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RISK FACTORS FOR *TOXOPLASMA GONDII* INFECTION FOR RESIDENTS AND WORKERS ON SWINE FARMS IN ILLINOIS (USA)

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Une étude épidémiologique des facteurs de risque d'infection des travailleurs et des résidents dans des élevages de porcs par T. gondii a été réalisée dans 43 élevages porcins de l'Illinois. Des échantillons de sang ont été prélevés chez 174 adultes dans ces élevages en 1993. Le test de dépistage était le test d'agglutination modifié, avec un seuil de positivité de 1/25. Un entretien avec chaque participant a permis d'obtenir l'information sur la manipulation de chats, de leur litière, de nourriture animale et de viande crue, sur le jardinage et le lavage des mains après ces activités et avant de manger, en vue de déterminer les modalités possibles d'infection. Une analyse de régression logistique multiple a été utilisée pour étudier l'association de la séropositivité T. gondii avec ces comportements, l'âge des personnes, le nombre d'années de présence dans l'élevage ainsi que les facteurs de risque suivants : infection des chats de l'élevage par T. gondii, détection d'ookystes dans l'élevage, conservation des aliments dans des containers ouverts et accès des porcs à l'extérieur. Le taux de séroprévalence de l'infection humaine par T. gondii était de 31 p. cent (54/174). Les facteurs associés à un risque accru d'infection humaine par T. gondii étaient le nombre de chats séropositifs hébergés dans la ferme (p = 0,008), le sexe masculin (OR ajusté : 3,97, p = 0,01), l'élevage des porcs à l'extérieur (OR ajusté : 3,88, p = 0,03) et le jardinage (OR ajusté : 2,18, p = 0,05). La diminution de l'exposition de l'Homme à T. gondii dans les élevages porcins devrait viser essentiellement la réduction du nombre de chats infectés dans l'élevage.

INTRODUCTION

Human infection with the protozoan parasite *Toxoplasma gondii* is common worldwide. There can be serious health consequences for humans infected with *T. gondii* (Dubey & Beattie, 1988; Frenkel, 1990; Dubey, 1994). Initial maternal exposure to the parasite during pregnancy can cause fetal or neonatal complications, including mortality and mental and physical disabilities. Immunocompromised persons, such as cancer and AIDS patients and transplant recipients receiving immunosuppressive drugs, may also suffer serious health consequences due to *T. gondii* infection, including encephalitis and retinitis. Toxoplasmosis is a major cause of death in AIDS patients.

There are several potential sources of *T. gondii* infection for humans. Cats are the definitive hosts for the parasite. In the acute phase of infection, cats excrete oocysts in their feces. Transmission of *T. gondii* to humans can occur via handling of contaminated cat feces, or soil, water, or animal feed contaminated with *T. gondii* oocysts. The other primary suspected mode of transmission is through handling or consumption of raw or undercooked meat (particularly pork) infected with *T. gondii* tissue cysts (Dubey & Beattie, 1988; Frenkel, 1990; Dubey, 1994). Thus, human activities that are suspected to increase the risk of exposure *to T. gondii* include handling of cats and cat litter, gardening, handling raw meat or contaminated animal feed, whereas washing hands after conducting these activities is believed to decrease the risk of transmission. Although numerous studies have been conducted to determine the *T. gondii* seroprevalence in human populations, studies identifying specific risk factors for transmission to humans have been rare.

Transmission of *T. gondii* to humans is more likely in environments where the risk of exposure is high. Epidemiologic investigations have identified high rates of *T. gondii* infection in cats inhabiting swine farms (Smith et al., 1992: 42%; Dubey et al., 1995: 67%), and infection in cats has been implicated as a risk factor for *T. gondii* infection in pigs (Weigel et al., 1995). Thus, human residents and workers on swine farms have a high risk of environmental exposure to *T. gondii*. In a serological survey of abattoir workers and farmers in Finland, Seuri and Koskela (1992) found that farmers exposed to pigs had the highest *T. gondii* seroprevalence rate (37%; n= 142). Risk of *T. gondii* seropositivity was associated with having cats in the household.

The purpose of the study reported here was to conduct a survey of the *T. gondii* seroprevalence in residents and workers on swine farms, and to identify behavioral, demographic, and farm characteristics that are risk factors associated with *T. gondii* seropositivity.

METHODS

An epidemiologic investigation of risk factors for transmission of *T. gondii* infection to swine had been conducted on 47 swine farms in Illinois in 1992 and 1993 (Dubey et al., 1995; Weigel et al., 1995). Farm owners or managers were contacted by telephone to request further participation in a study of human exposure to *T. gondii* on swine farms. Consent was obtained for 43 (91%) of the farms. There were 174 adult farm workers and residents who participated in this study, conducted in the summer of 1993. Each participant was interviewed to obtain information on demographic characteristics and behaviors associated with possible acquisition of *T. gondii*

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infection. A licensed phlebotomist drew approximately 3 ml of blood from each subject. Serum samples were tested for antibodies to *T. gondii* at the Parasite Biology and Epidemiology Laboratory of the USDA Agricultural Research Service in Beltsville, Maryland. The modified agglutination test (Desmonts & Remington, 1980) was used, with a positive test result at the 1:25 dilution as the threshold for seropositivity.

The individual risk factors analyzed for their association with human *T. gondii* seropositivity were: resident versus non-resident status, sex and age of the worker/resident, years working/residing on the farm, whether or not the subject engaged in gardening, handled raw meat, handled cats, cleaned cat litter boxes, handled pig feed, ate food inside the pig facilities, and washed hands after handling raw meat, after leaving the pig facilities, and before eating. In addition, data on several farm level risk factors, obtained from the previous epidemiologic investigation (Dubey et al., 1995; Weigel et al., 1995), were included in the analysis: *T. gondii* seroprevalence in all cats on the farm, number of seropositive cats on the farm, *T. gondii* seroprevalence in juvenile cats on the farm, number of seropositive juvenile cats on the farm, detection of oocysts in cat feces, pig feed, or water samples on the farm, whether cats were present inside the pig facilities, whether pig feed was stored in closed containers, and whether pigs were housed entirely on pasture. Multiple logistic regression analysis (Hosmer & Lemeshow, 1989) was used to identify risk factors having an independent association with human *T. gondii* seropositivity. Variable selection was by initial forced entry of all risk factors, with backward elimination of all variables where $p > 0.1$. An alpha level of 0.05 (for 2-tailed p values) was selected for statistical significance.

RESULTS

The mean age of subjects was 39 years (median = 36; range: 18-83). Most (77%) were male. Approximately half (53%) were residents on the sampled farm. The mean number of years working or residing on the farm was 17 (median = 10 years; range: 2 months - 83 years). Most subjects handled raw meat (92%) and cats (74%); few subjects (14%) cleaned cat litter boxes. Less than one third (31%) handled pig feed. Almost two thirds (64%) engaged in gardening. Most subjects (60%) never ate food inside pig facilities; however, 10% did so daily. The majority of subjects always washed their hands after leaving the pig facilities (58%; 20% never did), after handling raw meat (67%; 18% never did), and before eating (52%; 0% never did). Among the farms in the sample, the mean *T. gondii* seroprevalence for all cats was 53% (median = 63%, range: 0%-100%), and for juvenile cats only was 21% (median = 0%, range: 0%-100%). The mean number of seropositive cats of any age on the sampled farms was 6 (median = 5; range: 0-26); and the mean number of seropositive juvenile cats was 1 (median = 0; range: 0-10).

The *T. gondii* seroprevalence rate for the farm workers and residents in this sample was 31% (54/174) [95% C.I.: 24-38%]. The multiple logistic regression analysis identified the followed factors associated with *T. gondii* seropositivity in humans working/residing on swine farms. Factors associated with an increased risk were an increase in the number of seropositive cats on the farm ($p = 0.008$), male sex (adjusted odd ratio [aOR] = 3.97; $p = 0.01$), raising pigs entirely on pasture (aOR = 3.88; $p = 0.03$), and gardening (aOR = 2.18; $p = 0.05$). Factors associated with a decreased risk were handling pig feed (aOR = 0.36; $p = 0.005$) and presence of cats in the pig facilities (aOR = 0.32; $p = 0.005$).

DISCUSSION

The *T. gondii* seropositivity rate of 31% for the Illinois farm workers and residents in this 1993 study was similar to the 37% seropositivity rate for the pig farmers in the Finnish survey (Seuri and Koskela, 1992). This is higher than the 9.1% *T. gondii* seroprevalence rate in the U.S. east-north central region (containing Illinois) in a recent (1989) survey of U.S. military recruits (Smith et al., 1996). A 1962 survey of U.S. military recruits found an 18% seroprevalence rate for the same region (Feldman, 1965). Although the age range in the current study is higher than for the studies of military recruits, it is unlikely that a threefold increased risk of *T. gondii* infection in swine farm workers, as determined by recent studies, can be accounted for entirely by age differences. Smith et al. (1996) reported that rural childhood rearing increased the risk of *T. gondii* infection fourfold.

The risk factor with the strongest association with human *T. gondii* seropositivity was the number of seropositive cats on farm. This is not surprising, considering that cats are the definitive host for the parasite and are the only species known to actively shed the resistant form of *T. gondii* into the environment. In previous epidemiologic investigations on these same farms, the risk factor with the highest association with *T. gondii* infection in pigs was the number of seropositive juvenile cats on the farm (Weigel et al., 1995). The specific association of swine infection with infection in the more actively shedding juvenile cats is probably due to shorter duration of residence of pigs on these farms compared to humans; i.e., the seroprevalence of all cats probably reflects more accurately the risk of *T. gondii* exposure for humans having resided on swine farms for several years.

Raising pigs on pasture and participation in gardening also increased the risk of human *T. gondii* infection. Both of these practices increase exposure to soil, which may be a reservoir for *T. gondii* oocysts. Men had a higher infection rate than women. The results of this study do not attribute these differences to sex differences in handling of raw meat or pig feed, or washing of hands. It is possible that these questions were not answered accurately in some cases, with socially acceptable responses given instead.

The decreased risk of human *T. gondii* infection associated with handling pig feed and for residing on farms where cats are permitted inside pig facilities are contrary to expectation. Replication of these findings are necessary before inferences can be made regarding the role of these factors in reducing *T. gondii* transmission to humans on swine farms.

Control of human risk of exposure to T. gondii on swine farms appears to be dependent upon elimination of the primary source of infection - infected cats. In addition, residents of swine farmers engaging in gardening should wear gloves and wash hands before eating to reduce the risk of exposure to *T. gondii* in soil.

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