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Enterobius vermicularis infection in schoolchildren: a large-scale survey 6 years after a population-based control

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SUMMARY

Pinworm infection remains prevalent in children in many parts of the world. This study was designed to determine the prevalence of this infection in schoolchildren in Taiwan after the termination of the 15-year population-based control project in 2001. Our results showed that 2·4% of 118 190 children in 385 primary schools were found to have enterobiasis by two-consecutive-day adhesive cellophane perianal swabs. The prevalences were significantly different in the 25 counties/cities surveyed (0·6–6·6%). A significantly higher prevalence was found in boys (2·6%) than in girls (2·2%) and the prevalence decreased by grade from 3·8% in grade 1 to 1·0% in grade 6. In the primary schools, 9·1% had positive rates $\geqslant$10%. In addition, pinworm infection was found to be significantly associated with the socioeconomic status, personal hygiene and sanitary conditions of the children. The results indicate that the overall prevalence of enterobiasis remains at a low level after the control programme was transferred to the local governments.

Key words: *Enterobius vermicularis*, schoolchildren, Taiwan.

INTRODUCTION

Infection of *Enterobius vermicularis* (pinworm) remains prevalent in children in many parts of the world. Recent surveys have revealed high prevalences in Venezuela (63·2%) [1], Argentina (43·4%) [2], Laos (35·7%) [3] and Turkey (23·3%) [4]. Although enterobiasis is mainly transmitted through the fingers route, pinworm eggs may also reach the human intestinal tract through the nose. Moreover, retro-infection by larvae through the anus is not uncommon. Nocturnal pruritus ani is the characteristic manifestation of enterobiasis. This infection is most common in temperate regions. It has been estimated that up to 10% of children in these regions harbour pinworm [5].

Before initiation of a 4-year population-based parasitic control project by the Taiwan Provincial Health Department in 1972, the overall prevalence of intestinal helminth infections in schoolchildren in Taiwan was 73%. After receiving blanket treatments with a mixture of santonin and kainic acid four times a year, the prevalence of *Ascaris* infection significantly decreased from 55% in 1972 to 13·7% in 1976. The Parasite Control Association was established in 1975 to continue the control of intestinal helminth infections in schoolchildren. After conducting repeated

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stool examinations and administering treatments with pyrantel pamoate in two 5-year control projects, the overall prevalence decreased to 0·19% (*Ascaris* 0·19%, hookworm 0·02%, *Trichuris* 0·33%) by the end of 1986 [6].

After the success in dramatically reducing the prevalence of soil-transmitted helminth infections, control of pinworm infection became a main theme in the next three 5-year control projects. From 1986 to 1991, parents were asked to take two-consecutive-day adhesive cellophane perianal swabs of their children four times a year and infected children were treated with mebendazole. Moreover, health education programmes were also carried out simultaneously. The prevalence decreased from 19·9% in 1986 to 4·5% in 1991 [6]. In addition to these control measures, family members of infected children also received mebendazole treatment in the next two 5-year control projects (1991–1996 and 1996–2001). The prevalence decreased to 2·5% in 2001. Since January 2001, when the population-based pinworm control project was terminated, the control programme has been carried out by the health and education bureaus of the individual county/city governments. In order to determine the current status of pinworm infection in schoolchildren in Taiwan, we conducted a large-scale survey of pinworm infection. Moreover, we also conducted a questionnaire survey on the factors associated with the infection.

METHODS

Study population

This study was conducted from March to December 2007. In the academic year of 2006 (August 2006 to July 2007), 1 798 436 children were enrolled in 2658 primary schools of Taiwan [7]. Since primary education for children in Taiwan is mandatory, this number represented the total school-age population. The administrative divisions in Taiwan include two municipalities (Taipei and Kaohsiung cities), 18 counties and five cities. These major divisions are further divided into 369 districts. From each district, one primary school was selected to participate in the survey. In the more populated districts, one or more additional schools were also randomly selected. All children in these schools were examined for pinworm infection. The study population included 124 238 children in 385 primary schools in different parts of Taiwan.

Cellophane perianal swab and questionnaire surveys

After obtaining informed consent, two-consecutive-day adhesive cellophane perianal swab preparations, including instructions for swab taking, and a questionnaire relating to family conditions were distributed to the parents of each child by the nurses and/or public health teachers in each school. Parents were asked to take perianal swabs and complete the questionnaire. Perianal swabs were taken from each child by the parents at home immediately after getting up in the morning on the next two days. The swab specimens and completed questionnaires were returned to the schools and then transferred to our laboratory. Microscopic examination of the specimens was performed by parasitologists and experienced medical technologists.

The questionnaire was designed to obtain information on the socioeconomic status of the parents, personal hygiene of the children and sanitary conditions in their families. In addition to the demographic data of the children, the educational levels and occupations of the parents were obtained. Moreover, history of pinworm infection was also inquired. To determine the personal hygiene of the children, information on hand washing, finger sucking and fingernail-cutting habits, and the method, timing, and frequency of bathing was collected. Household sanitary conditions were assessed by asking the parents about the frequency of cleaning house and bedding, and living conditions.

Chemotherapy and follow-up

Infected children were administered a single dose of mebendazole (100 mg/tablet). Follow-up examination was conducted 2–4 weeks after chemotherapy.

Statistical analysis

After checking the validity, results of microscopic examination, basic data of each child and information from the questionnaires were entered into Microsoft Excel spreadsheets (Microsoft Corp., USA) by research assistants. SPSS 12.0 statistical software (SPSS Inc., USA) was used for data management and analyses. Rates were compared by χ^2 test. Factors associated with pinworm infection were further analysed by stepwise logistic regression. Explanatory variables examined in the models included sex and grade of children; education and occupation of

Table 1. *Prevalence of* Enterobius vermicularis *infection in schoolchildren in 25 counties/cities of Taiwan*

County/city (no. of schools surveyed)	Total no. enrolled	No. (%) examined	No. (%) positive
North Taiwan			
Keelung City (7)	30 077	1884 (6·3)	46 (2·4)
Taipei County (29)	294 305	15 865 (5·4)	92 (0·6)
Taipei City (12)	178 494	9064 (5·1)	85 (0·9)
Taoyuan County (15)	176 400	9004 (5·1)	260 (2·9)
Hsinchu County (14)	42 897	2248 (5·2)	115 (5·1)
Hsinchu City (3)	35 283	1224 (3·5)	60 (4·9)
Miaoli County (17)	43 327	1960 (4·5)	73 (3·7)
Subtotal (97)	800 783	41 249 (5·2)	731 (1·8)
Central Taiwan			
Taichung County (21)	132 443	6196 (4·7)	154 (2·5)
Taichung City (8)	97 483	5576 (5·7)	150 (2·7)
Changhua County (26)	104 767	5050 (4·8)	169 (3·3)
Nantou County (13)	41 221	1986 (4·8)	57 (2·9)
Yunlin County (20)	53 320	2820 (5·3)	49 (1·7)
Subtotal (88)	429 234	21 628 (5·0)	579 (2·7)
South Taiwan			
Chiayi County (18)	37 755	2490 (6·6)	45 (1·8)
Chiayi City (2)	24 896	1609 (6·5)	50 (3·1)
Tainan County (31)	79 842	4835 (6·1)	192 (4·0)
Tainan City (6)	59 288	3188 (5·4)	116 (3·6)
Kaohsiung County (27)	92 529	5177 (5·6)	200 (3·9)
Kaohsiung City (28)	114 595	28 711 (25·1)	511 (1·8)
Pingtung County (33)	68 076	4497 (6·6)	199 (4·4)
Subtotal(145)	476 981	50 507 (10·6)	1313 (2·6)
East Taiwan			
Yilan County (12)	36 448	1670 (4·6)	50 (3·0)
Taitung County (16)	17 685	1098 (6·2)	73 (6·6)
Hualien County (14)	26 621	1277 (4·8)	54 (4·2)
Subtotal(42)	80 754	4045 (5·0)	177 (4·4)
Offshore County			
Penghu County (6)	6079	415 (6·8)	13 (3·1)
Kinmen County (5)	4044	282 (7·0)	11 (3·9)
Lienchiang County (2)	561	64 (11·4)	1 (1·6)
Subtotal (13)	10 684	761 (7·1)	25 (3·3)
Total (385)	1 798 436	118 190 (6·6)	2825 (2·4)

parents; pinworm infection history; hand washing before eating and after using toilet facilities; finger-sucking habit; keeping fingernails short; method, timing and frequency of bathing; frequency of cleaning house; style of residence; type of floor and bedding; and sharing a bedroom. $P<0·05$ was considered to be statistically significant.

RESULTS

Of the 124 238 children selected, perianal swab specimens were obtained from 118 190 (95·1%) children. Of the children examined, 2825 (2·4%) were found to be infected with *E. vermicularis*. Table 1 shows the prevalences in the 25 counties/cities of Taiwan. The prevalence was significantly different in the counties/cities ($P<0·001$). Taitung County had the highest rate of 6·6% and Taipei County the lowest of 0·6%. Significant differences were also found in geographical regions ($P<0·001$). The rate was highest in East Taiwan (4·4%) and lowest in North Taiwan (1·8%) ($P<0·001$). The positive rate of boys (2·6%) was significantly higher than that of girls (2·2%) ($P<0·001$). The rate also significantly decreased with grade from

Table 2. *Grade- and sex-specific prevalence of* Enterobius vermicularis *infection in schoolchildren in Taiwan by age and sex*

	Boys		Girls		Total	
Grade	No. examined	No. (%) positive	No. examined	No. (%) positive	No exa ıed	No. (%) positive
1	9918	426 (4·3)	9267	300 (3·2)	19 185	726 (3·8)
2	10 921	404 (3·7)	10 310	322 (3·1)	21 231	726 (3·4)
3	10 708	299 (2·8)	10 413	262 (2·5)	21 121	561 (2·7)
4	10 412	208 (2·0)	10 161	178 (1·8)	20 573	386 (1·9)
5	12 019	166 (1·4)	11 433	133 (1·2)	23 452	299 (1·3)
6	6466	73 (1·1)	6162	54 (0·9)	12 628	127 (1·0)
Total	60 444	1576 (2·6)	57 746	1249 (2·2)	118 190	2825 (2·4)

Table 3. *School size and* Enterobius vermicularis *infection in 385 primary schools in Taiwan*

School size (no. of children enrolled)	Positive rate (%)				
	0	0·1–4·9	5·0–9·9	⩾10·0	Total
<100	50 (33·6)*	42 (28·2)	29 (19·5)	28 (18·8)	149
100–299	16 (13·7)	78 (66·7)	17 (14·5)	6 (5·1)	117
⩾300	2 (1·7)	106 (89·1)	10 (8·4)	1 (0·8)	119
Total	68 (17·7)	226 (58·7)	56 (14·5)	35 (9·1)	385

* Values given are number (%) of schools.

3·8% in grade 1 to 1·0% in grade 6 ($P<0·001$) (Table 2).

Of the 385 primary schools that participated in this survey, 35 (9·1%) were found to have positive rates ⩾10%, 56 (14·5%) had positive rates of 5·0–9·9%, and 226 (58·7%) positive rates of 0·1–4·9%. Moreover, negative findings were obtained in the remaining 68 (17·7%) schools. The number of children enrolled in these schools ranged from 8 to 2817. Although negative results were obtained in 50 (33·6%) smaller-sized schools (<100 children), 28 (18·8%) were found to have positive rates ⩾10%. This percentage was significantly higher than those in the remaining two groups [100–299 children (5·1%) and ⩾300 children (0·8%)] ($P<0·001$). In the schools with ⩾100 children enrolled, 184 (80·0%) had positive rates <5% (Table 3). Pinworm infection was found in 1708 of a total of 4907 classes in the 385 primary schools surveyed. Most (60·5%) of the infected classes had only one infected child (Table 4).

A total of 96 419 questionnaires were returned with completed and relevant data. The response rate in the questionnaire survey was 77·6% (96 419/124 238).

Table 4. *Frequency of the number of infected children in 1708 infected classes with* Enterobius vermicularis *infection from 4907 classes in 385 primary schools of Taiwan*

No. of infected children	No. of infected class	% of infected class
1	1034	60·5
2	408	23·9
3	164	9·6
4	56	3·3
5	29	1·7
6	10	0·6
7	3	0·2
8	3	0·2
9	1	0·1

Statistical analyses were conducted based on this information and the results of parasitological examination. The positive rate was found to be significantly higher in boys (boys 2·8% *vs.* girls 2·3%), children in grades 1–3 [grades 1–3 (3·4%) *vs.* grades 4–6 (1·6%)], children having parents with lower educational level (secondary or below 2·7% *vs.* university

or above 2·0%), and children of labourers or farmers (labourers or farmers 3·2% *vs.* others 2·2%) ($P<0·001$). Children with a history of pinworm infection (5·8%) were found to have a significantly higher positive rate than those without previous pinworm infection (2·2%) ($P<0·001$) (Table 5).

The positive rate of pinworm infection was found to be significantly higher in children infrequently washing their hands before eating (infrequent 3·1% *vs.* frequent 2·1%) or after using toilet facilities (infrequent 3·8% *vs.* frequent 2·3%) ($P<0·001$). Although children with the habit of finger sucking had a significantly higher positive rate (3·6% *vs.* 2·3%) ($P<0·001$), no significant difference was found in the children with long (2·6%) or short (2·4%) fingernails ($P>0·05$). Children bathing in a tub (3·2%) were found to have a significantly higher rate than those taking a shower (2·2%). Moreover, those not bathing every day also had a significantly higher positive rate (3·8% *vs.* 2·4%) ($P<0·01$). However, there was no significance in the positive rate between the children taking bath after getting up and those that did not (2·4%) ($P>0·05$) (Table 5).

Although cleaning house every day did not significantly affect the positive rate of pinworm infection (2·5% *vs.* 2·4%) ($P>0·05$), children living in townhouses or on the ground floor (3·5%) had a significantly higher rate than those in apartments or single-family detached residences (2·3%) ($P<0·001$). Moreover, significantly higher positive rates were found in children living in a house with a concrete floor or carpet (concrete or carpet 3·3% *vs.* wood, plastic, or stone 2·4%) ($P<0·01$), sleeping in beds with matting (matting 3·0% *vs.* wood or spring mattress 2·4%) ($P<0·001$), and sharing a bedroom with family members (2·6% *vs.* 1·7%) ($P<0·001$) (Table 5).

Multivariate analysis revealed 11 independent predictors. These factors included history of pinworm infection (OR 2·598), younger children (grades 1–3) (OR 2·113), finger sucking (OR 1·466), sharing a bedroom with family members (OR 1·347), infrequent hand washing before eating (OR 1·332), living on the ground floor or in townhouses (OR 1·308), children of labourers or farmers (OR 1·300), sleeping on matting (OR 1·281), bathing in a tub (OR 1·259), parents with secondary or below education (OR 1·204) and boys (OR 1·170). Although sex was found to be a significant predictor of this infection, this factor was found to be more significant in younger children (grades 1–3) (OR 1·192) but not in older children (grades 4–6). Moreover, keeping fingernails short (OR 1·274) was also a significant predictor in younger children, while for older children infrequent hand washing after using toilet facilities (OR 1·449) and taking a bath after getting up (OR 2·218) were significant factors (Table 6).

Of the 2825 infected children, 2453 were treated with a single dose of menbendazole (100 mg) and 2183 were re-examined after chemotherapy. Of the children re-examined, 2093 (95·9%) became negative whereas 90 (4·1%) remained positive.

DISCUSSION

Pinworm is one of the common intestinal parasites in schoolchildren. Their eggs are not usually found in faeces. Although the cellulose tape perianal swab has been recommended as the most reliable method for detecting enterobiasis [8], prevalences determined by taking a single swab from each subject may be underestimated [9]. Moreover, it is difficult to obtain perianal swab specimens from older children. Therefore, since the beginning of the population-based pinworm control project, parents in Taiwan were asked to take swabs from their children using two-consecutive-day adhesive cellophane perianal swab preparations. This design not only overcomes the difficulty in taking swabs from older children but also increases the number of swabs taken. In this study, we obtained a high response rate of 95·1% in obtaining the swab specimens by the parents.

In 2003, 371 (3·1%) of 11 960 children from grades 1 and 4 of 59 primary schools in Taiwan were reported to be infected with pinworm [10]. This rate was higher than that obtained in the present study (2·4%). However, we have determined that the prevalence of enterobiasis decreases with grade. The higher prevalence obtained in the previous study may be due to differences in the study populations. Moreover, the prevalence of 2·4% determined in our large-scale survey is lower than that obtained under the population-based pinworm control project in 2001 (2·5%). This finding indicates that a feasible strategy for the control of pinworm infection is the initiation of a population-based control project in order to reduce prevalence to a significantly low level and then transferring the control programme to the local governments.

Although a relatively low overall prevalence of 2·4% was found in the schoolchildren, the prevalence varied significantly from 0·6% to 6·6% in different

Table 5. *Univariate analysis of factors associated with* Enterobius vermicularis *infection in 96 419 children from 385 primary schools of Taiwan*

Factor	No. examined	No. (%) positive	*P*
Demographic and socioeconomic factors			
Sex			<0·001
Boys	49 166	1382 (2·8)	
Girls	47 253	1091 (2·3)	
Grade			<0·001
1–3	51 788	1736 (3·4)	
4–6	44 591	728 (1·6)	
Education of parents			<0·001
Secondary or below	58 636	1562 (2·7)	
University or above	35 732	726 (2·0)	
Occupation of parents			<0·001
Labourers or farmers	16 866	544 (3·2)	
Others	77 474	1738 (2·2)	
History of pinworm infection			<0·001
Yes	5401	314 (5·8)	
No	84 909	1872 (2·2)	
Personal hygiene			
Washing hands before eating			<0·001
Infrequent	26 980	845 (3·1)	
Frequent	68 466	1472 (2·1)	
Washing hands after using toilet facilities			<0·001
Infrequent	7121	268 (3·8)	
Frequent	88 190	2046 (2·3)	
Finger sucking			<0·001
Yes	8047	289 (3·6)	
No	86 750	2006 (2·3)	
Keeping fingernails short			0·204
No	8427	215 (2·6)	
Yes	85 593	2054 (2·4)	
Method of bathing			<0·001
Bathing in a tub	23 039	738 (3·2)	
Shower	72 279	1574 (2·2)	
Taking a bath after getting up			0·483
Yes	796	20 (2·5)	
No	94 086	2283 (2·4)	
Taking a bath every day			<0·01
No	1474	56 (3·8)	
Yes	93 757	2254 (2·4)	
Family sanitary conditions			
Cleaning house every day			0·376
Yes	30 716	754 (2·5)	
No	61 984	1499 (2·4)	
Style of residence			<0·001
Ground floor or townhouse	13 311	461 (3·5)	
Apartment or single-family detached	78 023	1757 (2·3)	
Type of floor			<0·001
Concrete or carpet	6347	212 (3·3)	
Wood, plastic, or stone	85 574	2027 (2·4)	
Type of bed			<0·001
Matting	6578	200 (3·0)	
Wood or spring mattress	85 272	2025 (2·4)	
Sharing bedroom with family members			<0·001
Yes	71 439	1869 (2·6)	
No	18 794	312 (1·7)	

Table 6. *Multivariate analysis of factors associated with* Enterobius vermicularis *infection in 96 419 children from 385 primary schools of Taiwan*

	Overall		Grade			
			1–3		4–6	
Factor	OR	*P*	OR	*P*	OR	*P*
Sex (boys *vs.* girls)	1·170	0·001	1·192	0·003		
Grade (1–3 *vs.* 4–6)	2·113	<0·001				
Education of parents (secondary or below *vs.* university or above	1·204	<0·001	1·192	0·005		
Occupation of parents (labourers or farmers *vs.* others)	1·300	<0·001	1·299	0·001	1·304	<0·001
History of pinworm infection (yes *vs.* no)	2·598	<0·001	2·319	<0·001	3·203	<0·001
Washing hands before eating (infrequent *vs.* frequent)	1·332	<0·001	1·297	<0·001	1·403	0·001
Washing hands after using toilet facilities (infrequent *vs.* frequent)					1·449	0·030
Finger sucking (no *vs.* yes)	1·466	<0·001	1·418	<0·001	1·480	0·005
Keeping fingernails short (no *vs.* yes)			1·274	0·032		
Form of bath (bathing in a tub *vs.* shower)	1·259	<0·001	1·203	0·004	1·417	0·001
Taking a bath after getting up (no *vs.* yes)					2·281	0·012
Style of residence (ground floor or townhouse *vs.* apartment or single-family detached)	1·308	<0·001	1·345	<0·001	1·340	0·010
Type of bed (matting *vs.* wood or spring mattress)	1·281	0·003	1·324	0·007	1·339	0·049
Sharing bedroom with family members (yes *vs.* no)	1·347	<0·001	1·334	0·002	1·378	0·004

OR, Odds ratio.

parts of Taiwan. We also found higher positive rates in smaller-sized schools. These schools are usually located in the mountainous or remote areas of Taiwan. Owing to the limitation of educational resources in these regions, children of different ages use the same classroom. This arrangement may facilitate pinworm transmission. Moreover, 9·1% of the schools had a positive rate $\geqslant$10% and 14·5% of schools had a positive rate between 5·0% and 9·9%. Children in these schools should be repeatedly examined for enterobiasis and the whole family of the infected children should also receive drug treatment. Fortunately, over 60% of the infected classes surveyed had only one infected child. This finding indicates that transmission of enterobiasis may not frequently occur between classmates.

We determined 11 independent predictors of pinworm infection in the schoolchildren of Taiwan. Of these factors, parents' education and occupation were found to be significant. Similar findings have been reported in Taiwan as well as in other parts of the world [1–4, 11–16]. Moreover, children with a history of pinworm infection were associated with >2·5-fold odds of having enterobiasis (OR 2·598), suggesting that the family may be a reservoir for pinworm eggs.

In pre-schoolchildren in South Taiwan, enterobiasis has been reported to have a tendency of family aggregation [17]. Moreover, sharing the same bed or bedroom with family members and a floor covered with carpet or concrete have been found to be important risk factors [11]. A case-control study on schoolchildren in Central Taiwan revealed that significant risk factors included playing on the floor, nail biting, failure to wash hands before meals and living in non-apartment dwellings [12]. The present study demonstrates that children that infrequently wash their hands and have the habit of sucking their fingers are at higher risk for ingesting pinworm eggs from the environment. Moreover, washing hands before eating and taking a shower instead of bathing in a tub are feasible strategies in the prevention of pinworm infection. In addition to personal hygiene, we also found living on the ground floor or in townhouses, sleeping on matting, and sharing a bedroom with

family members to be significant risk factors. The floor in townhouses is usually covered with concrete. This material has been reported to have a very rough surface which allows the adhesion of pinworm eggs. Cleaning the floor with a broom may stir the eggs into the air and contaminate the environment [11]. This suggestion may also explain why there was no significant difference between children living in a household that was cleaned every day and those in a household that was not.

In the present study, we revealed a sex difference in prevalence by univariate and multivariate analysis. This finding is contrary to the general understanding that sex incidence is equal [9, 18]. However, results of recent studies have not shown a consistent pattern in this aspect [1–4, 14–17]. Moreover, we revealed sex as a significant independent predictor in younger children but not in older ones. The sex difference in the younger children may be due to the fact that girls have better personal hygienic measures against pinworms than boys. The level of personal hygiene may become similar as children get older.

It has been reported that a single dose of 10 mg mebandazole is sufficient to cure pinworm infection [9]. However, we administered most of the infected children with a single dose of 100 mg mebandazole and obtained a cure rate of 95·9%. Because there is a time limit in this large-scale survey, children with positive findings at re-examination were referred to the local health/educational agencies for re-treatment and follow-up examinations. Since there is a significant difference in the control schedule in the local health and education bureaus, it is possible to conduct the survey after the mass treatment. This may also lead to an underestimate of the prevalence.

Enterobius has a simple and short life-cycle. These special characteristics easily enable the spread and re-infection of enterobiasis. In Taiwan, the overall prevalence of this infection in schoolchildren was reduced from 19·9% in 1986 to 2·5% in 2001 after a 15-year population-based control. After transferring the control programme to the local governments, the overall prevalence of this infection remains at a low level of 2·4%. Mass examination, treatment, and follow-up should be continued until eradication of the infection.

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DECLARATION OF INTEREST

None.

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