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Chapter 1. Introduction

Parasitic zoonoses are becoming increasingly important in the spectrum of emerging and re-emergent diseases for both developed and developing countries, and are typically associated with poor marginalized countries in low-income countries. They are regarded as disease of the poorest among the poor [1–3]. Taenia solium is found in sub-Saharan Africa, Central Asia and Latin America where domestic pig husbandry is practiced, poverty, illiteracy and deficient sanitary infrastructures are common [1, 4, 5]. Similarly, the disease has been reported in urban areas where most of the infected pigs are transported and consumed. The incidence of the disease in humans is increasing and now is a re-emerging disease in some developed countries and in areas of non-endemicity, due to international...
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travel and immigration [6, 7]. Hence cysticercosis/neurocysticercosis/teaniosis complex caused by the larval stage of T. solium in both pigs and humans remains a significant cause of human morbidity and mortality in many parts of the world. It is seriously affecting pig production and also considered as a public health and economic problem in many developing countries affecting food security and negatively impacts the nutritional and economic well-being of the small holder farming community [8, 9].

2. Life cycle

2.1 Life cycle and pathogenesis

Taenia solium life cycle is sustained where free roaming pigs, have access to contaminated feces of tapeworm carriers. T. solium has a complex two host life cycle and is cyclically transmitted between pigs and man. Humans are the only definitive host and harbor the adult stages of these cestodes following ingestion of insufficiently cooked pork meat infested with cysticerci. Infection with the adult stage is relatively innocuous and carries mild clinical manifestations leading to taeniasis [1–11]. Pigs are the natural intermediate host, while human's acts as the accidental dead-end intermediate host and are both infected with T. solium by ingestion of embryonated eggs from feces of tapeworm carriers from contaminated soil, water, vegetation/foods to form cysticerci. Infection with the cysticerci leads to more severe symptoms including headache and neurocysticercosis when the pathology occurs in the CNS [11].

2.2 Epidemiology

Neurocysticercosis has been considered to be the most common parasitic infestation of the central nervous system and the single most common cause of preventable acquired epilepsy and mortality in developing countries [12–14], and a strong correlation was reported between the prevalence of epilepsy and seropositivity against T. solium cysticercosis [15]. The association between cysticercosis and epilepsy has been documented as a leading neurological condition worldwide including West Africa. Epilepsy is a frequent chronic neurologic disorder that affects approximately 70 million people of all ages worldwide [15] Studies of [10] in 2010 reported that the median prevalence of active epilepsy was 4.9/1000 (2.3–10.3) for developed countries, 12.7/1000 (3.5–45.5) and 5.9/1000 (3.4–10.2) in rural and urban studies in developing countries. Neurocysticercosis has been associated with 30% of adult onset epilepsy in endemic regions where 10–20% of the general population can have brain lesions consistent with neurocysticercosis on CT scans [16]. Neurocysticercosis creates a tremendous economic burden in endemic areas incurring significant costs due to diagnosis, treatment and disability [17]. Poor sanitary conditions, traditional pig farming, lack of awareness of the disease and poverty play an important role in the perpetuation of the Taenia solium/cysticercosis, and are present in West Africa [18]. Research in the region on Taenia solium cysticercosis and taeniasis in both human and pigs has been limited. Prevalence information of the disease in some countries within the region has been scanty leading to underestimation of the prevalence, epidemiology and clinical impacts of the disease which has made it difficult to make definitive recommendations on control strategies. Data on porcine and human cysticercosis are available from several countries. However, there is no recent information on T. solium taeniasis-cysticercosis complex in some countries including Guinea Bissau, Liberia, Ivory

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| Author Country/location | Diagnosis | Total | Epilepsy (n) | Neurocysticercosis | Cysticercosis | Taeniasis |
|-------------------------|-----------|-------|--------------|--------------------|---------------|-----------|
| [27] Benin Capture recapture/Neurlogist | 3134 | 20.1/1000 (n=66) | GP | ND | ND | ND |
| [29] Benin, Savolou | Ab-ELISA, skull/muscle X-ray and pathol. of cysts | 1443 | 1.5 (22/1443), 17/186 | GP | 4.0% (n=57) | 1% (n=14 skin nodules) | ND |
| [29] Benin | Ab-ELISA, skull/muscle X-ray and pathol. of cysts | 319 | GP | 3.5% (319) | ND | ND |
| [29] Benin | Ab-ELISA/(EITB) | 2625 | GP | 1.6% (n=41) | ND | ND |
| [30] Benin | AB,ELISA/(EITB) | 2625 | 41/1.3% (35) | GP | ND | ND |
| [32] Burkina Faso B158/B60 AG-ELISA | 3609 | GP | 0–11.5% (n=120) | ND |
| [33] Burkina Faso Ag B158/B60 ELISA | 1729/1719 | GP | 3·8% (n=65) | CC | 2.7% (n=47) | ND |
| [34] Burkina Faso´ a B158/B60 Ag-ELISA | 763 | GP | 6.29% (n=48) | ND |
| [35] Burkina Faso B158/B60 Ag-ELISA questionnaire/neurologist | 3696 | 3.9% (n=145), GP | 3.4% (n=129) | ND |
| [36] Burkina Faso AgELISA/CT scan/neurologist | 888 | 4.4% (39) | epi, VL | 29% (20/68) | ND | ND |
| [37] Burkina Faso Ag-ELISA, physician | 888 | 4.5% (39) of 70 VL | 5/39 epileptics (12.8%), 3.4% (28/814) | ND | ND |
| [38] Burkina-Faso | 16,627 | 10.6 per 1000, CB | ND | ND | ND |
| [39] Ghana Bunkpuru | Kato-Katz technique | 494 | ND | ND | 13.15% (n=65) |

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| Country/Location                  | Method                          | Total Sample | Neurocysticercosis | Cysticercosis | Taeniasis |
|---------------------------------|--------------------------------|--------------|--------------------|---------------|-----------|
| Ghana, Kintampo                 | Questionnaires, clinicians/western blot | 586,607     | 10.1/1000          | ND            | 0.01/ND   |
| Senegal                         | Direct fecal examination       | ND           | ND                 | ND            | ND        |
| Fecal egg count                 | ND                             | ND           | ND                 | ND            | 2/43*     |
| Nigeria, Ebonyi/Benue state     | Fecal egg count                | ND           | ND                 | ND            | 4/43**    |
| Nigeria, Abor/Enugu             | Worm expulsion/amorphological identification | ND           | ND                 | ND            | 1/43***   |
| Nigeria, Ukpo, Dunukofia, Anambra state | Questionnaire, neurologist | 6800         | 4.3/1000           | ND            | ND        |
| Nigeria, Nsukka, Enugu State   | Stool microscopy               | 1525         | ND                 | ND            | 8·6%      |
| Nigeria, Odeda, Ogun State     | Sodium acetate acetic acid/ formalin concentration method (SAF-Ether) | 428          | ND                 | 40%           | (n = 175) |
| Nigeria, Ile-Ife, Surgeon/histopathological, biopsy | Cysticercosis of breast | ND           | ND                 | ND            | ND        |
| Nigeria, Jos                      | Ab-ELISA                       | ND           | ND                 | ND            | ND        |
| Nigeria, Nasarawa, Ogun State   | Copro Ag ELISA, Questionnaire  | 10           | 30                 | (n = 3)       | ND        |

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The objective of the study will be to review and document data on the prevalence of human cysticercosis/neurocysticercosis in the region with emphasis on epilepsy.

2.3 Methods

A systematic literature search was done on studies carried out on cysticercosis in humans and pigs, seroprevalence of cysticercosis in humans and pigs, neurocysticercosis/taeniasis, risk factors for transmission of cysticercosis and epilepsy in West Africa published between 1980 and 2019. This search focused on the articles in which data was obtained using the following techniques and protocols: (1) enzyme-linked immunoelectrotransfer blot (EITB), (2) enzyme-linked immunosorbent assay (B158/B60 Ag-ELISA or HP10 Ag-ELISA), (3) copro-antigen ELISA and real-time polymerase chain reaction assay (copro-PCR). Language restriction was applied, the considered languages were English and French. The selected databases for this study were: PubMed (http://www.ncbi.nlm.nih.gov/pubmed/), Google scholar and others. The search was performed from May 22 to August 22, 2019.

2.4 Literature search

The following data were included in this study (1) peer-reviewed studies of *T. solium* taeniasis/cysticercosis/neurocysticercosis, porcine cysticercosis and epilepsy in West Africa. (2) "Gray literature" on *T. solium* taeniasis/cysticercosis, neurocysticercosis presence in West Africa which consisted of informally published written materials including reports. We performed a literature search using PubMed (http://www.ncbi.nlm.nih.gov/pubmed/) with date restriction from January 1, 1980 to January 5, 2019 using the following search term: (solium OR Tapeworm OR Taeniasis OR Taeni* OR Taeniosis OR Neurocysticercosis OR Cysticerc* OR epilepsy) AND West Africa (Benin OR Burkina Faso OR Ivory Coast OR Cape Verde OR Gambia OR Ghana OR Guinea OR Guinea Bissau OR Liberia OR Libya OR Malawi OR Mali OR Mauritania OR Niger OR Nigeria OR Senegal OR Sierra Leone OR Togo). We also searched other databases such as Google Scholar (http://scholar.google.com), Cab Direct (http://www.cabd direct.org) and African Journals Online (http://www.ajol.info) using the following keywords: "*Taenia solium*, "porcine cysticercosis, "neurocysticercosis, "human cysticercosis" and "taeniasis" Epilepsy, West Africa.

2.5 Data extraction and collection

Presence of *T. solium* in this study was defined as a documented case of disease related to the tapeworm, whether it was diagnosed and documented as human cysticercosis, neurocysticercosis, porcine cysticercosis, taeniasis or epilepsy. Initially, we reviewed all titles and abstracts, if accessible, and excluded studies outside West Africa, and studies with no specified diagnostic technique, studies written in languages other than English and French, and studies not having full paper, that is, abstracts only experimental studies were also excluded.

2.6 Study selection

Figure 1 describes the review process and the number of articles selected at each stage of the review. From an initial number of 550 articles, only 121 were eventually used. The search selected by removal of duplicate studies from the title selection and studies performed before 1980. Secondly, another set of articles were excluded due to: (1) parasites other than *T. solium*; (2) studies performed in non-west African...
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3. Results

The search identified 66 studies that reported the prevalence of *T. solium* taeniasis/cysticercosis/neurocysticercosis and epilepsy in West Africa from 1980 to 2019. The study identified porcine cysticercosis in 18 countries, human cysticercosis in 19 countries, taeniasis in 4 countries and epilepsy was reported in 25 countries.
Figure 1 shows the flow chart of the selection of literature for the informed prevalence estimations of studies included in this review; 8 from Benin (1PC/7HCC/PWE), 11 from Burkina Faso (3PC/8HCC/PWE), 1 from Gambia (PC), 4 from Ghana (2PC/1EP/1TE), 2 from Liberia (PWE), 1 from Mali (PWE), 1 from Mauritania (PWE), 24 from Nigeria (PC10/HCC/PWE14), 3 from Senegal (1PC/2PWEI) and 4 from Togo (4 PWE).

3.1 Porcine cysticercosis in West Africa

One epidemiological studies from Benin [20] used carcass inspection to determine the prevalence of porcine cysticercosis and obtained a prevalence of 0.06–0.69% among a total of 118,073, slaughtered pigs. Two studies from Burkina Faso used carcass inspection to determine the prevalence of porcine cysticercosis and obtained a prevalence of 0.22–0.57% in a total of 179,337 pigs [21, 58]. One study used B158/B60 Ag-ELISA to determine the prevalence of active cysticercosis in pigs and obtained a seroprevalence of 32.5–39.6% among 336 pigs [22]. Two studies from Ghana determined the prevalence of porcine cysticercosis by carcass inspection and obtained the prevalence of 2.31–11.70% [59, 60], among a total of 4181 pigs. A total of 10 studies in Nigeria determined the prevalence of porcine cysticercosis by carcass inspection and obtained a prevalence of 1–20% [23–26, 61–65] among a total population of 12,781 pigs. While one study determined the seroprevalence of porcine cysticercosis and obtained a seroprevalence of 46% IgG antibodies among 115 pigs [66]. A study in Senegal determined the prevalence of porcine cysticercosis by lingual inspection and obtained a prevalence of 0.1–1.0%, while Ag-ELISA gave a seroprevalence of 4.8% [67]. All the data are presented in Table 1.

3.2 Human cysticercosis, taeniasis and epilepsy in West Africa

Sero-epidemiological studies from 16 countries were selected for the West African region, 3 studies [29] from Benin used Ab-ELISA, skull/muscle X-ray and pathology of cysts and a study used both Ab-ELISA and EITB [30]. The total number of individuals sampled for serological testing in this region was 4387. Prevalence of circulating antibodies ranged from 1 to 4%. Detailed description of each study is given in Table 2. The total number of individuals examined for epilepsy survey in the region was 27,848, excluding 1443 individuals that were involved in the serological study by [29]. Three studies used door-to-door method of survey in estimating the prevalence of epilepsy [27, 30, 31]. Two of the authors used capture/recapture method. They used questionnaires/neurologist to diagnose epileptics [27, 30, 31] and according to definition by the ILAE 1989, and PAANS [68, 69]. The prevalence of epilepsy in the country ranged from 8.08/1000 to 20.1/1000. A study [29] linked the 1.5% seroprevalence epilepsy to the prevalence of human cysticercosis. A 0–29% human cysticercosis seroprevalence in Burkina Faso was obtained from six studies using Ag-ELISA [32–34, 36, 37] and the prevalence of epilepsy in the region ranged from 4.5 to 14% per 1000. The total individuals sampled for seroprevalence studies were 13,413. Three of the studies associated the prevalence of epilepsy to cysticercosis [36, 37]. Two studies [34, 38] estimated the prevalence of epilepsy only, with a total individuals sample size of 29,315 excluding studies that associated the prevalence of epilepsy with cysticercosis.

Human taeniasis from Ghana was obtained from a study performing the Katao Khazt method and obtained a prevalence of 13.3% in a total sample size of 44 individuals [39]. Human cysticercosis in Ghana was obtained from a study by western blot and obtained a prevalence of 0.01% and the same study estimated the prevalence of epilepsy as 10.1/1000 in a total population size of 586,607 [40].
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Human cysticercosis from Nigeria was obtained from two studies [47, 48] by using Ab ELISA with prevalence of cysticercosis ranging from 9.6 to 14.3% in a total of 425 individuals. There were five studies selected for epilepsy [43, 44, 51, 70] with prevalence ranging from 4.3/1000 to 20.8/1000 in a total of 64,979 individuals for the epilepsy study. Five studies in the region were case report of cysticercosis [45, 49, 50, 71] involving the ocular and breast cysticercosis. Human taeniasis was obtained from two studies by stool microscopy [25, 46] with a prevalence ranging from 8.6 to 40% among a total of 1953 individuals in the region. Human cysticercosis in Senegal was obtained from one study performing antigen and antibody ELISA [42]. The total number of individuals in the study were 403, and prevalence of both antigen and antibody was 7.6%. The prevalence of epilepsy in the country was obtained from two selected studies [52, 53] and the prevalence of epilepsy ranged from 8.3/1000 to 14.2/1000 in a total of 12,182 individuals. Prevalence of epilepsy from Liberia was obtained from two studies [41, 54] and the prevalence of epilepsy across the region ranged from 28.0/1000 to 43.0/1000 among a total of 7169. Prevalence of epilepsy from Mauritania was obtained in one study [55] with a prevalence of 34.7/1000 in a total of 236 individuals. Human cysticercosis was obtained from two sero-epidemiological studies from Togo by antibody ELISA and gave a prevalence of 23.3 [57] and cysticercosis 38/1000 [56] among a total of 14,419 individuals. The two studies also estimated the prevalence of epilepsy and obtained 16/1000 and 18.6/1000 [56, 57] among a total of 6607. A detailed description of each study is given in Table 2.

3.3 Risk factors for human cysticercosis in West Africa

Out of the selected articles reviewed, 16 identified risk factors associated with the prevalence of *Taenia solium* cysticercosis, taeniasis, epilepsy and porcine cysticercosis. Lack of proper meat inspection, clandestine slaughtering of pigs and illegal sales of meat leading to poor sanitary control were all risk factors that were associated with an increased prevalence of cysticercosis in Benin Republic [30] as it will promote sale of infected pork carcass to unsuspecting consumers (since condemnation cannot be carried out) and predispose them to infection by these parasites (taeniasis) which increases transmission of infection in the community while increase age, stigma and lack of medical facilities were associated with increase prevalence of epilepsy, people with epilepsy may hide their true identity due to fear of marginalization and may not get proper health care [31]. In Burkina Faso, being a male, pig farming including percentage of soil in sand, residing in poor homes, lack of latrine. Males may have poor hygiene compared with females as they are likely to eat improperly washed fruits or vegetables after purchase and may eat food from food vendors prepared outside the home who might be carriers of the adult tapeworm. The authors also thought the acidic nature of the gastrointestinal tract might have made the eggs tolerate slightly more acidic soil. The higher soil (sandy) percentage might have favored spread of taenid eggs unto vegetation and water by wind. Carabin et al. [32] and living in communities with higher percentage of traditional pig husbandry [32, 36] were risk factors associated with the seroprevalence of cysticercosis [32]. Other factors include pig ownership, preparation method of pork by mothers, access to latrine [33] and pork consumption, pork consumption is associated with cysticercosis either by self-infection or through ingestion of contaminated food and water [32, 37]. Interestingly, previous consumption of pork, being a paid worker or trader as against farmer and housewives was also associated with the seroprevalence of cysticercosis [22, 37]. It was also observed that free roaming pigs in the rainy season and knowledge of porcine cysticercosis. 

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5. Conclusions

The high prevalence of porcine and human cysticercosis and epilepsy in the region indicates that there is a need to get more updated prevalence data of cysticercosis in rural areas where epilepsy is suspected to be more prevalent, compared to urban regions due to parasitic infection. Studies determining the association between epilepsy and cysticercosis should be carried out in countries where it has not been done. The conditions necessary for the parasite to thrive and be transmitted in the region is present in West Africa. Interventions studies including Health education has only been done recently in Burkina Faso, such intervention measures should be carried out in other parts of the region so as to enlighten the populace on the menace caused by the parasite and how it could be prevented.

6. Limitations

The present study has some limitations as the criteria for inclusion and exclusion of articles might have increased or reduced the number of studies used in the region and not all risk factors and causes of epilepsy were discussed. The study did not determine the prevalence of epilepsy and both porcine and human cysticercosis, in the region as the aim of the study was to show data on studies done by other researchers in the region.

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The authorship criteria are listed in our Authorship Policy: https://www.intechopen.com/page/authorship-policy.

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Conflict of interest

The authors declare no conflict of interest.

Notes/thanks/other declarations

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Acronyms and abbreviations

PWE people with epilepsy
HCC human cysticercosis
Ag-ELISA antigen ELISA
Ab-ELISA antibody ELISA
ND not done
GP general population
VL villagers
CR cross sectional survey
CT computed tomography
HB hospital based
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