

# “I’m better than you”: assessing the presence of optimistic bias among Italian hunters

Annafrancesca Corradini,<sup>1</sup> Eugenio Demartini,<sup>1</sup> Roberto Viganò,<sup>2</sup> Maria Elena Marescotti,<sup>1</sup> Anna Gaviglio<sup>1</sup>

<sup>1</sup>Department of Veterinary Medicine and Animal Science (DIVAS), University of Milan, Lodi; <sup>2</sup>Studio Associato AlpVet, Busto Arsizio (VA), Italy

Correspondence: Annafrancesca Corradini, Department of Veterinary Medicine and Animal Science (DIVAS), University of Milan, via dell’Università 6, 26900 Lodi, Italy.  
E-mail: anna.corradini@unimi.it

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Informed consent: this study was explained to consumers in the online questionnaire. Participants gave informed consent via the statement “I am aware that my responses are confidential, and I agree to participate in this survey” where an affirmative reply was required to enter the survey. They were informed that all data will be de-identified and only reported in the aggregate. All participants acknowledged an informed consent statement to participate in the study. They were able to withdraw from the survey at any time without giving a reason.

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## Abstract

According to the latest scientific evidence, consumers appreciate hunted wild game meat (HWGM), but its consumption may expose them to some risks. Hunters produce HWGM, even if they may find it hard to identify themselves as food producers since in Western countries, hunting is practiced mostly as a leisure activity. Thus, hunters may underestimate the risk associated with HWGM handling, failing to preserve its safety during the production process. To test this hypothesis, our study aims to explore the presence of optimistic biases (OB) in a sample of Italian hunters. A sample of 408 hunters was asked to indicate their own risk and the perceived risk of their peers causing a foodborne disease to the final consumer, as well as the practices implemented during the phases of HWGM handling and preparation. Moreover, information about HWGM destinations, hunters’ knowledge of basic principles of food safety, and risk perceptions of HWGM preparation were collected. Our results show that hunters generally tend to perceive themselves as “better than their peers” when performing actions to preserve HWGM safety, especially if the peers are unfamiliar to the respondent. Furthermore, OB correlates knowledge of basic principles of food safety with risk perceptions of HWGM preparation-related practices. Finally, hunters perceived themselves as “nature lovers” and “hunting enthusiasts” and did not recognize their role as food producers. Therefore, our findings emphasize the importance of improving hunters’ training to preserve public health, addressing the need for more targeted strategies able to enhance hunters’ awareness of their role as food producers.

## Introduction

A strain of recent literature reports that segments of European consumers appreciate hunted wild game meat (HWGM) (Corradini *et al.*, 2022). Motivations may be found in the fact that HWGM has an optimal nutritional profile and consumers perceive it as healthy meat that derives directly from animals that live wild in nature (Demartini *et al.*, 2018; Marescotti *et al.*, 2019, 2020), which contributes to the perception of more natural, more respectful of animal welfare, and more sustainable meat when compared to farmed options such as pork and beef (Tolušić *et al.*, 2006; Tomasevic *et al.*, 2018; Fiala *et al.*, 2020; Hartmann and Siegrist, 2020; Marescotti *et al.*, 2021; Demartini *et al.*, 2021).

However, research that focuses on HWGM safety highlights the flipside of the coin, where HWGM consumption may expose consumers to different hazards deriving primarily from toxic metal contamination (Thomas *et al.*, 2020; Nkosi *et al.*, 2021) and/or microbiological agents causing foodborne infections (Di Cola *et al.*, 2021; Gomes-Neves *et al.*, 2021; Guardone *et al.*, 2022). As pointed out by several authors, HWGM hygiene level highly

depends on post-hunting practices implemented by hunters (*i.e.*, Gill, 2007; Paulsen *et al.*, 2012; Gomes-Neves *et al.*, 2021). The role of hunters is therefore crucial throughout the different phases of the production process.

This is regardless of whether such meat is commercialized or self-consumed; the first stages of its production are always in their hands (Ranucci *et al.*, 2021). Soon after the harvest of the game, hunters may perform throat cutting to bleed the animal and evisceration on the field (Gill, 2007). Nevertheless, it must be emphasized that hunters are not professional food handlers. European hunters are mostly portrayed as enthusiastic hobbyists who practice this activity for recreational purposes (Gamborg and Jensen, 2017); thus, the hypothesis that they may find it hard to recognize themselves as fully-fledged food producers seems reasonable.

Noteworthy, hunters' awareness and knowledge of the risks related to HWGM unhygienic handling and mechanisms of food-borne disease exposure acquired during training can play a crucial role in protecting consumers (Paulsen and Winkelmayer, 2004; Paulsen *et al.*, 2011; Hedman *et al.*, 2020).

A lack of hunting and post-harvesting food safety practices, such as gut rupture due to poor placement shot during killing (Gill, 2007; Branciaro *et al.*, 2020), late bleeding (Viganò *et al.*, 2019) delayed evisceration (Avagnina *et al.*, 2012), may decrease the quality of the meat and increase the risk of microbiological proliferation, especially pathogens that can be harmful to consumers. Enteric pathogens such as *Salmonella* spp., *Yersinia enterocolitica*, *Campylobacter* spp., and *E. coli* can contaminate the carcasses during evisceration processes (Avagnina *et al.*, 2012; Sales and Kotrba, 2013; Fredriksson-Ahomaa, 2019; Ranucci *et al.*, 2021; Peruzzy *et al.*, 2022). Furthermore, insufficient or delayed carcass cooling may negatively affect meat hygienic quality since proper cooling of the carcass minimizes microbial growth (Paulsen and Winkelmayer, 2004; Hedman *et al.*, 2020; Ranucci *et al.*, 2021). Thus, what may happen if hunters underestimate the importance of these practices?

As mandated by Regulation (EC) No. 853/2004, European hunters are not required to be trained on food safety issues that ensure that they are aware of the potential risks connected to their actions when handling their games, unless in the case of commercialization (European Commission, 2004). Thus, according to the same Regulation, non-officially inspected HWGM could either be supplied directly from hunters to the final consumer or "to local retail establishment supplying the final consumer" (*e.g.*, local restaurants, butchers, small grocery stores) or consumed at home by hunters and their families and friends (Schulp *et al.*, 2014; Gaviglio *et al.*, 2018; Sevillano Morales *et al.*, 2018). However, due to a lack of data about the destination of HWGM according to the aforementioned options provided by European legislation, it has become challenging to know with any degree of accuracy how HWGM reaches the consumer.

Nevertheless, it is essential to highlight that an inaccurate implementation of practices intended to guarantee HWGM safety may jeopardize consumers' health, especially vulnerable groups, such as the elderly, immunocompromised individuals, pregnant women, and infants that are at increased risk of morbidity and mortality from foodborne infections (Lund and O'Brien, 2011; Hedman *et al.*, 2020).

Literature suggests that human behavior plays a crucial role in food safety outcomes (Jespersen and Huffman, 2014; Evans *et al.*, 2021). Hence, people involved in product processing must be trained to be adequately aware of the possible contaminations due to improper food handling; nonetheless, even trained food handlers may fail in the implementation of correct practices (da Cunha *et*

*al.*, 2014; da Cunha *et al.*, 2015; Rossi *et al.*, 2017). Among the possible explanations for this unwanted outcome, some authors tested the role of the optimistic bias (OB) in food handlers. The OB, also called "unrealistic optimism", is a cognitive bias defined as "a positive outlook regarding future events, in which individuals find themselves less likely than others to experience negative events" (Weinstein, 1984; Gouveia and Clarke, 2001).

In other words, individuals do not make the same estimate of risk when comparing risks to themselves and other people in general, as suggested by da Cunha *et al.* (2014). The presence of OB in food handlers might lead to an increase in the risk of food-borne diseases among consumers due to negligence in implementing food safety-related practices. Thus, biased hunters could overlook some protection attitudes and, not only, unintentionally contaminate HWGM but also mishandle the product during the entire HWGM production process. Previous studies assessed the existence of OB in food handlers, observing its possible correlation with other factors such as risk perception, knowledge, and the utilization of that knowledge during food handling. These studies focused on food services (Rossi *et al.*, 2017), street food kiosks, restaurants, hospitals, and school catering services (da Cunha *et al.*, 2014; da Cunha *et al.*, 2015); however, previous research never focused on the presence of OB among hunters.

The present contribution aims to fill this gap by testing if hunters underestimate the risk related to the bad handling practices of HWGM when comparing themselves to other peers. Our research contributes to the literature by exploring the presence of OB and discussing its possible implications for HWGM food safety management. Such a glimpse can be useful in designing public interventions aimed at protecting hunters' and consumer health, along with the future perspective of creating a safe Italian HWGM supply chain. Moreover, the present research intends to collect information about the Italian hunters' knowledge and perception of risk connected to the implementation of HWGM safety-related practices; possible correlations of these variables with OB will also be explored.

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## Materials and Methods

### Data collection and survey instrument

Data have been collected with an online survey distributed from July to August 2022 to a sample of Italian hunters of large wild ungulates (*Cervus elaphus*, *Capreolus capreolus*, *Rupicapra r. rupicapra*, *Ovis musimon*, *Dama dama*, and *Sus scrofa*). To reach the participants, a first contact list has been provided by veterinary experts who hold training courses, workshops, and seminars specifically addressed to hunters. Then, with a snowballing process, hunters themselves spread the survey through social media (such as WhatsApp and Facebook). Before launching the survey, a preliminary pilot test with 50 subjects was conducted to test the flow, quality, and clarity of the questions. Minor modifications were made to improve the quality of the questionnaire. The survey was completed by 408 out of 1271 hunters.

The survey started with an informed consent sheet for data collection and analysis, followed by a brief text explaining the focus of the interview. The survey tool was composed of four sections. The questions in the first section were related to the sociodemographic characteristics of the hunters, their training level in HWGM handling practices, and the destination of the meat obtained during the hunting season. To detect the hunters' training level, the participants were asked if they were or were not "trained

hunters” as defined by Regulation (EC) No. 853/2004 and completed the course on appropriate handling practices of HWGM carcasses, stating that this would allow them to commercialize their games. The second section aimed at detecting the presence of OB and risk perceptions of HWGM food safety-related practices. As described in Table 1, the estimation of OB was based on five items [adapting from Cunha *et al.* (2014) and Rossi *et al.* (2017)] related to the probability of suffering a foodborne disease caused by consuming HWGM handled or cooked by themselves (Q2 and Q5) or the following peers: i) their hunting partner (Q4); ii) an unfamiliar hunter with the same age and training of the respondents (Q1); or iii) an unfamiliar hunter with a different training of the respondents (Q3). Furthermore, as described in Table 2, the analysis of hunters’ risk perceptions of HWGM preparation-related practices was assessed using four items adapted from the Risk Perception of Foodborne Diseases Questionnaire proposed by Rossi *et al.* (2017). Items have been formulated considering different critical points related to HWGM management that play a prominent role in HWGM safety, such as evisceration and bleeding, cooling and transportation of the carcass, sanitization of kitchen tools, and meat thawing. In both cases, to measure hunters’ perceptions, participants were asked to express their agreement using a 7-point interval scale ranging from “strongly disagree” to “strongly agree”.

The third section was related to hunters’ knowledge of and self-reported practices. To evaluate hunters’ knowledge about the fundamentals of HWGM safety and proper handling practices, six multiple-choice questions with three response options were developed with experts in the field, and a knowledge score was calculated as the number of correct answers provided by each respondent. Then, relying on what has been done by Paulsen and Winkelmayer (2004) and Gaviglio *et al.* (2017), respondents were asked about their practices during and after the culling of their games using a set of questions, including, for example, “do you bleed the game just after shooting?” or “how do you mature the game?” or “where does the game mature?”. Finally, in the fourth section at the end of the questionnaire participants were asked to define their role as hunters. Participants were asked to express their agreement to six statements on a 7-point interval scale ranging from “strongly disagree” to “strongly agree”.

## Analytical approach

Using SPSS® (IBM, Armonk, NY, USA) to assess the presence of the OB, a set of paired *t*-test was performed between the perception of risk due to personal behaviors (Q2) and the perception of risk due to behaviors of different peers (Q1, Q3, and Q4), and between the perception of risk due to personal improper behaviors (Q2) and the perception of risk due to improper behaviors of the hunting partner (Q5). Furthermore, to explore the relationship between the OB and hunters’ knowledge about the fundamentals of HWGM safety and their risk perceptions of HWGM food safety-related practices, a two-step procedure was applied. Firstly, the individual OB was calculated for all the statistically significant comparisons calculated with the paired *t*-test (*e.g.*, Q1-Q2 was calculated for each responding hunter if the *t*-test resulted significantly). Then, the Pearson correlation between each significant OB and knowledge score and the risk perception item was calculated.

## Results

### Sociodemographic characteristics of the sample

Table 3 reports a synthesis of the sociodemographic characteristics of the respondents. Of 408 respondents, the most representative age group was the one between 55 and 65 years (26.47%). The majority of respondents were male (97.06%) (with 2.94% being huntresses). The level of education was high, with 51.72% of the hunter population surveyed having completed high school. The distribution of areas of residence was homogeneous among respondents, with a slight majority of residents in peri-urban areas (42.16%), and most of the sample was from north-western Italy (71.08%). Unfortunately, no recent statistics on the demographic characteristics of the Italian hunters are available that allow a comparison of the sample with the entire Italian hunter population. However, data referred to at the end of the 1990s shows that the most represented group was men (99.40%) aged between 30 and 49 years (60.00%).

**Table 1.** The optimistic bias questionnaire (translated from Italian).

Please indicate how likely do you think is that a consumer will suffer a foodborne disease (stomach-ache and/or vomiting) caused by consuming meat from large ungulates with the following characteristics	
Q1 - Unfamiliar hunter with same characteristics	The prey was hunted and the HWGM was cooked by another hunter, who is the same age as you and possesses your same level training
Q2 - Interviewed hunter	You hunted the prey and cooked the HWGM
Q3 - Unfamiliar hunter with different characteristics	The prey was hunted and HWGM was cooked by a hunter who does not possess your same level of training

HWGM, hunted wild game meat.

**Table 2.** Hunters’ risk perception of hunted wild game meat preparation-related practices (translated from Italian).

Please indicate how likely you think it is that a consumer will suffer a foodborne disease (stomach-ache and/or vomiting) caused by consuming meat from large ungulates hunted and cooked by you, under the following conditions	
R1 - Field operation (evisceration and bleeding)	You fail to eviscerate and bleed the carcass properly
R2 - Transportation	You fail to cool the carcass in a short time and the transportation to the refrigerated cell is not immediate
R3 - Kitchen behavior	You do not properly sanitize a tool used for HWGM processing
R4 - Kitchen behavior	You prepare HWGM that has been improperly thawed

HWGM, hunted wild game meat.

## Hunted wild game meat destination, self-reported practices, and hunters' self-definition

With regards to the destination of the HWGM, the interviewed hunters answered that 65.30% of the meat is consumed at home, 29.24% is given as a gift to friends and relatives, and the remaining 3.24% and 2.23% is supplied directly to consumers or small local businesses or commercialized respectively. Moreover, 97.10% of hunters declared that they personally take care of HWGM evisceration, and, in most cases, they immediately bleed the animal after the shot (90.70%). Hunters stated that the evisceration takes place immediately after (59.07%) or within an hour after the shoot (38.48%), whereas only a small percentage of hunters (2.45%) declared that this practice is performed after an hour from the shoot. Next, most hunters (76.70%) declared that they are personally responsible for the secondary dressing processes of the HWGM of carcasses (*i.e.*, skinning, slaughtering, and portioning). Finally, to understand how aware the surveyed hunters were of their role as food producers, some questions were aimed to explore how hunters perceive themselves. The results are presented in Figure 1 and show that the best self-descriptions for hunters were “nature lover” [mean=6.60; standard deviation (SD)=1.04], “someone that has a role in nature conservation” (mean=6.44; SD=1.13), or – generally – “hunting enthusiast” (mean=6.21; SD=1.49). On the other hand, hunters were less inclined to describe themselves as “someone that carries on a local tradition” (mean=4.98; SD=1.97) or “hobbyist, passionate about outdoor sports” (mean=3.57; SD=2.27). In the end, the item “I recognize myself as a food producer” was less representative of Italian hunters (mean=2.91; SD=2.15).

### Risk perception of hunted wild game meat preparation

The results on hunters' perception of risk related to poor hygiene management of HWGM are presented in Table 4. No relevant differences were found between the items since values resulted to be comprised from R1 (mean=3.44; SD=1.99) and R4 (mean=3.86; SD=2.05). This means that the steps involved in the processing are perceived as, at least, similarly risky for the HWGM safety outcome. Among the practices considered, the two that are perceived by hunters as riskier are those involving carcass cooling (mean=3.60; SD=1.84) or HWGM thawing (mean=3.86; SD=2.05).

### Hunters' training and knowledge of basic principles for hunted wild game meat safety

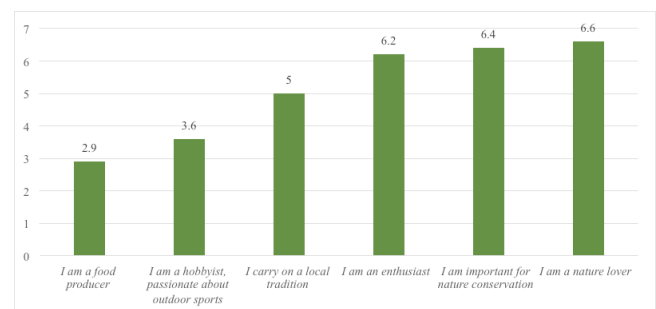
Table 5 reports the results related to hunters' knowledge of basic principles for HWGM safety. In this regard, it is worth emphasizing that two questions (K and K4) were answered in line with good practices by a very high percentage of respondents, while the rest of the test was answered in line with good practices by less than half of the respondents. This evidence appears to con-

tradict the general response pattern as a high percentage of participants (81.86%) among the interviewed declared they hold the title of “trained hunters”, indicating that they had undergone a training course on HWGM handling (as required by EU law 853/04). Of these, 11.98% stated that they followed the training course in the current year (2022), 8.98% followed the course 1-2 years ago, 32.93% 3-4 years ago, and most (46.11%) of the trained hunters obtained the title more than 5 years ago.

**Table 3.** Sociodemographic characteristics of the sample.

Variables	n	%
Age		
18-25 years	15	3.67
26-35 years	47	11.52
36-45 years	68	16.67
46-55 years	98	24.02
56-65 years	108	26.47
66-70 years	72	17.64
Gender		
Male	396	97.06
Female	12	2.94
Education		
First and secondary school	91	22.3
High school	211	51.72
Degree	73	17.9
Higher education	33	8.09
Residence area		
Rural	129	31.62
Periurban	172	42.16
Urban	107	26.23
Geographical region of residence		
Northeast Italy	88	21.57
Northwest Italy	290	71.08
Central Italy	23	5.64
Southern Italy and islands	7	1.72

Number of subjects = 408.



**Figure 1.** Italian hunters' self-definition.

**Table 4.** Hunters' risk perception of hunted wild game meat preparation-related practices.

Item	Mean	SD
R1 - You fail to eviscerate and bleed the carcass properly	3.44	1.99
R2 - You fail to cool the carcass in a short time and the transportation to the refrigerated cell is not immediate	3.60	1.84
R3 - You do not properly sanitize a tool used for HWGM processing	3.46	1.89
R4 - You prepare HWGM that has been improperly thawed	3.86	2.05

SD, standard deviation; HWGM, hunted wild game meat; 1, “not likely at all”; 7, “absolutely likely”.

### Italian hunters' optimistic bias

The results shown in Table 6 reveal that the OB occurred in all the cases considered in the present research (all  $p \leq 0.001$ ). The analysis indicates that hunters rated the probability that their behavior implies specific risks related to HWGM consumption lower than that of their peers. In other words, hunters rated the chance that a consumer might be at risk of food poisoning lower if they performed firsthand the HWGM handling and preparation; they then rated this probability of risk higher when asked about their peers. Specifically, the OB was found comparing the responding hunters' evaluations of themselves with an unfamiliar hunter with the same characteristics (mean OB=-0.451; SD=1.575; Cohen's  $d=-0.286$ ), an unfamiliar hunter with a different training

(mean OB=-1.772; SD=2.193; Cohen's  $d=-0.808$ ), and their hunting partner in typical conditions (mean OB=-0.210; SD=-1.298; Cohen's  $d=0.162$ ) or when they did not wash their hands before cooking (mean OB=-0.900; SD=2.102; Cohen's  $d=-0.428$ ). Interestingly, risk perception varies when linked to hunter familiarity with the peer, meaning that the greater the distance with the peer (unfamiliar), the higher the value of OB.

To further explore the nature of OB among the interviewed hunters, Table 7 shows the correlations between risk perceptions of HWGM preparation-related practices, knowledge of basic principles for HWGM safety, and OB. OB items were found negatively correlated with knowledge, namely Q2 *versus* Q3 (Corr.=-0.113;  $p=0.022$ ) and Q2 *versus* Q4 (Corr.=-0.134;  $p=0.007$ ) indicating

**Table 5.** Hunters' knowledge of basic principles for hunted wild game meat safety.

Question	Correct answer (%)
K1 - The meat maturation must take place at temperatures between 0 and 4 °C	80.39
K2 - The typical 'dark' colour of game meat can result from high myoglobin content and higher pH values	48.53
K3 - A correct meat maturation needs the game to have sufficient glycogen reserves	26.72
K4 - The biological hazards linked to game meat consumption are pathogens such as <i>Salmonella spp.</i> , <i>Campylobacter spp.</i> , <i>Escherichia Coli O:157</i> and <i>hepatitis E</i>	89.46
K5 - Food-borne diseases can be transmitted to humans during consumption of any food, whether raw or cooked	33.82
K6 - <i>Trichinella britovi</i> is typically found in the muscles of wild boar	65.44

**Table 6.** Optimistic bias among Italian hunters.

Optimistic bias	Personal risk		Peer risk		Personal - Peer risk		Paired <i>t</i> -test		Cohen's <i>d</i>
	Mean	SD	Mean	SD	Mean	SD	<i>t</i>	<i>p</i>	
Q2 - Interviewed hunter <i>versus</i> Q1 - Unfamiliar hunter with same characteristics	1.770	1.510	2.220	1.460	-0.451	1.575	-5.785	0.000	-0.286
Q2 - Interviewed hunter <i>versus</i> Q3 - Unfamiliar hunter with different characteristics	1.770	1.520	3.540	1.890	-1.772	2.193	-16.320	0.000	-0.808
Q2 - Interviewed hunter <i>versus</i> Q4 - Hunting partner of the respondent performing improper behaviours	1.770	1.530	2.670	1.680	-0.900	2.102	-8.642	0.000	-0.428
Q5 - Interviewed hunter performing improper behaviours <i>versus</i> Q4 - Hunting partner of the respondent	2.460	1.680	2.670	1.680	-0.210	-1.298	3.280	0.001	0.162

SD, standard deviation.

**Table 7.** Correlations among optimistic biases and hunters' knowledge of basic principles for hunted wild game meat (HWGM) safety and risk perception of HWGM preparation-related practices.

	Knowledge	R1 - Field operation (evisceration and bleeding)	R2 - Transportation	R3 - Kitchen behavior	R4 - Kitchen behavior					
						Corr.	<i>p</i>	Corr.	<i>p</i>	Corr.
Q2 - Interviewed hunter <i>versus</i> Q1 - Unfamiliar hunter with same characteristics	-0.095	0.056	-0.118*	0.017	-0.145**	0.003	-0.053	0.288	-0.113*	0.022
Q2 - Interviewed hunter <i>versus</i> Q3 - Unfamiliar hunter with different characteristics	-0.113*	0.022	-0.320**	0.000	-0.349**	0.000	-0.272**	0.000	-0.354**	0.000
Q2 - Interviewed hunter <i>versus</i> Q4 - Hunting partner of the respondent	-0.134**	0.007	-0.328**	0.000	-0.353**	0.000	-0.248**	0.000	-0.268**	0.000
Q5 - Interviewed hunter performing improper behaviours <i>versus</i> Q4 - Hunting partner of the respondent	0.032	0.517	0.063	0.208	0.133**	0.007	-0.086	0.084	-0.076	0.127

Significance levels: \*\*\* $p < 0.001$ ; \*\* $p < 0.010$ ; \* $p < 0.050$ .

that the more hunters knew about HWGM safety, the less prone they were to have thought they were better than other unknown hunters with different characteristics and their hunting partners. Interestingly, the same pattern was found in the correlations between OB and the items measuring hunters' risk perception of HWGM preparation-related practices; all the correlations were in fact negative and significant (all  $p < 0.000$ ). Negative and significant correlations were also found between the OB related to self-evaluation compared to the hunting partner with three out of four risk perception items ( $0.003 < p < 0.022$ ). However, it is worth emphasizing that the correlations were strongest when surveyed hunters compared themselves to unfamiliar hunters with different characteristics and when interviewed hunters compared themselves to one of their hunting partners for all preparation-related practices. This suggests that the knowledge might play a role in mitigating the OB, especially when the OB is higher.

## Discussion

The present study aimed at identifying the presence of OB among Italian hunters and collecting data about HWGM destination and hunting practices, hunters' self-definition and level of training, and hunters' knowledge of basic principles for HWGM safety. Moreover, our study explored the correlations between OB and hunters' risk perception of HWGM preparation-related practices. First, our findings suggest that most of the hunters use HWGM for domestic consumption, confirming what has been previously claimed by Marescotti *et al.* (2021): the Italian hunting sector seems to continue to be a "private affair" since the commercialization of this resource is still, although fostered by different stakeholders, not yet implemented, and sustained by an organized supply chain (Gaviglio *et al.*, 2017; Gaviglio *et al.*, 2018). Next, considering self-reported practices, findings appear to be slightly encouraging since most of the hunters surveyed declared to implement what literature indicates to be the best practices for HWGM handling. Immediate bleeding and proper evisceration of the prey are two essential procedures to preserve HWGM hygiene and quality (Paulsen and Winkelmayr, 2004; Hoffman and Wiklund, 2006; Gill, 2007; Avagnina *et al.*, 2012; Viganò *et al.*, 2019; Branciarri *et al.*, 2020). In particular, it is interesting to highlight that higher contamination levels have been found in carcasses eviscerated 3 hours after the shot (Avagnina *et al.*, 2012; Peruzzy *et al.*, 2022) and hunters surveyed in our sample declared to perform this action immediately after the shot. Regarding self-definition, our findings confirm what was previously suggested by Gaviglio *et al.* (2017, 2018) and Marescotti *et al.* (2021), who emphasized that, despite hunting activity providing HWGM, Italian hunters seem to refuse to consider themselves as potential primary actors involved in a food supply chain, while they see themselves as "nature lovers" and "important for nature conservation". Such evidence may suggest that hunters do not possess a complete awareness of their role, which includes also being producers, especially in view of the future implementation of an Italian supply chain for HWGM commercialization, which may result in an issue for public health (Gaviglio *et al.*, 2018; Demartini *et al.*, 2021; Orsoni *et al.*, 2020).

Our results revealed the presence of OB among Italian hunters. Previous studies focused on detecting the presence of OB in food handlers, reported similar results and showed that higher OB is

normally estimated when individuals compare themselves with unfamiliar than familiar peers (da Cunha *et al.*, 2014; da Cunha *et al.*, 2015; Rossi *et al.*, 2017; de Andrade *et al.*, 2019; de Andrade *et al.*, 2020), confirming that the variation of OB is linked to the psychological closeness with the target (Perloff and Fetzer, 1986; Harris and Middleton, 1994; Aliche *et al.*, 1995; Helweg-Larsen and Shepperd, 2001). This means that people such as a close friend or a family member, or in this case, a hunting mate, can be judged differently than an unknown peer, since, for example, the respondents might have more prior information about peers' behavior (Helweg-Larsen and Shepperd, 2001). Furthermore, OB can occur when people have little personal experience with a hazard or when a negative outcome is commonly judged of low probability, thus minimizable or avoidable with the implementation of a specific precaution (Weinstein, 1989). Generally, individuals tend to formulate risk judgments that do not threaten self-esteem, since self-judging less at risk than others may be directed toward the preservation of one's self-esteem and personal skills (Miles and Scaife, 2003). In fact, as emphasized by Miles and Scaife (2003), especially when a threat is controllable or in some way preventable, asserting that other individuals are less or equally exposed to potential danger than oneself may threaten one's perception of competence and self-esteem. In this sense, an overconfident individual about their skills (Dunning *et al.*, 2004) has been proven to affect the OB displaying. This could also be a key to understanding why OB also emerges when a hunter compares himself with an "identical" peer (Q2 versus Q1) (defined in our study as a hunter of the same age and having the same level of training).

Moreover, it is important to emphasize that hunters judged themselves as less likely to incur a negative outcome even if they performed the same risky behavior as their hunting partners (not washing their hands before preparing HWGM). According to da Cunha *et al.* (2014) and Rossi *et al.* (2017) who observed the same phenomenon in food handlers, this biased evaluation might stem from egocentric thinking (Shepperd *et al.*, 2013). Egocentrism may be due to many causes, such as the individual tendency to focus on themselves rather than on others and have different or more information about themselves when making judgments compared to others (Shepperd *et al.*, 2013). Next, a comparison with the findings of Siegrist and Árvai (2020) in their recent review on risk perception can be proposed. Laypeople and professionals should possess different level of risk perception since experts possess domain-specific knowledge that allows them to be aware of domain-specific hazards. Besides, other individual factors that have been related to risk perception (*e.g.*, levels of scientific reasoning ability and reasoning style) prompt the role of specific-domain knowledge to be prominent since the more people are informed about a particular hazard, the more their perceptions of risk tend to be highly correlated with domain-specific knowledge. Considering this, the present study results may be alarming, since hunters, although not professionals as food handlers, are supposed to possess high(er) knowledge of HWGM-related risk. In this sense, the results here presented may suggest that it is necessary to increase the level of knowledge among Italian hunters. This is especially remarkable because, for example, hunters showed an insufficient level of knowledge linked to the risk associated with the presence of *T. britovi* in Italian wild boars, since this parasite is one of the most problematic for consumers' health, (Sgroi *et al.*, 2023). This may help them understand the risks they face and expose consumers to, as hunters are HWGM's first consumers.

## Conclusions

Taking a cue from the literature that has recently detected the presence of OB in food handlers, this study aimed to assess the presence of OB in Italian hunters. The peculiarity of this study relates to the population in which this bias was identified. Results show that hunters defined themselves mostly as nature lovers showing difficulties in recognizing their role as primary meat producers who could potentially introduce the HWGM to the market as allowed by European and National Regulations.

Hunters have been found to be the primary consumers of HWGM since they declared they use this resource mainly for home consumption. Moreover, the hunters involved in the study declared that self-reported practices related to carcass handling appear to be in line with those recommended for maintaining HWGM food safety. However, the presence of OB was detected. This means that hunters judge themselves better than their peers when asked about assessing the risk of causing a foodborne disease to the final consumer of HWGM. The role of OB has been studied in many research domains in the last four decades (Shepperd *et al.*, 2017) and only in recent years, has OB gained attention in food safety studies (Zanin *et al.*, 2021). Food handlers, and thus in our case hunters, with low-risk perception may have difficulties in understanding and applying the concepts and practices at the foundation of food safety. Italian hunters have been proven to fail to distinguish among different risks triggered by different hazards. In line with what has already been argued by several authors, there is an urgent need to design better strategies to train and inform the Italian hunters' population (Avagnina *et al.*, 2012; Ranucci *et al.*, 2019; Branciarri *et al.*, 2020; Orsoni *et al.*, 2020; Ranucci *et al.*, 2021; Guardone *et al.*, 2022; Peruzzy *et al.*, 2022). Implementing communication and hunters' knowledge by designing tailored training strategies is therefore recommended to encourage changes in hunters' behavior and foster good practices to reduce the presence of OB. Finally, the present work focused on hunters as the main figure, but a fundamental previous stage related to hunters' training, namely the "training of trainers", has not been considered. In such context, further investigation on the ageless "*quis custodiet custodes?*" issue may be relevant, since European law prescribes only a program of contents for hunters' training, without actually identifying professional figures who are nominated as educated trainers. In fact, this could be one of the issues causing different levels of hunting training. In addition, making hunters aware of their role as producers could make them conscious of the potential risk of producing HWGM in an unprofessional manner, enhancing the centrality of their role as possible food producers, responsible for consumers' health.

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