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IMPROVING BACKYARD POULTRY HUSBANDRY AND ADDRESSING AVIAN DISEASE RISKS THROUGH INFORMATION AND COMMUNICATION INTERVENTIONS IN RESOURCE-POOR COMMUNITIES IN MOROCCO

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ABSTRACT

This study, conducted in Khemisset province, Morocco, investigates the impact of educational outreach on enhancing technical skills and transforming risky practices, attitudes, and behaviours among backyard poultry keepers to promote safe and controlled background poultry farming. Throughout the intervention trial, spanning from November 2020 to July 2021, 300 backyard poultry farmers from five rural counties participated. Before the intervention, data was gathered through a structured questionnaire and on-farm observations involving 160 poultry keepers. A follow-up assessment six months later included 118 trainees. Initially, baseline findings highlighted limited awareness among farmers regarding various aspects of poultry farming. However, after the educational intervention, significant improvements were noted in knowledge and practices related to confinement, shelter hygiene, disease transmission, and biosecurity. Notably, while knowledge enhancement was evident, changes in actual practices were more restrained. Statistical analyses identified factors such as age, gender, flock size, and income from poultry as influential in the adoption of recommended practices. The study underscores the effectiveness of education in elevating knowledge levels but acknowledges challenges in implementing recommended practices due to constraints such as limited resources, high costs, labour demands, inconvenience, stigma, and time constraints. The conclusion emphasizes the potential role of veterinary authorities and national extension services in conducting widespread education programs for backyard poultry keepers, with a call for community engagement to ensure the sustained application of acquired knowledge and practices.

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INTRODUCTION

Backyard poultry farming is being recognized as a sustainable and effective mean of improving the economic conditions and livelihoods of impoverished individuals in rural areas, especially among landless labourers, small farmers, and rural women. Backyard poultry farming is a considerably low-input and environmentally sustainable practice (Branckaert, 2007). It provides a cheap source of protein for household consumption and acts as a source of

immediate income for the family. Despite that the poultry industry in Morocco has experienced great a substantial growth over the past decades (IFPS, 2021), backyard poultry farming has remained viable because of the consumer's increasing interest in organic and harmful residues-free eggs and meat (Sarter, 2004). Moreover, during the COVID-19 pandemic backyard poultry farming ensured food security for the population from distant rural areas in Morocco and elsewhere (Muruganandam and Bihari, 2022). Similar to other African countries, backyard poultry farming in Morocco is constrained by endemic diseases, especially Newcastle disease (ND), but also by farmer's limited knowledge of poultry health management and disease prevention practices, poor husbandry skills, insufficient and low-quality feed, the lack of animal health services adapted to this system, lack of housing and confinement and the lack of a market chain for backyard poultry farming products (Fagrach et al., 2023). These observations suggest that backyard poultry farming plays a role in the transmission and spread pathways of avian diseases.

Moreover, backyard poultry owner's lack of knowledge about poultry health and good husbandry practices, in addition to the risky practices such as the irrational and inappropriate use of antibiotics and drugs approved for other animal species or human use may pose an additional risk related to zoonotic diseases, such as Highly Pathogenic Avian Influenza (HPAI) (Kandeel et al., 2010; Rabinowitz et al., 2010), food-borne pathogens, such as Salmonella and Campylobacter (Anderson, 2003; Behravesh et al., 2014), and human exposure to antimicrobial resistance and residue through poultry products (Cornejo et al., 2020).

Improving technical skills and changing risky practices, attitudes and behaviours, through educational outreach are among the recommended interventions that urgently need to be implemented to mitigate any potential risks associated with the sustainability of backyard poultry farming. Farmers' outreach and education have been proven in many studies to be the best way to impart valuable information that can enhance their knowledge and practices, to improve their knowledge and practices and thereby their risk-free profits of the available resources helping them to ensure food security and move out from poverty (Alfredo, 2015; Kambarage et al., 2003; Ngowi et al., 2008; Sarti et al., 1997).

The present study aimed to evaluate the effectiveness of an educational outreach intervention on increasing knowledge and awareness about at-risk practices and behaviours in backyard poultry flocks in the province of Khemisset, to issue relevant policy recommendations for promoting safe, controlled and sustainable backyard poultry farming development at regional and national levels.

MATERIALS AND METHODS

The study received ethical approval from the Committee on Ethics in Animal Sciences and Veterinary Public Health of Institut Agronomique et Vétérinaire Hassan II. In accordance with ethical guidelines, all study participants provided oral consent for the publication of their pictures.

Study area

The study was conducted in the rural province of Khemisset, in the Rabat-Sale-Kenitra region, located in the North-West of Morocco (33.12°N and 6°W). It is a predominantly rural subdivision covering an area of 8,305 km2 with an estimated human population of 542,221 inhabitants (HCP, 2014). Administratively, the province is divided into four circles with a total of 31 rural counties. The province is characterized by a semi-arid climate, with an annual average rainfall of 300 to 600 mm. Agriculture is one of the main economic activities in this province, as it is a source of livelihood for the majority of the rural population. The main crops grown in the region are wheat, barley, olives and fruits. After crop production, animal husbandry is the second primary means of generating alternative income to support farmer's livelihoods. The herd kept includes cattle, goats, sheep, and chickens is estimated at 924,600 heads with sheep accounting for 63.8% of the total. The region was selected because of its proximity, its ease of access, the support of the local authorities and above all for the abundance of backyard poultry rearing along with the high density of commercial poultry farms.

Study design

The study was carried out over approximately two years, 2021 and 2022, and consisted of an educational outreach intervention trial. To develop an effective educational intervention, it was necessary to identify the perceived needs of the BPF (backyard poultry flock) owners about husbandry practices, health and biosecurity management. For this matter, a cross-sectional survey was initiated to assess farmer's

knowledge of poultry health, husbandry and biosecurity practices, based on interviews with 160 BPF owners from the rural counties of Khemisset, using a structured questionnaire and a field observation during flock's visits. The survey has also investigated the owners' level of awareness, the at-risk practices and risk factors that might represent a threat to human or animal health. Once the initial survey had been conducted and data gathered and analysed, an adapted educational material was elaborated according to survey findings. Educational sessions were implemented in five rural counties within the Khemisset province, namely Brachoua, Moulay Driss Aghbal, Rommani, Aîn Sbit, Ezzhiliga, and Had Lagwalem (Figures 1 & 2). A total number of 300 backyard poultry flock (BPF) owners have participated. To benefit as many households as possible, the number of participants has been limited to one member per household. Sessions were organized in close collaboration with, local authorities, local veterinary and extension services. After six months, the same questionnaire and on-field observation study were used to evaluate changes in the knowledge and practices of 118 participants, representing almost 40% of those who received the training previously.

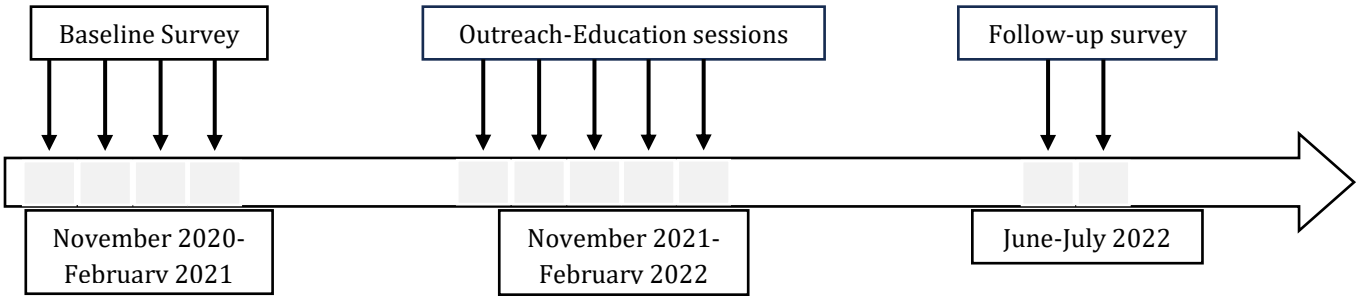

Figure 1. Timeline of the study, including surveys and education sessions.

Figure 2. Education sessions in rural counties of Khemisset province.

Intervention protocol

Based on the findings of the initial survey, a suitable outreach-education program was developed in collaboration with the scientists and experts from the Pathology and Veterinary Public Health Department of the Institut Agronomique et Vétérinaire Hassan II and the National Office of the Agricultural Council, to improve the backyard poultry farming practices. The educational program for backyard poultry farming aimed to enhance the knowledge and skills of flock

owners in fields of poultry health management, biosecurity practices, housing, feeding, and marketing. The education program included the following:

(1) The health component is concerned with comprehensive information on avian diseases, covering their transmission, prevention, and control.
(2) Poultry housing focused on the construction of shelters using local materials, as well as confinement and hygiene.
(3) Poultry feeding included topics such as feed composition, feeding frequency, mineral and vitamin supplementation and water provision.
(4) Lastly, the marketing component covered topics such as record-keeping, identifying new market channels, selling cockerels at six months of age, professional groups and cooperative organizations.

Description of educational material

Educational material, consisting of five PowerPoint presentations regarding health, biosecurity, housing, feeding and marketing (Figure 3).

The initial presentation addressed the benefits of backyard poultry farming, particularly from a socio-economic standpoint, such as the potential for generating income during crises.

The second presentation focused on poultry housing, including recommendations for ideal shelter size and location, as well as suggestions for locally available building materials.

The third presentation dealt with feeding practices, covering topics such as appropriate feed types, water supply, nutritional requirements, and feeding frequency.

The fourth presentation described poultry diseases, transmission, biosecurity and prevention practices.

The fifth presentation deals with marketing.

The education session took one or two days per rural county and was provided in dialectal Arabic. To accommodate the high illiteracy rate (47.5%) among the local rural population (HCP, 2014), most of the textual content in the presentations was replaced with pictures and illustrations. Throughout the training session, participants were actively invited to ask questions and share their experiences and challenges in raising village poultry. The shared experiences of the participants proved to be invaluable for the program. During each session, team members and local partners were invited to provide feedback on the process to simultaneously make improvements to the content and the way of presenting.

Questionnaire survey

The knowledge about poultry farming was collected by face-to-face interview method from 160 backyard poultry flock owners (October 2020-February 2021) through a structured questionnaire that consisted of five sections of four to five statements that prompted the respondents on various themes related to health, biosecurity, housing, feeding, and general husbandry practices. This data was then used to design the content of an educational intervention. The assigned score for the right statement was “1” and for the false statement, a score of “0” was given, for each survey question, the percentage of correct answers was calculated.

Field observation

As the survey was conducted at the farm level, the research team took the opportunity to evaluate the respondent’s attitudes and practices towards poultry farming to develop an idea about the existing situation. The observation included the confinement system, the use of water and feeding equipment, the hygienic status of the poultry shelters and equipment, the disposal of dead birds and the quarantine application at poultry introduction. The assigned score was 1 for the right practice and 0 for the inappropriate practice, a. The percentage of correct statements was then calculated.

Post-education evaluation

After conducting the educational outreach intervention in February 2021, the impact of the program was assessed by re-evaluating the knowledge uptake and husbandry practices of 118 trainees. The same interview-based questionnaire and field observation that were used in the initial baseline survey were used to measure the effectiveness of the education campaign.

Data gathering and analysis

Data collected was entered into MS Excel and posteriorly exported to SPSS version 26® for analysis. To describe the demographic characteristics, knowledge, attitudes, and practices of the participants, descriptive statistics were used to calculate proportions and frequencies.

The pre-and post-educational outreach intervention data were then compared using Cochran's Q test to

determine differences in knowledge and changes in practices and attitudes. Additionally, the Spearman test of correlation was used to identify any possible associations between independent variables and the adoption of practices. A significance threshold of 5% was set for all statistical tests.

Figure 3. Educational Material for Backyard Poultry Keepers (a) Raising backyard chickens (b) How to build and improve chicken shelter (c) Egg Production, incubation, and chicks rearing (d) Poultry nutrition, (e) chicken health care, and disease prevention.

RESULTS

Demographic attribute of the study participants

Participants' sociodemographic characteristics are shown in Table 1. A total of 118 trained poultry keepers were interviewed in the post-education survey. The majority of the participants were women (91%) and under the age of 45 years (66.2%). Most participants were married (81%), and the average family size was 5.5 ± 0.3. The majority of participants were illiterate (73.1%) or had completed primary school (22.5%). The main source of income for participants was crop and livestock farming (87%). A majority of participants had land holdings (68.1%), and the average annual income from poultry was 3629.40 ± 740.00 MAD.

Knowledge and practices among study subjects pre- and post-poultry farming education

Levels of knowledge and practices assessed at baseline and follow-up 6 months after backyard poultry farming education are provided in Table 2. Before education sessions, respondents were not much aware of confinement advantages and risks, poultry shelter construction and hygienic measures. Among the study subjects, only 24,4% knew about the importance of confinement at baseline, though 80% of BPF owners practice overnight confinement, and the vast majority (84,4%) had poultry shelters in very bad conditions at baseline.

Despite, the significant knowledge uptake improvement in knowledge 6mo after the education intervention (61,9%; p<0,001), the proportion of farmers who practice solely the overnight confinement remained practically the same (71%, p=0,088) and no changes were observed toward the practice of total confinement practice. Interestingly, (51%; p<0.001) of the trained BPF owners had complied with construction recommendations. Only 32,5% of the baseline survey participants knew of the importance of poultry coop hygiene, at 6 months follow-up, (67,8%; p<0.001) of respondents had improved their knowledge significantly. Observations of poultry coop hygiene showed that only 31.9% of the farmers maintained good

hygiene conditions in their poultry coops, while more than 68% had poor hygiene. However, after the educational intervention, a significant improvement was noticed, with only 32.2% (p <0.001) of farmers practising poor hygiene and 67.8% (p<0.001) maintaining good hygienic conditions.

Table 1. Socio-demographic characteristics.

Variable	Category	Frequency (%)
Age	≤ 45 years	106 (66.2)
	> 45 years	54 (33.8)
Average age (years)		44.2 ±13.6 (18-84)
Gender	Women	145 (91)
	Men	15 (9)
Marital status	Married	130 (81)
	Unmarried	30 (19)
Average family size		5.5 ± 0.3
Education level	Illiterate	117 (73.1)
	Primary school	36 (22.5)
	Secondary/University	7 (4.4)
Source of income	Crop and livestock	139 (87)
	Other	21 (13)
Land holding (ha)	Yes	109 (68.1)
	No	51 (31.9)
Average annual income from poultry (MAD)		3629.40 ± 740.00

Furthermore, at baseline, only 36% of the participating farmers reported feeding their birds according to their age (table 2). After the educational intervention, the percentage of farmers providing age-appropriate feed increased to 40%. However, the difference was not statistically significant. Only 17,5% of BPF owners were providing the recommended aliment and diet and practically no mineral or vitaminic supplementation was observed at baseline. However, at follow-up, more than 37% (p <0,001), 15,3% (p≥ 0,05) and 15,9% (p< 0,001) of the trained farmers had adopted the recommended diet and provided vitamin and mineral supplementation, respectively.

At baseline, only 13,7% of the farmers were aware of disease transmission patterns and the zoonotic potential of some avian diseases. The follow-up assessment showed that the trained farmers had significantly improved their knowledge about disease transmission compared to baseline (53.4%; p<0.001). Disease recognition was correctly described by 78,75% and 73,7% of farmers at baseline and follow-up respectively. Before the education intervention, a low level of awareness demonstrated by the BPF owners lack biosecurity practices such as restriction of farm entry (12,5%), use of footbath at the farm (1,9%), cleaning of feeding utensils and/or drinking trough (41,6%), quarantine application of newly introduced birds (13,1%), daily observation of the health status of the flock (20,6%), isolating diseased birds from healthy ones (18,1%), disposal of carcass by burning or burial (10%), keeping away wild birds (24,3%), consulting the veterinarian before treatment (10,6%), respect of dosage and withdrawal period of antibiotics (14,4%), the practice of vaccination (0,6%).

After providing the educational outreach to the backyard owners, a significant changes in practices were noticed in cleaning of feeding utensils and/or drinking trough (62,7%; p< 0,001), quarantine for the newly introduced birds (54,2%; p< 0,001), daily observation of the health status of the flock (66,2%; p< 0,001), isolating diseased birds from healthy ones (72,8%; p< 0,001), disposal of carcass by burning or burial (30,5%; p< 0,001), keeping away wild birds (37,3%; p < 0,001), consulting the veterinarian before treatment (27,1%; p<0,001). However, no significant change was recorded regarding restriction of farm entry (21,2%; p<0,001), use of footbath at the farm (4,3%; p< 0,001), respect of dosage and withdrawal period of antibiotics (%; p< 0,001) and

vaccines application (1,7%; p< 0,001). The very low practice was recorded regarding the marketing section such as record keeping (5,1%; p< 0,001), selling birds at the age of 6mo (0%; p< 0,001), entering new market channels (%; p< 0,001) and developing farmers organizations (5,6%; p< 0,001).

Table 2. Evaluation of changes in knowledge and practices regarding health, biosecurity, housing, feeding and poultry marketing, 6 months after outreach-education intervention in Khemisset province, Morocco.

Knowledge and practice aspect				Baseline (%) (n=160)	Follow-up at 6 months (n=118)	Difference (p-value)
Housing	Confinement	Knowledge of confinement advantages and risks		39 (24.4)	73 (61.9)	<0.001
		Practice of confinement	Overnight	128 (80)	84 (71)	p=0.088
			No	32 (20)	34 (29)	
	Poultry shelter	Construction compliance to recommendations	Good	25 (15.6)	60 (51)	<0.001
			Bad	135 (84.4)	58 (49)	
		Knowledge of hygienic conditions		52 (32.5)	80 (67.8)	<0.001
		Hygienic status	Good	51 (31.9)	80 (67.8)	<0.001
			Bad	109 (68.1)	38 (32.2)	
Feeding	Providing feed according to poultry age			58 (36)	47 (40)	p=0.370
	Following the recommended aliments and diet			28 (17.5)	44 (37.3)	<0.001
	Vitamin supplementation			14 (8.75)	18 (15.3)	p=0.093
	Mineral supplementation			6 (3.75)	23 (19.5)	<0.001
	Use of feeding and/ or watering equipment			36 (22.5)	51 (43.2)	<0.001
	Water source		Public network	153 (96)	107 (90.7)	p=0.097
			Environmental sources	7 (4)	11 (9.3)	
	Hygienic status of feeding and watering equipment		Good	15 (41.6)	32 (62.7)	<0.05
			Bad	21 (58.4)	19 (37.3)	
Health & Biosecurity	Diseases transmission			22 (13.7)	63 (53.4)	<0.001
	Diseases recognition			126 (78.75)	87 (73.7)	0.328
	Diseases prevention measures	Limiting visitors' contact with poultry		20 (12.5)	25 (21.2)	0.052
		Use of disinfectant and footbath at farm		3 (1.9)	5 (4.3)	0.244
		Quarantine application of new birds		21 (13.1)	64 (54.2)	<0.001
		Daily observation of the birds' health status		33 (20.6)	79 (66.9)	<0.001
		Isolating diseased birds from healthy ones		29 (18.1)	86 (72.8)	<0.001
		Segregating the brooding hen and chicks		30 (18.8)	66 (55.9)	<0.001
		Disposing of dead birds by burning or burying		16 (10)	36 (30.5)	<0.001
		Keeping away wild birds and other backyard poultry from the farm		39 (24.3)	44 (37.3)	<0.001
		Consulting veterinarian before treatment		17 (10.6)	32 (27.1)	<0.001
		Knowledge about withdrawal periods and antibiotic residues		18 (11.2)	82 (69.5)	<0.001
		With respect to dosage and withdrawal periods		23 (14.4)	25 (21,2)	0.137

	Use of vaccines	1 (0.6)	2 (1.7)	0.396
	Ectoparasites treatment using appropriate products	44 (27.5)	60 (50.8)	p <0.001
Marketing	Records keeping	2 (1.25)	6 (5.1)	0.059
	Selling cockerels at 6months of age	1 (0.6)	0 (0)	-
	Entering new market channels	17 (10.6)	20 (16.9)	0.125
	Developing farmer's groups and organising cooperatives	4 (2.5)	6 (5.1)	0.253

Table 3 displays the correlation estimates between the adoption variable and the independent variables. Age exhibited a significant negative correlation with the adoption, while gender, flock size, and income from poultry showed significant positive associations with adoption. The adoption variable displayed a positive but insignificant correlation with education level, family size, and land holding among the respondents.

Table 3. Overall adoption of backyard poultry rearing practices and their correlations with independent variables.

Area	Percentage	Coefficient of correlation (r) with independent variables						
		Age	Gender	Education Level	Family size	Flock Size	Income from poultry	Landholding
Housing	63,9	-0.15*	0.162*	0.012 NS	0.009 NS	0.274**	0.068*	0.013 NS
Feeding and Watering	39	-0.193*	0.169**	0.016 NS	0.0224 NS	0.25*	0.196*	0.122*
Health & Biosecurity	43,9	-0.18*	0.172*	0.049*	0.010 NS	0.126*	0.16*	0.008 NS
Marketing	7,8	-0.154NS	0.134 NS	0.015 NS	0.036 NS	0.161 NS	0.066 NS	0.037 NS
Overall Adoption	41,22	-0.178*	0.153*	0.018 NS	0.044 NS	0.132*	0.091*	0.005 NS

NS: Non-significant; *Significantly different at $p < 0.05$; **significantly different at $p < 0.01$.

DISCUSSION

As a part of the study, we designed and implemented a multifaceted educational package to improve rural population knowledge, attitudes, and practices towards backyard poultry farming, based on a "One Health" approach. Our study is consistent with previous findings that backyard flock owners have poor knowledge regarding many aspects of poultry management practices (Di Pillo et al., 2019; Hamilton-West et al.,2012; Özdemir, 2020). Although the intervention has significantly improved farmers' knowledge about the importance of permanently confining poultry and proper poultry coop hygiene, none of the farmers adopted the total confinement system due to food scarcity, especially during the cold season. This finding is consistent with previous studies conducted by Conan et al. (2013) who reported a low adoption of permanent confinement of poultry and ducks among backyard farmers, with a high adoption of regular cleaning of poultry's coops. Sims & Swayne (2016), also asserted that the adoption of confinement measures for backyard poultry farmers in Cambodia was very limited. This was because transitioning from scavenging to confinement requires that the poultry be provided with food, which was too expensive for poor households. As an alternative, some farmers confined young chicks or temporarily confined poultry during periods of high mortality. Similarly, Chilundo et al. (2020) found that even with high knowledge uptake regarding the importance of total confinement, backyard pig confinement was not practised. Practising full confinement can result in a higher demand for feed and can result in the loss of 10-25% of the annual income of the poorest families (Sonaiya, 2007). Some trainees continued practising inadequate coop hygiene and inappropriate construction, which is likely due to the high financial cost of construction materials and labour required, irrespective of encouragement to use inexpensive local

materials. According to Garrett et al. (2006), the most significant barriers to adopting new practices are time and cost rather than willingness and awareness.

Feeding is crucial for productive performance in poultry management. Mapiye and Sibanda (2005) highlighted that timing, frequency, and quantity of feeding, are important aspects to consider in developing strategies to improve the nutrition of village or local chickens, and inadequate feeding affects considerably the birds' health. In our study, despite intervention, many backyard flock owners did not provide appropriate feed based on age and mineral supplementation. One of the major reasons behind this rejection is the inconvenience and cost, backyard poultry flock owners found it easier to provide the same food to all chickens regardless of their age. Moreover, vitamin supplements are expensive, and the BPF owners claim to not have the resources to invest in them. In contrast, mineral supplementation was significantly more adopted because of the promotion of eggshell powder use.

The habit of not using feeders and appropriate drinkers allowing poultry to drink from environmental water sources can pose several risks to birds' health, because feed on the ground can be contaminated with dirt, feces, and other debris, which can be a risk of disease transmission to chickens. Environmental water sources can also be contaminated with pathogens. Moreover, this feeding and drinking technique can attract pests such as rodents insects and wild birds, which can create an additional health risk for the chickens. At the follow-up, there was a significant increase in using elevated feeders and waterers, and also a significant improvement in the equipment's hygiene. The growing concern among breeders regarding health risks could explain the increase in equipment cleaning, which supports the hypothesis described by Perry and Grace (2009) saying that poor farmers are rarely willing to make changes from "no care" to "care" unless they get external help.

Despite poor knowledge, there were some health aspects such as disease recognition where there was already moderate knowledge. The reason for the existing knowledge regarding disease recognition could probably be explained by the fact that devastating diseases are very often encountered and represent the major constraint that affects backyard poultry farming (Fagrach et al., 2023). In contrast to avian diseases, participants in our study had very little knowledge of many aspects in relation to prevention and biosecurity at the baseline study. The lack of knowledge at baseline, regarding prevention and the zoonotic aspects of some avian diseases, was in accordance with other studies (Di Pillo et al., 2019; Hamilton-West et al., 2012; Özdemir, 2020). Among the recommended husbandry practices, restricting visitors' contact with birds, the use of disinfectant and footbath at the farm would limit the risk of introduction and spread of infectious agents into flocks (Alhaji & Odetokun, 2011; Henning et al., 2009). These recommendations appear to be not accepted by trained backyard poultry owners. such contradiction has been observed in previous studies in Bangladesh (Rasel, 2019), and Cambodia (Conan et al., 2013). Farmers mentioned that restricting access to the farm is perceived as unfriendly or unneighborly behaviour and that the use of disinfectants and footbaths may incur additional expenses. Sims & Swayne (2016) found that although standard communication and extension methods can improve knowledge, changing long-standing behaviours would be more difficult. To achieve behaviour change, it is important to have a good understanding of existing practices and their driving factors, as well as the costs and constraints associated with implementing new measures. In Bangladesh, a survey of backyard poultry farmers on practices and perceptions concerning the zoonotic transmission of avian influenza has revealed that the farmers were unwilling to adopt suggested preventive measures if additional time and resources would be involved (Sultana et al., 2012).

Nevertheless, our educational interventions have shown a positive influence on the (1) adoption of daily observation of the birds' health status; (2) quarantine application at new birds introduction; (3) isolation of diseased birds from healthy ones; (4) segregation of the brooding hen and chicks; (5) disposal of dead birds by burning or burying, (6) keeping away wild birds and other backyard poultry from the farm; and (7) consulting the veterinarian before any treatment. The high adoption rates for the above practices after our training implementation were similarly reported in India by (Ithika et al., 2013) and (Kushwah et al., 2016). These observed results may be attributed to the collective awareness that has been fostered among the rural population through the national campaign for COVID-19 prevention and control. This campaign has encouraged better general hygienic practices and has laid the groundwork for improved comprehension of

hygiene and biosecurity recommendations about backyard poultry farming. According to (Conan et al., 2013), villagers tend to change their practices only after experiencing adverse events. In our case, the COVID-19 pandemic had a beneficial impact on raising awareness among villagers about biosecurity and health management. The global pandemic has highlighted the importance of good hygiene practices and biosecurity measures to reduce risks of disease transmission. Resource-poor communities face challenges in controlling diseases under free-range conditions, making disease prevention difficult to implement (Mutua, 2018). However, practising good husbandry and biosecurity measures, such as regularly cleaning chicken coops, quarantining newly introduced birds, and isolating diseased birds from the flock, can be a relatively inexpensive and effective way to prevent the spread of infectious diseases. Despite the effectiveness of these measures, vaccination remains the most effective way to control diseases, resulting in reduced mortality rates and increased income (Bessell et al., 2020). Similarly, in our case, vaccination was not adopted as farmers were not in a position to purchase vaccines due to the high cost and the need for veterinarian intervention. The high dose number of commercial vaccines can make it difficult and cost-prohibitive for backyard poultry farmers to purchase the vaccines they need for their small-sized flocks, irrespective of the alternative options available that we recommended, such as the purchase of appropriate vaccines manufactured in smaller packages specifically designed for backyard poultry flocks, or working with their local veterinary service or veterinarian to find cost-effective solutions for vaccination, such as vaccine clinics or group purchases with other backyard poultry farmers in their community. Given the incapacity of vaccination, the use of antibiotics and other drugs has become widespread, often without a clear understanding of their purpose or proper usage. Respondents confirmed the common use of antibiotics to prevent diseases in their flocks, as well as using antibiotics, and drugs intended for human use (Fagrach et al., 2023). They were unaware of the health risks associated with excessive use of antimicrobials to treat animal diseases, such as the presence of antibiotic residues in chicken meat and eggs, and the importance of adhering to the withdrawal period. However, after the intervention, a noticeable improvement was observed in breeders' awareness of antibiotics and Antimicrobial Resistance (AMR). Many were finally aware that antibiotics should only be used to treat bacterial infections, that antibiotic residues can end up in meat and eggs, and that resistant bacteria can develop in animals and transfer to humans. Despite this, no changes were observed regarding appropriate antibiotic dosage or adherence to the withdrawal period. Reasons for the persistence of these risky practices are linked to the lack of adequate measuring instruments and the quantity of antibiotics is often applied based on their own appreciation. Furthermore, many farmers still consider the benefits of using backyard farming products during the withdrawal period as outweighing the risks. Once again, it has been observed that effecting behavioural change is a complex task that may necessitate a multi-pronged strategy that encompasses not only education and information provision but also addresses fundamental social, economic, and cultural factors. Additionally, it is crucial to acknowledge that the effects of education on behavioural change may not manifest immediately. To comprehensively assess the efficacy of educational interventions, it is imperative to conduct prolonged evaluations that can thoroughly capture their impact. Correlation coefficients for seven independent variables have revealed several interesting patterns regarding adoption behaviour of husbandry practices. Age was found to be significantly related to the adoption, suggesting that younger backyard poultry keepers are more likely to adopt recommended husbandry practices such as cleaning, disinfection, and biosecurity practices on their farms. This might be due to the fact that younger farmers have more physical stamina and energy, which afford them an increased ability to implement recommended husbandry practices more expeditiously. In contrast, older farmers may prioritize preventive medicines due to potential limitations in their physical abilities, such as the use of antimicrobials and other drugs.

Moreover, the results show that gender plays a significant role in the adoption of good husbandry practices in poultry farming. Female trainees are more likely to adopt the new practices than their counterparts because female participants are assumed to be the ones in charge of poultry raising. According to (Ahmed et al., 2021), gender roles and responsibilities in poultry production affect the adoption of good husbandry practices, with women being more involved in poultry raising and thus more likely to adopt new practices. This

could be explained by the fact that poultry keeping is neglected by men because it is mainly oriented toward home consumption and does not make a great profit. These findings highlight the need for targeted interventions to improve the adoption of good husbandry practices in poultry farming, with a focus on educating female farmers. Flock size and income from BYPF have a positive and significant relationship with adoption rate, suggesting that farmers with larger numbers of poultry on their farms and those with high income from BYPF products are more likely to adopt the educational package. Farmers with a high flock size may perceive themselves to be highly susceptible to risks, resulting in significant economic losses. As a result, these farmers may take proactive measures to maintain the integrity of their farms and reduce the risk of potential challenges. Existing research shows that farmers' adoption behaviour is correlated to a combination of personal, social, and economic factors. Pao et al. (2023) identified relationships between the socioeconomic characteristics of broiler farmers and their adoption level of biosecurity practices. For example, farmers' education and age have a positive association with their biosecurity practices. Nath et al. (2012) found that the level of education, age of farmers, farm size, income from poultry, extension contact, and credit facility were the major determinants of backyard poultry rearing practices adoption. Other variables that could explain part of the adoption behaviour in other studies are not found to be significant in our analysis, such as education level, family size, and land holding. Thus, any efforts towards developing animal-based educational programs should involve a meticulous analysis of the social and economic situation of the training beneficiaries. Extension and educational outreach programs are essential for addressing many challenges and help improving the knowledge and skills of backyard poultry farmers. Such programs can provide farmers with the necessary information and skills on best practices in poultry management, including feeding, disease prevention, and housing that can help mitigate the risks associated with backyard poultry farming, improve animal welfare, and increase productivity and income. Based on the findings, the educational outreach intervention was successful in enhancing the participants' knowledge and attitudes towards backyard poultry farming practices, although some farmers still lacked risky practices changes.

CONCLUSION

The implementation of an education intervention to raise awareness and disseminate public health-related messages about backyard poultry farming resulted in considerable improvement of knowledge and change in several practices favouring better public health and lesser risk. This could be an important step to enhance preparedness against highly pathogenic avian influenza emergence. The impact of these measures may not be immediately discernible, highlighting the importance of maintaining long-term and consistent efforts to achieve ultimate success. Therefore, veterinary authorities with the national extension services may consider implementing mass education programs for backyard poultry keepers and provide support for its sustainability through the involvement of the local communities to ensure that the knowledge and practices learned are maintained.

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