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Abstract

Cystic echinococcosis (CE) or hydatidosis is a common parasitic disease worldwide, especially in poor and developing countries. In Morocco, CE is a major zoonosis, despite the implementation of a national control program since 2007. Therefore, in 2016, a field trial that associates the EG95 vaccine (lambs) and anthelmintic treatment (dogs) was started in the Mid Atlas, the most endemic region in Morocco, with preliminary positive results. Here, a qualitative approach was used to analyze the feasibility and social acceptability of this strategy. Fifteen focus group discussions were separately conducted with breeders and with their wives, and forty-two individual interviews were performed with private-sector veterinarians and officers from structures responsible for the CE control program. Recordings were transcribed and analyzed with the R software, using the RQDA package. This qualitative research was validated using the credibility, transferability, dependability and confirmability criteria. This study showed that the professionals' views on sheep vaccination and anthelmintic treatment were divided between acceptability and concerns. Conversely, breeders and their wives highlighted the issue of the costs of procedures the utility of which was not immediately clear to them. All participants proposed solutions to improve this strategy, and also stressed the lack of education on CE. By bringing together the views of the communities and the professionals, this study traced the main lines (targeting the different aspects of CE and taking into account the local socio-cultural beliefs) that must be taken into account to ensure the short- and long-term CE control in Morocco.

Keywords: Cystic echinococcosis; Morocco; EG95 vaccine; Anthelmintic treatment of dogs; Feasibility; Acceptability.

1 Introduction

Cystic echinococcosis (CE) is a neglected major zoonosis that occurs mostly in developing countries (Singh *et al.*, 2014). CE in humans and ruminants (i.e. intermediated hosts) is caused by the ingestion of water or food contaminated by the eggs of the tapeworm *Echinococcus granulosus* that are eliminated with the dog feces (i.e. definitive host) (Thompson and McManus, 2002; Budke, Deplazes and Torgerson, 2006).

The first CE control program was introduced in 1863 in Iceland (Craig and Larrieu, 2006) and the implementation of similar programs has significantly reduced its incidence in several previously highly endemic countries (Craig *et al.*, 2017). However, CE still remains a major public health problem in many countries, especially in the Mediterranean region (Battelli, 2004; Moro and Schantz, 2007), North Africa, Middle East, South America, Eastern Europe, Central Asia, Russia, and China (Craig *et al.*, 2017). The reasons of CE control program failure in these countries are multiple, including underfunding and premature withdrawal of funding for their implementation, difficulties in managing the dog population, political unrest (Craig and Larrieu, 2006; Craig *et al.*, 2017), the overlap of the activity/power of the different stakeholders implicated in CE control, conflicts of interest among stakeholders, and lack of adequate training (Saadi, Moussiaux, *et al.*, 2021; Saadi, Sahibi, *et al.*, 2021).

Mathematical modeling of hypothetical CE control scenarios led to the conclusion that anthelmintic treatment of dogs is a key strategy, if at least 60% of dogs are treated every 3 months (Torgerson, 2003). However, this is difficult to implement, especially in developing countries, where the population is not interested in dog treatments. Vaccines also are often used to control parasitic and infectious diseases. In the case of zoonoses, preventive veterinary treatments not only protect the health and well-being of animals, but also reduce the risk of their transmission to

humans. A vaccine against CE, based on the recombinant protein EG95, has been developed, and vaccine trials in Australia and Argentina demonstrated its effectiveness (Heath *et al.*, 2012; Larrieu *et al.*, 2013, 2015). Mathematical models showed that CE control interventions in which sheep vaccination and anthelmintic treatment of dogs are combined represent an effective strategy (Torgerson, 2006) that might allow controlling CE in about 15 years (Torgerson, 2003, 2006).

In Morocco, CE is endemic, despite the presence of a national program of CE control since 2007 (Aubry, 2013). This CE control program includes two axes: i) preventive measures to interrupt the parasite life cycle, protect the livestock (offal seizure, slaughterhouse development), and control the dog population; and ii) the detection/treatment of hydatid cysts in humans and CE awareness raising (Comité interministériel de lutte contre l'Hydatidose /Echinococcose, 2007). This program failed because CE is still highly endemic, especially in farming areas (El Berbri *et al.*, 2021). The economic losses caused by this zoonosis in Morocco are estimated at 73 million US dollars (i.e. about 0.07% of the country gross domestic product) (Saadi *et al.*, 2020). The infection prevalence ranges between 23.5% and 38.8% in owned dogs and between 51.3% and 68.5% in stray dogs (Amarir *et al.*, 2020). CE prevalence in humans is estimated at 1.9% (Chebli *et al.*, 2017). In livestock, CE prevalence at slaughterhouses was 42.9% in cattle, 11.0% in sheep, and 1.5% in goats (I El Berbri *et al.*, 2015). The high number of dogs that have access to condemned offal at slaughterhouses, to pastures and livestock housing, the poor organization of slaughterhouses, and the stakeholder multiplicity are the major elements of CE persistence in Morocco (Ikhlass El Berbri *et al.*, 2015; Bardosh *et al.*, 2016; Saadi, Sahibi, *et al.*, 2021). Therefore, Moroccan authorities have been looking for alternatives to improve the CE control strategy. In this context, a five-year research project entitled "Strengthening the strategy to control the zoonotic cystic echinococcosis in Morocco: veterinary, economic and sociological aspects" was launched in 2015. The aim of this project was to carry out field trials of sheep vaccination with the EG95 vaccine associated with

anthelmintic treatment of dogs in the Mid Atlas region during the period 2016-2020. A field evaluation of this strategy showed that sheep vaccination with the EG95 vaccine very effectively reduces CE transmission in sheep (Amarir *et al.*, 2021). However, to be fully effective the vaccination of lambs and anthelmintic treatment of dogs should be carried out for 15 years (Torgerson, 2003, 2006). Therefore, the objective of this study was to assess the acceptability and feasibility of each part of this strategy (lamb vaccination and dog treatment) before its possible implementation on a larger scale. A qualitative research approach was used to investigate how the program managers and the target population perceived this new control strategy.

2 Materials and Methods

2.1 Ethical approval and consent to participate

Close attention was paid to respect the ethical considerations and to follow the instructions of the Guidelines for Research Ethics in the Social Sciences, Humanities, Law and Theology (Norwegian National Research Ethics Committees, 2016). In a formal interview, setting the right to informed consent was strictly observed: verbal consent was sought from all respondents after giving them as much information as possible about the interview purpose, the estimated time required, and the study objectives/outcomes. Verbal consent was chosen instead of written consent because the latter implies a signature, which could embarrass some interviewees or make them anxious. It was explained that participation was voluntary. No explanation was asked in case of refusal to be interviewed. The respondents' anonymity and confidentiality were respected during the fieldwork and data analysis. This work was authorized by the ethics committee of the Department of Pathology and Veterinary Public Health, Agronomic and Veterinary Institute Hassan II, Rabat, Morocco, in 2015.

2.2 Study area

The Mid Atlas is the Moroccan region with the highest prevalence of human and livestock CE (Azlaf and Dakkak, 2006; Chebli *et al.*, 2017). The study was carried out in the province of Khenifra (Fig. 1). According to the Ministry of Health records, the incidence of CE-related surgical interventions in this province is higher than in other Moroccan regions, and sheep farming plays a key role in the economy of this area (Direction Générale des collectivités Locales, 2015). The Mid Atlas is among the poorest regions of Morocco and its inhabitants are mostly Berbers and Muslims (Haut-Commissariat au Plan du Maroc, 2014). The study was carried out in the city of Khenifra and in four rural municipalities (Ait Ichou, Zaouiate Ait Isshak, El Kbab and Tighssaline).

Figure 1: **Khenifra province (in green)**. *(Source: Wikimedia commons*: https://commons.wikimedia.org/wiki/File:Khenifra_in_Morocco.png?uselang=fr)

2.3 Study design

Data were collected from 2016 to 2018, a periods that overlap with the EG95 vaccine field trials that demonstrated its value (Amarir, 2021). Semi-structured interviews were carried out at the project start with the target population (professionals and communities) to determine the acceptability and feasibility of each control option (lamb vaccination and dog treatment). A qualitative research approach was adopted using the non-probability snowball sampling technique by selecting a group of individuals corresponding to the desired profile (described below), and then asking them to identify other subjects with similar characteristics (Patton, 1990). The first list of recruits included officials of the health delegation, physicians, local authorities, and officials of the veterinary services of the National Office of Food Safety (ONSSA). They were identified because they are in charge of the current CE control program. Breeders also were included in the first list of recruits because they are the people who will accept or not to vaccinate their lambs and treat their dogs. Then, ONSSA veterinarians suggested private-sector veterinarians because they are in

136 constant contact with breeders, and ONSSA often ask them to carry out preventive actions targeting
137 several animal diseases. Physicians and ONSSA veterinarians also suggested to add the breeders'
138 wives because they are in charge of the household hygiene, take care of dogs, and contribute to
139 livestock management. Separate focus group discussions (FGD) were organized with breeders and
140 with their wives because these two groups have different tasks and responsibilities in the sheep
141 breeding system, and therefore might have different perceptions about CE control measures. To
142 limit the influence of power/authority relationships, physicians, representatives of ONSSA
143 veterinary services and of the health delegation, and local authorities were interviewed in face-to-
144 face in-depth individual interviews (IDI). In total, 15 FGDs (n=8 with women, n=7 with breeders)
145 (Table 1) and 42 IDIs (n=12 with local authorities, n=9 with ONSSA veterinary service
146 representatives, n=7 with physicians, n=8 with officials of the health delegation, and n=6 with
147 private-sector veterinarians) were performed.
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157 *Table 1 Characteristics of the focus group discussions (FGDs) in each rural municipality*

Municipality	Category	Number of FGDs	Number of participants	Age group	Education level
Ait Ichou	Breeders	2	7	30-50	Illiterate/middle school
			8	27-50	Illiterate/high school
	Women	2	8	20-30	Primary school/middle school
			9	30-50	Illiterate/middle school
Zaouiate Ait Isshak	Breeders	2	6	40-80	Illiterate/high school
			9	25-40	Illiterate/high school
	Women	2	7	30-40	Primary school/middle school
			8	18-30	Primary school/high school
El Kbab	Breeders	2	9	30-40	Illiterate/high school
			11	40-70	Illiterate/high school
	Women	3	10	20-40	Primary school/high school
			9	40-70	Illiterate/Primary school
			9	16-40	Illiterate/high school
Tighssaline	Breeders	2	13	30-80	Illiterate/high school
	Women		8	16-50	Illiterate/high school

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159 ## 2.4 Data collection

160 Three semi-structured interview guides were developed: one to animate the FGDs with breeders
161 and women, one for the private-sector veterinarians, and one for the ONSSA officials, medical
162 doctors, health delegation representatives and local authorities (Table 2). All FGDs and IDIs were
163 conducted face-to-face. To animate the discussions, a moderator led the discussion and a reporter
164 took notes. All interviews were done in a quiet room, and were recorded with an audio recorder
165 and a video camera to facilitate their transcription and reviewing the different interviewees'
166 reactions on the videos. All participants agreed to be filmed, but for one medical doctor. FGDs and
167 IDIs were carried out in Arabic, except the FGDs with women that were in Berber. The duration
168 of the discussions (FGDs and IDIs) varied between 20 and 45 minutes.

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Table 2: Summary of the interview guides

Common topics: -Acceptability and feasibility of the EG95 vaccine -Acceptability and feasibility of the anthelmintic treatment for dogs -Constraints -Suggestion for implementing the approach based on the EG95 vaccine for lamb and the anthelmintic treatment for dogs
Topics for ONSSA officials, physicians, health delegation officials, and local authorities: -CE evaluation in humans and animals -The perceived success/failure of the current CE control program
Topics for private-sector veterinarians: -Acceptability to participate in the CE control program -Requirements to participate in the CE control program
Topics for breeders and women: - CE perception -Knowledge of CE economic impact, especially, loss in productivity/livestock

2.5 Data analysis

The video and audio recordings were transferred to a computer and reviewed by the entire research group. They were transcribed and translated from Arabic and Berber into French. The notes and transcriptions were anonymous and checked by the interviewer and the reporter. To improve reliability, another team researcher examined the transcripts. Transcripts were loaded on the R software to be analyzed using the RQDA package. The interviewer and the reporter did the coding of the anonymous transcripts independently. Provisional codes (themes) were developed: success/failure of the current CE control program, acceptability and feasibility of each proposed measure. Suggestions and constraints were added as emerging themes during the analysis. The themes were grouped in two sub-categories: argumentations and incentives. The coding tree for the lamb vaccination measure is presented in Figure 2.

Figure 2: Coding tree for the "EG95 vaccine" topic

2.6 Data validation

The biggest criticism that arises when using a qualitative approach is data validation. Unlike quantitative research, it is difficult to prove the accuracy or falsity of a qualitative observation. Therefore, Guba and Lincoln proposed four alternative criteria for judging the merits of qualitative research: credibility, transferability, reliability, and confirmability (Lincoln and Guba, 1985). The whole team validated the credibility of the obtained results because the data collected were sufficient to understand the research subject from the point of view of all participants. Transferability was respected by carefully describing the research context and process, and was adapted to the local socio-cultural and religious beliefs and to the used control measures. Dependability was guaranteed by the structured method of data codification and classification through the construction of themes and sub-categories (Fig. 2). Confirmability was ensured by the neutrality of the data collected and their interpretation. Figure 3 shows the validation process.

Figure 3: ***Criteria used to validate the qualitative approach of this study***

3 Results

3.1 Perception of the current CE control program

ONSSA veterinarians considered that the program had failed because the quantities of seized cysts were still important. ONSSA technicians working at slaughterhouses reported that CE prevalence had decreased in these last 10 years, but ONSSA veterinarians thought that this was not the case. They explained this perceived decrease by the fact that usually young animals are slaughtered, whereas CE is a chronic disease that takes years to develop.

> *"I have been working in this slaughterhouse for more than 19 years and I find that the number of cysts found is not as important as before" (IDI/ONSSA technician/M'rirt)*

"The CE control program did not give the desired results. It was expected that with this program we would have reduced CE incidence by 50% in 2015, but that was not the case." (IDI/ONSSA veterinarian)

For medical doctors, the program failed because the number of human cases per year has remained stable. Local authorities also expressed their dissatisfaction with the CE control program.

"The truth is that CE is still here! I see the reports, there is no decrease" (IDI/ Local authorities)

ONSSA veterinarians, medical doctors and local authorities thought that the program failed to achieve its objectives because the implementation of the measures listed in the guide was "difficult, if not impossible", particularly the reorganization of all slaughterhouses in Morocco and the control of stray dogs. Private-sector veterinarians believed that the program was "not compatible with the existing Moroccan infrastructure", especially slaughterhouses. All participants declared that other approaches were needed to control CE.

"How can this program be successful while its axes include the restructuring of slaughterhouses?! Because in that case, it is necessary to reorganize all slaughterhouses in the country!" (IDI/ Private-sector veterinarian)

ONSSA veterinarians, physicians, and local authorities said that the current CE control program was well designed because it targets the different aspects of CE: slaughterhouse development, control of the dog population, health education, and treatment of human cases. However, the program has failed to achieve its objectives because the implementation of the measures described in the guide is difficult or even impossible. Indeed, this would require huge investments/manpower

that the regions do not have. Moreover, the dog population control is difficult because dogs are "semi-wandering" and protected by their owners.

3.2 CE perception by the local population

Breeders and women know the human disease, and can detect hydatid cysts in slaughtered animals. However, they have very limited knowledge about the parasite life cycle and the role of dogs in its transmission. They also declared that hydatid cysts have no effect on their flocks.

"These hydatid cysts exist in all animals, but they have no harmful effects"

(FGD/Breeders)

ONSSA veterinarians mentioned that they have already carried out several awareness raising campaigns and that consequently, the population was becoming more aware about this zoonosis. However, ONSSA veterinarians, doctors, and local authorities thought that the current awareness raising strategy needed to be improved.

Women said that as the current awareness raising campaigns were in Arabic or in French, they could not be understood by a large part of the Berber population.

Women (W)3: "Posters are in French or classic Arabic, while we can barely understand the local Arabic dialect."

W5: "The posters must be understandable." (FGD/Women/M'rirt)

Breeders and women highlighted the need of awareness raising campaigns in their mother tongue (Berber). Moreover, women proposed to raise awareness through associations and social networks.

"Assemblies like what you have done now is the best way to raise awareness, already after this rewarding discussion you will go home and you will be 100%

sure that we have well assimilated all the information and explanations you gave us about this disease." (FGD/Women/Zaouiate Ait Isshak)

During a FGD with women, they also suggested the need of awareness raising campaigns in schools. Indeed, they said that their children were talking about their school activities at home. Conversely, they though that messages through the mosques were less diffused in households.

W12: "If the teacher asks children to send a message to their parents, they will do it."

W6: (laughs a little before speaking) "We ask our husbands about what the imam said in the mosque; they answer with a sentence or two, but sometimes they just refuse to answer (women laughing), while my child tells me everything." (FGD/Women/El Kebab)

3.3 Proposals for the new approach

3.3.1 Lamb vaccination

Table 3 summarizes the acceptability and feasibility of lamb vaccination. ONSSA veterinarians thought that this vaccine was a very acceptable solution if its effectiveness was confirmed. However, they expressed their concerns about a limited efficacy if sheep were the only species covered, highlighting the need to expand the vaccination program to other species. Local authorities were in favor of vaccinating sheep. Medical doctors said that vaccination would be a good way to cut the parasite life cycle. Private-sector veterinarians saw the vaccine as a good solution; however, they thought that breeders would not agree to pay for it, especially because CE is asymptomatic.

"I think this vaccine is a good solution to fight against hydatidosis. Breeders will only accept the vaccine if they see it as useful." (IDI/ONSSA veterinarian)

Breeders said that they generally vaccinated their livestock against diseases with high mortality and morbidity, such as bluetongue, foot-and-mouth disease and enterotoxemia. They thought that these vaccines were already expensive and they would not have the means to add another vaccine to their vaccination schedule. Breeders did not consider CE as a serious disease. They said that they would not vaccinate their animals because CE was not a danger to their livestock. According to women, their husbands prefer to invest in things that have visible effects. Women suggested a free vaccination campaign.

"We vaccinate our sheep against enterotoxemia because a lot of animals die. Already this vaccine is expensive. Hydatidosis does not do anything to our animals?! Why should we buy a vaccine for that?!!!" (FGD/Breeders)

For ONNSA and private-sector veterinarians the vaccine must be subsidized and added to another vaccine, for instance the one against enterotoxemia. They also thought that a good awareness raising campaign was needed to show to the breeders the production losses caused by CE of which they are completely unaware. In addition, breeders may accept a new vaccine if they see other breeders using it.

"It takes time for breeders to get used to a new vaccine. Breeders will accept it if they are well informed about the damage and losses that this disease can cause." (IDI/Private-sector veterinarian)

Table 3 Categories and topics extracted from the FGDs and IDIs on the EG95 vaccine

Category	FGD/IDI	Acceptability A: For him/her B: For other participants	Argumentation	Feasibility
ONSSA	IDIs	**A:** Acceptable with concerns	- The current strategy has not given good results -Concerns: sheep is the only species covered	-Demonstration of its effectiveness -Subsidized -Incorporated with enterotoxemia vaccine - Awareness raising campaign
		B: Not acceptable for breeders	CE is asymptomatic	
Physicians	IDIs	**A:** Acceptable	Cut the parasite life cycle	- Awareness raising campaign
		B: Conflicts of interest among departments	Which institution should subsidize it?	
Local authorities	IDIs	**A:** Acceptable	The current strategy has not given good results	-Subsidized
		B: Not acceptable for breeders	Financial constraints	
Private-sector veterinary doctors	IDIs	A: Acceptable	Cut the parasite life cycle	-Subsidized -Incorporated with enterotoxemia vaccine
		B: Not acceptable for breeders	CE is asymptomatic	
Breeders	FGDs	A: Not acceptable	-CE has no effect on their animals -Financial constraints	-See other breeders using it to be reassured -Beneficial effects on living animals - Free
		B: No idea		
Women	FGDs	A: Not acceptable	CE has no effect on their animals	Free
		B: Not acceptable for breeders		

3.3.2 Anthelmintic treatment for dogs

Table 4 summarizes the acceptability and feasibility of the anthelmintic treatment for dogs. All participants thought that non-violent approaches to control CE in dogs were acceptable, and expressed their rejection of violent methods (i.e. culling by gunshot or strychnine poisoning). However, ONSSA veterinarians thought that non-violent approaches would be difficult to put it into practice due to the lack of staff and the need to repeat the treatment several times per year (4-6).

Breeders declared that they never deworm their dogs. Moreover, even for rabies and despite their awareness about its danger for human health, they only vaccinate dogs during the free vaccination campaigns. They mentioned that they would totally refuse to buy an anthelmintic for a dog. For them, dog treatments are a waste of money.

Moderator (M): "Would you buy praziquantel to treat your dogs?"

B6: "Absolutely not."

M: "Why?"

B4: "We buy vaccines and medicines for our livestock, but not for dogs!"

B1: "We will not buy it."

B10: "(shocked) Buying drugs for dogs!" (FGD/Breeders)

ONSSA veterinarians said they could administer the anthelmintic during dog vaccination campaigns against rabies, but they could not ensure the treatment continuity for the rest of the year. Local authorities suggested to distribute free anthelmintic drugs to people for treating their dogs. However, breeders said that they would not give the drugs correctly to their dogs because they would either forget to give the drugs at regular intervals, or would not make sure that the dogs swallow the drug. ONSSA and private-sector veterinarians said that even if the anthelmintic would be distributed to the families, they expected that dog owners would not follow the instruction correctly, especially in rural areas where people do not care about dog treatment. Women also said that they might forget to treat their dogs. ONSSA veterinarians suggested that private-sector veterinarians could do the anthelmintic treatment of dogs because they regularly visit farms for their work and breeders trust them. The private-sector veterinarians said that they would need to be subsidized for implementing this control measure.

"Private-sector veterinarians could be the solution. They are in permanent contact with breeders. They could treat dogs during their farm visits. However, we have to pay them." (IDI/ONSSA veterinarian)

Table 4: Categories and topics extracted from FGDs and IDIs about the anthelmintic treatment for dogs

Category	**FGD/IDI**	**Acceptability** A: For him/her B: For other participants	**Argumentation**	**Feasibility**
ONSSA	IDIs	**A:** Acceptable with concerns	-Lack of staff -Treatment must be done several times per year	-Anthelmintic during dog vaccination campaigns against rabies -Private-sector veterinarians could do it
		B: Refusal by the population	No interest in dog treatments	
Physicians	IDIs	**A:** Acceptable	Cut the parasite life cycle	- Awareness raising campaign - Free
		B: Acceptable		
Local authorities	IDIs	**A:** Acceptable	Cut the parasite life cycle	- Distribute the drugs to people for treating their dogs
		B: Not acceptable for breeders	Financial constraints	
Private-sector veterinary doctors	IDIs	A: Acceptable	Cut the parasite life cycle	- Need of subsidies to implement this control measure
		B: Not acceptable for the population	-No interest in deworming their dogs	
Breeders	FGDs	A: Refusal	-Not interested in deworming their dogs -Financial constraints	-They would not give the drugs correctly to their dogs - Veterinarians should do it
		B: No idea		
Women	FGDs	A: Refusal	-Not interested in deworming their dogs -Forget to treat their dogs	-Free -Veterinarians should do it
		B: Breeder would refuse		

4 Discussion

In Morocco, a new approach was proposed to control CE based on lamb vaccination and anthelmintic treatment of dogs. Theoretically, this strategy could control CE in 15 years

335 (Torgerson, 2003). Here, we used a qualitative research methodology to collect the perspectives of
336 the targeted population and of the involved professionals.

337 Human and animal health professionals recognized the persistence of CE in their region, despite
338 the current CE control program. Programs to eradicate other zoonoses, such as rabies and
339 leishmaniasis, are also failing, and this represents an important public health concern (Nassiri *et*
340 *al.*, 2016; Direction de l'Epidémiologie et de Lutte contre les Maladies, 2018). In Morocco,
341 zoonosis control programs are hindered by overlapping authority/functions among the involved
342 stakeholders, conflicts of interest, lack of proper training, and professional practices (Saadi,
343 Moussiaux, *et al.*, 2021). As many ministries are responsible for implementing the zoonosis control
344 programs, this hierarchical complexity causes conflicts due to differences in priorities and power
345 issues (Saadi, Sahibi, *et al.*, 2021). Additionally, the CE control program is based on four control
346 measures: offal seizure, slaughterhouse development, control of the dog population, and awareness
347 raising (Comité interministériel de lutte contre l'Hydatidose /Echinococcose, 2007). However, the
348 control of the dog population and awareness raising are neglected (Saadi, Sahibi, *et al.*, 2021).
349 Moreover, the lack of commitment and the poor execution of measures can seriously hinder the
350 whole project (OMS and CDS, 2011). This opens the discussion on the design of effective and
351 implementable zoonosis control programs, and the need to adapt them to the infrastructure,
352 geographic features and socio-cultural patterns of each region.

353 This study, like other studies on CE perception, found that the population is unaware of the parasite
354 life cycle, the contamination routes, and its effects on livestock. This lack of awareness contributes
355 to the CE persistence in developing countries (Ikhlass El Berbri *et al.*, 2015; Thys *et al.*, 2019). As
356 CE is transmitted through the ingestion of food or water contaminated by dog feces, the adoption
357 of good hygiene practices is an important aspect for its control. A well-informed person can

changes his/her practices (Vincent de Biasio, 2006), and for this reason health programs are usually supported by awareness raising campaigns. However, our study revealed a significant language barrier linked to the CE awareness raising campaign. Indeed, this is based on information material in French or classic Arabic (the official language of Morocco), although there are five spoken national languages: darija, hassani, tarifiyte, tamazighte and tachelhiyt (HCP, 2005). It also highlighted that women were less informed than men. Awareness raising campaigns are more frequent during the feast of the sacrifice (each family sacrifices a sheep at home), and generally messages are transmitted in the mosques that are frequented more by men than women. Moreover, women said that their husbands did not convey to them what they heard in the mosques. Women's tasks, such as treating water, washing hands and adopting good hygiene practices, are recognized as effective behaviors that reduce the risk of many diseases; therefore, the lack of awareness among women remains a major obstacle to improve CE prevention (Sen, Östlin and George, 2007). The importance of health education in schools also was emphasized, to protect children from diseases and also to convey the message to their family. It was suggested to incorporate hygiene principles into school textbooks to underline the role of school children as a vector of "innovation" for their illiterate or almost illiterate parents. These two suggestions reflect again the exclusion of women, this time in terms of schooling. Overall, 44% of Moroccans never went to school and this rate is much higher among women (57.9% for women and 28.2% for men) (HCP, 2018). In this study, women suggested alternative means to overcome this exclusion by stressing the important role of associations in raising awareness through relationships of trust and simplicity. Associations can constitute a new source of dissemination of health and awareness messages. The need of an inclusive and local prevention strategy is clearly expressed.

Alternative scenarios for CE control are possible, based for example on the systematic anthelmintic treatment of dogs and the reduction of the canine population, or on the combination of sheep vaccination and a less intensive anthelmintic treatment of dogs (Torgerson, 2006). However, both approaches face challenges and limitations. The use of praziquantel presents several logistical challenges: unpleasant taste and smell for dogs, no assurance that the dog will ingest the full dose, difficulty in determining the correct dose (weight is estimated and not measured), and the reluctance of dog owners to administer the many pills necessary for each deworming (Larrieu and Zanini, 2012). For lamb vaccination, the major challenge is the cost and the resistance of farmers who do not see the impact of hydatidosis on their herd, contaminated pastures, and limited resources (Larrieu and Zanini, 2012).

We considered here that acceptability is a mechanism of appropriation. Appropriation consists in understanding, assimilating and sharing the results of a process, and it is based on the real participation of all stakeholders in the construction of the ideas (Dechamp *et al.*, 2006). The study results showed that the level of acceptability regarding the EG95 vaccine was different among breeders/their wives and the professionals. Professionals accepted the vaccine, but expressed some concerns, while the breeders and their wives were not ready to invest in this vaccine. This suggests different ways of reasoning and issues in these two categories. First, breeders did not seem to perceive the indirect losses linked to CE, and preferred to invest in the fight against diseases with measurable direct effects. Considering their limited economic resources, this might represent a cost/benefit analysis for choosing the most appropriate control strategy. This is an important point because public health prevention measures are based on the assumption that adherence to a program depends on the degree of knowledge (World Health Organization, 2003; Guédéhoussou *et al.*, 2009). However, other factors also could influence the acceptability and adherence to a program,

403 such as the symbolic representations of the drug, side effects and costs, as noted in a study on
404 malaria control and the populations' adherence to a new therapeutic strategy (Le Hesran, 2009). In
405 Morocco, especially in rural areas, CE life cycle is poorly understood (Thys *et al.*, 2019).
406 Therefore, animal and public health professionals could be in favor of the proposed control
407 measures, but a lack of involvement by the populations could slow down, or even negatively affect
408 the successful implementation of any CE control strategy. Veterinarians expressed some concerns
409 about the vaccine effectiveness because it was a new approach. EG95 vaccine trials in other
410 countries (e.g. Australia and Argentina) validated its effectiveness in controlling CE (Lightowlers
411 *et al.*, 1999), even in difficult and remote areas where only half of the lambs could be vaccinated
412 (Larrieu *et al.*, 2019). Moreover, the vaccine is effective in cattle as well (Heath *et al.*, 2012). The
413 results of these studies and field trials in Morocco (Amarir *et al.*, 2021) could convince
414 veterinarians about the efficacy of this vaccine. Yet, efficacy is not always a sufficient argument
415 to trigger the community support (Le Hesran, 2009). Awareness of CE economic impact could play
416 an important role in vaccine acceptance, especially because breeders ignore the loss of production
417 caused by this parasite.

418 Currently in Morocco, dog population control by municipalities is mainly based on culling by
419 gunshot or strychnine poisoning (Saadi, Moussiaux, *et al.*, 2021). Dog culling is ineffective in the
420 long term because the killed animals will be replaced by new dogs from other neighboring
421 communities (Smith *et al.*, 2019). Planning a dog control campaign requires the collection and
422 analysis of epidemiological data, the involvement of the local population, and training a specialized
423 team (Carter, 2008). However, in Morocco, dog culling campaigns are normally initiated on request
424 by citizens and are carried out by unqualified personnel (Saadi, Moussiaux, *et al.*, 2021). Other
425 strategies could be used, such as sterilization and pharmacological treatments. For example, in

426 Jaipur (India), a rabies control strategy, based on dog sterilization and vaccination led to the
427 elimination of human rabies in the program area (Reece and Chawla, 2006). The management of
428 the dog population, which is a key factor in the fight against several zoonoses, is complex. In
429 Morocco, 78.5% of owned dogs in rural areas are free to seek food, and owners abandon more than
430 53% of pups (Bouaddi *et al.*, 2018). Owned dogs that are left free but return to their home in the
431 evening are a major source of human contamination, particularly rabies, leishmaniasis and
432 hydatidosis. This dog category should be targeted for treatment. With the exception of breeders,
433 most participants were in favor of treating dogs with anthelmintic drugs to control CE. New
434 Zealand and Tasmania managed to eliminate CE after more than 30 years by implementing a
435 strategy based on regular arecoline purgation and quarantine, and on an anthelmintic (praziquantel),
436 associated with education of the population (Craig *et al.*, 2007). Praziquantel is an excellent
437 deworming drug with cestocidal activity and allows controlling CE; however, the logistics of
438 regular mass treatment of dogs are difficult, and many countries that have adopted this strategy
439 failed to control CE (Craig *et al.*, 2017). Hence, to improve its implementation, the possible
440 difficulties reported by our interviewees should be taken into account.

441 Breeders listed the lack of money to buy praziquantel, but they also said that they were not
442 interested in dog treatments and considered them foolish, which highlights, again, the importance
443 of education. On the other hand, the population would prefer preventative measures instead of the
444 current brutal methods for dog population control (RAPAD Maroc, 2016). This attitude and
445 awareness raising among breeders might encourage them to use the anthelmintic treatment for CE
446 control in dogs. In addition, the owner-dog relationship needs to be taken into account. In the
447 framework of our study, dogs can be defined as "cash dogs" because they are seen as a useful
448 animal and not as a pet, object of human projection, as defined by Gouabault and Burton-Jeangros

449 (Gouabault and Claudine Burton-Jeangros, 2010). According to these authors, humans are
450 generally interested in animals that are useful or that represent an interest for their existence
451 (Gouabault and Claudine Burton-Jeangros, 2010). This explains why humans spend money on an
452 animal if they perceive benefits for themselves. In the case of CE, people do not treat dogs because
453 they do not perceive the advantages. The studied population is aware that dogs might transmit
454 several disease, and expressed their opposition to the use of violent methods (culling) in the
455 framework of preventive actions against zoonoses. Therefore, choices should be oriented towards
456 the sanitation of the living environment, the development of individual and collective hygiene, the
457 correct conservation and protection of food from contamination related to dog feces (Ménard,
458 2000).

459 Before embarking on the nation-wide implementation of new disease control strategies, a study on
460 the population's expectations was necessary, not only to comply with an ethical requirement
461 specific to the bottom-up approach, but also to ensure a positive impact. CE control includes several
462 actors. Therefore, the needs, expectations, and beliefs of each actor should be apprehended and
463 taken into consideration. It should be remembered that the population's health behavior, such as
464 the adoption of preventive measures, is often determined by prioritization (Vincent de Biasio,
465 2006). Therefore, we studied the feasibility of the proposed strategy among different actors because
466 understanding their emotional and material needs is the first pillar for the implementation of CE
467 control strategy. Participants gave several suggestions, such as providing vaccination of sheep for
468 free, the need of awareness campaigns to explain its benefits, incorporating the EG95 vaccine in
469 another widely used vaccine (e.g. enterotoxemia), and confirming its effects in field studies in
470 different regions. Breeders said that they would more easily accept a treatment or a vaccine if one
471 of their neighbors had used it and if they could see the direct effects. For the anthelmintic treatment

of dogs, many participants proposed to delegate it to the private-sector veterinarians who are trusted by breeders (Ellis-Iversen *et al.*, 2010). The involvement of experts and legitimate authorities, and the introduction of rewards are useful to ensure compliance. Moreover, information/marketing approaches and the use of valued referents (e.g. private-sector veterinarians) are essential factors for changing the population's beliefs (Kelly and Thibaut, 1978).

Our study investigated the perceptions and expectations of the target population and of representatives of the structures in charge of the CE program, particularly the professionals who are implementing it in the field. Participants worked together to develop strategies to overcome each challenge, highlighting problems encountered in the field, and seeking opportunities to bring their goals together to establish the first step towards a One Health approach. Besides the practical suggestions for the vaccine and dog treatment, they all stressed the importance of considering the socio-cultural context in strategic planning and communication.

Figure 4 Circumstances and barriers that affect the acceptability and feasibility of the EG 95 vaccine for lambs and the anthelmintic treatment for dogs

5 Conclusion

The results of this study based on a qualitative approach should contribute to the development and implementation of a new strategy to control CE in Morocco, while taking into account the values of each key actor. Specifically, to be accepted, the lamb vaccine must be safe and its effectiveness demonstrated, and it must be free of charge and combined with another vaccine. Dog deworming is poorly accepted by breeders and difficult to put in place (repeated 2 to 4 times per year). Therefore, its implementation seems to be particularly complex. Identifying and understanding the different concerns and beliefs and launching a dialogue with the different categories will help to find a way towards the successful control of CE. This study brings many questions and also many perspectives and propositions that should be taken into account and addressed, particularly the need

to better inform and educate the population and also the different stakeholders. Thus, it is important to continue the epidemiological and economic modeling of the various control approaches with the aim of obtaining a clear assessment of the expected profitability and societal benefits.

Acknowledgements

We thank the Department of Epidemiology and Diseases Control (DELM), the National Office for Food Safety (ONSSA) and local authorities.

Funding

The Research and Higher Education Academy of Wallonie and Brussels (ARES- Belgium) and Agronomic and Veterinary Institute Hassan II, Rabat, Morocco funded this study.

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