



Challenges and opportunities in detecting *Taenia solium* tapeworm carriers in Los Angeles County California, 2009–2014

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Abstract Carriers of the pork tapeworm, *Taenia solium*, are the sole source of neurocysticercosis, a parasitic tissue infection that can be chronic and severe. Identifying *T. solium* tapeworm carriers is challenging. Many are asymptomatic and go undetected and unreported. In addition, *T. solium* is difficult to distinguish from other *Taenia* species of less concern. From 2009 to 2014, 24 taeniasis cases were reported to the Los Angeles County (LAC) Department of Public Health. Twenty reports were received solely from our automated electronic laboratory reporting system (ELR), two from health care providers, and two were generated internally from investigation of households with a reported neurocysticercosis case. Further investigation identified one *T. solium* carrier originally reported by ELR and one identified from a neurocysticercosis case investigation. These results suggest that *T. solium* tapeworm carriers can be identified from investigation of ELR reports of unspciated *Taenia* cases as well as from households of neurocysticercosis cases. Published by Elsevier Ltd. on behalf of Ministry of Health, Saudi Arabia. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

Carriers of the pork tapeworm, *Taenia solium*, are the sole source of cysticercosis, a parasitic tissue infection [1]. When tapeworm eggs excreted by the carrier are ingested, tapeworm larvae can form cysts. When cysts form in the brain, the condition is called neurocysticercosis and can be especially

severe. The burden of neurocysticercosis in Los Angeles County (LAC) is appreciable, with an average of 136 county residents hospitalized annually [2]. The prevalence of *T. solium* carriage is largely unknown because carriers are generally asymptomatic, making detection difficult. The identification and treatment of tapeworm carriers is an important public health measure that can prevent further neurocysticercosis cases [1].

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An increase in *Taenia* reports solely from our automated electronic laboratory reporting system (ELR) has recently been recognized. These cases were not identified by a LAC Department of Public Health (DPH) neurocysticercosis investigation, which has been the source of such reports in the past [3]. These ELR reports are generally based on the identification of *Taenia* eggs which are morphologically indistinguishable between *Taenia* species. Therefore, ELR reported *Taenia* cases may not be the species of public health interest (*T. solium*). Speciation can be performed at our public health laboratory, but can be challenging.

We performed a retrospective review of all taeniasis cases reported over the last 6 years in LAC. Case demographics, laboratory information and reporting source were reviewed.

2. Methods

Cases reported to the LAC DPH from 2009 to 2014 with supportive laboratory documentation were identified for review. Laboratory supportive evidence included (1) *Taenia* eggs identified via microscopy exam of stool performed at a private or our public health laboratory or (2) serological testing for *T. solium* antibodies specific for the tapeworm form using Enzyme-linked Immune-electro Transfer Blot (EITB) performed at the Center for Disease Control (CDC). Taeniasis case demographics and rates were calculated using population data provided by Urban Research [4], excluding LAC regions of Pasadena and Long Beach which are served by their own respective health departments. *Taenia* speciation, reporting source and birth place of cases were also reviewed. Medical, laboratory and DPH nursing records were reviewed where available. All effort was made to protect the personal health information of cases and all data were analyzed anonymously.

3. Results

3.1. Demographics (N = 24)

There were 24 taeniasis cases identified in LAC from 2009 to 2014, with an average annual rate of 4.1 per 10 million residents. Cases were much more likely to be male than female (79.2% vs. 20.8%) (Table 1). The average age of a case was 43.0 years (range 3–70 years). Many cases were Hispanic (37.5%) and a majority resided in the San Fernando Service Planning Area (58.3%). The annual rate of taeniasis was higher for men (6.5 per 10 million) and for persons age 35–44 years (9.5 per 10 million) and persons age 65 years and

older (8.3 per 10 million). Asians had the highest rate of taeniasis by race ethnicity (7.7 per 10 million) and the San Fernando Valley Service Planning Area of LAC had the highest rate by geographic region (10.6 per 10 million).

3.2. Epidemiology (n = 14)

Prior to 2011, only basic demographic and testing information was captured with the taeniasis survey tool utilized. The survey tool was updated in 2011 and detailed birthplace, symptoms, treatment and employment information for the 14 cases occurring after this change. Of these, 13 were born outside of the US; Mexico (n = 6), Cuba (n = 1), Nicaragua (n = 1), Vietnam (n = 1), Italy (n = 1), Ethiopia (n = 1) Iran (n = 1) and Guatemala (n = 1). The one US born case frequently traveled to South East Asia for business trips. The average time for a case to have lived in the US before being diagnosed was 11 years (ranging 0–36 years). None of these cases were employed as a food handler.

Mild gastrointestinal symptoms were reported by seven of the 14 cases (i.e. stomach cramps, nausea). Of the seven cases that did not report gastrointestinal symptoms, four observed “worms in their stool” and sought medical attention. All 14 cases received treatment, which included praziquantel (n = 13) and albendazole (n = 1) and mebendazole (n = 1), with one case receiving multiple treatments over a two-year period. This case was initially treated with praziquantel (600 mg) followed by two additional treatments with albendazole (100 mg both times) from a private provider and a fourth treatment of praziquantel (600 mg) from a county clinic. The case reported no worms one year after the fourth treatment, but declined further stool testing. The case reported no travel outside the US during this two-year period.

3.3. DPH notification source (N = 24)

Twenty of the 24 taeniasis cases were reported solely by ELR (83.3%). No health care provider notification was ever submitted. Further investigation of these ELR reports identified one *T. solium* case. This was a 60 year-old male who had emigrated from Ethiopia 20 years earlier and was reported with *Taenia* eggs in one of three stool specimens tested by a private lab. Three additional stool specimens collected from this case and tested at the public health lab identified a *T. solium* proglottid in one specimen. This case reported abdominal pain and was diagnosed with distention. Treatment consisted of a single dose of praziquantel (600 mg).

Table 1 *Taenia* tapeworm carrier demographics and rates for cases reported in Los Angeles County, California from 2009 to 2014.

	N	Case distribution (%)	Average annual rate per 10,000,000 population
All reports	24	100	4.1
Gender			
Male	19	79.2	6.5
Female	5	20.8	1.7
Age			
15–34	8	33.3	4.6
35–44	8	33.3	9.5
45–64	3	12.5	2.2
65+	5	20.8	8.3
Race ethnicity			
Hispanic	9	37.5	3.2
White	5	20.8	2.9
African or African American	4	16.7	7.4
Asian or Pacific Islander	6	25.0	7.7
Residence (SPA)			
San Fernando Valley (2)	14	58.3	10.6
San Gabriel Valley (3)	2	8.3	2.0
Metro (4)	6	25.0	7.7
Other LAC (1, 5, 6, 7)	2	8.3	1.1

Examination of three stools 1 month post treatment did not identify evidence of *Taenia* and the case was considered cleared of infection. Two additional family members were also screened for *Taenia* tapeworms. No evidence of *Taenia* was identified from any of the three stool specimens collected from each family member and the investigation was closed.

Another public health investigation of an ELR reported taeniasis case identified this person with a *Taenia saginata* tapeworm. This case was a 37 year-old female who emigrated from Guatemala nine years earlier. Three additional specimens collected by a public health nurse and examined in our public health laboratory. The laboratory identified a *T. saginata* proglottid in one specimen. This case was referred for treatment, but no additional follow-up or testing was performed as *T. saginata* is not of public health interest. Speciation was attempted on four additional taeniasis cases reported by ELR, but no worm segments were identified to speciate. These four cases, and the remaining unspciated *Taenia* cases, were referred for treatment. No additional stool collection or testing was performed by LAC DPH.

Two taeniasis cases (8.3%) were identified from two separate public health investigations of provider reported neurocysticercosis cases. One

neurocysticercosis investigation involved an 18 year-old case with recent onset of seizures and evidence of neurocysticercosis by magnetic resonance imaging. A 44 year-old Hispanic male living in the household and emigrating from Mexico 12 years earlier was identified with evidence of *T. solium* tapeworm (EITB). This tapeworm case was treated with one dose of praziquantel (600 mg) and the investigation was closed. The second neurocysticercosis investigation involved a 33 year-old female case suffering from hydrocephalus, with positive cysticercosis serology and magnetic resonance imaging suggesting neurocysticercosis. A 37-year old Hispanic female emigrating from Guatemala eight years earlier was identified with *Taenia* eggs in one of three stool specimens by our public health laboratory. The tapeworm case was treated with 600 mg of praziquantel. Three stool specimens collected 1 month post treatment found no evidence of *Taenia* and the investigation was closed. Details of this case have previously been reported [5].

Two taeniasis cases (8.3%) were reported by private health care providers; one from a county refugee clinic and one from a county hospital. Both cases were referred for treatment by a LAC DPH nurse, but no further stool collection or testing was performed by DPH.

4. Discussion

Taeniasis appears to be a rare disease in the LAC, but the asymptomatic nature of the disease makes any estimation of the true prevalence difficult. Cases in the US have been identified previously through screening at risk populations [6,7] and by screening household members of neurocysticercosis cases [3,8–11]. Taeniasis rates in LAC appear higher for men than women. This gender trend appears consistent with neurocysticercosis mortality in the US, with men comprising 62% of the deaths [12]. If men are more likely to travel and eat higher risk foods, this may put them at a higher risk of taeniasis or exposure to a taeniasis case. Whereas other studies indicate that taeniasis in the US primarily affects Latinos [6,7] our study indicated that other race-ethnicities are also impacted.

Taeniasis cases are increasingly being reported by our automated electronic submission of laboratory reports (ELR) that are not accompanied by a provider report and have no known association with a neurocysticercosis case. In this review, a majority of reports were received in this manner, with one case identified with *T. solium* tapeworm. Reporting of taeniasis by providers is mandated by law in California; however reporting from laboratories is currently voluntary. Mandatory laboratory reporting will ensure that public health departments continue to receive these ELR reports and have the opportunity to identify *T. solium* carriers. DPH should ensure that *T. solium* cases are not working as a food handler, receive adequate treatment and are cleared of infection.

One *T. solium* carrier and one *T. saginata* case discussed in this review were identified by light microscopy exam of stool performed at our public health laboratory. This method has a low sensitivity for detecting *taenia* tapeworms [13], however, most private laboratories utilize this method and it is indicative of active infection. Further speciation requires either identification of the tape worm's scolex (tapeworm attachment mechanism) or identification and enhancement of the tapeworm's proglottid (tapeworm segment containing reproductive organs) and is best when performed on a stool specimen collected in a saline solution with no preservative. Stool specimens collected for ovum and parasite testing are typically collected in a formalin solution that renders them non-infectious, but often degrades the worm segment and makes them difficult to speciate. Speciation is usually only performed at a public health lab.

One *T. solium* tapeworm carrier was identified with a positive EITB serological test performed at the CDC. This test has superior sensitivity to microscopy exams, is capable of distinguishing the tapeworm form from the larval form of *T. solium* and can distinguish *T. solium* from other *taenia* species [14]. It also eliminates any possible exposure of the case or laboratory personnel to the tapeworm eggs while collecting and testing stool specimens. *T. solium* eggs are directly infectious to humans. However, this method cannot distinguish current from recent infection and is not commercially available [13].

It is difficult to speculate how many of the 21 unspicated *Taenia* cases presented in this review were *T. solium* carriers. Studies of taeniasis cases globally suggest that *T. saginata* tapeworm infection is much more common than *T. solium* tapeworm infection (50 vs. 5 million, 1996) [15], indicating that many of the taeniasis cases in our study may actually have a *T. saginata* infection and are not of public health interest.

With improved collaboration between public health, private laboratories and private health care providers, cases of neurocysticercosis can be prevented through the identification and successful treatment of *T. solium* tapeworm carriers. Public health needs to be part of this process; speciating cases when possible and ensuring that *T. solium* cases are successfully treated and cleared of infection. Hopefully, improved laboratory techniques will become more available to public health laboratories.

Much of the laboratory and medical information presented in this study was collected retrospectively, which has inherent limitations. In addition, the rates of taeniasis presented in this review by demographics may be unstable due to the small number of cases. The capabilities and techniques of private labs to correctly identify and report *Taenia* using microscopy exams of stools may vary, which would influence the cases reported in this review.

Conflict of interest

We have no conflicts of interest to disclose.

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