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The impact of pig ownership, history of exposure to worms, and personal hygiene on taeniasis infection in Silou Kahean District

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ABSTRACT

Taeniasis remains a zoonotic public health concern in communities with traditional pig farming systems. Silou Kahean District, Simalungun Regency, is an endemic area where free-range pig husbandry increases exposure risk and may sustain persistent local transmission. This study aims to analyze the relationship between pig ownership status, the number of pigs owned, and pig husbandry practices with the incidence of taeniasis in Silou Kahean District, Simalungun Regency. This cross-sectional quantitative study (October 2024–June 2025, Silou Kahean, Simalungun) analyzed 270 cluster-randomized respondents from a population of 21,149 using structured questionnaires and Kato-Katz fecal examination. Associations between pig ownership, pig density, husbandry method, and taeniasis infection were tested using chi-square (95% CI). The findings revealed a significant relationship between pig ownership and the occurrence of taeniasis (p-value = 0.002; PR = 5.513; 95% CI: 1.953–15.560), indicating that respondents who owned pigs had a higher risk of infection than those who did not. The number of pigs owned also showed a significant association with infection (p-value = 0.035). Furthermore, husbandry methods significantly influenced the occurrence of taeniasis (p-value = 0.0001), with a higher prevalence observed among respondents practicing free-range pig rearing compared to those using pen systems. Pig ownership, higher pig density, and free-range husbandry are significant risk factors for taeniasis in Silou Kahean District. Community education, sanitation improvement, and stronger livestock supervision are critical to interrupt transmission in endemic areas.

Keywords: *Taeniasis, livestock, pigs, endemic area*

1. Introduction

Taeniasis is a zoonotic disease that falls under the category of Neglected Tropical Diseases (NTDs), which are infectious diseases often overlooked but have a significant impact on public health, especially in developing regions. In many developing countries, including rural areas in Africa and Latin America, free-range pig farming practices have been shown to be a significant risk factor for Taenia solium infection, both in animals and humans. For example, a study in Tanzania reported that free-roaming pig farming systems increase the incidence of porcine cysticercosis because pigs dig up and consume worm eggs from human feces and contaminated environments (Mulilo et al., 2023).

Similar findings were confirmed by studies in Burkina Faso and Mozambique, indicating that the recurrence of worm infections in pigs is higher in freely raised animals compared to those kept in strict confinement (Pray et al., 2019). Furthermore, research in Colombia noted that unorganized pig farming

systems and minimal meat inspections are significantly associated with the prevalence of cysticercosis in pigs, which also increases the risk of transmission to humans (Arango-Londoño et al., 2024).

In Southeast Asia, taeniasis accounts for more than 80% of global cases (WHO, 2022), with Indonesia being one of the countries with a fairly high prevalence, especially in areas with consumption of undercooked pork and beef and traditional farming practices. This disease is caused by infection with adult tapeworms Taenia saginata, Taenia solium, or Taenia asiatica, which use humans as the definitive host. Pigs are the main intermediate host for Taenia solium and Taenia asiatica, with transmission to humans occurring through the consumption of raw or undercooked pork containing larval worms.

One of the areas known as an endemic region for taeniasis in Indonesia is Silou Kahean Subdistrict, Simalungun Regency, North Sumatra Province. This area has environmental and socio-cultural characteristics that support the life cycle of tapeworms, including the high practice of pig rearing around the home, the habit of consuming dishes made from semi-cooked pork such as hinasumba, and limited access to sanitation and clean water. According to a preliminary survey, there are 365 households in Silou Kahean Subdistrict that raise pigs. Research by Kusolsuk et al. (2021) shows that communities raising pigs around the home have a 5.8 times higher risk of contracting taeniasis.

A cross-sectional study conducted in Oyam District, Uganda, showed that pig husbandry practices involving free-range systems and tethering (tethered but then released to forage) were significantly associated with an increased prevalence of cysticercosis in pigs compared to semi-intensive systems, as free-range pigs had greater access to human feces containing T. solium eggs. Solium (Were et al., 2025). In addition, a seroprevalence study of porcine cysticercosis in Indonesia reported that extensive farming systems (which include free-range practices) showed a higher likelihood of cysticercosis than intensive systems (OR ~5.0), with a significant association between the absence of toilet facilities and infection rates in pigs (Detha et al., 2022).These findings are consistent with global evidence that free-range systems increase contact between pigs and contaminated environments, while restricting pig movement to enclosed areas (e.g., pens/pens) has the potential to reduce exposure to T. solium eggs.

Another equally important factor is personal hygiene, including handwashing habits and maintaining environmental cleanliness. Sari et al (2024) emphasizes that poor personal hygiene significantly affects the incidence of worm infections, with an odds ratio of 5.756 (95% CI: 2.96–11.19; p-value = 0.0001). Based on this explanation, it can be concluded that the combination of pig farming practices, history of worm infections, and low clean and healthy living behaviors are important factors that need to be further studied in the Silou Kahean District as an endemic area for taeniasis.

2. Methods

This study is a quantitative study with a survey approach using a cross-sectional design. This design is used to assess the relationship between independent and dependent variables at a single point in time. This study aims to analyze the effect of pig ownership, history of deworming, and personal hygiene on the incidence of taeniasis in endemic areas, particularly in Silou Kahean District, Simalungun Regency. This study was conducted from October 2024 to June 2025.

The population in this study was the entire population in Silou Kahean District, Simalungun Regency, with a total of 21,149 people based on data from the Central Statistics Agency (BPS Kabupaten Simalungun, 2023). This population was the main target because it was a group at risk of taeniasis infection based on geographical location, consumption behavior, and environmental and sanitation conditions.

The sample size was determined using the Isaac and Michael table (in Sugiyono, 2020) with a 10% margin of error, resulting in a sample size of 270 people. The sampling technique was carried out using the cluster random sampling method, which is random sampling based on the division of administrative areas of villages or sub-districts in Silou Kahean District. This technique was chosen to ensure an even and representative distribution of samples for each region, so that the research results could describe the actual conditions of the local community.

The inclusion criteria in this study included: (1) residents aged at least 17 years, (2) residing in the Silou Kahean District, (3) not Muslim or Adventist due to the prohibition on pork consumption, and (4) willing to participate in the study by signing a written consent form (informed consent). Respondents were selected randomly using a list of household numbers, where random numbers were generated using the random function in Microsoft Excel, and then selected based on the highest order of the random results.

The method of measuring the dependent variable in this study was through laboratory examination using the Kato-Katz microscopic technique to detect the presence of Taenia eggs in the respondents' stool samples. The measurement results were classified nominally into two categories, namely positive taeniasis and negative

taeniasis. This examination was carried out at the Parasitology Laboratory of the Faculty of Medicine, University of North Sumatra, to ensure the validity of the taeniasis diagnosis.

Meanwhile, the independent variables consisted of pig ownership and pig husbandry methods. Data were collected through a structured questionnaire. Pig ownership was measured nominally with the categories "owns pigs" and "does not own pigs." The number of pigs owned was measured on a ratio scale based on the number of pigs mentioned by the respondents. Farming methods were categorized nominally into 'caged' and "free-range." The measurement scale was adjusted for each variable, with nominal and ratio scales used depending on the characteristics of the data collected.

The research process began with the submission of an ethical clearance application to the Health Research Ethics Committee of the University of North Sumatra, which was approved under letter number 469/KEPK/USU/2025. After passing the ethical test, the researchers submitted a research permit application letter from the Faculty of Medicine, University of North Sumatra, addressed to the Simalungun District Health Office and the Silou Kahean Subdistrict Office. After all permits were obtained, the research process could be carried out. Respondents diagnosed with taeniasis through laboratory tests were given therapy in accordance with applicable procedures.

The statistical test used in the bivariate analysis was the chi-square (χ^2) test with a 95% confidence level ($\alpha = 0.05$). The results of the bivariate analysis were considered significant if the p-value was < 0.05 and were accompanied by odds ratio (OR) and 95% confidence interval (CI) values to describe the magnitude of the risk or strength of the relationship between variables. Variables that showed a significant relationship in the bivariate analysis were then entered into a multivariate analysis using logistic regression testing. This test aims to determine the simultaneous effect of each independent variable on the occurrence of taeniasis and to identify the most dominant factor. The results of the logistic regression test are presented in the form of adjusted odds ratio (AOR) and 95% confidence interval, with the significance level determined at p-value < 0.05.

3. Results

Bivariate analysis results show that pig ownership is significantly associated with taeniasis, with respondents who own pigs having a 5.5 times greater risk of infection than those who do not own pigs (POR = 5.513; 95% CI: 1.953–15.560; p-value = 0.002). The number of livestock also showed an increased risk; respondents who owned <5 pigs had a 4.9 times greater risk (OR = 4.886; 95% CI: 1.594–14.978; p-value = 0.006), while those with ≥5 pigs had an almost 9-fold higher risk compared to those who did not own livestock (OR = 8.958; 95% CI: 1.558–51.500; p-value = 0.014).

For the variable of history of expelling worms, the results showed a highly significant relationship. Respondents who had expelled worms in the last <1 year had the highest risk of taeniasis (OR = 181.500; 95% CI: 33,697–977,608; p-value = 0.0001), and those who had done so ≥1 year ago also had a significant risk (OR = 21.656; 95% CI: 3.373–139.052; p-value = 0.001) compared to those who had never done so.

The personal hygiene variable showed a statistically significant relationship, where all cases of taeniasis were found in the group with poor hygiene (p-value = 0.027). In the personal hygiene subcomponent, the habit of cooking meat thoroughly was significantly associated with the incidence of taeniasis (OR = 9.018; 95% CI: 2.002–40.168; p-value = 0.004), as did environmental cleanliness (OR = 6.050; 95% CI: 1.678–21.811; p-value = 0.006). Meanwhile, the habit of washing hands with soap (CTPS) did not show a significant relationship (OR = 6.525; 95% CI: 0.844–50.468; p-value = 0.072). Data for the raw meat consumption variable were not statistically analyzed because all cases were in the risk group, so odds ratio and p-value values were not available (N.A.).

Table 1. Results of Bivariate Analysis of Pig Ownership, History of Worm Expulsion, and Personal Hygiene with Taeniasis Infection in Silou Kahean Subdistrict

Variable	Taeniaisis				POR*	*95% CI*	*P-value*
	Positive		Negative				
	n	%	n	%			
Ownership of pigs							
No pigs	215	96.4	8	3.6	5.513	1.953 – 15.560	0.0028
Have pigs	39	83.0	8	17.0			

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Table 1. Continued Results of Bivariate Analysis of Pig Ownership, History of Worm Expulsion, and Personal Hygiene with Taeniasis Infection in Silou Kahean Subdistrict

Variable	Taeniaisis				POR*	*95% CI*	*P-value*
	Positive		Negative				
	n	%	n	%			
Number of pigs owned							
None	8	3.6	215	96.4	*Ref.*		
< 5 pigs	6	15.4	33	84.6	4.886	1.594 – 14.978	0.006
≥ 5 pigs	2	25.0	6	75.0	8.958	1.558 – 51.500	0.014
History of worm expulsion							
Never	2	0,9	231	99.1	*Ref.*		
<1 year ago	11	61,1	7	38.9	181,500	33,697 – 977,608	0,0001
≥1 year ago	3	15,8	16	84.2	21.656	3.373 – 139.052	0.001
Personal Hygiene							
Good	0	0	62	100	*N.A.***	*N.A.*	0.027****
Poor	16	7,7	192	92.3			
Handwashing with soap (HWWS)							
Good	1	1,3	77	98.7	*Ref.*****	0.844 – 50.468	0.072
Poor	15	7,8	177	92.2	6.525		
Cooking meat							
Good	2	1,4	143	98.6	*Ref.*	2.002 – 40.168	0.004
Poor	14	11,2	111	88.8	9.018		
Environmental sanitation							
Good	3	2,0	148	98.0	*Ref.*	1.678 – 21.811	0.006
Poor	13	10,9	106	89.1	6.050		
Consumption of raw meat							
Poor	16	5,9	254	94.1	N.A.	N.A.	N.A.

Description:
* *POR; Prevalence Odds Ratio*
** *N.A.; Not Applicable*
*** *Fisher's Exact Test*
**** *Ref.: Reference*

Multivariate analysis results show that a history of expelling tapeworm segments is the most influential factor in the incidence of taeniasis. Respondents who had expelled tapeworms within the past year had a 1,136 times greater risk of being infected with taeniasis than those who had never expelled tapeworms (Adjusted POR = 1136.852; 95% CI: 136.954–9436.954; p-value = 0.0001), while those who had expelled worms ≥1 year ago still had a significant risk of 54.5 times (Adjusted POR = 54.536; 95% CI: 5.629–528.410; p-value = 0.001).

Pig ownership was also significantly associated with taeniasis infection, with an adjusted OR of 13.213 (p-value = 0.003), meaning that respondents who raised pigs were more likely to be infected than those who did not. Furthermore, based on the number of livestock, respondents who owned <5 pigs had a 52.5 times greater risk (Adjusted POR = 52.471; 95% CI: 5.947–462.993; p-value = 0.0001), and those with ≥5 pigs had a 30.1 times higher risk (Adjusted POR = 30.102; 95% CI: 5.957–152.109; p-value = 0.0001) compared to respondents who did not own pigs. Meanwhile, the personal hygiene variable could not be further analyzed statistically in the regression because all cases of taeniasis were found only in the group with poor hygiene,

while no cases were found in the group with good hygiene, so the adjusted POR, CI, and p-value values were not available (N.A.).

Table 2. Multivariate Analysis Results of Pig Ownership, History of Worm Expulsion, and Personal Hygiene with Taeniasis Infection in Silou Kahean Subdistrict

Variable	Taeniasis				Taeniasis	95% CI	P-value
	Positive		Positive				
	n	%	n	%			
Ownership of pigs							
No pigs	215	96.4	8	3.6	13.213		0.003
Have pigs	39	83.0	8	17.0			
Number of pigs owned							
None	8	3.6	215	96.4	*Ref.*		
< 5 pigs	6	15.4	33	84.6	52.471	5.947 – 462.993	0.0001
≥ 5 pigs	2	25.0	6	75.0	30.102	5.957 - 152.109	0.0001
History of worm expulsion							
Never	2	0.9	231	99.1	*Ref.*		
<1 year ago	11	61.1	7	38.9	1136.852	136.954 – 9436.954	0.0001
≥1 year ago	3	15.8	16	84.2	54.536	5.629 – 528.410	0.001
Personal Hygiene							
Good	0	0	62	100	*N.A.***	*N.A.*	*N.A.*
Poor	16	7.7	192	92.3			

** POR; Prevalence Odds Ratio*
*** N.A.; Not Applicable*
**** Fisher's Exact Test*
***** Ref.: Reference*

4. Discussion

Based on the analysis results, pig farming practices were found to have a significant association with the prevalence of taeniasis in the endemic area of Silou Kahean Subdistrict, Simalungun District. Respondents who raised pigs showed a much higher infection rate compared to those who did not. The risk of infection increased more than fivefold (OR = 5.513; p-value = 0.002) and remained significant in multivariate analysis (adjusted OR = 13.213; p-value = 0.003). The more pigs raised, the higher the tendency for infection, with respondents with <5 and ≥5 pigs having adjusted ORs of 52.471 and 30.102, respectively.

Although not all ownership numbers showed positive cases, the pattern of increasing prevalence in line with the increase in livestock numbers indicates a relationship between farm scale and infection risk. In terms of husbandry practices, there was a striking difference between respondents who kept pigs in pens and those who let them roam free. Respondents who let their pigs roam free showed a higher prevalence of infection than those who kept them in pens. This suggests that careless pig husbandry practices can increase the risk of environmental contamination and facilitate the life cycle of Taenia solium, thereby increasing the chances of infection in humans.

Research by Mulilo et al. (2023) in Tanzania shows that even when inspected, pork consumption still carries a high risk of T. solium transmission, especially when not cooked thoroughly. This supports the findings in Silou Kahean, where raw or undercooked pork consumption is a significant risk factor. A similar study in Indonesia by Detha et al. (2022) also found that free-range farming systems increase the risk of cysticercosis infection in pigs more than fivefold compared to closed pens. Although the use of closed pens is safer, inadequate sanitation still allows transmission.

A history of expelling tapeworm segments showed a very strong association with taeniasis. Respondents who had expelled worms in the past <1 year had an adjusted POR of 1136.852 (p-value = 0.0001), and those in the past ≥1 year had an adjusted POR of 54.536 (p-value = 0.001). These results indicate that clinical symptoms such as expelling worm segments can be strong indicators of active or chronic infection, as well as

reinfection due to an unbroken transmission cycle. These findings are consistent with studies in Peru and Thailand, which emphasize the importance of early diagnosis and complete treatment to break the chain of Taenia transmission (Jayashi et al., 2012; Kusolsuk et al., 2021).

Personal hygiene factors also have a significant influence on the incidence of taeniasis. All cases of taeniasis were found in respondents with poor personal hygiene (p-value = 0.027), which included habits of not washing hands with soap, not cooking meat thoroughly, poor environmental hygiene, and consumption of raw meat. Although it could not be included in the multivariate regression because no cases were found in the good hygiene group, bivariate evidence shows that behavioral aspects greatly determine the risk of infection.

Personal hygiene has been proven to play an important role in determining the risk of taeniasis, where poor hygiene knowledge and practices including not washing hands and not ensuring meat is fully cooked are correlated with an increased risk of infection as shown in a community survey in Pak Chong, Thailand (Phumrattanaprapin et al., 2024). Consumption of raw or undercooked pork, which is part of traditional eating habits, has been shown to increase the likelihood of taeniasis in a case-control study in Laos (Larkins et al., 2025). Quantitative risk assessments in Tanzania confirm that consuming improperly cooked pork, poor sanitation, and minimal meat inspection practices increase the potential for Taenia solium transmission from animals to humans (Mulilo et al., 2023).

Research by Sari et al. (2024) shows that poor personal hygiene increases the risk of worm infection by up to five times (OR = 5.756; 95% CI: 2.96–11.19; p-value = 0.0001). This is consistent with the study by Agustina et al. (2022) in Bali, which found that traditional farming practices, poor sanitation, and low education increase the risk of zoonosis, although it did not specifically study Taenia. In addition, the literature review by Rosyidah et al. (2024) emphasizes that personal hygiene, such as washing hands before eating, wearing footwear when in contact with soil/environment, as well as maintaining nail hygiene and environmental sanitation consistently, can significantly reduce the risk of worm infections .These results confirm that promotional and educational interventions targeting hygienic behavior are very important in efforts to control taeniasis.

The One Health concept is relevant in the prevention of taeniasis because Taenia solium transmission occurs through interactions between humans, pigs as intermediate hosts, and the environment. Prevention is not sufficient by improving individual hygiene alone, but must also be integrated with pig health control, such as routine deworming, keeping pigs in closed pens, and regular veterinary examinations to prevent cysticercosis in pigs. Environmental improvements particularly the provision of adequate sanitation and protection of water sources from fecal contaminationare important to prevent soil and water from becoming reservoirs of Taenia eggs that can infect livestock and return to humans. Cross-sector collaboration between health, livestock, and environmental management services enables simultaneous chain-breaking, community-based hygiene education, and sustained zoonosis surveillance. Thus, the One Health approach supports holistic promotive, curative, and preventive strategies to reduce infection risk and prevent reinfection with taeniasis in endemic agricultural areas such as Silou Kahean.

The One Health approach supports the prevention of taeniasis through integrated interventions in humans, pigs, and the environment. However, this study has limitations. Potential selection bias may occur because respondent recruitment was likely not based on probability sampling, so the results are less representative of populations that do not access health services. In addition, there is information bias, particularly recall bias and social desirability bias, because exposure variables were measured through self-reported questionnaires, which carry a risk of misclassification. The cross-sectional design also does not allow for the assessment of causal temporal relationships. Therefore, the results should be interpreted as strong associations, with caution exercised in generalizing them.

5. Conclusion

This study shows that pig ownership, number of pigs, history of tapeworm expulsion, and personal hygiene are significantly associated with the incidence of taeniasis in Silou Kahean Subdistrict, Simalungun District. A history of tapeworm expulsion in the last <1 year is the most dominant factor contributing to the incidence of infection. The risk of infection also increases with the number of pigs owned, especially in uncontrolled husbandry systems. All cases of taeniasis were found in respondents with poor personal hygiene.

This study recommends the need to increase public education about the dangers of taeniasis and the importance of maintaining personal hygiene, cooking meat thoroughly, and using proper toilets. Local governments and health officials need to promote more hygienic pig farming systems, such as closed pens, and expand mass screening and treatment programs for high-risk populations. Further research is also recommended to explore other behavioral factors and the effectiveness of community-based interventions in controlling taeniasis in endemic areas.

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