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REGULAR ARTICLES

The effectiveness of community-led initiatives in livestock disease control: a case of African swine fever in rural areas of Uganda

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Abstract

Proper implementation of biosecurity is currently the only control measure of African swine fever (ASF) in the absence of an effective vaccine or drug against the disease. Despite the efforts that Uganda's local and central governments have invested to reduce livestock diseases, ASF outbreaks still persist in the country. In this study, we assessed the effectiveness of community-led initiatives in the control of ASF in Mukono District, central Uganda. In Mukono district, a community-led pilot program was initiated where stakeholders in the pig value chain organized themselves into an ASF control task force to enforce on-farm and pig value chain activities intended to limit the spread of ASF. Semi-structured interviews with pig famers ($n=211$) were conducted in two areas with contrasting practices: one with active community-initiated and monitored ASF control initiatives since 2016 (Kasawo and Namuganga) and the other without such initiative as the control (Mpunge and Ntenjeru). A significant decline (Wilcoxon ranked sign test: $Z=-5.412$, $p=0.000$) in the annual frequency of ASF outbreaks in both Kasawo and Namuganga sub-counties was observed after the implementation of community-led initiatives. The level of practice of most ASF control measures was significantly higher ($p<0.01$) in sub-counties that instituted community-led ASF control initiatives than in the control sub-counties. The results of this study demonstrate the power of community-led initiatives in reducing ASF disease outbreaks in endemic areas.

Keywords African swine fever control · Community-led initiatives · Effectiveness · Endemic areas

Introduction

In sub-Saharan Africa (SSA), pig production is extremely important for food security and household income (Mulumba-Mfumu et al, 2019). Indeed, in some communities, pigs are known as "walking banks" because of the ease with which a farmer can get financial returns from the pig at any stage of growth. Pigs are important capital reserves for many rural households in SSA (Doble, 2007). Additionally, the pig industry is a very attractive sector for smallholder farmers (FAO, 2004) because pigs have a short reproductive cycle, give high returns, and convert low-quality waste feeds into nutritious pork products (Phiri et al., 2003). As a result, the pig industry is quickly expanding in many SSA countries including Uganda. Uganda has the second most rapidly growing pig sector in Africa (Phiri et al., 2003; FAOSTAT, 2018). In the last decade, Uganda's pig population significantly increased from 0.19 million in 1980 to 4.0 million in 2016 (UBOS, 2008) and currently standing at 4.1 million (UBOS, 2017). Pig production in the country is therefore not only widespread but also increasing at a high rate making Uganda the top pork-consuming country in Africa (ILRI, 2016). However, this industry is faced with many diseases that affect pigs (Thomas et al., 2013) and most feared of all is the devastating African swine fever (ASF) disease (Dione et al., 2014) that kills up to 100% of infected pigs (Arias and Sanchez-Vizcaino 2002; Penrith et al., 2004; Costard et al., 2013) depending on the genotype. Currently, there are 24 globally known genotypes of ASF virus (Quembo et al., 2017). ASF has neither cure nor vaccine (Penrith

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et al., 2004; Costard et al., 2013). The disease is present in 26 SSA countries (Penrith et al., 2013) including Uganda where the disease in endemic with outbreaks reported annually (Muwonge et al., 2012; Kalenzi Atuhaire et al., 2013; Chenais et al., 2017; Muhangi et al., 2015).

In low-income countries like Uganda, animal diseases adversely impact on income and food security (Perry and Grace, 2009; Herrero et al., 2013) because of the diverse roles the animal plays in rural communities. Controlling ASF is therefore critical for food security, reducing rural poverty and improving household livelihood (Dobble, 2007). ASF control is through quick diagnosis and strict implementation of biosecurity measures which to date has remained a big challenge among smallholder poorly resourced pig farmers that dominate this sector in Uganda. In Uganda, several laws and policies exist that govern the management of infectious livestock diseases at both local and central government. For instance, the Animal Diseases Act 2000 provides guidelines for instituting quarantines in the event of an infectious livestock disease outbreak by prohibiting the movement of livestock and livestock parts from and to disease outbreaks areas without authorization, and provides guidelines on how to handle and dispose diseased animals and carcasses. Additionally, the Act gives power to the police and veterinary officers to enforce these regulations intended to prevent and control livestock diseases. The implementation of animal disease control policies and laws is overseen by a network of veterinarians at all sub-counties in collaboration with the Ministry of Agriculture Animal Industry and Fisheries (MAAIF), the responsible ministry. Despite the presence of these measures, ASF outbreaks are still frequent in the country. It is now well known that proper implementation of biosecurity can help in controlling livestock diseases like ASF but the biggest challenge is how best can the community be involved to accept and participate in practicing such measures for successful disease control.

Community participation has been proven vital in disease control, for example, in malaria control (Atkinson et al, 2011). Recently, a community-led experiment to control ASF was initiated in Mukono, in central Uganda by pig farmers and other value chain actors. The detailed description of the organization and activities in the experiment are described in full in the study area section. In the sub-counties of Kasawo and Namuganga in Mukono district, pig stakeholders (included veterinarians, pig farmers, traders, consumers, and agricultural officers) organized themselves and formed an "ASF task force" in 2016. The range of activities of the "ASF task force" is described in the study area section below. This study assessed the effectiveness of community-led initiatives towards the control of ASF in Mukono district, central Uganda.

Methods and materials

Characteristics of study area and selection criteria of study communities

The study was conducted in Mukono District (0.2835° N, 32.7633° E), central Uganda (Fig. 1).

The district has 13 sub-counties with a total 144,160 households (UBOS, 2017). Of these, 43.8% of the households are involved in livestock keeping. The study was conducted in two distinct (one with community-led ASF control initiatives in place and the other as a control) rural areas of Mukono district in the sub-counties of Kasawo, Namuganga, Ntengeru, and Mpunge. In the sub-counties of Kasawo and Namuganga (Mukono north constituency), 54.7% of the population keep pigs while 50.4% of the population in Ntengeru and Mpunge sub-counties (Mukono south constituency) are pig farmers. In Kasawo and Namuganga, community-led initiatives against ASF were being implemented since 2016 while in Ntengeru and Mpunge, there were no such initiatives put in place by the community. According to the Government of Uganda Animal Diseases Act 2000, measures such as institution of quarantines, reporting of outbreaks of livestock diseases, sensitization of farmers on livestock diseases, prevention of unauthorized animal movements, and sale of diseased animals or animal product are practiced to some extent all over the country including the sub-counties of Ntenjeru and Mpunge although the adherence level is low. The community-led ASF prevention and control practices that were instituted included fencing of pig farms using chain links (Fig. 2), construction of affordable raised pig pens (Fig. 3), placing foot baths (with disinfectants) at farm gates and pig pen doors (Fig. 4), and confining pigs in pens to eradicate free range system of pig production management.

Additional community-led measures used were isolating suspected ASF-infected pigs from the rest of the herd, burying or burning carcasses of ASF-infected pigs, monitoring adherence to quarantine in outbreak areas, pork inspection before sale, and restricting pig slaughtering to only designated slaughter slabs (Fig. 5).

This study was conceived following a visit to Kasawo and Namuganga sub-counties which revealed the existence of self-help community-led initiatives against ASF code-named the "ASF task force." This task force was formed in 2016 and it was composed of veterinarians, pig farmers, traders, butchers, pork consumers, and local council leaders in the two sub-counties with an ultimate goal of controlling the spread ASF. The task force was engaged in sensitization, monitoring movement of pigs in the area, ensuring that there was adherence to ASF control

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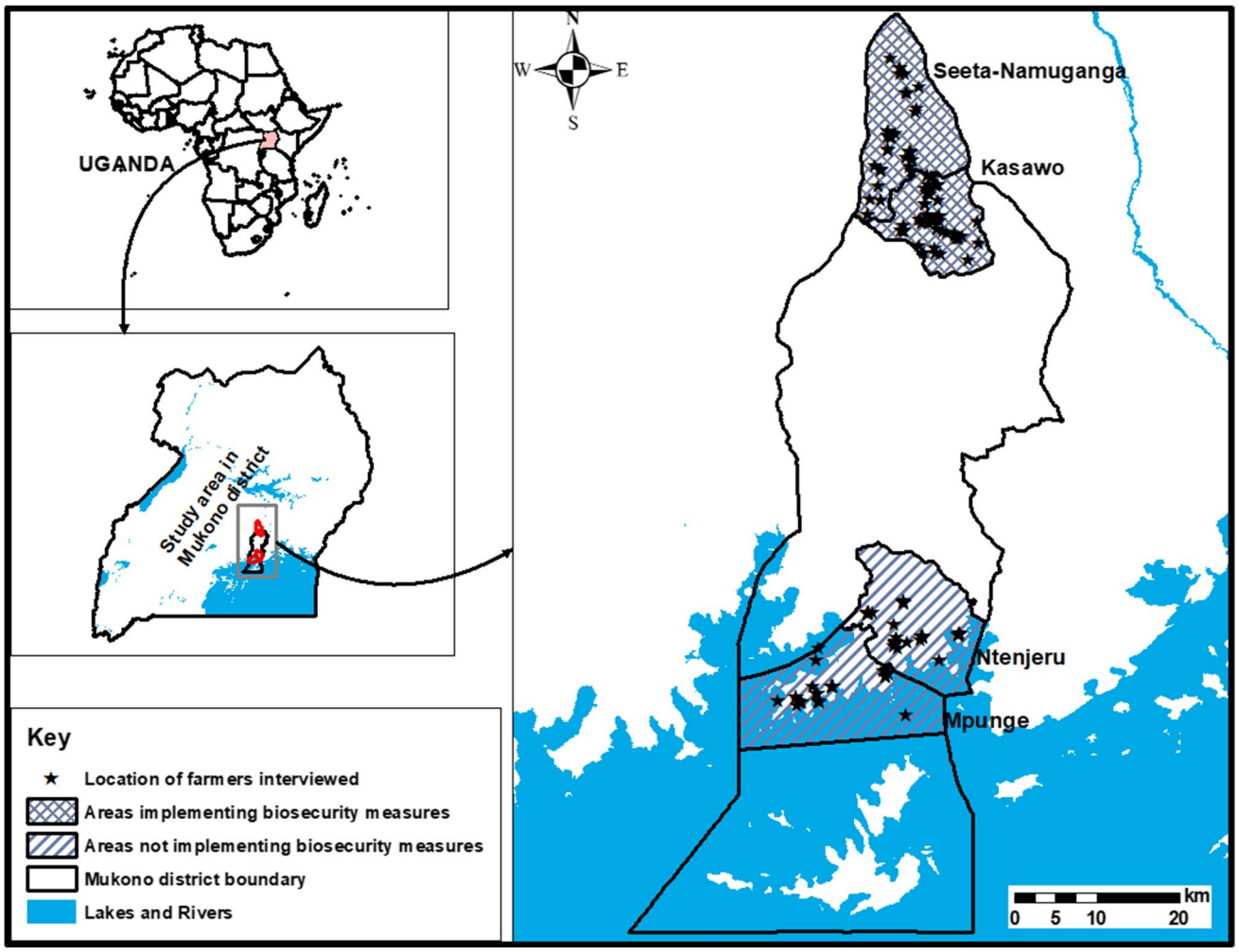


Fig. 1 Distribution of the farms in the four sub-counties where interviews were conducted in Mukono District in central Uganda

prescribed measures and ASF surveillance. ASF task force activities were coordinated by the Kasawo sub-county veterinarian who also doubled as the Mukono District ASF focal person. All parish veterinarians reported cases of ASF outbreaks to their respective sub-county veterinarian through the "ASF task force" chairperson who then reported to the district ASF focal person, who then finally reported to the district veterinary officer. The sub-county veterinarian together with the Local Council three (L.C.3) chairperson and the police implemented quarantine when needed and monitored the implementation of community-led initiatives in their respective sub-counties.

At the parish level, the parish veterinarian together with the L.C.2 chairperson sensitized farmers, consumers, and traders on community-led ASF control initiatives and ensured that the initiatives were being implemented by all stakeholders in the pig value chain in each parish. This was done in close collaboration with the different village leaders of farmers, consumers, and pig traders. Parish veterinary officers also ensured that pigs were slaughtered at the central slaughter slabs in each village and inspected to declare pork fit for consumption before sale by the butchermen. The farmers in each village were responsible for putting into practice the agreed upon practices on their farms in addition to policing fellow farmers in the implementation of these practices. These practices included confining pigs by either tethering or housing, putting foot baths with disinfectants at the farm entrance, double fencing the farms, and disinfecting all visitors before entering the farm. Additional measures that were used included ensuring that no ASF-infected pigs were sold or slaughtered and reporting suspected ASF outbreaks instantly to the veterinarians. The traders bought and sold only ASF clean pigs/pork in addition to keeping proper hygiene at the butchers and reporting any trader that violated these initiatives. The leader of pork consumers inspected all butchers in the village for proper hygiene and sale of non-ASF-infected pork. All new ASF outbreaks were reported to the task force chairperson who

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Fig. 2 A pig farm fenced with chain links



Fig. 3 A raised pig pen to keep pigs off the ground and confined

convened monthly meetings to evaluate the performance of all stakeholders. This initiative to control ASF was only restricted to the two sub-counties because it was community-led, accepted and driven to boost the income of community members through pig keeping. This kind of community-led organization with a sole purpose of enforcing the implementation of ASF control measures by all stakeholders in the pig production value chain aimed at reducing the spread of ASF and economic losses associated to the disease is the first of its kind in Uganda.

Data collection tools and techniques

The study employed semi-structured questionnaires to selected pig farmers to establish the effectiveness of community-led initiatives in reducing ASF outbreaks. The questionnaire was designed to obtain information on farm demographics, management systems, the level of farmer's awareness of ASF, the frequency of ASF outbreaks before and after commencement of the community-led initiatives, and the level of adherence to agreed practices. The questionnaire was pretested by facilitators in the local language (Luganda) to twenty pig farmers in Kasawo and corrections made to the questionnaire, before finally administering it in the study area. Four facilitators who were native local language-speakers and fluent in English administered the questionnaires from 5 to 16th November 2018. Since not every member of the community reared pigs, a snowball sampling design was used to select farmers in the study area by the facilitator with the guidance of the parish Veterinary Officer. The facilitators administered 211 questionnaires in total ($n = 111$ in the treatment area and $n = 100$ in the control areas). The selected study areas had a history of reported and laboratory confirmed outbreaks of ASF to minimize the risk for recall bias. All reports of confirmed outbreaks were recorded by each sub-county veterinary officer and copies sent to the district veterinary officer as well.

Farmer's knowledge of ASF definition

A farmer's knowledge of ASF was defined as a farmer who had experienced ASF outbreak on their farm or on a neighbor's farm.

Data management and analysis

All data were entered into Microsoft Excel spread sheets (Microsoftâ Excel 365, version 16.28) and cleaned before

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Fig. 4 A foot bath placed after the farm gate



Fig. 5 A designated slaughter slab in Kasawo sub-county

being analyzed. The percentages of descriptors for the farm characteristics, management systems practiced, the level of practice, and importance of each biosecurity measure were calculated in STATA (Version 20). The farmers' knowledge of ASF and ASF signs was compared between the two contrasting areas of study using the chi-square goodness-of-fit test in STATA (Version 20). This was done to ascertain whether there were any differences between the observed and expected number of farmers who know about ASF disease and its signs across the sub-counties studied. The comparison of annual frequency of ASF outbreaks before and after the implementation of biosecurity measures was done using the Wilcoxon sign ranked test. The difference in presence and implementation of community measures in the two contrasting areas was done using the chi-square goodness-of-fit test in STATA (Version 20) and the correlation between the sub-county and presence of community-led ASF control measure was deduced using Crammers V.

Results

Farm characteristics

The respondents were mostly female (more than 54%) in all the four sub-counties with most farmers having reared pigs for not more than 5 years (48% and above). Majority of the respondents were in the age brackets of 18–38 in Kasawo (44.6%) and Ntenjeru (43.3%), 39–58 in Mpunge (52.5%), and in Namuganga, 41.3% of the respondents were in the age ranges of 18–38 and 39–58 years. The highest number of respondents was married (69% and above) in all the sub-counties. More than 69% of the households (HHs) interviewed were headed by males. At least 40% of the HHs were graduates of secondary level of education across the sub-counties except in Namuganga where majority of the HHs were of primary level (47.8%). Most HHs in the four sub-counties had a combination of jobs (Table 1). The farm pig herd sizes in all the four sub-counties ranged between one and five and the number of farmers decreased with increase in the herd size. Generally, most farmers kept local and cross breeds with few farmers keeping the exotic pig breeds in the study area (Table 1). In the sub-counties that instituted the community-led ASF control initiatives, most farmers practiced the semi-intensive system of pig management (Kasawo, 95.4% and Namuganga, 76.1%) compared to the control sub-counties (Ntengeru, 51.7% and Mpunge, 40%). The free range and tethering management systems, which have been reported to aid ASF transmission, were more popular in the control sub-counties (Ntengeru, free range 20% and tethering 55%; Mpunge, free range 20% and tethering 42.5%) than in the sub-counties that instituted community-led ASF control initiatives (Kasawo, free range 6.2% and tethering 9.2%; Namuganga, free range 4.3% and tethering 32.6%) (Table 1).

Farmer's knowledge of ASF disease and its clinical signs

Table 2 presents findings on farmers' knowledge of ASF disease in the four sub-counties. Surprisingly, results show

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Table 1 Percent distribution of farmer and farm characteristics in the four sub-counties in the study area. Kasawo and Namuganga sub-counties instituted the ASF prevention and control measures while Ntenjeru and Mpunge sub-counties were controls

Variable	Description	Sub-county			
		Kasawo ($n=65$)	Namuganga ($n=46$)	Ntenjeru ($n=60$)	Mpunge ($n=40$)
Respondent's age (years)	18–38	44.6	41.3	43.3	37.5
	39–58	43.0	41.3	36.7	52.5
	59–69 +	12.4	17.4	20.0	10
Respondent's gender	Male	46.2	34.8	36.7	30.0
	Female	53.8	65.2	63.3	70.0
Duration in piggery (year)	0–5	67.7	52.2	48.3	62.5
	6–20	30.7	45.7	38.3	35.0
	21–50	1.6	2.1	13.4	2.5
Respondent's marital status	Married	73.8	69.6	71.7	70.0
	Not married**	26.2	30.4	28.3	30.0
Household head (HH)	Male	69.2	69.6	90.0	75.0
	Female	30.8	30.4	10.0	25.0
HH's education level	None	0.0	6.5	1.7	10.0
	Primary	24.6	47.8	21.7	27.5
	Secondary	56.9	34.8	50.0	40.0
	Tertiary	18.5	10.9	26.7	22.5
HH's main occupation	Livestock	20.0	30.0	20.0	30.0
	Crop	13.8	17.5	16.7	17.5
	Trade	12.3	5.0	8.3	5.0
	Civil servant	3.1	2.5	0.0	2.5
	Other	3.1	12.5	0.0	12.5
	Combination	47.7	32.5	55.0	32.5
Pig herd size	1–5	33.8	54.3	60.0	62.5
	6–10	30.8	28.3	15.0	12.5
	11–20	16.9	10.9	16.7	15.0
	20 +	18.5	6.5	8.3	10.0
Pig breeds on farm	Local	52.3	63.0	66.7	57.5
	Cross	69.2	41.3	43.3	52.5
	Exotic	36.9	17.4	20.0	22.5
Management system*	Free range	6.2	4.3	20.0	20.0
	Tethering	9.2	32.6	55.0	42.5
	Semi-intensive	95.4	76.1	51.7	40.0

*Categories are not mutually exclusive due to multiple responses. That's why sum of percentages exceeds 100%, **Includes single, divorced, and widowed (they were grouped as one because they had very small individual values)

that almost as many farmers in Mpunge and Ntenjeru (control sub-counties) know about the disease as in Kasawo and Namuganga (sub-counties that instituted community-led initiatives against ASF). There was no variation in Namuganga sub-county but slight variations in the rest of the sub-counties. The test revealed that the observed differences in the farmers' knowledge of ASF diseases were significantly different from the expected (chi-square goodness fit test, $p<0.05$) in Kasawo, Mpunge, and Ntenjeru. In other words, farmers' knowledge of ASF disease was equally distributed across the three sub-counties. Similarly, across all the four sub-counties studied, the chi-square goodness of fit test showed that there was no significant difference in respondents' knowledge of ASF disease signs. This indicated good knowledge of ASF signs in all sub-counties meaning that most farmers in all the sub-counties had either experienced ASF outbreak on their farm or on a neighbor's farm (Table 3).

Annual frequency of ASF outbreaks before and after implementation of community-led initiatives

As expected, most farmers reported a reduction in the frequencies of ASF outbreaks after the introduction of

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Table 2 Percentages of farmers' knowledge of African swine fever disease and chi-square goodness fit test values in the four sub-counties in the study area

Sub-county	Know ASF disease		Chi-square[g]	df	*p-value*
	No (%)	**Yes (%)**			
Kasawo[f]	4.6	95.4	53.554	1	*
Mpunge	2.5	97.5	36.1	1	*
Ntenjeru	3.3	96.7	52.267	1	*
Namuganga[f]	0.0	100			

[f]Sub-county implementing ASF control community-led initiatives, [g]chi-square goodness of fit test, *significance level $p < 0.05$ (Right tailed)

Table 3 Percentages of farmers' knowledge of African swine fever disease clinical signs and chi-square goodness of fit test values in the four sub-counties in the study area

Sub-county	Know ASF signs		Chi-square[g]	df	*p-value*
	No (%)	**Yes (%)**			
Kasawo[f]	10.8	89.2	40.015	1	*
Mpunge	15.0	85.0	19.6	1	*
Ntenjeru	6.5	93.5	34.783	1	*
Namuganga[f]	18.3	81.7	24.067		

[f]Sub-county implementing ASF control community-led initiatives, [g]chi-square goodness of fit test, *significance level $p < 0.05$ (Right tailed)

Table 4 Comparison of annual frequency of ASF outbreaks in the sub-counties of Kasawo and Namuganga before and after implementation of community-led initiatives

Ranks				Test statistics	
	N	**Mean rank**	**Sum of ranks**	***Z***	***P*-value**
Negative ranks	60[a]	42.48	2549	−5.412	*
Positive ranks	17[b]	26.71	454		
Ties	26[c]				
Total	103				

[a]Freq of outbreaks after < Freq of outbreaks before, [b]Freq of outbreaks after > Freq of outbreaks before, [c]Freq of outbreaks after = Freq of outbreaks before, *Wilcoxon sign ranked test, significant level $p < 0.05$

community-led initiatives against ASF while fewer farmers reported an increase in the frequencies of ASF outbreaks after the introduction of control measures in the sub-counties of Kasawo and Namuganga (Table 4). The annual frequency of ASF outbreaks significantly reduced (Wilcoxon sign ranked test: $Z = -5.412$, $p = 0.000$) after the introduction of community-led ASF control initiatives in both Kasawo and Namuganga sub-counties (Table 4).

Level of practice of ASF control measures

The number of farmers that practiced the ASF control measures was significantly higher ($p < 0.01$) in the sub-counties that instituted community-led ASF control initiatives (Kasawo and Namuganga) than in the control sub-counties (Ntengeru and Mpunge) (Table 5). Such measures included the use of particular boots for moving in the pig sty, use of own boar on farm, isolation of newly acquired pig, restricting visitors to the pig sty area, restriction all visitors (including traders) to get into contact with pigs, isolation and confining of suspected sick animals, disinfection of pig sties, cleaning and disinfection of farm equipment, and frequent disinfection of feeding and drinking utensils. Other ASF control measures such as provision of a foot bath at the entrance of the pig farm, fencing of the pig farm to keep out free ranging animals outside the farm, and controling of rodents and pests on the farm were also practiced by a significantly high number ($p < 0.05$) of farmers from the sub-counties of Kasawo and Namuganga (instituted community-led initiative) than in Ntenjeru and Mpunge sub-counties (control). A significantly higher number ($p < 0.01$) of farmers in Ntengeru and Mpunge were involved in taking their pigs to the neighboring farms for mating during breeding seasons than in the Kasawo and Namuganga, yet this is one of the mechanisms of spreading ASF between farms. The use of swill in feeding pigs varied significantly ($p < 0.01$) among the sub-counties studied, such variation could be attributed to differences in financial capacity of and individual farmer to buy better pig feeds rather than the presence of community-led ASF control initiative or not among the sub-counties studied. Much as measures such as the use of family members in pig farms, instant reporting of suspected sick pigs to area veterinarians, and control of ticks were the most widely adopted measures against ASF across the four sub-counties studied they were not significant. Control measures that required money for implementation were the least practiced by most farmers across all sub-counties studied. This included the use of disinfectants at the gate, sty, spraying vehicles before loading animal feeds, and entering the farm. The level of practice of the rest of the ASF control measures was more less the same across all the four sub-counties in the study area.

Comparison of implementation of community-led initiatives

In Table 6, the chi-square test of independence revealed that the differences in proportions of respondents confirming presence of community-led initiative against ASF are significant ($\chi^2_{(3,0.05)} = 96.628$; $p = 0.000$). A significantly higher

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Table 5 Percentage level of practice of each ASF control measure between the sub-counties that instituted community-led ASF control initiatives (Kasawo and Namuganga) and the control sub-counties (Ntenjeru and Mpunge)

ASF control measure	Sub-county				*p-value*
	Kasawo[a]	Namuganga[a]	Ntenjeru	Mpunge	
Use of family member for labor	90.8	93.5	85	90	ns
Instant reporting of suspected sick pigs to area Veterinarian	80	76.1	66.7	77.5	ns
Use of particular boots for moving in the pig sty	61.5	54.3	26.7	27.5	***
Control of ticks and flies on farm	61.5	63	53.3	60	ns
Use of own boar on farm	53.8	52.2	26.7	32.5	***
Isolation of newly acquired pig	43.1	39.1	15	15	***
Restricting visitors to the pig sty area	41.5	52.2	10	15	***
Restricting all visitors (including traders) to get into contact with pigs	40	32.6	11.7	12.5	***
Isolation and confining of suspected sick animals	35.4	47.8	18.3	10	***
Disinfection of pig sties	33.8	47.8	10	20	***
Sows brought to boar	30.8	47.8	10	45	***
Cleaning and disinfection of farm equipment	27.7	34.8	5	10	***
Frequently disinfecting of feeding and drinking utensils	26.2	39.1	10	20	***
Use swill to feed the pigs	26.2	63	35	62.5	***
Use of a village worker/employee to feed the pigs	18.5	8.7	13.3	10	ns
Disposal of suspected ASF dead animals by burying	16.9	19.6	16.7	10	ns
Isolate the pigs for selling	16.9	17.4	8.3	10	ns
Take pigs to neighboring farms for breeding	15.4	32.6	60	35	***
Slaughter of pigs on farm	13.8	13	18.3	20	ns
Disposal of suspected ASF sick/dead animals by selling	10.8	30.4	21.7	15	ns
Gate at the entrance to the pig farm	9.2	13	0	2.5	*
Disposal of suspected ASF sick/dead by slaughter	7.7	8.7	11.7	2.5	ns
Disinfecting all visitors that visit pig sty area	7.7	10.9	1.7	0	ns
Fencing to keep out all other animals outside the farm	7.7	17.4	1.7	2.5	*
Disinfectant used in footbath	6.2	10.9	1.7	0	ns
Foot basin at the farm entrance	4.6	10.9	1.7	0	ns
Don't return the pigs touched by traders to the pig sty	4.6	6.5	5	5	ns
Control of rodents and pests on farm	4.6	15.2	6.7	0	*
Disinfecting vehicles delivering feeds and other supplies before entry	3.1	0	0	0	ns
Disinfecting vehicles before loading them with feed, water, sawdust etc	1.5	0	0	0	ns
Foot basin outside the farm	1.5	2.2	1.7	0	ns
Foot basin inside the farm	0	6.5	0	—	*

[a]Sub-county instituted community-led ASF control initiatives. Significance levels, $^{***}p < 0.01$; $^{*}p < 0.05$; *ns*, non-significant

Table 6 Comparison of the level of implementation of community-led initiatives against ASF in the study area

Sub-county	Presence of community-led initiative				Chi-square	*p*-value
	Observed *n* (%)		**Expected *n* (%)**			
	Yes	**No**	**Yes**	**No**		
Kasawo[f]	56 (87.5)	8 (12.5)	39 (60.9)	25 (39.1)	96.628	*
Namuganga[f]	44 (100)	0 (0)	27 (61.4)	17 (38.6)		
Ntengeru	15 (25.0)	45 (75.0)	36 (60.0)	24 (40.0)		
Mpunge	10 (26.3)	28 (73.7)	23 (60.5)	15 (39.5)		

[f]Sub-county that instituted community-led ASF control initiatives, *chi-square statistic is significant at $p < 0.05$ (two tailed), Cramer's $V = 0.692$

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proportion of respondents in Kasawo (88%) and Namuganga (100%) confirmed presence of community-led initiatives than in Mpunge and Ntenjeru. This is confirmed by the adjusted residuals which show that the number of respondents who confirmed presence of community-led initiative against ASF in Kasawo and Namuganga was significantly higher than expected. The results also show a very strong correlation between sub-county and presence of community-led initiatives against ASF (Cramer's $V \approx 0.7$).

Discussion

Results of this study demonstrate for the first time in Uganda, the ability of community-led initiatives in reducing incidences of animal disease outbreaks. In Uganda, enforcement of regulations intended to control livestock disease is in place (Government of Uganda Animal Diseases Act, 2014); however, enforcement has remained a problem. For example, the recurrent outbreaks of foot-and-mouth disease in many parts of Uganda (Kasambula, 2011; Kerfua et al, 2013, 2018) were attributed to failure to enforce restriction of movement of livestock and livestock products from outbreak areas by key actors. In fact, enforcement of disease control measures is not only a problem in Uganda but indeed a problem in many sub-Saharan African countries. The failure to effectively enforce animal disease control in sub-Saharan Africa has been reported in Cameroon (Miranda et al, 2018), South Africa (Fasina et al, 2015), Kenya (Thomas et al, 2013), and in Ethiopia (Ayelet et al, 2012). Many times, farmers in poor resource communities in Africa who are the majority resist and also fail to comply to such measures. Resistance and non-compliance to enforcement of disease control measures in developing countries could be attributed to the high poverty level among smallholder farmers who are incapable of continuously investing in animal disease control measures. Secondly, failure by technocrats to employ a bottom-up approach which involves the local community from the initial stages of policy formulation and implementation rather than the top–bottom approach could be responsible for failure of these policies (Wesonga et al, 2018). Previous studies have reported similar findings involving zoonotic diseases were people insist on consuming milk and meat from infected animals (Espinosa et al, 2020). More notable examples have been reported in studies where animals were infected with diseases such as anthrax (Muturi et al, 2018), brucellosis (Nyokabi et al, 2018), and Rift valley fever (Leach et al, 2017; Mutua et al, 2017). Results of this study demonstrate the potential of community-led initiatives in significantly reducing ASF outbreaks and could be explored for upscaling in Uganda and other developing countries.

It is however vital to note that, much as community initiated, monitored, and implemented interventions significantly reduced ASF outbreaks in the study area, some of the measures that required the farmer to incur costs were unpopular among farmers (Table 5). Such measures included use of disinfectants at the gate, disinfecting sties, spraying vehicles before loading animal feeds or entering the farm, spraying sties to control ticks and flies which the farmers considered expensive. Such unwillingness of smallholder farmers to implement disease control measures that involve incurring costs was also reported in previous studies in Uganda (Chenais et al. 2017). Additionally, some measures like burying dead ASF-infected pigs were considered a taboo among most farmers as earlier mentioned in previous studies in Uganda (Mutua et al, 2017; Chenais et al., 2017) and other parts of the world such as Russia, Georgia, and Sardinia (Zaberezhnyì et al., 2012; Costard et al, 2013; Gogin et al, 2013). Lastly, restricting visitors from farms as a disease control measure was also considered by some farmers as being anti-social in the community. This was confirmed in this study since very few farmers in the control sub-counties adopted the ASF control measure which involved restricting visitors from their farms compared to a significantly high proportion of farmers in the sub-counties that implemented community-led ASF control initiatives in this study. This calls for continuous public awareness and education.

Raising public awareness has been successfully used to contain several diseases across the world, for example, Ebola hemorrhagic fever in Uganda (Okware et al, 2015) and rabies in Azerbaijan (Hasanov et al, 2018). In the case of ASF in Uganda, Chenais et al. (2017) reported that farmers had adequate knowledge about ASF and the measures required on the farm to control the disease. Similarly, in this study, most farmers (Table 3) knew about ASF indicating an increased level of disease awareness. This increased public awareness of ASF could be responsible for the farmers preferred use of intensive pig management system in intervention areas than in non-intervention areas (Table 1) pointing out a remarkable change.

The findings of this study (specifically from the community intervention areas) showed that the semi-intensive system of pig management was most preferred by farmers (Kasawo, 95.4% and Namuganga, 76.1%). This results contrasts earlier reports that the most preferred pig management system by smallholder farmers in Uganda was the free range system (Penrith et al, 2013; Chenais et al. 2017; 2019). The community-led initiatives in the intervention areas may have led to the change in pig management system from free range and tethering to semi-intensive system (Table 1). As a result of the change in the community pig management system, significant reductions in annual frequency of ASF outbreaks (Table 4, Wilcoxon sign ranked test: $Z = -5.412$, $p = 0.000$) were registered in the sub-counties of Kasawo

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and Namuganga after implementation of the community-led initiatives. In addition, the level of practice of on-farm ASF control measures in the study area was higher in the intervention sub-counties than in the control sub-counties (Table 5). This confirms that increased community involvement directly increases public awareness about animal diseases which then improves on the implementation of animal disease control measures.

Conclusion

Results from this study offer a sign of hope and demonstrate that when communities take up an initiative by themselves, the potential for success is high unlike when the initiatives are imposed on them by technocrats. Secondly, it also shows that community-led approaches that are initiated, monitored, and implemented by local communities in conjunction with all stakeholders in the pig value chain reduce ASF outbreaks in ASF endemic areas. Thirdly, the observations in this study can potentially be adopted for the control of ASF in other endemic situations in Uganda and Africa at large.

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Author contribution PO, RO, VBM, IK, and CM conceptualized and designed the study; PO, RO, and IK collected data; PO and VBM analyzed and interpreted data; PO, CM, and VBM drafted and critically revised the manuscript; CM obtained funding; and VBM and CM supervised the study.

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical considerations Permission to carry out the study was granted by the Ugandan National Council for Science and Technology under the reference number A497. Consent from the District veterinary officer was obtained prior to the start of interviews in Mukono District. All participants were informed that the study was voluntary and confidential, and that they had the choice of ending their participation at any time of the interview. An informed consent was given by all participants prior to the implementation of the study.

Conflict of interest The authors declare no competing interests.

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