall. Other researchers have already indicated the importance of individual differences in risk perception (Siegrist, Keller, & Kiers, 2006).

4 Implications for risk communication

In order to develop successful communication strategies concerning health- and food-related hazards, it is important to understand people's risk perceptions. The results of the present research are an important foundation for the development of strategies to optimize communication materials. The need to inform people underlies the concept of informed decision making. An informed decision is one where a rational choice is made by a reasonable individual using relevant information about the advantages and disadvantages of all the possible courses of action, aligning with the individual's beliefs (Bekker, et al., 1999). Therefore, people's mental models of the topic are essential for

the specific information materials, the basis of which people will use to design informed decisions.

Chapter II indicates that people arrive at different conclusions depending on the role they will be addressed. In their roles as reasonable citizens, people perceive a vaccination strategy as an ethical way to fight highly contagious animal diseases if the alternative is a culling strategy. However, as consumers, they are unwilling to accept meat from animals vaccinated against an animal epidemic or a zoonosis. As people who were unwilling to consume meat from vaccinated animals also had rather high values on the concerns about animal welfare scale, considerations of the fact that animals only need to be vaccinated because of large-scale farming might play a role. Future research should focus on this specific aspect. This result was additionally supported by the study in Chapter V, as we found that people also indicated concerns about animal welfare to be important for their meat consumption decisions. Concerns about animal welfare were associated with the 'importance of origin' and 'quality importance' and were additionally associated with 'risk perception at the production stage'. Therefore, risk communication in food-related areas should be highly sensitive to the topic of animal welfare, which also supports findings from past research (Issanchou, 1996; Verbeke & Viaene, 1999; Verbeke & Viaene, 2000). A mental model approach would be useful for the investigation of people's conceptions about animal welfare and in a broader perspective, people's knowledge and beliefs regarding the total meat supply chain and its production processes would give further insight into possible future public reactions concerning major food scandals related to meat. Certain changes have already taken place, with people changing their meat consumption behaviour even in long-term perspectives (Burton & Young, 1997; Verbeke, Van Oeckel, Warnants, Viaene, & Boucque, 1999). For the agriculture sector to be continuously successful, such concerns are essential and should, therefore, be implemented into their production processes and marketing efforts.

In addition, the so-called amplification of risk (Kasperson, et al., 1988) is important in major food crises (Seward, 2003; Verbeke, et al., 2006). This framework describes how some incidents become major issues in the media and, consequently, in public debate, and how others are not considered with the same intention and, therefore, do not become a major public scare. This effect has often been found regarding food scares; regulatory bodies should be aware of the fact that, especially in today's world of rapid social media tools such as Twitter, they need to communicate quick. Therefore, the communication bodies for public health should already inform the public during non-scare situations, but at least have the information campaigns available in a form

that makes them promptly usable for public communication in emergency situations, such as major food scares.

Chapter III of the present work underlines the fact that experts differ in their risk assessments, as we found gender effects among experts, which were as strong as those among the general population. This also indicates that the current state of the art for risk assessments of health- and food-related hazards is a reflection of the average expert opinion. Although female experts still perceive less risk, on average, than males in the general population, this difference is not as strong as for male experts and males in the general population. Therefore, female experts base their professional decisions on different aspects than male experts and it would be of interest for future studies to investigate the variables that influence those differences. Some of our findings support the suggestions of other researchers that women possess different expectations and values (Eccles, 1987), therefore, the explanations of this effect should be searched in the social and political fabric of our society (Slovic, 1999). Whatever the differences between male and female risk perceptions is, the present research highlights the fact that the inclusion of female experts may lead to other estimations of a problem and that this will more closely represent the overall population demand. This differentiation within samples also highlights the individual differences (see Chapter III and Chapter V). Therefore, risk communication strategies should target information to specific groups, as there obviously are noteworthy differences within the investigated samples that should be carefully attended.

Investigation into people's conceptions about vaccinations has already been performed (Downs, et al., 2008). Therefore, we already know that people have many misconceptions about vaccination. This circumstance could be quantified with both of the studies from Chapter IV. Whereas people have a great deal of knowledge regarding certain aspects, such as the efficacy of vaccinations, they lack information in other areas, such as how the immune system works. Therefore, the implementation of an information campaign seems to be needed. Moreover, a claim to future public health communication efforts also is that they are evidence based (Betsch, 2011). This requires not only medical researchers and public health actors but also communication science and psychology to be involved. Especially noteworthy is the fact that it should be avoided to create new misconceptions. As outlined before, the fact that diseases prevented by vaccinations no longer serve as a reminder (Gellin, et al., 2000), complicates the implementation of communication campaigns, as people might not appreciate the urgency of the topic. To eradicate certain diseases, such as pertussis and measles, a vaccination rate of at least 92–95% of the population is required (Bundesamt für

Gesundheit, 2010). Vaccination is not a self-seller; therefore, the public needs to be constantly reminded of this circumstance to be able to draw informed decisions. However, it should be clear that according to people's limited cognitive capacity, the information approach should be chosen in a way that it does not overload people with too many information. The use of general information about vaccination, as has been done in Chapter IV, is therefore a useful approach to meet those requirements.

Further, the importance of trust for risk communication has been recognized (Slovic, 1993), however, past research also showed that besides the credibility of the source, the message itself also influences the evoked level of trust, meaning that communications about potential health risks are more trusted than communications that inform people not to worry (Siegrist & Cvetkovich, 2001). This is another indicator next to the request of informed decision making that people should also be delivered with information about possible side effects. Past studies indicated that, although parents see doctors as trustworthy information sources, hectic practices limit the time for information exchange between doctors and patients (McMurray, et al., 2004). This factor might force people to use the Internet as a source of information (Downs, et al., 2008). However, the Internet is a conglomerate of non-reviewed information (Clements, et al., 1999). Therefore, the Internet does not control for reliable information concerning vaccination. In addition, the appearance of new media should not be underestimated, which is why vaccination campaigns should be a constant pursuit and responsible institutions should also use new social media for their own communication, as previous communication channels might not be fast enough in the future.

5 General conclusion

In the domain of risk psychology, it has been shown that people perceive risks differently compared to experts' estimations (Slovic, 1987). Although we found the results of our studies to be in line with this research, we also found strong differences within those two groups—there were gender effects for both samples. Additionally, we found that the perceptions of the general public differed depending on the roles people were addressed. When considering the present subject of health- and food-related hazards, one should be sensitive not only to inter-individual differences, but also to how an issue is framed, as this results in people coming to different conclusions.

Risk perception and knowledge were found to significantly be associated with people's decision making under risk. Providing people with more information and miti-

gating their misconceptions should make them act more according to informed consent. When people have little obvious knowledge, they may have many misconceptions and perceive fewer risks in areas in which they should perceive more. Therefore, providing people with more information is also an ethical step, as it allows them to base their decisions on more solid foundation. The challenge is that some potentially risky situations appear non-threatening during normal periods. This makes it difficult for information campaigns to make an impact on audiences. Additionally, during major crises, people also use other aspects for their decisions, such as affect (Loewenstein, et al., 2001), which is difficult to investigate during non-scare situations.

The present work found huge differences within one single food-risk area (see Chapter V), which highlights the importance of clearly investigating risks in detail. The need for consumer perspective investigations prevails, as the perceptions of the general public differ from those of experts. The need for a deeper understanding of why lay people perceive risks differently from experts and how the environment can be shaped or information delivered to enable the public to make informed decisions were the conclusions indicated by the results of this thesis.

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Summary

The general public is said to perceive risk in domains where it should perceive less risk according to probability, whereas it perceives too much risk in domains where only mere possibilities exist, leaving it exposed to real danger in the end. The aim of the present work is to investigate which factors are associated with public risk perception, and further, how risk perception is related to people's decisions. The present work investigates risk perception in health- and food-related risk areas. The identification of the factors that are associated with people's risk perception is important in developing risk communication in a way that makes the information usable so that people can make informed decisions.

Several studies were performed to identify the factors that are associated with people's risk perception and the influence that risk perception had on their decisions. Chapter I introduces the research domain of the present thesis and the current state of research, ending with an overview of the research questions. In the first study (Chapter II), people were found to readily accept animal vaccinations as a valuable strategy to prevent disease; however, they were rather unwilling to eat meat from vaccinated animals. This result shows the difference in people's decisions depending on the role they are addressing, i.e. as responsible citizens or consumers. The subsequent study in Chapter III continues the initial subject and finds that the general public differs substantially in its risk perceptions compared to those of experts. Moreover, we found substantial gender effects, not only for the public, but also for the experts, supporting the research that challenges the long-held notion that differences in risk perception between men and women are based upon knowledge. As knowledge is said to be a relevant aspect of people's risk perceptions, Chapter IV investigates the influence of knowledge on people's decision making under risk, examining the public debate concerning vaccination. The general public was found to hold little knowledge and to possess many misconceptions. Overall, people with abundant knowledge and few misconceptions rather decide to vaccinate themselves and their children. Attaching to the initial subject of people's risk perception of animal treatments for human health through consumption of animal products, Chapter V examines people's risk perceptions at each step of the food supply chain. Although experts believe that most cases of food-borne illness originate from foods prepared at home, people perceive significantly less risk at home than at the production stage. The last section (Chapter VI) of the present work integrates and discusses the findings of all studies and addresses possible limitations. The thesis concludes with central implications for research and practice.

Zusammenfassung

Der Öffentlichkeit wird nachgesagt, dass sie in Bereichen, in denen gemäss Wahrscheinlichkeit weniger Risiken wahrgenommen werden sollten, mehr Risiken wahrnimmt, während sie in Bereichen, in denen lediglich die Möglichkeit eines Risikos existiert, viele Risiken wahrnimmt, wodurch sie sich schlussendlich wahren Risiken aussetzt. Die vorliegende Arbeit hat zum Ziel, jene Faktoren zu untersuchen, die mit der öffentlichen Risikowahrnehmung in Bezug stehen, und in einem weiteren Schritt, zu erforschen, inwiefern die Risikowahrnehmung die Entscheidungen der Menschen beeinflusst. Der Untersuchungsgegenstand der vorliegenden Arbeit ist die Risikowahrnehmung in gesundheits- und ernährungsbezogenen Risikobereichen. Die Identifikation der Faktoren, welche mit der Risikowahrnehmung der Menschen in Bezug stehen, ist essentiell, um zu gewährleisten, dass die Risikokommunikation in einer Weise gestaltet wird, dass die Information für die Öffentlichkeit so zugänglich ist, dass sie in den jeweiligen Bereichen fundierte Entscheidungen treffen kann.

Zur Identifikation der Faktoren welche mit der Risikowahrnehmung der Menschen in Bezug stehen und zur Untersuchung des Einflusses der Risikowahrnehmung auf die Entscheidungen der Menschen, wurden mehrere Studien durchgeführt. Kapitel I führt in den Forschungsbereich der vorliegenden Doktorarbeit und den momentanen Stand der Forschung ein, und endet mit einem Überblick der Forschungsfragen dieser Arbeit. In einer ersten Studie (Kapitel II) wurde herausgefunden, dass die Menschen Tierimpfungen als eine wertvolle Strategie zur Vermeidung einer Krankheit erachten, die auf grosse Akzeptanz stösst, hingegen, nahmen sie eher eine ablehnende Haltung ein, wenn es um den Verzehr des Fleisches von geimpften Tieren ging. Dieses Ergebnis zeigte den Unterschied im Entscheidungsverhalten von Menschen in Abhängigkeit von der Rolle, in der sie angesprochen werden, auf, d.h. ob sie als verantwortungsvolle Bürger oder aber als Konsumenten angesprochen werden. Die nachfolgende Studie in Kapitel III schloss an den anfänglichen Untersuchungsgegenstand an und fand, dass die Öffentlichkeit sich in ihrer Risikowahrnehmung substantiell von derjenigen von Experten unterschied. Darüber hinaus zeigten sich sowohl bei der Öffentlichkeit als auch bei den Experten substantielle Geschlechtsunterschiede, was jene Forschung unterstützt, welche die lange Zeit vorherrschende Hypothese, dass die Unterschiede in der Risikowahrnehmung zwischen Männern und Frauen eine Folge von unterschiedlichem Wissen sind, anfechtet. Da Wissen als ein relevanter Aspekt der Risikowahrnehmung bezeichnet wird, untersuchte Kapitel IV den Einfluss von Wissen auf die Risikoentscheidungen der Menschen. Die öffentliche Debatte über das Impfen wurde als Grundlage

der Untersuchung verwendet. Die Ergebnisse zeigten, dass die Öffentlichkeit nicht nur wenig Wissen in Bezug auf das Impfen besitzt, sondern, dass auch viele Missverständnisse vorherrschen. Allgemein entschieden sich Menschen mit viel Wissen und wenig Missverständnissen eher dazu, sich selbst und ihre Kinder impfen zu lassen. Die Thematik der anfänglichen Studie zum wahrgenommenen Risiko von Tierbehandlungen für die menschliche Gesundheit durch das Konsumieren von tierischen Produkten aufgreifend, untersuchte der letzte Teil der vorliegenden Arbeit (Kapitel V) die Risikowahrnehmung der Menschen in Bezug auf jeden einzelnen Schritt der gesamten Lebensmittelkette. Obwohl Experten schätzen, dass die meisten Fälle von Lebensmittelvergiftungen von Nahrung stammen, die zu Hause zubereitet wurde, nehmen die Menschen zu Hause signifikant weniger Risiken wahr als beim Produktionsprozess. Der letzte Abschnitt (Kapitel VI) der vorliegenden Arbeit integriert und diskutiert die Ergebnisse aller Studien und thematisiert allfällige Einschränkungen. Die Doktorarbeit endet mit zentralen Implikationen für Forschung und Praxis.

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Curriculum vitae

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