Exploring pig raising in Bangladesh: implications for public health interventions

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Summary
Pigs are intermediate hosts and potential reservoirs of a number of pathogens that can infect humans. The objectives of this manuscript are to understand pig raising patterns in Bangladesh, interactions between pigs and humans, social stigma and discrimination that pig raisers experience and to explore the implications of these findings for public health interventions. The study team conducted an exploratory qualitative study by interviewing backyard pig raisers and nomadic herders (n = 34), observing daily interactions between pigs and humans (n = 18) and drawing seasonal diagrams (n = 6) with herders to understand the reasons for movement of nomadic herds. Pig raisers had regular close interaction with pigs. They often touched, caressed and fed their pigs which exposed them to pigs' saliva and feces. Herders took their pigs close to human settlements for scavenging. Other domestic animals and poultry shared food and sleeping and scavenging places with pigs. Since pigs are taboo in Islam, a majority of Muslims rejected pig raising and stigmatized pig raisers. This study identified several potential ways for pigs to transmit infectious agents to humans in Bangladesh. Poverty and stigmatization of pig raisers make it difficult to implement health interventions to reduce the risk of such transmissions. Interventions that offer social support to reduce stigma and highlight economic benefits of disease control might interest of pig raisers in accepting interventions targeting pig borne zoonoses.

Indagine sulle problematiche relative all'allevamento di maiali in Bangladesh: implicazioni per possibili interventi di sanità pubblica

Parole chiave
Allevatore di suini,
Bangladesh,
Discriminazione sociale,
Interazione maiale-uomo,
Sanità pubblica,
Suini,
Zoonosi.

Riassunto
I maiali sono ospiti intermedi e potenziali portatori di agenti patogeni infettivi per l'uomo. Questo articolo identifica le conseguenze delle metodiche impiegate nell'allevamento di maiali in Bangladesh, le interazioni tra maiale e uomo, la discriminazione sociale a cui sono sottoposti gli allevatori di maiali, analizzando le possibili implicazioni su eventuali interventi di sanità pubblica. Lo studio qualitativo è stato condotto intervistando allevatori di maiali stanziali e nomadi e osservando le interazioni giornaliere tra uomo e maiale. Lo studio riporta, inoltre, i diagrammi effettuati in collaborazione con gli allevatori per individuare le ragioni del nomadismo stagionale. Pur evidenziando regolari contatti tra esseri umani e animali, lo studio ha permesso di accertare come in Bangladesh alcune abitudini favoriscano la trasmissione di agenti infettivi dal maiale all'uomo. Allo stesso tempo, si è potuto rilevare come la povertà e i dettami della religione islamica contribuiscano ad ostacolare l'attuazione di interventi di sanità pubblica atti a prevenire il rischio di infezione. Programmi di supporto, che sottolineino agli allevatori i benefici economici del controllo delle malattie, potrebbero essere d'aiuto per rendere accettabili interventi pubblici mirati al controllo delle zoonosi suine.

Introduction

Pigs are the intermediate hosts and potential reservoirs of a number of viruses, bacteria, and parasites that can also infect humans (9, 13, 17, 21, 35, 44, 48, 49). These types of interspecies transmissions of diseases are defined as zoonotic diseases. The first recognized human Nipah virus outbreak, which caused 105 deaths in Malaysia, resulted from human contact with sick pigs (10, 15, 34). Pigs are an important amplifying host for Japanese encephalitis virus, which is endemic in South and Southeast Asia (43, 49). In 2009, a novel strain of influenza A, H1N1, which included genetic material from a swine influenza virus, became a global pandemic (36).

Several human pathogens are present in Bangladesh, which can infect both pigs and people, though there is limited evidence of the zoonotic transmission of these pathogens (7, 18, 26, 27). However, studies from the neighboring country India suggested several disease transmissions between pigs and humans. Epidemiological investigations among pig farmers found that 18.5% of them were affected by *Taenia solium taeniasis* and 15% of them were affected by Neurocysticercosis caused by helminth parasite *Taenia solium*, which can be transmitted between humans and between humans and pigs (39, 40). Another study from India identified 3% of slaughtered pigs as having Neurocysticercosis in their brains (38). Investigation of multiple outbreaks of trichinellosis, with high mortality rates, from 2008 to 2011 in India found that all the cases consumed pork before getting the illness (42). A genomic analysis of a human group A rotavirus G6P (6) strain reported pig-to-human transmission of this virus in eastern India (31). A study examining serum samples from pigs and plasma samples from pig handlers and the general population from urban and rural areas found presence of hepatitis E virus in some pigs. A very high number of pig handlers were positive for antibodies against hepatitis E indicating the possibility of zoonotic transmission (50). A temporal relationship of Japanese encephalitis virus transmission has been identified in pigs, mosquitoes and humans that was significantly associated with Japanese encephalitis in humans in India (6). India borders Bangladeshi land from all three sides and there are many cultural similarities between the countries. Similar to India, in Bangladesh, impoverished communities raise pigs. They consume pork and live in close proximity with their domestic pigs in a poor condition, which might put them at risk of zoonoses as identified in India (4, 40).

Pigs as a zoonotic reservoir have not been explored in detail in Bangladesh, partially because pig raising is commonly ignored in this predominantly Muslim country. In Bangladesh, published data are available on the number of cattle, goats, chickens and ducks (2) but not on the number of pigs and pig raisers. After the publicity regarding swine flu in 2009, the Bangladesh Department of Fisheries and Livestock conducted a census to estimate the number of domestic pigs but until July 2012 there is no published data available. Since pigs are taboo in Islam, raising pigs is often associated with social stigma in Bangladesh (4). Social stigma and discrimination have public health implications (45). Stigma can affect peoples' lives socially, economically physically and psychologically (45, 47). Stigma affects the quality of life through isolating a community, limiting their social and health opportunities and making them reluctant to seek help as they are concerned about discrimination and rejection (51). In this manuscript, we describe pig raising practices, interactions between pigs and humans, social stigma and discrimination that pig raisers experience and the implications of these findings for public health interventions.

Material and methods

Materials and methods of this study have been described elsewhere (32). The following is a brief description of the study design and methods.

Study design

This is an exploratory qualitative study. Such studies can contribute substantially to issues that have received little prior investigation (37). Exploratory qualitative studies often generate hypotheses to frame further investigations (28). In addition, qualitative investigation prioritizes the views of the population that is being studied (24) which is helpful when there is an interest in developing interventions.

Study population

We included both backyard pig raisers and mobile pig herders as our informants, since these are the two main ways of raising pigs in Bangladesh. 'Sweepers' and indigenous communities in Bangladesh raise pigs in their backyards. We selected two 'sweepers' communities from two districts and a matrilineal Mandi indigenous community from central Bangladesh who raised backyard pigs. We selected mobile pig herds from the central northern part of Bangladesh.

Study sites

We purposively selected three backyard pig raising communities from three districts. These were Faridpur, Chapainobabgonj and Tangail District (Figure 1).

As pig herders were mobile, it was difficult for the data collection team of five qualitative researchers

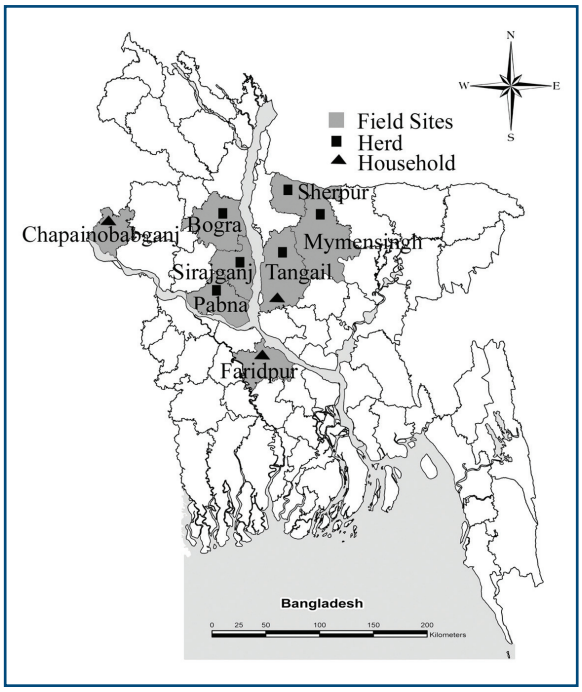

Figure 1. *Field sites of the pig raising study in Bangladesh, 2007-2008.*

including three of the authors (N.N., M.U. and R.S.) to identify the herders. The team visited the weekly pig market in Mymensingh District and developed a rapport with a pig herder. Later, the team visited his herd and interviewed him and asked him to take them to another pig herd that he knew. He took them to the next pig herd and they interviewed the new herders and asked the herders to take the team to another herd. In this way, they selected six pig herds from six districts in Bangladesh: Mymensingh, Tangail, Sherpur, Sirajgonj, Bogra and Pabna Districts.

Rapport building

A crucial element of this study was to build rapport with the pig raisers. Although pig raisers never refused to participate, initially they were often unwilling to provide any time for interviews unless the team went to them with an introduction from someone that they knew and could trust. Later, they explained that since the greater Muslim community did not accept pig raising, they were skeptical about the motivations for the study.

Sampling

The team selected people as informants who directly cared for pigs. Both for backyards and herds, they continued interviewing pig raisers until receiving similar information repeatedly. In this process, they ended up including 34 informants, 17 each from backyards and herds.

Data collection

The team collected data from August 2007 until September 2008 (Table I). They conducted in-depth interviews with backyard pig raisers and herders in Bengali. They recorded the interviews by audio recorders. They also performed observations and took notes on the interactions of pigs with humans and other animals. They worked with herders from each herd to make a diagram of the seasonal movements from one grazing location to another.

Data analysis

The team transcribed the recorded interviews verbatim. The three authors (N.N., M.U. and R.A.S.) reviewed all the interviews and observation notes to make a coding list based on the study objectives and the emerging themes from the data. They manually coded the interviews, grouped related codes and compared the findings from all research tools.

Ethical consideration

The Ethical Review Committee of icddr,b reviewed and approved this study. Since it was difficult to gain trust of pig raisers for written consent, the team obtained informed consent from all the pig raisers before conducting interviews and observations.

Results

Demographics

Backyard pig raisers raised pigs mostly in their backyards with poultry and cattle. These pigs were semi-scavengers, which means they were partially fed by their owners and they also searched for their own food. Both males and females provided daily care to the pigs. Mobile herders moved pigs from one district to another. Their pigs were free scavengers. Herding pigs was a male occupation (Table II).

Backyard pig raisers and herders used hand pumps to collect drinking water. When herders were far away from villages, they used water from a ditch, pond, river or irrigation canal to drink, cook and clean utensils. Backyard pig raisers used non-sanitary latrines. These latrines had open canals that carried

Table I. *Research tools used to collect data in the pig raising study in Bangladesh, 2007-2008.*

Research tools	Number		Duration
	Backyard	Herd	
Indepth interview	17	17	40-90 mins
Observation	12	6	6-8 h
Seasonal diagram	0	6	20-30 mins

Table II. *Demographic characteristics of the pig raisers of backyards and herds, Bangladesh, 2007-2008.*

Demographic characteristics	Backyard Frequency (%)		Herd Frequency (%)	
Sex				
Male	10	(59)	17	(100)
Female	7	(41)	0	(0)
Age				
Average age in years [range]	30	[18-60]	34	[14-50]
Education				
Average years of attendance [range]	3	[0-12]	1	[0-5]
Religion				
Hindu 'lower caste'	12	(71)	17	(100)
Christian	5	(29)	0	
Occupation				
Cleaner (sweepers)	11	(65)	0	(0)
Agricultural work	6	(35)	0	(0)
Pig raising in nomadic herds	0	(0)	17	(100)
Average number of pigs [range]				
Faridpur sweeper colony	3	[2-9]		
Tangail	2	[1-3]		
Chapainobabgonj	52	[34-92]		
In the herds			104	[40-195]

feces to a pond or river or to drain latrine water outside. Their small children defecated in the open space. Mobile herders practiced open defecation.

Settings: close proximity of pigs and humans

Backyard pig raising

The backyard pig raising communities differed in terms of home settings, pig keeping places and pig raising patterns which influenced pig caring and feeding practices. The Faridpur sweeper colony was a congested area in the city, mostly with one-room households built on government-owned small pieces of land where almost every square inch of land was used. On one side, there was the entrance to the community and the rest was surrounded by a pond. Because of the scarcity of land, pig raisers kept pigs together in five different places, adjacent to their houses and in pigpens along the edge of the pond. Two households kept one pig each in front of their houses tied with a rope. The team noticed that pigs often freely roamed around inside the colony compound.

The pig raising community from Chapainobabgonj District consisted of three households located in the area around the local market in a peri-urban area. They were related by marriage. One household owned a house with a pigpen in the backyard near the market. The other two households were landless and their houses were built over a pond (on a wooden platform) in the middle of the market. During the daytime, all the raisers took pigs out to the surrounding areas in their locality to feed them. The household with the pigpen kept pigs in the pigpen at night and sometimes the other two households also kept their pigs in this pigpen. The two households who did not have a pigpen reported that they kept their pigs in the nearest mango gardens (minimum one kilometer away) at night during July to February. In March, the beginning of mango season, they moved their pigs close to an abandoned swamp in the village. They also tied their pigs in front of their huts when pigs became sick.

Pig raisers from Tangail District owned small homesteads in a village. They kept pigs tied with a rope in the west corner of the homestead close to the house to avoid the smell of the pig feces coming into the house, since they believed that air does not flow from the west. They did not let their pigs roam freely.

Mobile herds

Herders moved the pigs from one district to another based on the seasonal availability of food and water for pigs. They stayed in a place for a few days until the food was finished. During the dry season (November to April), they moved their pigs to lowlands close to the swamp or river. In that period, the water level went down and tubers and roots became available for the pigs. Sometimes, because of minimal rainfall, the water dried up and the herders moved their pigs close to the villages to get water from irrigation systems. During the rainy season (May to October), they moved the herd to highland areas, i.e. villages and gardens where water did not stand.

Herders reported that caring for 30 to 90 adult pigs required three to seven people. Usually they were family members or close relatives. When each of them had only a few pigs, sometimes they kept all their pigs together and raised them in a herd. When the number of pigs increased, they employed people from their own caste to take care of the pigs. In mobile herds, pigs scavenged their own food from dawn to dusk. Overnight, herders made a tent using a polythene sheet, in an open field close to a body of water keeping a distance from village homesteads. They kept their pigs close to the tent. One herder described a usual day:

"I wake up before sunrise. I take the pigs out for feeding. Others prepare food. Then we eat. For the whole day, we move with pigs, keep our eyes on them; we follow them everywhere, making sure that they don't destroy crops. In the evening, we stop in a place to spend the night. One cooks, another brings water from the village and the last one looks after the pigs. We prepare food

and eat. Then two of us go to sleep and one stays awake to keep an eye on the pigs. Yesterday I started by 8:30 am and went to sleep by 3 am."

The herders reported that once in every two to four months, each of them took a few days off and visited their families. However, they reported that they never took the herd to the place where their families were living because they were poor. They generally had neither enough space to keep pigs at home nor enough money to buy food for pigs. In addition, if they brought pigs to their homes, local people might protest and look down on them, since they sometimes did not disclose to their Muslim neighbors that they raised pigs.

Feeding pigs

The informants from Faridpur mainly fed pigs with leftover human food that they collected from restaurants. They either cleaned the restaurant or paid a minimal fee in exchange of leftovers (US$ 0.07 for a bucket). In Tangail, they provided husks and rice that are the byproducts of homemade rice liquor. They spent about US$ 0.28 per day purchasing husks. In Chapainobabgonj, pigs scavenged in the surrounding areas.

Herders led the pigs to scavenge in abandoned land, empty grain fields, orchards or villages where pigs looked for roots, leaves and seeds of many varieties of plants and grasses, worms, insects, and rotten fruits and vegetables. They also scavenged human feces, garbage dumping places and occasionally carcasses of cattle and poultry. On a few occasions, the study team observed that people asked pig raisers to bring the pig herd to clean their open toilet by eating feces or clean a place by eating rotten potatoes.

Interactions of pigs with humans, birds and animals

In backyards and herds, we observed direct and indirect physical interactions of pigs with humans, other domestic animals and birds (Table III).

Exposure to pig feces

Pig-keeping places both in backyards and herds were muddy with pigs' urine and feces, which the field team never observed to be cleaned. Pigs' bodies were smeared with this mud. Sometimes pigs splattered mud on pig raisers' clothes while they were caring for or serving food to the pigs (Table III). In backyards, we observed dry and fresh pig feces in the surroundings of pig-raising communities. When it rained during an observation, the rainwater was trapped in the yard with pig feces and children played, glided and jumped in that water and mud.

Caressing pigs

Both herders and backyard pig raisers often caressed their pigs. Backyard pig raisers believed that pigs did not return to the home unless they were 'tamed'. The best way to tame pigs was through caressing them while they fed them. They also held or caressed the piglet to calm it so they could inspect it for lice. While caressing, sometimes pigs jerked their bodies and dirt splattered on pig raisers' body and clothes.

Exposure to pig saliva

Pig raisers offered pigs the palms of their hands to lick food from them. Both in backyards and in herds, we noticed that pigs tried to eat food for human consumption from raisers' plates and bowls or scavenged for food from cooking pots used for human consumption, which were waiting to be cleaned.

Taking care of piglets

Pig raisers reported that they took care of the newborn piglets by cleaning them after they were born. Herders kept the mother pig with the newborns adjacent to their tent. They carried young piglets on their back in a piece of cloth that they wore and slept on. They frequently brought the piglets out of that cloth by hand and let them be nursed by their mothers.

Children with pigs

In backyards, children often played with piglets by touching, holding, caressing and hugging them. Children also beat, kicked and chased pigs. Sometimes children provided food to the pigs and caressed pigs. They also came in close contact with the mud of the pig-keeping places.

Sharing the same water source

The team observed that pigs, cattle, poultry and humans used the same water source. Herders washed their cooking pots and utensils in the ditch in which pigs bathed and drank water. A herder drank water from a ditch after a few pigs drank water and made their bodies wet from the same ditch. Pigs went down in ponds and rivers where people bathed and ducks swam. The team also observed a dead pig floating in the river where other people were bathing.

Interaction with other animals

Cattle, dogs, poultry and wild birds often scavenged food from pig-keeping places or from the food pot of the pigs. In backyards, raisers kept pigs, cows and goats closely together or under the same shed. The following note from an observation report from a backyard shows the complexity of pig, poultry and human interactions.

Table III. *Observed direct and indirect interactions of pigs with humans, birds and animals in backyards and herds, Bangladesh, 2007-2008.*

Type of contact	Number of pig-raising communities with observed contact			
	Backyard N=3	(%)	Herds N=6	(%)
Direct contact between pig and human				
Caressing pigs	3	(100)	6	(100)
Beating, kicking, pushing, chasing pigs with hands and legs	2	(67)	6	(100)
Pigs licking the palm of the pig raisers while feeding	3	(100)	2	(33)
Carrying piglets in their clothes	0	(0)	2	(33)
Touching own nose, mouth, face after touching and caressing pigs	3	(100)	6	(100)
Wiping hands on their clothes during or after touching or caressing pigs and later wiping childrens' nosesor mouths with the same cloth	2	(67)	0	(0)
Touching pig feces or feces mixed with mud by hand	3	(100)	6	(100)
Stepping on and/or feeding pigs, sitting and standing barefoot on feces mixed with mud	3	(100)	6	(100)
Direct contact with children				
Playing with piglets while holding, hugging, kissing, bathing and chasing	3	(100)	0	(0)
Babies crawling on the ground with pigpen mud dropped from chickens feet	1	(33)	0	(0)
Feeding pigs sitting and standing barefoot on feces mixed with mud	2	(67)	0	(0)
Indirect contact with surroundings				
Pig putting mouth close to the plates of the raisers while they were eating	1	(33)	3	(50)
Pig putting mouth on cooking pots and utensils with or without food for human consumption	2	(67)	3	(50)
Pig raisers drinking water from and/or washing cooking pots and utensils in the ditches in which pigs bathed and drank water	0	(0)	2	(33)
Pigs eating human feces from toilets	0	(0)	2	(33)
Pigs standing in the pond containing human excreta from the toilet	1	(33)	0	(0)
Chickens entering human houses and stepping on the chairs, table and bed after scavenging in pig-keeping places	3	(100)	0	(0)
Interaction of pigs with other animals and birds				
Chickens scavenging in the pig-keeping places	3	(100)	0	(0)
Pigs, poultry, cattle and wild birds sharing food and water	3	(100)	6	(100)

"One of the roosters went to the pig pen and scavenged food from the pot and from the ground of the pig keeping place. The rooster walked on the pig's feces mixed with mud and leftover food of the pigs. Then it came inside the house, scavenged food from the yard, walked on the dining table for a while and then went in front of the kitchen."

Hand washing practices

Pig raisers almost never washed their hands after touching and caressing pigs. Backyard caregivers occasionally rinsed their hands after touching the pig food. Informants from all study sites said that they used soap when they bathed and washed clothes. Herders reported less frequent use of soap than backyard informants. Herd owners provided one bar of soap (usually a local brand of a medicated soap) to each herder once a month to bathe with and wash clothes. However, the team did not notice any soap use during their observation of herds. Both backyard raisers and herders explained that they were too poor to buy soap to wash their hands. Backyard raisers reported using soap, mud or ash to wash their hands after feeding pigs but our observational data often did not support this report. One of the backyard raisers explained that he did not wash his hands after providing food to pigs as he did not consider pigs as a dirty or filthy animal.

Pig raisers' experience of stigmatization

Disrespect and violence

All the informants reported that Bengali Muslims often showed disrespect and expressed verbal and physical abuse and violence towards pigs and pig

raisers because they considered pigs a 'forbidden animal'. Being 'forbidden' meant that, for example, touching, raising, eating, seeing, or uttering the term 'pig' in local language 'shuor' (in standard Bengali shukor) were strongly offensive to Bengali Muslims. People often did not allow the pig raisers to use the main road with their pigs because of odor and thus pig raisers had to look for other travel routes. People sometimes beat the pig raisers and injured pigs if pigs spoiled anything. A backyard pig raiser shared his experience:

"In the last Chaitra mash (Bengali month referring from mid March to mid April), one day, when the owner of a mango garden was collecting green mangos, our pigs spoiled 74 kg of mangos (worth US$10-12). The man became so angry that he tied me to a mango tree and beat me. My legs were bleeding. I was crying and begging, 'Please don't hit me anymore. I will reimburse you'. He was not listening to me. He was saying, 'I will get the reimbursement by killing you'."

We noticed that while a herd passed by looking for food in villages, many villagers of all age groups beat pigs when they could reach one. Often this beating annoyed the herders but they rarely expressed their annoyance in front of the villagers because then the villagers might force them to leave the locality.

Insecurity

All the herders talked about their personal security, and their security concerns were greatest at night. They were often victims of theft, robbery and physical abuse. The following quotation reflects what almost all the herders reported to us:

"We can't keep ourselves clean because people might think that we have money. We can't wear anything nice even if we like to do so. If we wear a very cheap watch, people say, 'Shala (addressing them in offensive manner) pig raiser is wearing a watch.' They beat us and snatch everything from us. If we feel cold, we can't wear a shawl. They take our shawl, shirt, money, everything. And we, we are human beings. We want to live like humans. We want to have quilts on the floor to sleep but we can't because people steal them. We raise pigs and we live like pigs. What is the point of using soap and cleaning our clothes when it increases the risk to be beaten?"

Social exclusion and coping strategies

Pig raisers often expressed their fear of being a minority and a pig raiser. They added that Muslims strictly reject them by not socializing with them. A few pig raisers from Faridpur said that when they went out to work or for other purposes, they often hid their identity as pig raisers to be accepted by others. Sometimes they used a Muslim alias publicly and in official documents because a Muslim name sometimes helped them to get a job as the authorities preferred to employ Muslims. A backyard pig raiser portrayed their situation as follows:

"Pigs are prohibited to Muslims. Since we raise pigs, usually they do not come to our houses and eat anything from us. We also do not go to their houses. We live in fear because we are a minority here. Muslims are comfortable with other Hindus who do not raise pigs. They do business together."

Herders said that people prohibited them from bringing herds and pitching a tent on their land. We also observed herders persuading villagers to allow them to access their communities by explaining that pigs would clean the locality by eating garbage and weeds. The following statement is from a herder:

"It's difficult to get a place for us to stay at night. People complain when they see us making a tent near their houses. They say, 'Our cattle will travel through the path, you can't keep your pigs here.' They say that we are lower caste. Even their young children beat us and rebuke us. We can't say anything."

Pig raisers often faced difficulties transporting pigs using public vehicles because of the negative attitude of Muslims. Besides scolding the pig raisers, people also rebuked the bus driver and conductor for letting them bring pigs on the bus. Pig raisers reported that as they paid fare for the pigs, they did not face any rejection from bus authorities. When they needed to transport pigs to a distant place, they put pigs in gunny bags to make them inconspicuous. If pigs made sounds and other passengers asked them what they had in their bags, they often answered that they had *kalkhashi* (black goats). They also called castrated pigs *khashi* which commonly refers to a castrated goat in Bangladesh. There were two reasons for using alternative words to refer to pigs; one was to avoid language that might be offensive to Muslims and the other was to conceal the fact that they were actually transporting pigs. Even if people understood, they might not be very angry because uttering or listening the word *kalkhashi* is not unholy like *shuor*. Otherwise, if they directly said '*shuor*', people might force them to leave the vehicle. We noticed that pig raisers used several different terms to refer pigs during interviews, such as *jongli* (wild) and *mal* (goods).

Resistance

Pig raisers often made arguments against the discrimination, domination and rejection that they faced in their everyday life. The following quotation was from a backyard pig raiser who was working in a hospital as a cleaner.

"Our main identity is that we all are human beings. It's a manmade difference that I am Hindu, you are Muslim, he is Christian. But there is only one God for all human

beings. You call him Allah; I call Sri- Krishna; he calls Jesus. In fact, we all go to the same place after death. We burn the dead body, while you bury. After burning, the ash and the residues are mixing with earth. Again, after death God will arrange the judgment in the same court for all human being. Even in our country, being the son of a cleaner, if I commit a murder, my judgment will be held in the same court as you if you (Muslim) do the same crime. If you cut your body, you will get red blood just like I would get. As we raise pigs, Muslims show hatred to us. They can tell us many things but will they give money to feed us? If our pigs do not harm them, what is their problem? But they do not consider our situation."

Discussion

Qualitative studies can significantly contribute to infectious disease control and prevention by understanding peoples' perception and behavior in relation to disease transmission and translating local concerns into appropriate heath interventions (23, 29, 37). In this qualitative study, we identified different pig-raising patterns in Bangladesh, pig interactions with humans and other animals, social stigma that pig raisers experienced and their struggle for survival. Our findings can help to outline future strategies for health interventions, identify difficulties that can appear in this process and indicate possible solutions.

Although pigs have not yet been confirmed to be an important source of zoonotic diseases in Bangladesh, studies from neighboring countries where big zoonoses have been confirmed also suggest a close interaction between pigs and people in these contexts. In India and Nepal, low income indigenous communities raise pigs in their backyards (25, 38). They have poor housing with the practice of open defecation and pigs live very close to human dwellings (38, 39, 40). These pigs are free ranging, loose to scavenge in garbage dumps and sewerage and have been identified to be infected by Neurocysticercosis and trichinellosis when pig raisers have been found to be infected by *Taenia solium taeniasis* (25, 38). Pig-raising communities in Bangladesh raise pigs in similar settings, practice open defecation and let pigs access the garbage. Considering these similarities, Bangladeshi pig raisers and their pigs might be exposed to similar diseases as in India and Nepal. (32). Indeed, in one backyard study site, we observed pigs were fed restaurant scraps that could also include the meat of poultry and cattle which may pass pathogens to pigs. Slaughtering and consuming sick birds and animals is common in Bangladesh (8, 46). From our study, we do not know if pigs eat the meat of pigs that died of illness, a pathway that could efficiently transmit pig pathogens; however, we found that pigs eat dead poultry and other dead animals, so it is likely that at least occasionally they also eat dead pigs. We identified several types of contact that people had with domestic pigs, which might provide a pathway for zoonoses, especially when people came in contact with pig saliva and feces very frequently. Other domestic animals and poultry had frequent interactions with pigs that might lead to cross species transmission and could be a pathway to spread disease to humans (14, 16).

Poverty has significant implications on the health of the population (20, 41). Pig raisers in Bangladesh live within extreme resource constraints that severely restrict options to modify their practices. Simple behavior change recommendations like "wash your hands with soap after touching a pig", "keep a safe distance from pigs" or "don't feed your pigs carcasses from animals that died" are unlikely to be implementable and so are unlikely to substantially reduce the risk of transmission of pathogens from pigs to people. A similar example comes from the low income Roma community in Romania that raises pigs to maintain their livelihood. This community has been affected by several trichinellosis outbreaks (33). Because of poverty, the Roma are known to consume the carcasses of pigs that died in uncertain circumstances and health interventions are often unsuccessful in changing their behavior. Although we do not know exactly which diseases pig raisers in Bangladesh suffer from, or the health and economic burden of these diseases, we do know that low-income populations and their domestic animals are more likely to be affected by infectious disease and that zoonoses have an important economic impact at individual and national levels (41). Since diseases can promote poverty, controlling these diseases would be one step toward improving the economic productivity of the low-income pig raisers (20). One option would be highlighting economic benefits of controlling human and pig disease. This might be in the interest of pig-raising households as well as the government, because it is related to poverty reduction that can contribute to the national economy (12, 19). To pursue the economic benefit of disease prevention, which affects both pigs and humans, OneHealth surveillance could be initiated to detect and treat both human and animal diseases that we described elsewhere (32). Briefly, the OneHealth approach could be accomplished through the collaboration between public health and veterinary sectors to work together to combat zoonoses (22).

Pig raisers in Bangladesh face substantial social stigma. Such stigma has important community health implications (5). Stigma can impede access to health care and as a result, delayed treatment, which contributes to the spread of disease. Social marginalization can cause poverty and neglect

that make the population susceptible to infectious disease. Stigmatized populations can distrust health authorities and decline cooperating during health emergencies. Finally, stigma can create mass panic among citizens by distorting public perception of risk. The study team experienced difficulties accessing the pig raisers in the beginning of our study. We also know the unwillingness of health practitioners to provide treatment created mistrust and compelled pig raisers to treat their pigs by themselves (32). Thus it is likely that stigma will present a barrier to engaging pig raisers in public health interventions. Since the majority of Muslims do not accept pigs, targeting only pig-borne diseases in a separate health intervention risks increasing stigma and marginalization. Considering their vulnerable social situation, at the very beginning it would be worthy to develop interventions that will provide social support to reduce the effect of stigma (51). In addition, highlighting pigs' contributions to agriculture and the environment could provide acceptance of pig raising to broader Muslim communities. When pig herds pass by they often eat weeds with roots and dig the soil of the agricultural fields, which makes it easier for farmers to cultivate their lands. Pigs also clean the environment by eating organic garbage when there are minimal efforts to use such waste as fertilizer. However, messages regarding garbage need to be carefully framed, such that they do not include human feces in garbage list.

The primary limitation in our research was that most of the field team members were Muslims. Although we invested substantial time in building rapport, these social differences could not be eliminated because of the existing Islamic hegemony in Bangladeshi society. These differences likely limited our ability to ask questions and interpret information. Our study is a qualitative exploratory study with a modest sample and the study sites were purposively selected. This does not allow us to generalize our result like a study with a large random sample but it is an effective way to develop a nuanced, in-depth understanding of the perspectives of affected individuals to understand the issues and motivations pertaining to complex human behavior (30). Findings from this study were based on pig raisers' reports and our observations. It would be useful to incorporate the views of the majority Muslims towards pigs, especially to understand the hostility and rejection we documented in our study. We conducted this study with two main types of pig raisers in Bangladesh, though we did not collect data to compare backyards and herds or explore the relationships between Hindu and Christian pig keepers. Our intention was to develop a basic understanding of both types of pig raising in Bangladesh and establish a good relationship with the pig raisers so that we could use this network for future quantitative studies.

Bangladesh is a low income country with an under-resourced health care system (1). The majority of the rural population use untrained or informally-trained health practitioners to address most of their health concerns (3, 11). Quality primary healthcare from the public sector is often unavailable or inaccessible by the rural population, a situation which increases the risk of widespread transmission of new human pathogens before they are recognized (11). In addition, the high population density in Bangladesh makes people more vulnerable to the spread of infectious diseases to the wider population. The issue of pig zoonoses might appear to be the local problem of a minority population, pig raisers. However, emergence of a new disease can also appear as a global threat, as we already experienced with swine flu in 2009 (36). The next initiative would be working with pig raisers to explore how social stigma and marginalization could be minimized as a prerequisite for implementing interventions to improve their health and economy, which might also contribute to reducing the risk of zoonoses.

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Conflict of interest/competing interests

The authors declare no conflicts of interest.

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