Discover Viruses

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Drama-based mobile phone-delivered virtual learning as a way to support improved biosecurity in smallholder pig farming

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Abstract

This study describes a novel approach for delivering knowledge to pig producers about preventing African swine fever in domestic pigs: a virtual learning course consisting of audio recorded drama sketches, employed to support improvements in implementation of biosecurity in smallholder pig farming in Uganda. The course was delivered via system-generated, automated mobile phone calls. Participation was automatically registered and followed up by an interview with the objectives to investigate the usability as well as the potential of this type of learning for instigating change. The 155 participants were active at different nodes of the smallholder pig value chain, and in total 148 of these could be reached for an interview. Results were both quantitative and qualitative. They were analysed by descriptive statistics and thematic analysis respectively. All participants completed the first audio, and 121 participants completed all ten audios. Almost all interviewees said that they had learned something new, and reported to have implemented some changes in their pig management or disease prevention routines. Three dominant topics emerged from the thematic analysis concerning what interviewees reported that they had learned, what they considered important and what they had changed/not changed: *"cleanliness"*, "*separation of pigs"* and *"general pig health"*. These dominant topics support recent calls for mainstreaming ASF prevention into general herd health messages. We conclude that the interactive learning course was appreciated by those reached by it and led to widespread reporting of new and relevant knowledge gained about ASF. As such, a virtual learning course could be an important complement to other forms of advisory services on ASF.

Keywords African swine fever, Disease prevention, Herd health, Adult learning, Remote mobile learning, Educational theatre

1 Introduction

In Uganda, pig farming is common, and the majority of pigs are kept by poor smallholders in free-range management systems with low levels of biosecurity [1, 2]. African swine fever (ASF), a viral disease affecting domestic pigs with severe clinical signs and high mortality, is endemic in Uganda. Disease spread occurs mainly in the domestic pig

epidemiological cycle driven by the daily activities of stakeholders (farmers, traders in live pigs or pork, slaughterers) along the smallholder pig value chain [2–5]. With suitable vaccines still not available, consistently applied biosecurity and hygiene measures remain the only way to prevent and reduce the spread of ASF [6–8].

Previous research in the study area has shown that many stakeholders at different nodes in the smallholder pig value chain are aware of ASF and that many have a generally positive perception of biosecurity [2, 9–12]. At the same time, some people might lack important and specific knowledge regarding for example ASF prevention and control [13]. It has further been shown that knowledge might not be sufficient for making stakeholders adopt measures that can reduce ASF spread [14]. In Uganda, as in other low-income settings, societal and structural factors such as lack of access to infrastructure, financial institutions, animal-health extension and veterinary services, as well as the effects of poverty in and of itself, make it challenging for many stakeholders to invest in and implement biosecurity and hygiene measures [15, 16].

Studies to date have suggested community engagement approaches for overcoming some of the challenges hindering improvements in biosecurity [17–19]. In two previous publications we report on one such community engagement approach focusing on biosecurity measures for ASF along the smallholder pig value chain. The aims of that community engagement approach were to increase the feasibility of biosecurity measures, reduce costs, and promote local ownership of disease control [20, 21]. The essence of the approach was co-created community contracts on biosecurity. Several activities intended to support implementation of biosecurity were included (repeated group discussions, engagement with village leaders, posters). One of these support activities was a drama-based mobile phone-delivered virtual learning course (in short: a virtual learning course) on ASF. This virtual learning course is the subject of the study presented here.

It is often assumed that improved knowledge will lead to changed practice, but such a direct correlation is seldom observed [22, 23]. This does not mean that new knowledge is unimportant. Indeed, local stakeholders frequently request more information on livestock disease transmission and prevention, and raised levels of awareness have been found important for improving biosecurity and reducing disease occurrence in low-income settings [24, 25]. New information on its own will however not lead to change if it is obstructed by practical barriers to operationalizing the new information. Research has also shown that other factors than new information can be equally (or perhaps more) important for instigating change. These factors include enculturation, empowerment and peer-pressure [26]. Even if a stakeholder envisages a particular training as useful, there might also be practical obstacles to participating in training. If we exclude different forms of overt discrimination, there is an abundance of examples where relevant stakeholders are excluded from information meetings or trainings because organizers have insufficiently reflected on how to accommodate for people's different possibilities to take part in meetings on particular times and in particular places [27–29]. In this regard, offering training in ways that can be accessed from a place, and on a day and time, chosen by participants could facilitate more equal participation. To the extent that the information communicated is relevant and possible to act on for the target audience (referred to in the aim and subsequently in the text, as being usable), such strategies to deliver more accessible training might lead to a wider uptake of the delivered messages and the proposed change [30]. The aim of this study was to investigate the usability of a

mobile phone-delivered virtual learning course on ASF as a form of accessible learning for stakeholders in the smallholder pig value chain in Northern Uganda.

2 Materials and methods

This paper describes and analyses a mobile phone-delivered virtual learning course on ASF conducted in Northern Uganda from December 2020 to October 2021. The learning course was delivered as an implementation support in a field study investigating co-creation as a way of improving biosecurity in smallholder pig farming [20, 21].

The study, including all methodologies, was reviewed and approved by the School of Health Sciences Institutional Review Board and Ethics committee (MAK-SHS-IRB), Makerere University (ref 2019-062). All activities were carried out in accordance with relevant guidelines and regulations and adhering to the Global Code of Conduct for research in resource poor settings (https://www.globalcodeofconduct.org/). All individ uals are anonymised.

2.1 Study area, study site and participant selection

The selection of study area, study sites and participants are described in two previous publications [20, 21] and summarized here for the purpose of clarity.

The study was conducted among stakeholders in the smallholder pig value chain from the greater Gulu area of the Acholi sub-region of Northern Uganda. The Acholi sub-region is among the poorest in Uganda, in part due to a period of civil unrest lasting from 1986 to 2006 [31]. In Gulu, access to veterinary and animal health extension services is lower than in other less poor, remote or rural parts of Uganda [32–34]. Further, smallholders in general, and women in particular, have even lower access to these services than commercial farmers and men [35, 36]. Extension services by radio and via digital platforms have been proposed to overcome this challenge [37–39]. Since the end of the civil unrest, pig farming has been promoted by the government and donors as a pathway out of poverty in Gulu [40]. Pig herd size is generally very small (less than five animals including piglets), and most pigs are kept on free-range in smallholder family farms with very limited use of farm inputs, low outputs and low levels of biosecurity [41]. In this region, and in contrast to other livestock, pigs are kept by smallholders almost exclusively to be sold for slaughter (i.e., not for home consumption but as a source of cash income) [40]. The smallholder pig value chain in Northern Uganda consists of smallholder farmers holding a few pigs for sale, traders buying live pigs, butchers, and those selling raw or grilled pork for human consumption. Many stakeholders perform several of these activities. As in other parts of Uganda, ASF is endemic in the study area, causing high mortality in affected herds [42]. The socioeconomic impact of ASF outbreaks can be difficult to assess, and varies with for example herd size and the level of invested inputs [41].

For the purpose of the field study, six villages from three districts (Gulu, Omoro and Amuru) in the greater Gulu area were purposively selected for inclusion based on previous field confirmation of ASF, perceived interest in ASF control, availability of smallholder pig farmers, and presence of several different stakeholders along the small-scale pig value chain in the respective villages. Participants from each study village were purposively selected and invited by the community animal health workers in the respective villages. Inclusion criteria were being an active stakeholder in the smallholder pig value

chain in the selected villages, over 18 years old, and willing to participate in the study. Specific attention was paid to including both male and female participants. The field study centred on co-created community contracts about biosecurity. It included focus group discussions (FGDs), other semi-structured and structured group and individual interviews, field observations, and activities for supporting the implementation of biosecurity. The final study design included one initial meeting and two follow-up meetings with each group during approximately one year. During the meetings, different kinds of interviews as mentioned above were performed, serving as part of the co-creation and for data collection. At the second follow-up meeting, all participants ($n = 155$, 56 women and 99 men) were invited to enrol for the virtual learning course on ASF, which was developed as an implementation support adapted to the COVID-19 pandemic, and described in the present paper. It was explained that the course would cover prevention of ASF, and that participation was voluntary and free of charge. No other incentives were given for participating. Participation in the form of listening to audio sketches (audios) on the phone was automatically registered and followed up by an interview.

2.2 Study performance

The contents of the virtual learning course were based on a course previously delivered by the International Livestock Research Institute (ILRI) in Luganda language in the Masaka region of Uganda [30]. For the present study, ten short (around five minutes) drama sketches (initially written by one of the authors (RK) for ILRI), were translated from English to Luo and recorded by a team of performing artists led by RK at the Department of Performing Arts and Film at Makerere University in Kampala (see Supporting information 1). The audios were edited using Adobe Audition software installed on a personal computer (PC). A mobile phone-delivered interactive voice system was set up at ILRI in Kampala to deliver the course using the same technology as previously described by Dione et al. (2021). In short, it comprised an in-house system of hardware, software, and telecommunication infrastructure service on a Centos operating system with the telephone application Asterisk Interactive Voice Response Private Branch Exchange (Asterisk IVR PBX) by Digium and a python script to run the commands. The system was installed on a standard PC with a peripheral component interconnect express slot to accommodate the digital telephone interface card (Digium TE122P PCI Card) for the connection that was used for the voice service. The fibre connection was provided by a local telephone company. At enrolment for the course, participants' ($n = 155$) phone numbers and preferred day of the week and time for being called were registered. The system was set to automatically call the participants on the indicated day and time once per week for delivery of one audio recorded drama sketch (audio). If no one answered the phone, the system would call again on the next indicated day and time until the end of this part of the study period. As it was the system calling the participants, they did not pay any fees for the call. At the end of each audio recording, participants could choose to replay the audio or choose any of the nine other audio recordings. The system was active from December 2020 to July 2021. When the system closed, a report was generated including the participant mobile number, time and date for the calls, number of audios listened to, number of calls made, duration of the calls and indication of the call status (no answer, call failed, busy, answered, unknown).

After delivery of the virtual learning course, during September and October 2021, all participants were contacted via mobile phone and interviewed about their participation, learning experience and outcomes from the course. The interviews followed an interview guide with eight closed and three open-ended questions (see interview guide in Supporting information 2) and were conducted by RK in Luo and audio recorded. Answers to closed questions were noted by RK in English in an excel file. Answers to open-ended questions were summarised by RK in English in a word file. The recordings were not transcribed but were kept and used to cross-check notes during the analysis.

For all activities confidentiality was assured and permission sought to make voice recordings. It was explained that participation was voluntarily and that participants could leave the study at any time.

2.3 Data analysis

Results from the automated report from the virtual learning course system were summarised by some brief descriptive statistics performed by EC. Results from the closed interview questions (see interview guide in Supporting information 2, questions 1–7, 10) were analysed by EC using descriptive statistics including sums, percentages and medians.

Results from the answers to the open-ended interview questions (see interview guide in Supporting information 2, questions 8, 9 and 11) were imported to NVivo qualitative data analysis software (QSR International Pty Ltd. Version 12, 2018) and subjected to thematic analysis by KF. Answers for each question were pooled and imported as three separate files into Nvivo. Subsequently, the responses for each answer were coded separately. In question eight, the respondents were asked to explain in their own words what they learned from the virtual learning course, or if they did not learn anything. In question nine, they were asked to mention the most important thing that they had learned. In question eleven, respondents were asked to describe if they had changed anything or if they had not and, in that case, why. KF created themes inductively based on the coding of question eight and then used the same themes for questions nine and eleven, adding new emerging themes in the analysis as they appeared in the data of those questions. One response could be coded under several different themes, e.g. a person might mention that they learned both that they should “confine pigs” (in the study context this means constructing a simple enclosure, most often out of wood and with a simple roof, hereafter referred to as ”pigsty”) and “disinfect shoes”, which were then recorded as two separate themes. KF subsequently counted the frequency of different themes mentioned under different questions.

To be able to evaluate to what extent respondents’ answers resonated with the information included in the virtual learning course KF manually extracted all factual statements and prompts on ASF (see Supplementary information 3), and compared the respondents’ comments with what they had been informed about.

The original answers were consulted during the analysis to get a deeper understanding of the reasoning behind different themes that emerged.

Table 1 Background data about participation in a study investigating a mobile phone-delivered interactive virtual learning course on African swine fever in Uganda in 2021

	Female	Male	Total
Participants that enrolled (No (%))	56 (36.1)	99 (63.8)	155 (100)
Participants that were interviewed (No (%))	50 (33.7)	98 (66.2)	148 (100)
Participants not reached for interview (No (%))	6 (85.7)	1 (14.2)	7 (100)
Participants interviewed by phone (No (%))	30 (28.6)	75 (71.4)	105 (100)
Participants interviewed by SMS (No (%))	20 (46.5)	23 (53.4)	43 (100)

No number

Table 2 Quantitative interview results (questions 1–5, 7, 10) from a study investigating a mobile phone-delivered interactive virtual learning course on African swine fever in Uganda in 2021

Question	Female	Male	Total
Q1: Took part in previous activities in the study (No. (%))	Yes: 47 (94.0) No: 3 (6.0) No answer: 0 (0)	Yes: 97 (98.9) No: 0 (0) No answer: 1 (1.0)	Yes: 144 (97.3) No: 3 (2.0) No answer: 1 (0.7)
Q2: Age (min-max, median)	22–88, 34	19–97, 33	19–97, 34
Q3: Main pig activity (No. (%))	Butcher: 0 (0) Farmer: 42 (84.0) Pork seller: 8 (16.0) No answer: 0 (0)	Butcher: 2 (2.0) Farmer: 90 (91.8) Pork seller: 5 (5.1) No answer: 1 (1.0)	Butcher: 2 (1.4) Farmer: 132 (89.2) Pork seller: 13 (8.8) No answer: 1 (0.7)
Q4: Years of experience in pig business (min-max, median)	< 1–36, 4	< 1–40, 4	< 1–40, 3
Q5: Have listened to the audios (No. (%))	Yes:49 (98.0) No: 0 (0) No answer: 1 (2.0)	Yes: 96 (97.9) No: 2 (2.0) No answer: 0 (0)	Yes: 145 (97.9) No: 2 (1.4) No answer: 1 (0.7)
Q7: Learned anything new (No. (%))	Yes: 48 (96.0) No: 2 (4.0) No answer: 0 (0)	Yes: 97 (98.9) No: 1 (1.0) No answer: 0 (0)	Yes: 145 (97.9) No: 3 (2.0) No answer: 0 (0)
Q10: Changed anything in pig management (No. (%))	Yes: 46 (92.0) No: 4 (8.0) No answer: 0 (0)	Yes: 93 (94.9) No: 4 (4.1) No answer: 1 (1.0)	Yes: 139 (93.9) No: 8 (5.4) No answer: 1 (0.7)

Q question, *No.* number

3 Results

All participants at the second follow-up meeting of the field study enrolled for the virtual learning course. In total 148 of the 155 participants in the course, 98 men and 50 women, were interviewed. Out of the 148 respondents, 105 were interviewed by phone and the remaining 43 by short messaging service (SMS). Out of the seven participants that had signed up for the course but that could not be reached for the interview, six were women. Likewise, a higher share of the women (20 out of 50 interviewed women, 40%) compared to the men (23 out of 98 interviewed men, 23.5%) chose to be interviewed by SMS rather than by phone (see Table 1). As more men than women enrolled for the study, more women dropped out, and more women were interviewed via SMS, we concluded that our data does not reflect women's perspectives as well as men's. Therefore, we did not make a gendered analysis.

Most of the respondents ($n = 132$, 89%) self-reported to be farmers, with the others reported being butchers ($n = 2$, 1.4%) or pork-sellers ($n = 13$, 8.8%). In the study setting, stakeholders often engage in several activities in the value chain, we therefore asked for the main activity. All butchers were men whereas women were represented in both the farmer and pork-seller categories. The respondents were between 19 and 97 years (median 34) and had between less than a year and 40 years of experience with pigs (median three). See Table 2.

According to the system-generated report, 121 (78%) participants completed all ten audios, 145 (94%) completed up to the fifth audio, and all 155 participants completed the first audio. In the interviews, 145 (98%) respondents said that they had listened to the audios, without specifying how many. In total, 56 respondents said that they had listened to all audios (38%), 94 (64%) to approximately five audios and 15 (10%) participants did not know or chose not to answer this question (see Fig. 1). There were no obvious gendered differences in how many audios the respondents had completed according to the system-generated report nor in how many audios they said they had listened to in the interviews.

Out of the 148 respondents, 145 (98%) reported that they had learned something new during the course and 139 (94%) that they had changed something in how they managed their pigs after the course. Out of the nine respondents that did not change anything, two belonged to the group of three participants that answered that they had not learned something new. Both these participants had taken part in the previous activities in the field study. The six respondents who said that they had learned new things but not changed anything were four men and two women aged 21–50 years and had between less than a year and 40 years of experience with pigs. According to the system generated report, five of these respondents had listened to all audios and one participant to five audios. The respondent that said he had not learned anything new, but still had made some changes, was a male farmer that had 12 years of experience with pigs and that had listened to all audios according to the system-generated report and two audios according to the interview results.

3.1 Thematic analysis

We coded the responses to questions 8, 9, and 11 into 37 different themes. Each of these themes appeared at least once in a response to any of the three questions under investigation. Table 3 reports on the frequency of different themes mentioned under each of

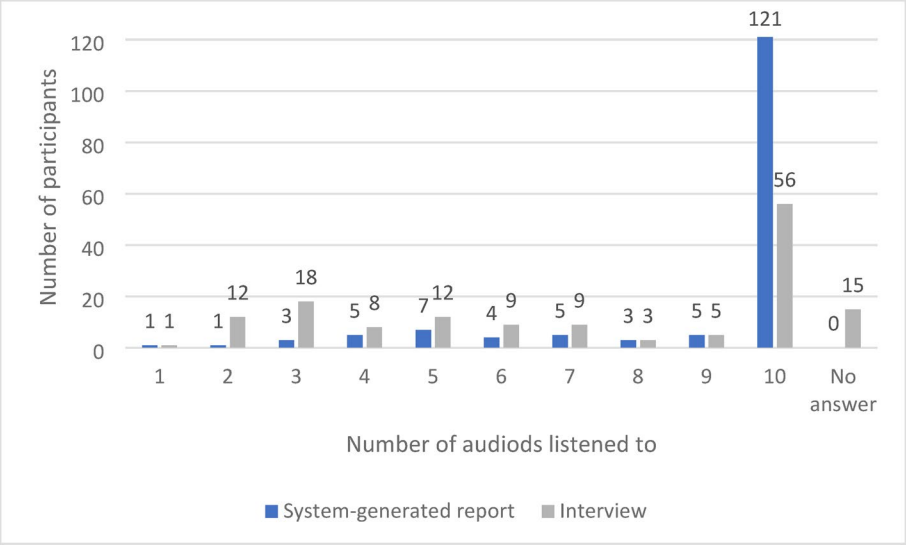

Fig. 1 Total number of audios listened to according to a system-generated report and an interview. From a study investigating a mobile phone-delivered interactive virtual learning course on African swine fever in Uganda in 2021. For the interview the respondent gave the answers as an approximate interval, with the number in the graph representing the upper number in that interval

Table 3 Number of thematic responses to questions eight, nine and eleven from a study investigating a mobile phone-delivered interactive virtual learning course on African swine fever in Uganda in 2021

Theme/Question	Q8: What did you learn? (No. mentions)	Q9: What was most important? (No. mentions)	Q11: What did you change/did not change(No. mentions)	Theme was mentioned in skits (Y/*N* and comments)
Cleanliness				
Change or disinfect shoes/clothes	34	14	12	Y
Clean feed	30	12	14	Y
Clean pigsty	28	13	12	Y
Clean slaughter conditions	9	1	2	Y
Clean farm equipment	5	1	4	Y
General cleanliness	4	11	7	Y
Separation of pigs				
Keep pigs in pigsty	19	25	48/4	Y
Isolate new pigs	15	3	5	Y
No free-roaming	13	6	6	Y
Isolate sick pigs	10	4	1	Y
General pig health				
Give good quality feed	18	8	9 /1	Y
How to keep pigs healthy	0	1	0	Y
Vaccination and other treatments/ medication, deworming	12	8	5	N (Not specifically mentioned. Can be partly inferred from instructions. Clearly stated that there is no vaccine for ASF)
Watch your pigs to observe their health status	3	1	1	Y
Check pigs thoroughly for sickness before purchase	0	7	5	Y
Other answers with bearing on ASF biosecurity				
Do not let others enter where you keep your pigs	23	15	20	Y
Interpreting signs of ASF	18	11	7	Y
Call vet if pig is infected	12	11	4	Y
Bury or burn sick pig	11	2	0	Y
Do not sell meat from a sick pig	5	2	1	Y
Do not buy pork and bring home if you have pigs	4	3	1	N (Can be inferred from instructions)
Do not share equipment	3	2	2	Y
Do not eat sick pig	3	0	0	N (Can be inferred from instructions)
Alert neighbours if pig is sick	2	0	0	N (Can be inferred from instructions)
Do not slaughter a pig that you just bought	1	0	0	N (Can be inferred from instructions)
Learn from successful neighbours/ work together	1	1	0	N (Can be inferred from instructions)
Other answers				
Generic answer, unable to tell what was learned	11	18	13	-
I did not learn anything new	7	1	10	-
Do not remember/did not listen	2	2	3	-
I did not learn how to sell a pig	0	1	0	-
Problem of theft	0	1	0	-

Table 3 (continued)

Theme/Question	Q8: What did you learn? (No. mentions)	Q9: What was most important? (No. mentions)	Q11: What did you change/did not change(No. mentions)	Theme was mentioned in skits (Y/*N* and comments)
ASF comes during the dry season	0	1	0	N
I think you should come and talk to us physically	0	1	0	-
No answer to the question	0	0	1	-
Lack of money is an issue	0	0	2	-
I have no pigs at the moment	0	0	2	-

Q question, *No.* Number, *ASF* African swine fever

questions 8, 9, and 11, as well as if and how a theme corresponded with an issue that was mentioned in the virtual learning course. In question 11, we asked respondents both if they had and had not changed something. In the cases where respondents decided to mention that they had not implemented a measure (e.g., not keeping pigs in an enclosure, not giving them good quality feed), this was invariably connected to a comment about not being able to afford to do so. The open-ended responses to why certain measures were not implemented give additional guidance regarding practical barriers to implementation; we discuss these further below.

A majority of responses under the 37 themes (Table 3) could be grouped into three dominant topics: *"cleanliness"*, "*separation of pigs"* and *"general pig health"*. It is also notable from Table 3 that, overall, respondents were able to list many practices of relevance to limiting the spread of ASF. Regarding the separation of pigs, 48 of the respondents mentioned that they had implemented the practice of keeping the pigs housed. Many said that they had built a new pigsty, whereas others described how they had improved their pigsties or started to keep the pigs confined in an existing structure more often. Four respondents stated that they wanted to build a pigsty, but were unable to afford it. Concerning cleanliness, many of the responses made clear that they had understood that ASF can be spread by indirect contact with materials such as farm and slaughter equipment, boots, etc., if they are contaminated, and that cleaning reduces this risk. Regarding general health issues, several responses indicated that many farmers had understood that keeping your pigs well fed and healthy makes them generally more resilient to infections.

Notably, under the theme "do not let others enter your pigsty" there were also responses from those trading in pork and live pigs who said that the most important thing that they learned from the virtual learning course was that they, as purchasers of pigs, should not enter homesteads. Several respondents also described that they had started implementing this practice, indicating that many took their responsibility of not spreading ASF seriously. For example, one respondent mentioned: "*we who buy pigs should stay out of the pigsty when buying a pig. The farmer should be the one to bring it outside to you*."

Although it is clear that many farmers had learned that one should not sell a pig that has died of unknown causes, but rather bury or burn it, the following response also makes it clear that this might be difficult to implement in practice under conditions where people are poor and not compensated for pigs lost to ASF: *"We once saw a pig that came from another village, you know I am also a LC 1 [Local Council 1, i.e. a village leader] of [name excluded for anonymity] village. We saw that the pig had turned*

yellowish then we called a doctor, the people were saying it should be sold but I told them that this pork was unhealthy and should not be eaten by people so the doctor who had come from [excluded for anonymity] confirmed that it was suffering from African swine fever and said it should be burnt. The owner was not happy with us as leaders but that is done to protect people's lives". An additional reflection on this theme is that burying dead pigs has been found to be taboo in this region (only humans should be buried) [20]. Indeed, as described in Table 3, no one mentioned having implemented the practice of burying or burning sick pigs. Thus, even though several people mentioned that pigs that died from sickness *should* be buried, it does not seem to have been implemented at all.

Recognising the signs of ASF was another issue that was frequently mentioned (Table 3). These responses included relevant lists of clinical signs in pigs such as "loss of appetite", "ears turn red" and it was clear that the respondents felt empowered by knowing how to interpret these signs. However, for a minority of respondents who listed knowledge of signs of ASF as an important new competence, this came with hope of being able to cure the sick pigs *"The most important thing is how to tell the signs of sickness so that you can find a way of helping the pigs."* This tendency was also seen in the responses mentioning vaccination, of which some responses can be clearly interpreted as implying that the respondent thinks vaccination prevents ASF (whereas others talked about it in terms of improving the pigs' general health and resiliency). One example of this is the following comment by a butcher engaged in trading pigs: "*According to me, the most crucial message is the vaccination of pigs and its importance. If the pigs are vaccinated, it reduces the risk of wide spread of African swine fever which in the long run keeps business going for me because if pigs contract the disease, they eventually die, then as a butcher, I will not have pork to sell since the course advised against the sale of pork from an infected pig*." Similarly, a smallholder pig farmer respondent answered: *"The necessary measures to control the disease […] include general cleanliness on the pig farm and vaccinating the pigs to curb the spread of African swine fever."*

It can be noted that the comments from respondents about vaccination, such as the ones above, represent the only notable and frequently mentioned erroneous statement about ASF. This is particularly notable as it was repeatedly mentioned (12 times across the 10 audios) that *"ASF has no cure and no vaccine"*.

Overall, the respondents said that they had learned a lot from the virtual learning course, which is confirmed by their relevant responses about clinical signs, transmission routes, and preventive measures for ASF. Some respondents expressed hopes for similar courses for other livestock health issues. One respondent mentioned that he had recorded every episode and re-played it regularly to remind himself and also let his children who helped out with the pigs listen and learn from the episodes. Amongst the minority of respondents saying they did not learn anything new, one still highlighted the value of the learning course *"Like I said, there is not really anything new I learned from the course because I knew these things already, however the course has been helpful and has taught many of my fellow farmers a lot of stuff they did not know, I have seen them make changes accordingly after listening to the audios"*.

4 Discussion

This study investigated the usability of a drama-based mobile phone-delivered virtual learning course on ASF as a learning platform for stakeholders in the smallholder pig value chain in Northern Uganda. It is based on a similar innovation referred to as Interactive Voice Response (IVR) that was successfully pilot tested in central Uganda [30]. According to the results of the study presented here, the virtual learning course was a useful way of informing stakeholders in the smallholder pig value chain about ASF. It was listened to by a majority of participants, and almost all participants reported that they had learned something new and that they had implemented some changes in their pig management or disease prevention routines. Overall, we judge that the results give relevant indications concerning what participants found to be important, what they aimed to change, and sometimes had changed. Nonetheless, participant observation, which would have allowed evaluation of the actual implementation of the reported changes, was not performed in this study. There were generally positive attitudes to the delivered messages and a large proportion of respondents reported implementing changes. It is notable that pig keeping and animal health in this setting remain strongly shaped by external factors such as resource constraints and the lack of infrastructure, for example, bio-secure trade, slaughter, and disposal of dead pigs [43].

The content of the three dominant topics that emerged from the thematic analysis, "*cleanliness*", "*separation of pigs*" and "*general pig health*", indicates that participants have gained new information of relevance to ASF prevention and control. Direct contact between infected and naïve pigs constitutes the main route for ASF virus transmission in the domestic pig epidemiological cycle, which is driving ASF spread in Uganda [44]. In most settings with smallholder pig keeping in Uganda, the risk for such contacts occurs frequently, as most pigs are free-roaming and ASF is endemic [7]. To prevent direct contact between infected and naïve pigs, fencing in or housing the pigs is fundamental. This is also a prerequisite for most other biosecurity measures at hand [45]. Previous research in the study area has indicated that building pig housing (pigsties) or fences can be unaffordable and hard to prioritise in the smallholder context. In the present study, however, only four respondents explicitly stated that they wanted to build a pigsty but could not afford to do so. This suggests that the respondents were not among the poorest of the smallholders in the area. In this regard, it is relevant to keep in mind that Gulu is among the poorest regions in Uganda and that smallholders in the study area generally have very few pigs (less than five), which are kept and traded under informal conditions, and with lower than national average access to district veterinary services [46, 47]. As such, the respondents still represent small-scale informal pig farmers, and a marginalised part of the general population in Uganda, allowing for conclusions to be drawn about the usefulness of the applied methodology for the purpose of delivering training to hard-to-reach parts of rural populations. Recent implementation research underlines that for biosecurity measures to be implemented, they need to be feasible and affordable but also prioritised by the farmers [48–50]. It seems like separating (naïve from infected) pigs by housing or fencing-in the pigs was prioritised by the respondents, bearing in mind that it can be a costly investment for the poorest and noting, as mentioned above, that participant observation would be needed to follow up to what extent respondents have actually constructed pigsties. Further, the findings indicate that the respondents felt empowered by learning about measures to improve general pig health. Programmes that promote

general pig health (or herd health) have proved to have higher adoption rates than programmes targeting one specific disease [51]. The results thus support recent calls for mainstreaming ASF prevention into general herd health messages [51]. Herd health approaches have been successfully implemented in a neighbouring district in Northern Uganda [52].

The importance of including the post-farm nodes (butchers and those trading in live pigs and pork) of the value chain in activities supporting animal health and in discussions about ASF spread has been previously highlighted [20, 53]. The value of including all stakeholders in the pig value chain in the present study was evident in how those purchasing pigs from farmers described how they, as a result of participating in the virtual learning course, had adopted new routines of not entering the homesteads but letting the seller bring out the pig.

While overall respondents in our study reported on several relevant and correct facts about ASF and biosecurity measures, the erroneous comments about vaccination as a solution stand out. The belief that ASF can be prevented by vaccination has been reported in previous studies from smallholder contexts in Northern Uganda [32]. In a study by Arvidsson et al. [32], several participants said that they thought that a vaccine existed (elsewhere), but that it was just not accessible for them as poor smallholder farmers. Further, the term "vaccination" is commonly used in informal Ugandan English to mean injection (of vaccines or medicines). This use of the term "vaccination", as well as a more general belief that there might be a treatment that is just not accessible to the respondents, can explain part of this confusion. However, there also seemed to be a more specific misunderstanding in this case, as many respondents specifically said they had learned in the course to "vaccinate the pigs every three months". This is not something mentioned at all in the audios. On the contrary, it is repeatedly mentioned that there is no vaccine for ASF. According to our experience and knowledge, a treatment that should be repeated every three months would most probably refer to deworming (although this is not administered through injection). One audio did mention deworming, but it did not specify the frequency. Other initiatives, such as aid projects and agricultural development programmes concerning pig management and health are ongoing in the study area, and it is possible that some of these have promoted deworming. Previous pig health actions in Uganda have been targeting cysticercosis [22, 54]. Concurrent deworming campaigns promoted as preventive measures for cysticercosis could possibly be part of the confusion regarding the prevention of ASF reported here. While we are not able to disentangle the exact reason or source for the confusion around vaccination for ASF, we can conclude that the virtual learning course failed to explain this specific content with enough clarity. In addition, if this type of virtual learning were implemented broadly, it is important to collaborate between initiatives to avoid confusion.

The study had some limitations. The recruitment was made amongst people who were already participating in a previous community engagement intervention on ASF, and, thus, were possibly more interested than others in learning about ASF and how to prevent it. This could have contributed to the positive results in terms of high listening-rate to the audios and willingness to implement biosecurity changes, as well as the high rate of relevant responses about what respondents learned from the virtual learning course.

The method of interviewing participants over telephone or SMS could have limited the detail and depth of the responses given. Our assessment is that the level of detail and

depth in the responses was sufficient for the purposes of our study [55, 56]. The advantages of telephone interviewing include its lower cost, and that it facilitated repeated efforts to reach the participants, as the interviewer did not need to travel to reach participants. The main reason for implementing the drama-based mobile phone-delivered virtual learning course, as well as for performing the interviews by telephone, was the need to adapt our research project to the restrictions during the COVID-19 pandemic. We conclude that these methods are useful in situations where face-to-face contact is not possible for a variety of reasons.

It is worth noting that many more women than men chose to be interviewed by SMS instead of by phone, which could have reduced the level of detail in their responses. The reasons behind this were not established but could have been related to interviewer bias (see below) or women having more chores and less time for talking on the phone. Another limitation is that the interviews did not take place immediately after the last audio display, resulting in possible recall bias. This may also be the reason behind the discrepancy between the system-generated reports and the interviewees recollection of how many audios they had listened to. Other explanations for this discrepancy, although speculative as this was not investigated, could be that the audio was started, but the respondent did not listen actively or had the audio running while doing something else. However, we do not see that this would have affected the conclusions.

The gender distribution of the participants was skewed towards men. This limits the generalisability of the findings. In the study region, small livestock such as pigs are often managed by women, even if the formal ownership might lay with the male head of household [32]. The researchers recruiting participants for the initial community engagement, as well as performing the interviews reported here, were both men. This could have been a disincentive for women to participate and be a reason for the lower share of women respondents [57]. It is also possible that in the study context women have more limited access to mobile phones compared to men, hindering participation. National data, however, indicates that there is no major gender difference in mobile phone ownership in Uganda, with 46.4% of men and 40.7% of women above 10 years of age owning a mobile phone [58].

The seeming ability to construct a pigsty as a biosecurity measure indicates that our study participants were not amongst the poorest farmers in the study region. The selection criterion of having access to a mobile phone could have contributed towards excluding the poorest farmers. The study did not include any direct or indirect measurements of poverty enabling to control if this possible selection bias occurred. However, as discussed above, rural areas in Gulu are among the poorest regions in Uganda, and the respondents therefore represent a marginalised segment of the country's population.

The present study aimed to test new ways for communicating and sharing information and knowledge that could be useful for hard-to-reach groups [29]. In the previous study by Dione et al. (2021), which our study was modelled on, it was concluded that a virtual learning course was an effective way for delivering information to pig farmers, significantly increasing their knowledge regarding biosecurity. An assumption guiding the study presented here, based on our previous knowledge of the context, was that mobile phone as the medium for delivering information would be accommodating for women's and marginalised smallholders' realities. Smallholders in Northern Uganda suffer from a general lack of access to district veterinary officers as well as paraprofessionals

[32, 59]. Information campaigns through these actors are thus unlikely to be particularly effective in reaching this group of people. Likewise, village meetings or group discussions, which otherwise are an important information channel, might aggravate existing gendered power relations in communities as women might not be invited, or have time or possibility to participate. These kinds of meetings often take place in community centres, which are more accessible to men than women. In addition, women more commonly than men have challenges leaving daily chores behind to spend time in meetings [28]. Thus, although face-to-face advice might be more effective [30], there are several practical circumstances that might make a virtual learning course more widely accessible for a diversity of smallholders. This, of course, is contingent upon these harder-to-reach smallholders having access to a mobile phone. While existing data indicate no major gender differences in mobile-phone access in Uganda, mobile phone ownership is overall lower in rural than in urban areas. This suggests that there are marginalised smallholders without a mobile phone who cannot be reached by this service [58].

We can conclude that for both women and men taking part in the study the virtual learning course seems to have been a successful mode of raising awareness of ASF and biosecurity. Agreeing with Dione et al. (2021), we do not suggest that mobile phone delivered advisory services should replace other modes of delivering advice. Nevertheless, it seems to have the potential of being a cost-effective and efficient complement. The ability to choose when to listen and the possibility for repeated listening to key messages may be regarded as an advantage over other methods. Future studies could benefit from clearer profiling of participants in terms of how they compare to their peers regarding knowledge on ASF as well as capabilities to access and operationalise available advice. This would give indications about to what extent findings are more generally applicable across smallholders in Northern Uganda. Future studies could also benefit from following up reported change with participant observation to confirm to what extent the new knowledge gained from a virtual learning course leads to change.

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

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Author contributions

EC, KF, KS and SSL designed the study. RK led a team of artists that recorded the audios and performed the interviews. EC and KF performed the analysis and summarised the results in writing, EC compiled a first draft of the manuscript, all authors (EC, KF, RK, MD, KS, SSL) contributed to the analysis and the finalisation of the manuscript.

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Data availability

All data is available from the first author upon reasonable request.

Declarations

Ethical approval and consent to participate
This study was reviewed and approved by the School of Health Sciences Institutional Review Board and Ethics committee (MAK-SHS-IRB), Makerere University, (ref 2019-062). All individuals are anonymised.

Consent for publication
All authors consent to publishing the manuscript.

Informed consent
Informed consent to participate was assured by all respondents in the study.

Competing interests
The authors declare no competing interests.

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