

Is pinworm infection still a public health concern among children in resource-rich region? The prevalence and time-trend analysis of pinworm infection among school-aged children in Hualien County, Taiwan: A retrospective longitudinal study

Yu-Chao Hsiao

Department of Pediatrics, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

Jen-Hung Wang

Department of Medical Research, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan.

Chia-Hsiang Chu

Department of Pediatrics, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

Yu-Hsun Chang

Department of Pediatrics, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

Yung-Chieh Chang

Department of Pediatrics, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

Rong-Hwa Jan

Department of Pediatrics, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

Shao-Yin Chu

Department of Pediatrics, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

Shang-Hsien Yang

Department of Pediatrics, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

Jui-Shia Chen

Department of Pediatrics, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

Ming-Chun Chen (✉ loveroflois1980@gmail.com)

Department of Pediatrics, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

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Abstract

Background: *Enterobius vermicularis* (pinworm) is a common parasitic intestinal infection in children. A gradual decrease in prevalence of pinworm infection has been noted in resource-rich settings, such as Taiwan. However, the influence of socio-demographic factors on the temporal trend in pinworm infection rates in children under the current pinworm infection prevention policy in Taiwan is not well characterized. This study aimed to evaluate the trend of pinworm infection prevalence and the associated socio-demographic risk factors among children in Hualien County, Taiwan.

Methodology: This retrospective longitudinal study included school-aged children in Hualien during 2009–2018. Children were screened for pinworm infection using adhesive cellophane perianal swabs while they were in grades 1 and 4 in school. The factors associated with pinworm infection were analyzed. Trend analysis of pinworm infection rate stratified by sex and residential setting (urban, suburban, and rural) were also performed.

Results: A total of 90,730 school-aged children from grades 1 and 4 during 2009–2018 were included. Young age and male sex were risk factors for pinworm infection ($P < 0.001$). Negative correlation between body mass index (BMI) and enterobiasis was observed and decreased pinworm infection was noted during the study reference period. Children in suburban and rural areas had higher odds ratio for pinworm infection than those in urban areas (suburban: 1.45; rural: 5.27; $P < 0.001$ for both). Trend analysis revealed a significant decrease in the overall pinworm prevalence rate during 2009–2018 (P for trend: < 0.001). However, there was no obvious change of pinworm infection rate in rural areas during this period ($P = 0.953$), and it was higher than that in urban and suburban areas.

Conclusions: Risk factors for pinworm infection included young age, male, and BMI. High pinworm infection among school-age children in rural areas of Hualien is still an important issue.

Background

Enterobius vermicularis, also known as pinworm, is a common intestinal parasitic infection worldwide despite advances in medicine. Pinworm infection is transmitted by the fecal-oral route. When an infected person scratches the perianal area, it leads to contamination of the hand and clothing with pinworm eggs. Contact with materials or food contaminated with pinworm eggs is one of the main modes of infection. Therefore, pinworm infection easily spreads in crowded settings such as home and school. Pinworm infection is particularly common in children, especially preschool and school-age children [1]. Previous studies have identified poor hand hygiene, lower socioeconomic status, and crowded environment as risk factors for pinworm infection [2–4]. Almost half of all individuals with pinworm infection are asymptomatic or show minimal symptoms. Perianal itching, especially at night, is a common symptom, which not only impairs the sleep quality, but also increases the risk of skin infection due to frequent scratching. Patients with pinworm infection may also have gastrointestinal symptoms such as chronic abdominal pain, poor appetite, or even malnutrition [5].

The reported prevalence of pinworm infection across the world ranges between 0.21% and 54.86% [3, 4, 6–9]. Taiwan is located in tropical and subtropical areas. Pinworm infection was an important public health issue in Taiwan. The Taiwanese government made concerted preventive efforts to control pinworm infection by screening of school-aged children with adhesive cellophane perianal swabs. Infected children and their family members were treated with mebendazole [10]. The prevalence of pinworm in Taiwan showed a significant decline from 19.9% in 1986 to 2.5% in 2001 [10]. After 2001, the responsibility for pinworm prevention was assigned to the individual county/city governments [10]. According to a population-based study conducted between 2006 and 2007, Taipei (0.9%) and Kaohsiung City (1.8%), the two largest cities in Taiwan, had a considerably lower prevalence of pinworm infection among school children than the average prevalence in the Taiwan Province (2.4%) [10]. In 2008, a low prevalence of pinworm infection, approximately 0.62%, was still noted in Taipei, the capital of Taiwan [11]. However, at that time, the prevalence of pinworm infection was

approximately 4.2% in Hualien, which has the largest aboriginal population (25% of all residents) and the second least urbanized county with 13 districts in the east of Taiwan [10].

A gradual decrease in the prevalence of pinworm infection has been noted in many resource-rich regions, and this phenomenon was also noted in previous time-trend analysis studies conducted in Taiwan [1]. However, the pinworm infection was still found to be an important public health issue in some areas of resource-rich regions, regardless of the decreasing prevalence rates. In our previous study in Hualien, pinworm infection was still an important issue among school-aged children in 2010 [2]. A growing body of evidence has demonstrated a significant correlation between socio-demographic factors and enterobiasis [12–15]. However, the influence of socio-demographic factors on pinworm infection in children residing in the same area on long-term follow-up under the current policy of pinworm prevention in Taiwan is not well characterized. To the best of our knowledge, this is the first study based on the annual health examination database of school-aged children in Hualien to evaluate the trend of pinworm infection prevalence and to identify the different socio-demographic risk factors for pinworm infection among children in Hualien, Taiwan.

Methods

Subjects

Data for this retrospective study were collected from the health examination of school-aged children from 2009 to 2018 in Hualien, Taiwan. The health examination was conducted annually for students in grades 1 and 4, and the pinworm survey was included in the health examination. Written informed consent for participation in health examinations was obtained from the parents and guardians of all students. This study was reviewed and approved by the Hualien County Government Education Bureau and the Protection of Human Subjects Institutional Review Board of Tzu Chi University and Hospital (REC No.: IRB110-025-B) [16].

Measurements and parasitological survey

Pinworm eggs are easier to be detected in the affected patients than pinworms. In Taiwan, adhesive cellophane perianal swabs have been used to detect pinworm eggs on the anal folds [3, 10]. The perianal swabs were used on two consecutive mornings, and the students were asked to bring the perianal swabs immediately after completing the examination. Microscopic examination was performed by experienced medical technologists, and pinworm infection was defined as the detection of pinworm eggs on microscopy [2].

Anthropometric measurements including weight and height were measured by school nurses prior to the dates of the physical examination. Body mass index (BMI) was calculated and students were classified into underweight, normal weight, overweight, and obese groups according to the age-sex-specific BMI cutoff levels in the new growth charts for Taiwanese children and adolescents, based on the standards of the World Health Organization, and health-related physical fitness related to health, developed by the Department of Health of Taiwan in 2010 [2, 16]. Demographic data in the health examination records included age, sex, and residential setting. Residential setting was categorized into three groups: urban, suburban, and rural, according to the population density, educational level, percentage of elderly population, percentage of the agricultural population, and the medical resources [17]. Among the 13 districts of Hualien, the urban areas included Hualien City, Xincheng, Jian, and the suburban areas included Shoufeng, Fenglin, Yuli, Guangfu, Fengbin, Ruisui, and Fuli. Rural areas included Xiulin, Wanrong, and Zhuoxi.

Statistical analysis

Descriptive statistics for sex, different BMI groups, urbanization, time periods, and pinworm infection rate are presented as frequencies or proportions. The age of students included in this study is presented as mean \pm standard deviation. The Chi-squared test was used to evaluate the association of categorical variables with sex. A logistic regression model was

used to evaluate the risk factors association with pinworm infection, including age, sex, BMI group, years of data collected, and urbanization status. The results are reported as odds ratio (OR) and 95% confidence interval (95% CI). Subjects were stratified by sex and urbanization to assess the trend of pinworm rate among the specific groups. *P* for trend was evaluated via the Cochran–Armitage test. Figures showing the prevalence rates of pinworm infection in different districts of Hualien were generated using R (version 3.6.3). *P* values < 0.05 were considered indicative of statistical significance. All statistical analyses were performed using Social Science statistical package version 17.0 (SPSS Inc., Chicago, IL, USA).

Results

This study was based on the annual health examination records of school-aged children between 2009 and 2018. We analyzed the prevalence, trend, and associated risk factors of *E. vermicularis* infection.

Demographic information pertaining to the 56197 school-aged children (grades 1 and 4) who underwent examinations during 2009–2018 is presented in Table 1, disaggregated by sex. Males accounted for 52.3% of all subjects. The average age of boys and girls was 8.23 ± 1.53 years and 8.27 ± 1.53 years, respectively. Most of the enrolled subjects resided in urban areas (males: 68.2%, females: 68.1%). There was no significant difference between urbanization status, age, and subjects in different time periods during the study period. However, there were differences between BMI groups and pinworm infection rates between males and females. Overweight and obese subjects were significantly more predominant among males than females ($P < 0.001$). The overall prevalence of pinworm infection was 4.4% (2497/56197), and male subjects had higher pinworm infection rate than female subjects (4.9% vs. 3.9%, $P < 0.001$).

Table 1
Demographics (n = 56197)

Characteristics	Boys (n = 29388)	Girls(n = 26809)	P-value
Age (yrs)	8.23 ± 1.53	8.27 ± 1.53	0.011*
Grade, n (%)			0.010*
1	13919(47.4%)	12405(46.3%)	
4	15469(52.6%)	14404(53.7%)	
BMI group, n (%)			< 0.001*
Underweight	6191(21.1%)	6210(23.2%)	
Normal	16617(56.5%)	15474(57.7%)	
Overweight	3342(11.4%)	2748(10.3%)	
Obese	3238(11.0%)	2377(8.9%)	
Urbanization, n (%)			0.372
Urban	20035(68.2%)	18261(68.1%)	
Suburban	6706(22.8%)	6209(23.2%)	
Rural	2647(9.0%)	2339(8.7%)	
Period, n (%)			0.436
2009	3673(12.5%)	3373(12.6%)	
2010	3535(12.0%)	3206(12.0%)	
2011	3077(10.5%)	2955(11.0%)	
2012	3133(10.7%)	2708(10.1%)	
2013	2827(9.6%)	2592(9.7%)	
2014	2793(9.5%)	2592(9.7%)	
2015	2487(8.5%)	2250(8.4%)	
2016	2580(8.8%)	2339(8.7%)	
2017	2562(8.7%)	2334(8.7%)	
2018	2721(9.3%)	2460(9.2%)	
Pinworm, n (%)	1450(4.9%)	1047(3.9%)	< 0.001*
Data are presented as n or mean ± standard deviation.			
*P-value < 0.05 was considered statistically significant after test			

The results of multiple logistic regression analysis to identify the socio-demographic factors associated with pinworm infection are presented in Table 2. Young age and male sex were associated with significantly higher pinworm infection rates ($P < 0.001$ for both). Interestingly, a negative correlation between BMI and enterobiasis was observed in the study. Students in obese (0.36) and overweight (0.52) groups had significantly lower OR for enterobiasis as compared to

subjects with normal BMI ($P < 0.001$ for both). Students in the underweight group showed a trend of higher OR (1.07) for pinworm infection compared with children in the normal BMI group; however, the between-group difference was not statistically significant ($P = 0.179$). During the study reference period (2009–2018), decreased pinworm infection rate was noted especially after 2013 ($P < 0.05$ from 2012 to 2018). According to residential setting, suburban and rural areas had higher OR for pinworm infection than urban areas (suburban: 1.45, rural: 5.27; $P < 0.001$ for both), and rural areas had a higher pinworm infection rate by a factor of approximately six compared to urban areas.

Table 2
Factors associated with pinworm. (n = 56197)

	Crude		Adjusted	
	Odds Ratio (95% CI)	P-value	Odds Ratio (95% CI)	P-value
Age	0.85 (0.83,0.88)	< 0.001*	0.86 (0.84, 0.88)	< 0.001*
Gender	-	-	-	-
Male	1.28 (1.18,1.39)	< 0.001*	1.29 (1.19, 1.40)	< 0.001*
Female	References	NA	References	NA
BMI Group	-	-	-	-
Normal	References	NA	References	NA
Underweight	0.91 (0.82,0.99)	0.043*	1.07 (0.97, 1.18)	0.179
Overweight	0.50 (0.43,0.59)	< 0.001*	0.52 (0.44, 0.61)	< 0.001*
Obese	0.35 (0.28,0.43)	< 0.001*	0.36 (0.29, 0.44)	< 0.001*
Year	-	-	-	-
2009	References	NA	References	NA
2010	0.96 (0.83,1.12)	0.634	0.96 (0.82, 1.12)	0.608
2011	0.92 (0.79,1.08)	0.320	0.91 (0.78, 1.07)	0.258
2012	0.90 (0.77,1.06)	0.197	0.87 (0.74, 1.02)	0.091
2013	0.85 (0.72,1.00)	0.052	0.82 (0.70, 0.98)	0.024*
2014	0.60 (0.50,0.72)	< 0.001*	0.59 (0.49, 0.71)	< 0.001*
2015	0.68 (0.56,0.82)	< 0.001*	0.66 (0.55, 0.80)	< 0.001*
2016	0.77 (0.64,0.92)	0.003*	0.76 (0.63, 0.90)	0.002*
2017	0.84 (0.71,0.99)	0.049*	0.83 (0.70, 0.99)	0.036*
2018	0.80 (0.67,0.95)	0.010*	0.77 (0.65, 0.92)	0.004*
Urbanization	-	-	-	-
Urban	References	NA	References	NA
Suburban	1.42 (1.29,1.58)	< 0.001*	1.45 (1.31, 1.61)	< 0.001*
Rural	4.99 (4.52,5.50)	< 0.001*	5.27 (4.77, 5.83)	< 0.001*
Data are presented as Odds ratio (95% CI)				
*P-value < 0.05 was considered statistically significant after test				

Table 3 shows the trend analysis of prevalence of pinworm infection from 2009 to 2018. Overall pinworm rate showed a significant decrease ($P < 0.001$ for trend). To further clarify the influence of socio-demographic characteristics on the pinworm infection, trend analysis was stratified by sex and urbanization. After adjusting for sex, both male and female students showed a decreased trend of pinworm rate ($P < 0.05$ for both). Urban and suburban areas reported significant

decrease from 2009 to 2018 ($P < 0.05$ for both). However, there was no obvious change of pinworm infection rate in rural areas over 10 years ($P = 0.953$), and the rate was higher than that in urban and suburban areas.

Table 3
Trend analysis of pinworm rate stratified by gender and urbanization.

Group	Total	Pinworm rate (%)										P-value for trend
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
Overall	56197	5.2	5.0	4.8	4.7	4.5	3.2	3.6	4.1	4.4	4.2	< 0.001*
Gender												
Male	29388	5.7	5.7	4.9	5.2	5.2	3.6	3.9	4.8	4.8	4.9	0.004*
Female	26809	4.7	4.4	4.7	4.2	3.6	2.8	3.2	3.2	4.0	3.5	< 0.001*
Urbanization												
Urban	38296	4.2	3.4	3.6	3.6	2.7	2.3	2.1	2.8	3.4	3.4	0.001*
Suburban	12915	5.5	6.3	4.6	4.0	5.2	3.2	3.8	3.5	3.7	3.2	< 0.001*
Rural	4986	12.7	14.6	15.2	14.3	15.8	10.7	14.6	15.5	14.7	12.8	0.953

Figure 1 shows the prevalence of pinworm infection in different districts of Hualien. Hualien is located between tropical and subtropical zones. Pinworm infection rates were low in urban and suburban areas of Hualien including Hualien City, Fenglin, Guangfu, and Yuli. Rural areas of Hualien included Xiulin, Wanrong, and Zhuoxi are near the mountains and at the junction of tropical and subtropical zones. Both sexes and students of grades 1 and 4 had a high pinworm infection rate in rural areas.

Discussion

The main findings of our longitudinal localization-based school children's pinworm cohort with prevalence and time-trend analysis are summarized as follows. The prevalence of pinworm infection showed a significant declining trend during the study reference period, both in males and females. Students residing in urban areas showed a significantly lower risk of enterobiasis. Interestingly, the trend of enterobiasis in urban and suburban areas decreased significantly from 2009 to 2018. However, there was no obvious trend of change in the rate of pinworm infection in rural areas. The occurrence of pinworm infection was higher in the younger age group in both males and females, but boys had a higher enterobiasis rate compared to girls. There was a negative correlation between BMI and pinworm infection throughout the study.

This study revealed that the overall pinworm infection among school-age children gradually decreased in Hualien from 2009 to 2018. Although the preventive strategy for pinworm infection had some variations between each local government in Taiwan after 2001, similar reducing trends of pinworm infection were observed in other areas of Taiwan [10]. However, a high prevalence of enterobiasis was still observed without a decreasing trend in the rural area of Hualien. In line with previous study in Germany, locally clustered enterobiasis is still a vital issue in some resource-rich countries [5].

The non-obvious decline in the trend of pinworm infection rate in the suburban and rural areas of Hualien was an important finding of this study. There is no clear consensus on the association between urbanization and the prevalence of pinworm infection. In a study conducted in the Republic of Marshall Island, the prevalence of pinworm infection in urban areas was found to be higher than that in rural areas [8]. Another study in Taiwan found that schoolchildren in rural areas are less likely to have pinworm infection than those residing in urban areas [1]. On the other hand, studies conducted in China found that children in rural areas were at a higher risk of pinworm infection than those residing in urban areas [12, 18, 19]. The reasons for the non-significant decrease in the trend of pinworm infection in remote areas of Hualien are likely to be multifactorial. Many studies have highlighted the association between socioeconomic status and pinworm infection [1, 3]. In the present study, the urbanization category was based on population density, educational level, percentage of the elderly population, industrialization, percentage of the agricultural population, and medical resources. Hualien, the largest county in Taiwan by area, includes 13 districts with considerable differences in urbanization levels. The rural areas in our study, including Xiulin, Wanrong, and Zhuoxi, have a relatively low socioeconomic status, such as low educational level, low industrialization, and low family income. Furthermore, in Taiwan, there are significant urban-rural disparities with respect to availability of health care and medical resources are located mainly in the urban areas of Hualien. The above socioeconomic factors may be responsible for the persistently high prevalence of pinworm infection among school-age children in the remote areas of Hualien.

Another reason for the persistent high prevalence of enterobiasis in the rural areas of Hualien was the proportion of young children in the population of the districts. Pinworm infection has been shown to be more common in young children aged 4 to 11 years [5, 20, 21]. Children under the age of two or those over the age of 14 and adults are less affected by pinworm infection [5, 22]. Young children tend to play on the floor, and show frequent nail biting or finger sucking behaviors and poor hand-washing compliance before meals; the above factors are known risk factors for pinworm infection [1, 4, 5, 8, 20]. According to the demographic data from the Hualien Civil Affairs Department, the three districts with the lowest population density were compatible with the rural areas in our study [23]. Despite the low population density, a higher percentage of children aged < 14 years in rural areas than in urban/suburban areas was a characteristic of Hualien according to the demographic data from the Hualien Civil Affairs Department [24], which may explain the high rate of enterobiasis in remote areas of Hualien.

Additionally, a previous study also revealed that small-size schools in remote areas is a potential risk factor for a higher rate of enterobiasis [10]. In a large-scale survey of schoolchildren in Taiwan, smaller schools (< 100 children) showed higher positivity rates of pinworm infection than larger schools (> 100 children). The authors concluded that children of different ages frequently use the same classroom due to the limited educational resources in these regions, which facilitates the transmission of pinworm due to the crowded environment [10]. According to the data of the Taiwan Ministry of Education, most schools in the rural areas of Hualien areas are small schools, which corresponded to the areas with the highest prevalence of pinworm infection. This finding was consistent with the findings of previous large-scale surveys [10]. In brief, the multiple reasons may explain the persistently high prevalence of pinworm infection in rural areas, including high percentage of young children and small schools.

Appropriate policy intervention for prevention of pinworm infection is important. Screening and eradication with mebendazole are the main policy interventions for pinworm infection in Taiwan, which led to a prominent declining trend of pinworm infection in recent decades. After 2001, the work of pinworm prevention was carried out by the individual county/city governments. The policy for pinworm infection was individualized by the local government according to the local prevalence rates. The main difference in the policy for pinworm infection in Taiwan is with respect to the groups targeted for screening. According to the 2007 report of the Taiwan Centers for Disease Control, some counties, such as Kaohsiung City, screened all elementary school students, and some counties, such as Taipei, screened students in grades 1 and 4 [25]. Due to the relatively low prevalence of pinworm infections in Taiwan, the screening groups among Taiwanese schoolchildren in recent years were mainly those in grades 1 and 4. However, this policy does not seem to be

adequate to decrease the prevalence of pinworm infection in remote areas of Hualien. Therefore, it might be necessary to adjust the screening group policy in the hot pinworm zone.

In this study, we identified other risk factors for enterobiasis in children, including sex, age, and BMI. Sex-based differences in pinworm infection have been widely reported, and in our study, boys showed a significantly higher infection rate than girls. However, a previous study in Taiwan found no significant sex-based difference in pinworm infection [3]. Most other studies have revealed higher infection rates in males [2, 4, 7, 14, 26]. The exception was a study conducted in Thailand, which found a higher risk of pinworm infection in girls compared to boys [20]. This phenomenon may be attributable to the fact that the boys have comparatively poor personal hygiene and indulge in more intimate contact activities with other children [4, 10, 26].

Our study also found a higher prevalence of enterobiasis in the younger age group in both males and females. This finding was consistent with previous studies that showed a higher risk of pinworm infection in preschool children compared to that in school-age children, toddlers, and infants [3, 4, 8]. Although our study dataset did not include data on pinworm infection in toddlers and preschool children, older school-age children in our study had a lower pinworm infection rate than younger subjects. This phenomenon may be associated with improved personal hygiene in older children [3]. Besides, the children in grade 4 with no pinworm infection may have a history of previous eradication of pinworm when they were in grade 1. However, there was no related data in this study to prove this hypothesis. Another potential reason may be related to the current screening method for pinworm infection in Taiwan, which entails the use of adhesive cellophane perianal swab for two consecutive days. Usually, this procedure is assisted by parents. Older children may be embarrassed to ask their parents for help and are likely to complete the procedure themselves. Therefore, the poor quality of perianal swabs may have introduced an element of bias in the detection of pinworm infection.

The negative correlation between BMI and pinworm infection was another interesting finding of this study. Underweight subjects in this study showed a trend for higher OR for enterobiasis infection compared to children in the normal BMI group, but without statistical significance. Malnutrition is associated with intestinal parasitic infection. Furthermore, childhood developmental disorder and growth showed an association with pinworm infection [5, 27, 28]. The above-mentioned reasons may explain the higher risk of enterobiasis among underweight students in our study. Instead, students in the overweight/obese BMI group had a significantly lower OR for enterobiasis compared to subjects with normal BMI. Similar findings have been reported in another study [29]. The potential reasons for the causality or association between high BMI and low pinworm infection rate are still uncertain. A previous study revealed that children with high BMI are more likely to spend more time on watching television and show decreased physical activity [30], and the lifestyle of children with high BMI may decrease the risk of contact with people or the environment contaminated by pinworms. However, further study is required to clarify this hypothesis about the association between high BMI and low pinworm infection rate.

Some limitations of our study should be acknowledged. First, enterobiasis is well-known to be a multifactorial disease. Data pertaining to many other socio-demographic risk factors, such as the parental education levels, family income and living conditions, number of siblings, personal hygiene, long fingernails, and habitual frequent sucking of fingers, were not collected, leading to potential confounding in the final analysis [4, 8, 31]. Second, the data in this study were collected from the annual health examination of students in grades 1 and 4. Therefore, there were no data of other students except grades 1 and 4, and this may have introduced an element of selection bias. However, the large dataset used for this analysis is a study strength. Further studies are required for in-depth characterization of the trend of prevalence of pinworm infection in children in Hualien.

Conclusion

Routine health examinations, including the pinworm survey, can detect enterobiasis in schoolchildren. Our study found that pinworm infection among school-age children gradually decreased in Hualien from 2009 to 2018. Related risk factors for pinworm infection included sex, BMI, age, and residential setting. High prevalence of pinworm infection was still observed in the rural areas of Hualien. Our study may help inform policy-level and public health interventions for prevention of enterobiasis in Taiwanese children.

Abbreviations

BMI
Body mass index

Declarations

Ethics approval and consent to participate

All experiments were performed in accordance with relevant guidelines and regulations. This study was reviewed and approved by the Hualien County Government Education Bureau and the Protection of Human Subjects Institutional Review Board of Tzu Chi University and Hospital (REC No.: IRB110-025-B).

Consent for publication

Not applicable

Availability of data and materials

All data generated or analyzed during this study are included in this published article

Competing Interests

The authors declare that they have no competing interests

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Author contributions

C-HC, Y-CC, R-HJ, S-YC, S-HS, J-SC, and M-CC contributed to data collection. Y-CH, J-HW and M-CC analyzed and interpreted the patient data. Y-CH and M-CC were major contributors in writing the manuscript. All authors read and approved the final manuscript.

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Authors information (optional)

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Figures

Figure 1

Prevalence of pinworm infection of different districts in Hualien

(A) Male (B) Female (C) Students of grade 1 (D) Students of grade 4