

Socio-cultural practices related to *Taenia solium* taeniosis and cysticercosis epidemiology in endemic areas

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SUMMARY

Socio-cultural settings and lifestyles of communities in *Taenia solium* taeniosis/cysticercosis (TSTC) in endemic areas influence significantly the epidemiology of the disease. This study investigated the community perceptions and practices influencing the occurrence and endemicity of TSTC. A cross-sectional survey focusing on pig-keeping households was carried out in three wards of Iringa District Council as a representative of other TSTC endemic areas. Questionnaire and observation checklists were employed for data collection. Eighty-seven (99%) of the 88 surveyed households had pit latrines, and 84(95%) of the households were found using their latrines. These latrines varied from good to a very good quality according to subjective qualitative scores. About 294 (85%) pigs were enclosed and 52(15%) were free roaming. The results indicated poor adherence to routine pig inspection at sales (50% inspection) and less pork inspection at slaughter (50% uninspected). Furthermore, there were no authorized centres for slaughter and sales. Health Officers and farmers were comfortable with the boiling form and home prepared pork (>90%). Health Officers perceived deep-frying and roasting of pork as inappropriate preparation methods. Generally, the social cultural practices and life style in the study area promoted the endemicity of *Taenia solium* life cycle. A strategy for surveillance on socio-cultural practices in the community is important during planning for TSTC control. This community needs sustainable health education on TSTC diseases control.

Keywords: Perception, pig, public-hygiene, risk factors, taeniosis/cysticercosis

INTRODUCTION

The epidemiology of infectious diseases such as *Taenia solium* Taeniasis Cysticercosis (TSTC), which is easily preventable, is associated with community ignorance and poverty (Ayim, 2011; Wang *et al.*, 2016). Public illiteracy on the source and spreading mechanisms of infectious agents make the diseases endemic in certain regions (Ayim, 2011).

The cultural values, beliefs, and practices also promote the replication of the agents of the diseases and automatically expose individuals to the risks of infection (Aung and Spelman, 2016).

Proper public health education can positively modify social-cultural activities and lifestyle and reduce the risks of infection (Solhi *et al.*, 2017). *Taenia solium* worm is an infectious agent of taeniosis and cysticercosis, which are endemic in Iringa region (Ngowi *et al.*, 2019; Yohana *et al.*, 2013). Humans acquire *Taenia solium* (adult worm) by inadvertent ingestion of cysticerci in raw or undercooked infected pork. The ingested cysticerci develop to adult worms that live in small intestines (Symeonidou *et al.*, 2018), the condition, which is called taeniosis.

Taenia solium cysticercosis condition refers to the occurrence of pork tapeworm cysts in the tissues of the intermediate host. Pigs are infected by ingesting eggs released by the adult tapeworms normally through human faeces (Flisser *et al.*, 2004). The normal intermediate host for the worm is the pig; however, humans can also be infected if they ingest the eggs of the parasite mostly through oral-faecal- route. Once the eggs are ingested, they hatch into hexacanth embryos in the gastrointestinal tract. The embryos invade through the interstitial wall to the bloodstreams and migrate to multiple tissues, especially to the striated muscles and the central nervous system where they mature into cysticerci (Symeonidou *et al.*, 2018). The infection by adult tapeworm and/or larval form is referred to as *Taenia solium* taeniosis/cysticercosis (TSTC) respectively.

Taenia solium cysticercosis in human is associated with neurological symptoms as a result of infection by the larval form of the parasite in the brain and spinal cord (neurocysticercosis) (Del Brutto, 2012; Winkler, 2012). *Taenia solium* cysticercosis is

the main cause of epilepsy in low-income countries (Blocher *et al.*, 2011).

Taenia solium cysticercosis is a zoonotic condition that causes a substantial burden in human beings such as acquired epilepsy, headache, reduced visual acuity, and other manifestations (Pal *et al.*, 2000; Winkler, 2012). *Taenia solium* cysticercosis is further related to disability leading to a loss of productivity (Mwang'onde *et al.*, 2014). The parasite in pigs, porcine cysticercosis, decreases the value of pork within the farmer's formal marketing system, hence provides poor returns in the pork industry (Mkupasi *et al.*, 2013). Given the nature of the spreading of the worm, TSTC endemic communities are mostly associated with poverty and illiteracy (Gweba *et al.*, 2010).

The life cycle of *Taenia solium* involves the development stages crossing between human and pig hosts, through undercooked meats and oral-faecal route (Galán-Puchades and Fuentes, 2013). This means that along with the illiteracy and poverty, the community practices involving public hygiene and pig husbandry systems play important roles in the epidemiology of the TSTC. Limiting pigs from accessing human faeces and avoiding eating pork with viable worm cysts are basic practical ways of breaking the continuity of the parasite (Ngowi *et al.*, 2017; Samorek-Pieróg *et al.*, 2018). Adhering to basic public health principles including proper use of toilet/latrines and hands washing after toilet and before eating is equally important. Achieving the outlined basics optimally depends on community customs adjustments and literacy levels (Gabriël *et al.*, 2016). Some traditional practices including lack of and/or failure of using toilets/latrines, and the manner in which people manage pigs, pose risks for contracting TSTC (Mwang'onde, 2019). Providing proper education is known to contribute positively to the community perceptions and practices towards prevention of such conditions (Kungu *et al.*, 2017; Ngowi *et al.*, 2017).

Communities vary significantly regarding their ways of life, and hence the provision of proper education requires understanding of the basics for a given society (Kimbi *et al.*, 2015). To control TSTC, a given community has to be

oriented towards the importance and mechanisms of getting quality toilets/latrines and of using them properly. According to the World Health Organization (WHO, 2020), a good quality toilet, in addition to ensuring lack of access of wastes, should be clean and safe to encourage usage and prevent entry of non-human beings such as livestock (e.g. pigs).

Likewise, farmers have to understand the importance of pig housing to provide comfortable environments for pigs. To educate society on a particular disease, a trainer has to understand a given society perception towards

the disease in question, its epidemiology, and control (Ngowi *et al.*, 2017).

Understanding the local community practices is important in providing education on TSTC control (Johansen *et al.*, 2014; Ngowi *et al.*, 2011). There are limited publications on current socio-cultural practices that promote TSTC diseases in the studied area. It has been reported that training resulted to the adoption of good practices known to reduce the diseases risks (Ngowi *et al.*, 2008). This study addressed the present socio-cultural practices related to the TSTC epidemiology in the context of the application of digital health education.

MATERIAL AND METHODS

Study area

The study was conducted in three wards (Izazi, Migoli, and Mlowa) in Iringa District Council, Iringa region in Southern Highlands of Tanzania (Figure 1). The area has the prevalence of TSTC of up to 33.3percent (Ngowi *et al.*, 2019; Yohana *et al.*, 2013). Based on the prevalence of the disease, the area was targeted for digital health education program with free internet access for communities to learn on the prevention and control of TSTC.

Due to limited resources, Izazi and Migoli Wards were selected for this digital health education piloting. Mlowa Ward was used as control. This program was implemented by the installation of the internet connectivity at the Ward Executive Offices (WEO).

The offices were provided with tablets for internet connection and access to the health education materials, which were created by the study team and uploaded in the local server at the Izazi and Migoli Wards. This was not done for Mlowa Ward (The control ward).

As adopted from key informant's report, traditionally Mlowa, like Izazi and Migoli, raises pigs. Also according to literature, Mlowa is among the endemic area for *Taenia solium* (Yohana *et al.*, 2013).

Being in the same geographical location with Izazi and Migoli, Mlowa was taken as a control, as this Ward was not targeted for internet connectivity and digital health information.

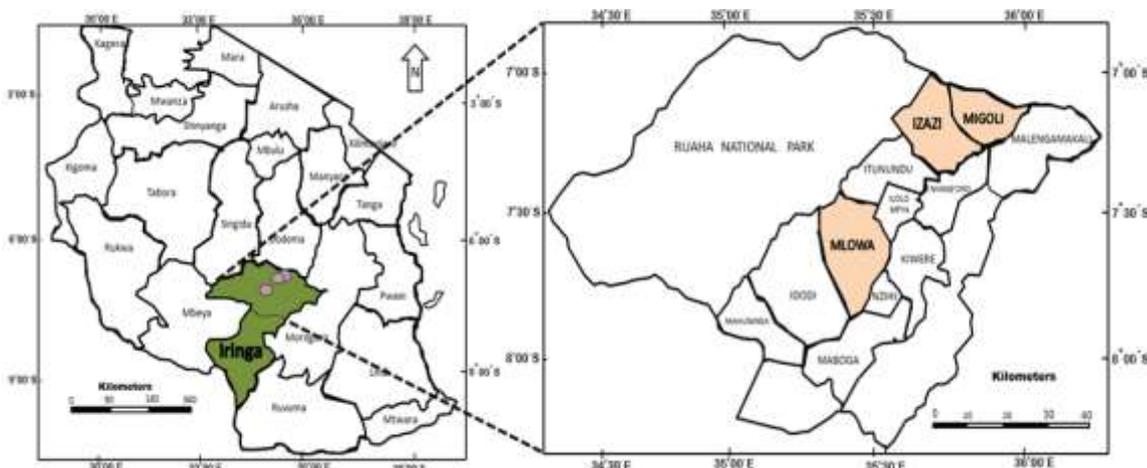


Figure 1: A sketch map of Iringa Rural Districts, southern Highlands of Tanzania, showing the location of the three wards covered in the study.

Study design and data collection

This was a cross-sectional study; a list of households keeping pigs (at least one pig) was made in each ward with the help of ward and village leaders. The studied households were selected from the list and these were visited once for data collection. About 423 households were known to keep pigs in the three wards. Since this socio-cultural study was planned to be carried out with the study of porcine cysticercosis prevalence, pigs sample size was calculated. The pig sample size was estimated using the formula: $n = Z^2PQ/L^2$ (Martin et al., 1987) where: n is the number of pigs to be examined and Z is the score for confidence level. P is a known or estimated prevalence of the factor in the study area, Q is $1-P$, and L is the acceptable estimation error. A confidence level of 95 percent and an estimation error of 5 percent were considered. Previously published prevalence of 32 percent (Maganira et al., 2019) was applied for the calculation of pigs sample size. The estimated sample size for pigs from the calculation was 334 ($n = 1.96^2 \times 0.32(1-0.32)/(0.05)^2$).

It was learned from the ward officials that pig keepers had an average of four pigs per household. According to the average number of pigs kept by households in the study area, the maximum of 100 households were aimed for the study. All households keeping pigs in the list were equally considered for their participation in the study. However, based on pig eligibility as in the selection criteria and the household willingness to participate in the study, 88 household heads (33 from Migoli, 14 from Izazi, and 41 from Mlowa) participated in the study. Pregnant and lactating pigs were excluded from the study whereas piglets above two month of age and clinically health pigs were included.

Selection of farmers was based on those households, which were keeping pigs. The non-pig keepers were investigated in a parallel study on digital health education on human cysticercosis (Radovanovic *et al.*, 2020).

Questionnaires were used to gather information. The respondents (household heads or adult representatives) were asked to provide information regarding pig rearing systems and experiences, sanitation and hygiene, pig

slaughtering, and meat preparations. The local government leaders were interviewed on village pig slaughtering and inspection activities, community pork eating behaviours, and general community understanding on the taeniosis and cysticercosis. Information on the presence and quality of the physical structures was supplemented through direct observation.

The observation study used a checklist with quality parameters described in Farmer's Hand Book on Pig Production (FAO 2009), in good practices for biosecurity in the pig sector (FAO 2010) and in a review of sanitation and hygiene in Tanzania, 2013.

Latrines and pigpen conditions were assessed by subjectively scoring ranging from 1 to 4 very poor to poor, and 7 to 10 good to very good. The quality of latrines was assessed by qualitative score numbered from 1 to 10 to rank latrines from very poor to very good respectively (Supporting Table 1). The same qualitative score was used for pig pens grading with numbers ranging from 1 to 10 referring to very poor to very good respectively (Supporting Table 2).

Kobo Collect (Kobo Collect v.1.27.3-3) downloaded freely from Google Play Store and installed on Android tablets was used for formulation of questionnaires and data collection.

Questionnaires results were supplemented with direct observation during visits to the households. The observation involved making a checklist on the presence of pigpen and latrine, and then scoring each for quality. This observation study was used to complement information collected from household heads, and from examining pig pen and latrine qualities according to subjective scores.

All participants signed a consent form after being briefed on the aim of the study and confidentiality terms. The consent forms were approved by the Tanzania National Institute for Medical Research (Ref. NIMR/HQ/R.8a/Vol.IX/2947). Permission to carry out the study was granted by Sokoine University of Agriculture (SUA) and the respective local government authorities (Ref. FA.255/265/01/PART 'C/72).

Data analysis

Data were imported from the KoBoCollect toolbox into Microsoft Excel Window 10 for cleaning and analysis. Thereafter, the data were transferred to a program for analysis in IBM Statistical Package for Social Sciences (SPSS)

version 20 of the year 2011, Armonk in New York. A descriptive statistic was carried out to determine the frequencies and percentages of variables.

RESULTS

Eighty-eight households and 346 pigs from nine villages in the three wards of Iringa District Council were investigated. Nine government officers namely, three Ward

Executive Officers, two Agricultural Extension Officers, and four Village Chairpersons were interviewed. In addition, 97 respondents were interviewed (Table 1).

Table 1: Distribution of the respondents and number of pigs in the villages and wards involved in the study

Ward	Village	Number of respondents	Number of pigs
Izazi	Izazi	3	10
	Makuka	4	22
	Mnadani	10	38
Mlowa	Mlowa	2	14
	Malinzanga	41	98
Migoli	Makatapora	10	49
	Mbweleli	5	8
	Migoli	13	58
	Mtera	9	49

Hygiene factors associated with TSTC risk

The results indicated that 87 out of 88 (99%) households owned pit latrine, one household (1%) had no latrine in the premises. As for the households with latrines, 95 percent were regularly using their latrines. The regular use was identified by a clear path towards it, the smelling, and/or remains of urine or water on latrine floor. Having unclear path towards latrine and/or lack of other mentioned features indicated irregular or lack of usage used. Alternatively, the presence of human deposits

on the surrounding bushes was the evidence of irregular use of latrine. The average score for latrine qualities was 7, which was interpreted as good start for quality. The majority of households had latrines ranging from good to very good latrines (Supporting Table 2). None of the households had latrines fixed with hand washing facilities of running water. Empty hand washing facilities were fixed near each visited latrine for demonstration purpose during the inspection.

Table 2: Distribution of the latrine conditions concerning subjective score

Score	Interpretation	Households n (%)
1-2	Very poor	1 (1)
3-4	Poor	8 (9)
5-6	Fair	24 (28)
7-8	Good	23 (26)
9-10	Very good	32 (36)

Pig husbandry and slaughter risk factors

During the time of visit, 15 percent of the households were keeping pigs for the first time and for less than six months period. Also among the studied households, 17 percent raised outdoor pigs or did not restrict pigs from free roaming at all. Fifteen percent (15%) out of these households confined their pigs during the night.

However, 83 percent of the households reported to restrict pigs from free roaming, 50 percent were found to be keeping free roaming pigs, since they only kept adult pigs indoor

while allowing piglets to roam around outdoor, and one (1%) household among them tethered animals (not shown). Eighty-three percent of pig keepers had pig pens and the remaining 17 percent of pig keepers had no any physical structure for sheltering their animals. Tethering was more practised as a temporal option following the damage to pigpens while waiting for renovation/reconstruction.

Pig pen conditions were graded, and on average, 33 percent of pigpens were graded as fair (Table 3).

Table 3. Summary of pig husbandry practices associated with TSTC risk

Parameter	% of households
Kept pigs for more than 6 months	85
Confine pigs in pig pens	83
Let pigs roam in day time only	15
Let pigs roam all the time	2
Let piglets roam in day time (adult indoor)	50
Pig pens used were old	86
Pig pens condition	
Very poor	4
Poor	20
Fair	33
Good	27
Very good	16

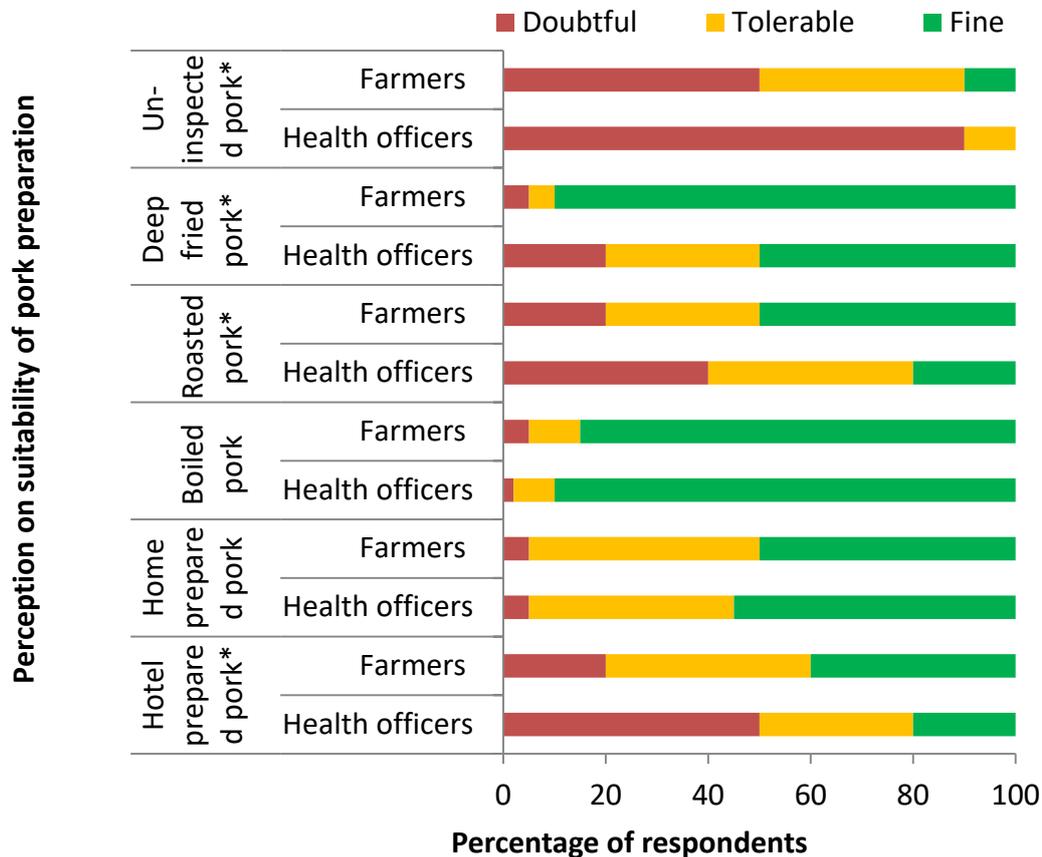


Figure 2: Perceptions from Health Officers and farmers on pig meat handling and pork preparation. Most health officers were in doubt with uninspected, hotel prepared, roasted and deep fried pork as indicated by *.

There were no formal/official slaughter points for pigs in the studied villages. Ninety percent of pigs were slaughtered at homesteads and 10 percent at groceries, which are also not legally authorised as pig slaughtering centres. Forty five percent of pork was eaten in the groceries, accompanied with beer and the rest was taken for preparation in the homesteads to be consumed by family members. Seventy-five percent of the pork in groceries was estimated to be deep-fried while the rest were open fire-roasted or boiled (Figure 2). Health Officers were concerned about the environment of pork preparation, cooking methods, and consumption of the

uninspected pork. Through questionnaire interview, respondents were required to estimate in range the percentage of pork consumption rate. However, farmers were not informed on the risks associated with handling of the pigs and pork trading related to TSTC (Figure 2). Pig keepers were selling live pigs to both rural and urban traders. Eighty (80%) and 50 percent of sold live pigs and of the locally slaughtered pigs respectively were not inspected. The Animal Health and Public Health Officers reported to have been informed on the mandatory pig trading protocol that recommends animals and meat inspection and permission by the authorized meat inspectors.

DISCUSSION

This study investigated socio-cultural practices based on pig management, hygiene, and sanitation in different wards of Iringa District representing TSTC endemic areas (Table 1).

Owning and using a latrine was a common phenomenon in the studied area and most of the latrines were in good condition (Table 2 and Supporting Table 1). In addition, only one

percent (1%) did not have latrines compared to twelve percent (12%) of the households previously reported not to have latrines (Yohana *et al.* 2013).

However, all visited latrines had empty hand washing facilities which appeared to be installed for demonstration purpose during public hygiene inspections. Some latrines were irregularly used as they were surrounded by bushes and unclear paths and some appeared to have been constructed recently as they had no fresh deposit in the pits.

Furthermore, it was revealed through direct conversations with respondents that almost each household had a latrine in response to a recently launched government and NGO's campaign on the use of latrines for sanitary environment. However, some household members were not using the latrine because of their taboos. Examples of the taboos include one whereby "the household head is *not supposed* to share a latrine with the in-laws" (Séverine Thys *et al.*, 2015).

Other reasons discouraging the use of latrines includes poorly maintained latrines, prompting people especially people with limited mobility and children to use the alternative (Asfaw *et al.*, 2016) including nearby bushes. This was evidenced with prevalent human deposits observed in bushes near the homesteads. Improper use of sanitary latrine facility (Komba *et al.*, 2013) and open ground defecation expose the community to the risk of TSTC infection. Better quality latrines provide higher chances for being used and avoid open defecation (Kumwenda *et al.*, 2017; Odagiri *et al.*, 2017). Good floor, wall, and roofing are important for sanitation and protection against non-human entrance (including pigs) hence minimizing the spread of TSTC (Thys *et al.*, 2015). Toilets availability and proper use of them break the cycle of TSTC in the community (Carabin and Traoré, 2014).

Evaluation of management and marketing practices revealed a significant proportion of households kept their pigs under free roaming condition with an excuse of exercising them and finding nutritional supplements (Table 3); similar results were reported by Yohana *et al.*, (2013) and other studies across sub-Saharan and other regions in Africa (Edia-Asuke *et al.*, 2014; Gabriël *et al.*, 2016; Pondja *et al.*, 2010).

In addition to the reasons already described, other reason for higher proportion of free roaming of pigs were previously linked to poorly constructed pig pens that allow easy escape of pigs from their confinements (Maganira *et al.*, 2018) and (Supporting Table 2). The predominance of poor pig pens made with wooden walls had limited animal space; earth floors caused physical stress to pigs prompting their escape from shelters (Kimbi *et al.*, 2015). According to Maziku *et al.* (2017), limited pig supplements and lack of pig housing and feeding skills are indicators of poor or no planned budget for pigs, and that is contributed by farmer's ignorance or poverty (Motsa'a *et al.*, 2018).

The study also found no official or formal slaughter slab/points in the studied area that would facilitate pork inspection. Furthermore, it was revealed 10% of the respondents had the perception that uninspected pork was not threat whereas as large proportion of farmers were least informed on the importance of pig and pork inspection (Figure 2). Pork preparation methods were not considered as one of the factors causing TSTC in the studied community, a similar finding was revealed in a study by Thomas *et al.*, (2017).

The home slaughter of pigs with limited veterinary supervision (Cook *et al.*, 2017; Hrynick *et al.*, 2019), is an indication that the community is at risk of *Taenia solium* infection (Mokoele *et al.*, 2015). Pork preparation by open fire roasting and deep-frying, unless done with extra care, would likely fail to kill the cysts hence putting consumers health at risk (Meester *et al.*, 2019). However, undercooked pork is consumed in some places in Tanzania (Maridadi *et al.*, 2011; Mwanjali *et al.*, 2013).

Consuming pork in local bars with alcohol increases the chances of eating undercooked meat. Drunkenness may erode people's ability of waiting for the meat to cook and for tasting the quality of good cooked pork.

Lastly, this study revealed that both social and cultural practices may be contributing to the TSTC endemicity in the studied area. The findings in this study emphasises the need for community health education as previously advocated (Ngowi *et al.*, 2011) with emphasis on importance of veterinary and animal health professionals and services (Sithole *et al.*,

2020), construction and use of latrines, construction of slaughter slabs and improved pig management with readily available resources as suggested by Kamage *et al.* (2014). In addition, sustainable training on pig feeding and good pig housing can improve pig management practices (Komba *et al.*, 2013) and minimises free roaming pigs.

A change of socio-cultural practises is important for the TSTC control and that can be achieved through continuous leaning of an individual on a subject and changes one's mind-set (Johansen *et al.*, 2017). Similarly, previous studies revealed that sustainable

health education could bring success on TSTC control (Ngowi *et al.*, 2011). However, the long-term outcome of health education in different social-cultural practices remain a subject of further investigation

Although the study was conducted in a relatively limited geographical area among several TSTC endemic regions that might have slightly different social-cultural practices, the findings are useful and applicable to a wide range of communities with similar settings as reported from different areas within and outside Tanzania.

CONFLICT OF INTEREST

Authors do not have any conflict of interest.

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SUPPORTING INFORMATION

Supporting Table 1: The latrine condition scores

Score	Condition	Elaboration
1-2	Very poor	No door (open doors), Earth-damp floors, Floor have see-through holes, Short walls (less than 1.5 m), Walls have see-through spaces, No roof
3-4	Poor	No lockable doors (have a cloth to protect view), Earth-damp floors, Short walls (less than 1.5 m), No roof
5-6	Fair	Have lockable doors, Earth but neat floors, high walls (more than 1.5 m), have a roof but cannot protect leakage from rainwater
7-8	Good	Have lockable door with a stopper, Earth but neat floors, high tight strong walls (more than 1.5 m), have a roof that protects rain
9-10	Very good	Have lockable doors with a stopper, concrete neat floors, high tight strong walls (more than 1.5 m), have a roof that protects rain, pit-hole have a cover, toilet in clean condition, have hand washing facilities

Supporting Table 2: Pig-pen condition scores

Score	Condition	Elaboration
1-2	Very poor	Unsteady woody stick walls, Earth-soggy floors, no feeders, the pen in dirty condition with heaped manure inside, no doors
3-4	Poor	Unsteady woody stick walls, Earth-soggy floors, broken dirty feeders, the pen in a dirty condition, no doors
5-6	Fair	Wood sticks walls, Earth floors, dirty feeders, and the pen in a dirty condition. Have a lockable entrances
7-8	Good	Wood timber or brick walls, wood timber raised floors, clean feeders. Have lockable doors/entrances
9-10	Very good	Wood timber or brick walls, full protection from sun/rain, concrete or wood timber raised floors, clean steady feeders, floor and walls clean. Have lockable doors/entrances