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Original article

Enterobiasis infections among Thai school children: spatial analysis using a geographic information system

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Background: *Enterobius vermicularis* (Nematoda: Oxyuroidae) is a nematode worm, parasitic in the intestine of humans, and especially infects school children in most parts of the world. Infection occurs after ingesting drinks or food contaminated by the pinworm eggs. Samut Prakan province is located south-east of the Bangkok metropolitan area.

Objective: To analyze enterobiasis infections among Thai school children in Samut Prakan province of Thailand, using a geographic information system.

Methods: A total of 1,255 school children from eleven primary schools in the Samut Prakan province were drawn by stratified random sampling and tested for the presence of *E. vermicularis* eggs from December 2000 to March 2001.

Results: Diagnostic results and socioeconomic information about students and their families were integrated into a Geographic Information System (GIS) and spatially interpreted, using SavGIS programmes. Other needed environmental data, extracted from satellite images using remote sensing, was used for further analysis. Laboratory analysis revealed a 17.5% overall prevalence with 10.5% of the children having a low infection rate, 2.6% a moderate, and 4.4% a heavy infection rate. The prevalence of *E. vermicularis* showed geographical heterogeneity with the lowest prevalence in the provincial administrative center. Parents' occupation was significantly correlated with the presence of infection.

Conclusion: Spatial analysis can help to identify patterns of high risk for enterobiasis otherwise called oxyuriasis.

Keywords: *Enterobius vermicularis*, pinworm, Geographic Information System, spatial analysis

Enterobius vermicularis (pinworm) is the most common nematode parasite in humans and has worldwide distribution. Adult pinworms live in the host's large intestine. Symptoms are generally mild and consist of perianal itching [1]. Infection can also lead to the invasion of the appendix [2]. Eggs become infectious a few hours after being deposited and can survive a few days on clothing or bed linens which allows person-to-person transmission. Airborne transmission is possible but rare [3]. High prevalence is usually linked with high population densities and especially overcrowded areas like slums [4-6]. Within these populations, schoolchildren in particular were reported to be at risk for the highest infection rates [7, 8].

In Thailand, where rapid economic development has led to major social changes since the eighties, the public health system has been developed with nation-wide coverage and access for all. In parallel, prevention and control programs dealing with parasitic diseases were implemented. Parasitic diseases,

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however still remain a serious health concern. Previous studies on *E. vermicularis* conducted in various provinces in Thailand showed it is particularly widespread among elementary school-aged children (**Table 1**).

A geographic information system (GIS) was set up in Samut Prakan province to support parasitic disease programs by spatially targeting actions. It integrates remotely sensed environmental data, demographic and health data to allow a spatial analysis and search for any spatial patterns which could explain pinworm infections.

Materials and methods

Study area

Samut Prakan province is located south of Bangkok on the Gulf of Thailand, and at the mouth of the Chao Phraya River (**Fig.1**). The western side of the river consists mainly of aquaculture, rice fields and mangrove forests. The eastern part is primarily urbanized. Some districts are considered part of the Bangkok metropolitan area, with belt industrial estates and residential areas. The province has a coastline of approximately 47.2 kilometers, but is not oriented toward tourism.

Table 1. Previous studies of *E. vermicularis* among elementary school-aged children in Thailand.

Location	Infection rate	Authors
Bangkok (Klong Toei, slum areas)	53 %	Tepmongkol, *et al*. [5]
Khon Khaen	50.9 %	Kaewkes, *et al*. [9]
Bangkok-Nonthaburi	65 %	Mameechai, *et al*. [6]
Nakhon Pathom (urban area)	38.2 %	Wahah & Ratanaponglakh [7]
Samut Prakan (Bang Phli district)	38.8 %	Nithikathkul, *et al*. [10]
Samut Prakan	21.9 %	Nithikathkul, *et al*. [11]

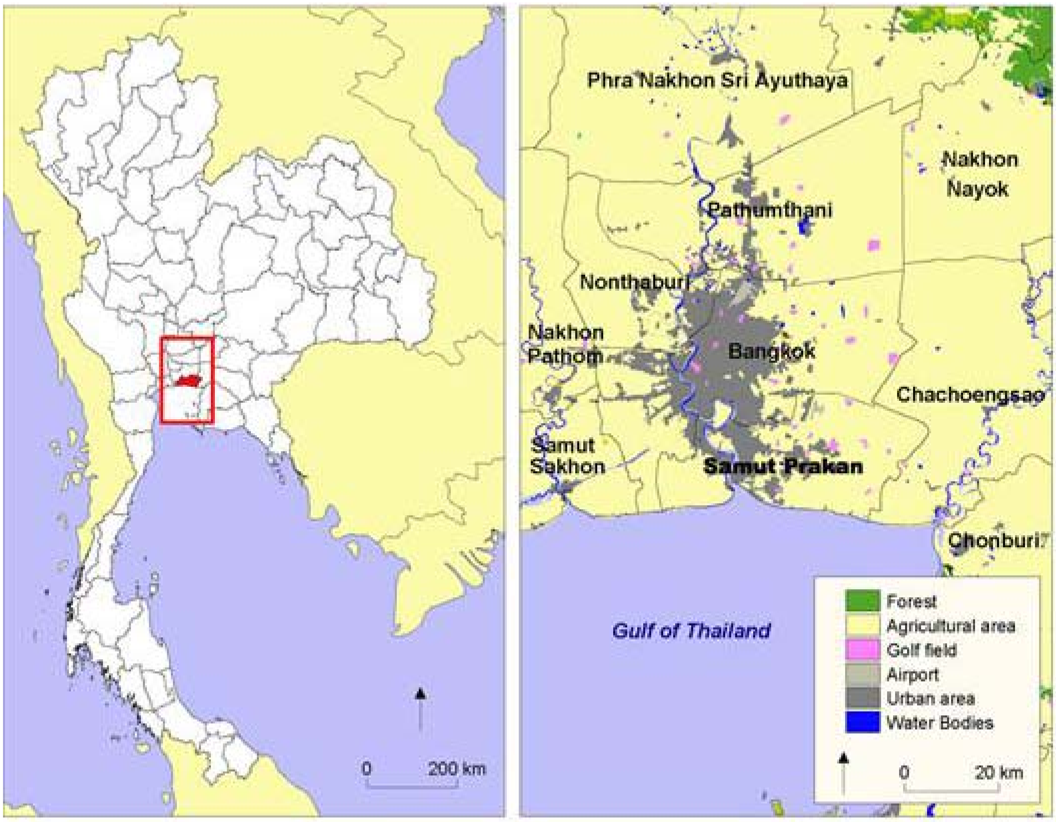

Fig. 1 Location of Samut Prakan province in Thailand.

Investigations were undertaken in eleven primary schools drawn from five districts of Samut Prakan province: Wat Phraekasa and Phichaisongkram schools in Muang district, Wat Saunsom, Wat Laeam and Suksawad schools in Phra Pradaeng district, Phra Samut Chedi and Wat Yai schools in Phra Samut Chedi district, Wat Bang Phli Yai Nai and Klong Paladpliang schools in Bang Phli district, and Wat Banrakard and Klong Kanya schools in Bang Bo district (**Fig. 2**).

Population

Samut Prakan province is densely populated (1,024 inhabitants/sq. km.) with Muang Samut Prakan district, the capital district, having the highest population of all districts in Thailand. The population structure of Samut Prakan is very unusual with multiple inhabitant identities. Age pyramids show a general diamond-shape drawn by the high percentage of active people in the population (**Fig. 2**). There are few elders indicating that the settlements are recent, the result of immigration from rural provinces. It is highlighted in Bang Phli district where industrial areas have attracted worker classes living in dormitories near the factories. Bang Bo district, to the east of the province, is more agricultural with older settlement and a more equilibrated age pyramid. Muang, Phra Pradaeng and Phra Samut Chedi appear as a continuity of Bangkok, with an urban structure.

Data collection

In each of the eleven primary schools sampled a target of at least 100 schoolchildren was randomly selected (approximately 10% of the total students in each school). A total of 1,255 students, 661 males and 594 females, aged between six and ten years, were included in the study. Examination took place in each school, as soon as the children reached school. The transparent tape technique (a two by six centimeter rectangle) was used to collect *E. vermicularis* eggs on the perianal skin. Slides were examined under the light microscope in laboratory. Different levels of infection were defined by the number of eggs: a low infection level with less than 50 eggs, a medium infection level with egg counts between 51 and 100, and a high infection level with more than 100 eggs.

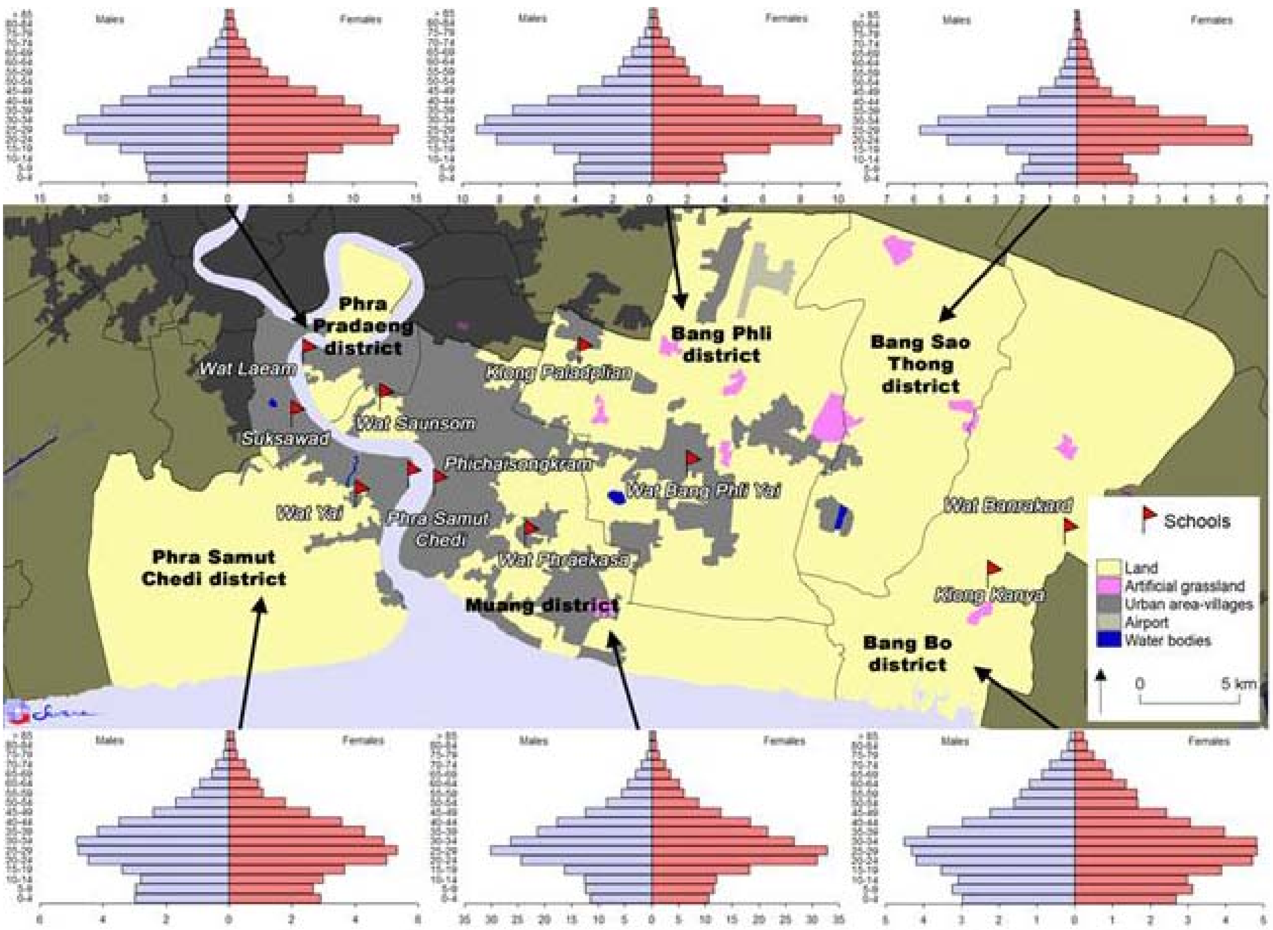

Fig. 2 Age pyramids in each district of Samut Prakan province (in thousands), and locations of the schools investigated.

In addition, a questionnaire was filled out by each family providing personal data about the children and the parents' socioeconomic status (i.e. parents' occupations, education and income).

GIS project

A GIS database for the study of pinworms was implemented using *SavGIS*©, a GIS freeware developed by the IRD (French Development Research Institute).

A land use map of Samut Prakan province, issued by the Royal Forestry Department, was derived from a mosaic of Landsat V TM images from the years 2000. It mainly separates agricultural areas from urban areas, and other man-made land uses as shown in **Fig. 2**. Geographic coordinates of each school were determined with a Global Positioning System. The generated geo-referenced database was overlaid on the digitized state.

Statistical analysis

Statistic data were analyzed using the Chi-square test and Student t-test.

Results

Infection rates

Of the 1,255 school children, investigated 17.5% were infected with *E. vermicularis*. Boys exhibited a slightly higher rate of infection (18.2% for males and 16.8% for females) but there was no significant statistical difference (P<0.9). Laboratory analysis revealed 10.5% of the children with a low, infection rate, 2.6% with a moderate, and 4.4% with a heavy infection rate. The highest prevalence of infection was found in the children of agricultural workers (24%), followed in decreasing order by industrial workers (19.9%), self-employed workers (16.6%), unemployed people (11.3%) and the children of government workers (5.7%). A positive significant correlation was found between the total infection rate and the percentage of children from working class families and negative significant correlations with children from self-employed private and government sector families (**Table 2**).

Multiple regression analysis showed the percentage of industrial workers and agricultural workers was the most predictive of pinworm infections but of no statistical significance. No significant correlation was found between the total infection rate and income of families, but, nevertheless, a trend could be observed in the coefficient correlation values (**Table 3**).

Correlation was positive under a 5,000 baht monthly income, nil for average incomes and negative for high incomes. The correlation coefficient was decreasing from low incomes to high incomes, showing a positive effect of higher incomes in lowering infections.

Spatial distribution

Families from agriculture were mostly in Bang Bo district where Wat Banrakard and Klong Kanya schools recorded high rates of pinworm infection (**Fig. 3**).

In Phra Pradaeng and Phra Samut Chedi districts, in the western part of the province, where high prevalences were recorded, over 80% of the school children's parents employed in industry. The lowest prevalences were found in Phichaisongkram School in the heart of the city Muang Samut Prakan. Only 44% of school children's families were industrial workers, while 30% were government workers and 20% self-employed workers.

Table 2. Correlation coefficient between total infection rate and occupation of families (in % of total).

Occupation	Unemployed	Farmers	Labor	Private	Government
Correlation coefficient	-0.41	0.35	0.66*	-0.62*	-0.63*

* Marked correlations are significant (□<0.05).

Table 3. Correlation coefficient between total infection rate and income of families (in % of total).

Income (Thai baht)	0-5,000	5,000-10,000	10,000-20,000	>20,000
Correlation coefficient	0.39	0.03	-0.25	-0.47

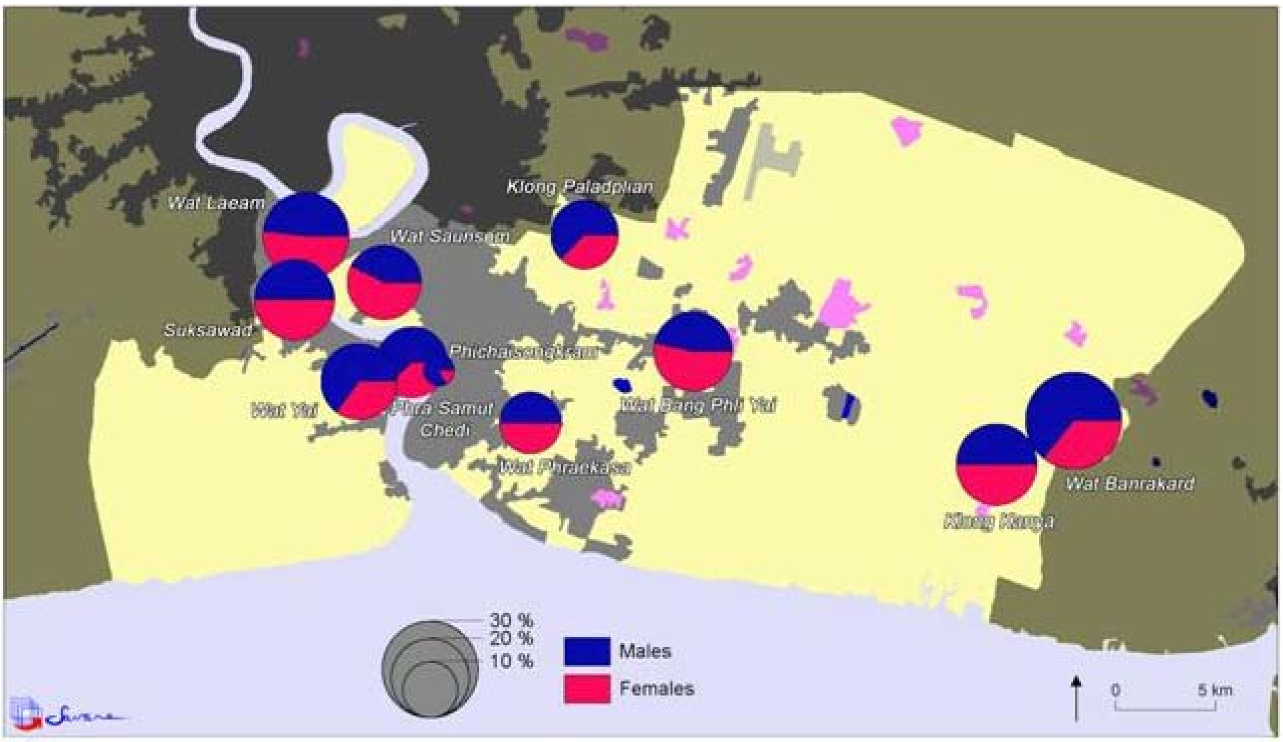

Fig. 3 Total oxyuriasis infection rate (%) and sex distribution by school.

Discussion

This study reveals an *E.* infection rate of 17.5% among students from eleven primary schools in Samut Prakan Province, Thailand. Students from low income families and younger students exhibited a slightly higher rate of infection. The study focused on six to tenyearold children with the highest infection rates found in six to seven year old children, Earlier studies [5, 10] found the highest prevalences to be in eight to nine year old children. Neither social nor environmental factors could account for the discrepancy between the studies. Future studies may investigate children younger than six years old and also take into account a relationship between individual infection rate and clinical manifestations.

An examination of the data concerning parental occupation provided some interesting results. The highest rate of infection was found in children of agricultural workers (24%), and the lowest in children of government workers (5.7%). A possible explanation for these results is that governmental employees have higher education, have financial means and more often work regular office hours, thus providing more time for the care of their children. Conversely, agricultural workers do not usually have adequate financial resources or much free time to attend to their children's care. It might be suggested that schoolchildren coming from small villages with an agricultural environment (with parents working in this field) are more likely to play in gardens or fields. Exposure is then related to this agricultural environment. This is strictly speculation, as there is no hard data supporting such observations. Additional factors influencing the infection rate may include personal hygiene, levels of parental care, social interactions at school, and teacher knowledge of and attention to hygiene e.g. hand washing and bathing.

Considering that infection rates are linked to the families' occupation, the spatial distinction between rural areas, urban areas and industrial estates, marked by remotely sensed images, allows focusing on different kind of exposure for children. The use of high resolution images would help to delineate industrial estates, residential areas and distance between houses and places of work. The season of the year may also affect infection rates due to climate and weather factors such as humidity and temperature. These factors could potentially affect the infection rate of *E. vermicularis*. These concerns might be studied using a dynamic spatial analysis.

Conclusion

This work was a first step in the use of space technologies to understand the spatial patterns of pinworm infections. To obtain more definite conclusions, more data will be needed on hygienic conditions and the demographic environment around single schools. An early spatial approach is needed to plan the field work and a comprehensive implementation of programs for the prevention and control of pinworm infections.

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References

1. Cerva L, Schrottenbaum M, Kliment V. Intestinal parasites: a study of human appendices. Folia Parasitologica. 1991; 38:5-9.
2. Jones JE. Pinworms. American Family Physician. 1988,38:159-64.
3. Hugot JP, Reinhard KJ, Gardner SL, Morand S. Human enterobiasis in evolution: origin, specificity and transmission. Parasite. 1999;6:201-8.
4. Vajarasthira A, Harinasuta C. The incidence of enterobiasis among children of five schools and two hospitals in Bangkok. Annals Trop Med Parasitol. 1960; 54:129-31.
5. Tepmongkol M, Suntadwoot C, Lamonand C, Chullabuspa C, Nakapanchai D, Suvajerun T, Sripochange S. Enterobiasis infection in young school children at slum Klongtey. Siriraj Hospital Gazette 1980;32:597-600.
6. Mameechai P, Tasanaswang C, Panyaruggij P. Survey of enterobiasis in school children in Bangkok and Nonthaburi Provinces. J Trop Med Parasitol. 1992; 15:39-49.
7. Wahah T, Ratanaponglakh D. Prevalence of enterobiasis in pre-school children in municipality area of Nakornpathom Province. J Trop Med Parasitol. 1992; 15:96-101.
8. Nithikathkul C. Pinworm and enterobiasis. Communicable Disease J. 2000; 26:192-4.
9. Kaewkes S, Tesana S, Sithithaworn P, Srisawangwonk T, Raengsangounwong P. Enterobiasis in young school children in Bangkok. J Trop Med Parasitol. 1983;6: 19-24.
10. Nithikathkul C, Changchup B, Wannapinyoship S, Poister C, Boontan P. The prevalence of Enterobiasis vermicularis among primary school students in Bangplee District, Samutprakarn Province, Thailand. Southeast Asian J Trop Med Public Health. 2001;32 (Suppl 2):133-7.
11. Nithikathkul C, Changchup B, Wannapinyoship S, Poister C, Boontan P. The prevalence of enterobiasis in children attending mobile health clinic of Huachiew Chalermprakeit University. Southeast Asian J Trop Med Public Health. 2001;32(Suppl 2):138-42.