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Epidemiological Studies on *Ascaris lumbricoides* Reinfection in Rural Communities in Korea

II. Age-specific Reinfection Rates and Familial Aggregation of the Reinfected Cases

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INTRODUCTION

In ascariasis as well as other parasitic infections of man, understanding of the age prevalence (or reinfection) together with the familial aggregation pattern is of much importance in epidemiological aspects and control (WHO, 1981). Such patterns are not only helpful to understand the principal mode of transmission (WHO, 1981) but also of great concern in the decision of primary targets in mass control programme. The age prevalence pattern, however, seems to be variable by localities according to extent of endemicity and many other socio-economic conditions (Morishita, 1972; Croll *et al.*, 1982).

In Korea, although the prevalence of *Ascaris lumbricoides* has been remarkably decreasing owing to the student-directed nationwide control activity, the present situation is still by no means satisfactory and continuous control activity is indispensable (Seo, 1983; Seo *et al.*, 1983). In spite of this situation, there is few information on the epidemiological characteristics of reinfection which is the main obstacle against control. The principal mode of transmission in rural communities remains to be elucidated and the question whether the student-directed control activity is to be continued should be solved. In this respect, this study was performed to observe the age-specific and familial aggregation patterns of *A. lumbricoides* reinfection in a rural area by means of repeated mass chemotherapy at various intervals and determination of the reinfected cases through collection of the expelled worms after each treatment.

MATERIALS AND METHODS

1. Observation of the Age(Sex)-specific Reinfection Rates

A total of 11 hamlets in Hwasŏng-gun, Kyŏnggi-do, Korea, each consisted of about 30 households and 140 inhabitants, were subjected for this study. The whole inhabitants in each hamlet irrespective of the results of egg detection were treated with 2.5~10.0 mg/kg pyrantel pamoate firstly on April to September 1977 according to hamlets. Afterwards the treatment continued every 2, 4, 6 and 12 months until May 1980 (Table 1). There had been some drop-outs in the blanket mass treatment largely

Table 1. The scheme of repeated mass chemotherapy to 11 hamlets of Hwasŏng-gun, Korea (1977-'80)

Hamlet code	Chemoth. interval (months)	Dosage of pyrantel (mg/kg)	Total freq. of tx.	Duration of control
I	2	2.5	18	Jun. '77~May '80
II	2	5.0	10	Jun. '77~Dec. '78
III	2	10.0	10	Jun. '77~Dec. '78
IV	4	10.0	5	Jan. '79~May '80
V	4	10.0	5	Jan. '79~May '80
VI	6	10.0	5	Apr. '77~Apr. '79
VII	6	10.0	5	May '77~May '79
VIII	6	10.0	5	Jun. '77~Jun. '79
IX	6	10.0	5	Jul. '77~Jul. '79
X	6	10.0	5	Aug. '77~Aug. '79
XI	6	10.0	5	Sep. '77~Sep. '79
IV*	12	10.0	5	Apr. '77~Apr. '78
V*	12	10.0	5	Apr. '77~Apr. '78

* Identical villages with 4-month interval group

due to population movement, about 3~6 immigrants and/or emigrants per two months in 2-month group for example (Seo *et* Chai, 1980), however, about 73~90% of the inhabitants in each hamlet had been treated and examined for reinfection.

The reinfection rates were obtained by means of stool examination and worm collection from 2 days' whole stools directly after each chemotherapy. The stool examination was performed by cellophane thick smear technique on the firstly passed stool after each treatment. Any of the inhabitant who revealed positive result for eggs and/or worm(s) was considered reinfected during the interval period after the previous treatment. So the reinfection rate in each treatment-interval group represented the cumulative reinfection rates for 2, 4, 6 or 12 months.

In order to compare the reinfection rates among the students of various schools and the people of various ages, the age grouping was done as follows: preschool children (0~5 years of age), primary (6~11), middle and high school ages (12~17), young adults (18~29), adults (30~49) and elderly people (50 & over) (Table 2, 3 and 4).

2. Observation of the Familial Aggregation Pattern

All of the 173 households (799 inhabitants) to which biannual repeated mass chemotherapy had been performed (Hamlets VI-XI in Table 1) were subjected for this observation. The biannual treatments continued for 5 times from 1977 to 1979. Any individual who was positive for eggs and/or worm(s) one or more times through 4 successive examinations was considered reinfected.

The number of households with 'n' family members and 'k' reinfected was counted and separately recorded (Table 5). And the expected values of the number of such households were calculated applying the binomial equation; $E_0+E_1+E_2+\ldots+E_k+\ldots+E_n=N_n\,(q+p)^n$ (n=1, 2, 3, ...; number of family members), where 'E_k' is the expected number of households with 'k' reinfected members, 'N_n' is each number of households with 'n' family members. The value 'p' is the overall reinfection rate, and q= 1-p (*i.e.*, q+p=1). The statistical analysis for significance of familial aggregation pattern was done by chi-square test (Table 6).

RESULTS

1. The Age(Sex)-specific Reinfection Rate

It was apparently seen that the shorter the treatment interval the lower the overall reinfection rate was (Table 2 & Fig. 1). In 2, 4, 6 and 12-month interval chemotherapy groups, the average reinfection rates irrespective of age were 3.2, 11.8, 19.0 and 41.8% respectively. In all of the 4 groups, the age tendency of reinfection was remarkable (Table 2). In 2-month (interval) group, for example, the reinfection rate was highest in preschool children (0~5 years of age), followed by primary school age (6~11), and by middle and high school age (12~17). Similar tendency was observed in 4, 6 and 12-month groups, but this time, a significant peak in reinfection rate was noted

Table 2. Age-specific reinfection rates of *A. lumbricoides* during mass chemotherapeutic control trials(1977～'80)

Chemoth. interval (month)	Reinfection rate(%) according to age group (years)						
	0～5	6～11	12～17	18～29	30～49	50+	Total
2	7.5 *(11/146)	4.8 (6/124)	3.6 (6/165)	3.1 (3/97)	1.1 (3/271)	1.5 (4/269)	3.2 (34/1,072)
4	12.1 (4/33)	15.1 (8/53)	11.1 (4/36)	7.7 (2/26)	14.4 (14/97)	4.8 (2/42)	11.8 (34/287)
6	28.4 (81/285)	25.5 (83/325)	17.2 (46/267)	14.9 (24/161)	17.1 (87/510)	12.2 (47/384)	19.0 (368/1,932)
12	71.4 (20/28)	40.4 (19/47)	57.6 (19/33)	14.3 (3/21)	36.4 (32/88)	35.3 (12/34)	41.8 (105/251)
Total	23.6 (116/492)	21.1 (116/549)	15.0 (75/501)	10.5 (32/305)	14.2 (137/966)	8.9 (65/729)	15.3 (541/3,542)

* Cumulative No. reinfected cases/Cumulative No. examined

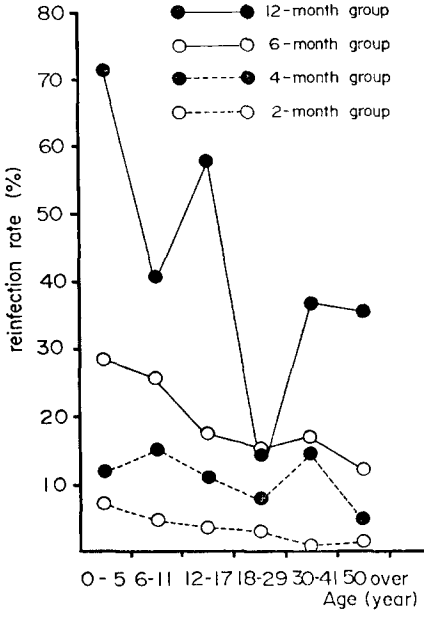

Fig. 1. Age-specific reinfection rate of *A. lumbricoides* according to masstreatment interval groups.

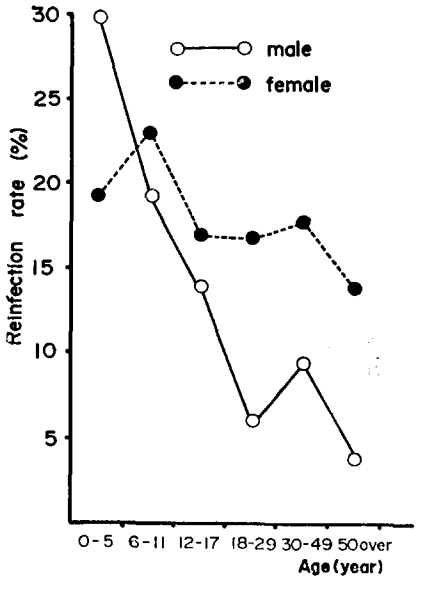

Fig. 2. Age-specific reinfection rate of *A. lumbricoides* in male and female villagers.

Table 3. Overall age-specific reinfection rates of *A. lumbricoides* in male and female inhabitants (1977～'80)

Sex	Reinfection rate(%) according to age group(years)						
	0～5	6～11	12～17	18～29	30～49	50+	Total
Male	29.8 *(59/198)	19.4 (54/278)	13.6 (41/302)	6.1 (11/180)	9.6 (41/426)	3.9 (14/360)	12.6 (220/1,744)
Female	19.4 (57/294)	22.9 (62/271)	17.1 (34/199)	16.8 (21/125)	17.8 (96/540)	13.8 (51/369)	17.9 (321/1,798)
Total	23.6 (116/492)	21.1 (116/549)	15.0 (75/501)	10.5 (32/305)	14.2 (137/966)	8.9 (65/729)	15.3 (541/3,542)

* Cumulative No. reinfected cases/ Cumulative No. examined

in adult age group (30~49). In 12-month group, a sudden fall of reinfection rate was noted in primary school age but considered an incidental finding.

The shape of age-reinfection pattern was somewhat different between male and female inhabitants (Table 3 & Fig. 2). In male, the reinfection rate was greatly higher in younger individuals (0~17) than in olders (over 18), and among them, the preschool children were the most highly reinfected. Another small peak in reinfection rate was observed in adults (30~49). On the other hand, in female, the age tendency was relatively less marked than in male and the highest reinfection rate was observed in primary school students. And, although less prominent, another peak in reinfection rate was also noted in adult (30~49) females.

The reinfection burden of *A. lumbricoides* was, in majority of cases, 1 (male or female) worm, therefore, the median values were 1 throughout the age groups. However, some younger (0~5) individuals frequently showed heavier reinfection burdens (up to 34 worms) than olders. So, the average values of reinfection burden were compared by age groups and the preschool children revealed the highest value in both sexes (Table 4). The overall reinfection burdens were 1.9 and 2.3 in male and female inhabitants respectively.

2. The Familial Aggregation Pattern

The number of family members per household unit varied from 1 to 11 and the number of reinfected in a family from 0 to 7 (Table 5). However, among the 173 households surveyed, the majority (163) consisted of less than 7 members each, and also the majority (167) revealed less than 4 reinfected members.

As the total number of reinfected persons and the total number of inhabitants were 252 and 799 respectively, the overall reinfection rate (cumulative rate for 6 months) was 31.5%. And the value 'p' and 'q' in the binomial equation were 0.315 and 0.685 respectively. Therefore, the expected number of houseolds $(E_0+E_1+E_2+\ldots+E_k+\ldots+E_n=\sum_{k=0}^{n} E_k)$ for 'k' reinfected among 'n' family members was as follows: $\sum_{k=0}^{n} E_k=N_n(0.685+0.315)^n$ (n=1, 2, 3, ...), where 'N_n' is the number of households with 'n' family members and $N_1(=17)+N_2(=15)+\ldots+N_{11}(=1)=173$ (Table 5). The expected values mean the theoretical numbers of households if *A. lumbricoides* reinfection occurred randomly to any person and to any family in 31.5% of probability.

The observed number of households with '0' reinfected member was of higher value than the expected, which means that certain families do not show the tendency of reinfection (Table 6 & Fig. 3). Also in case of the households with '4', '5', '6', '7' and more reinfected members, the observed numbers were higher than the expected, which reversely means that certain families do show greater tendency of reinfection. Contrary to this, the observed values of the number of households with '1' or '2' reinfected were much lower than the expected. The statistical test revealed poor fitness between the

Table 4. Worm burden of reinfected *A. lumbricoides* according to age and sex of the inhabitants(1977~'80)

Sex	Average worm burden according to age group (years)						
	0~5	6~11	12~17	18~29	30~49	50+	Total
Male	2.7 *(114/43)	1.3 (48/36)	1.3 (31/24)	1.3 (9/7)	1.8 (39/22)	2.8 (14/5)	1.9 (255/137)
Female	3.2 (128/40)	2.5 (102/41)	2.3 (39/17)	2.2 (28/13)	2.0 (114/57)	1.6 (48/30)	2.3 (459/198)
Total	2.9 (242/83)	1.9 (150/77)	1.7 (70/41)	1.9 (37/20)	1.9 (153/79)	1.8 (62/35)	2.1 (714/335)

* Total No. worms collected/Total No. worm positive cases

Table 5. The observed (expected) number of households according to number of total family members and reinfected members with *A. lumbricoides*

No. reinfec. members in a family	Observed (expected) No. households according to No. family members												Total No. reinfec. persons
	1	2	3	4	5	6	7	8	9	10	11	Total	
0	11 (11.6)	8 (7.0)	8 (4.8)	15 (7.0)	8 (4.8)	6 (3.4)	5 (1.3)	0 (0.2)	1 (0.1)	0 (0.02)	0 (0.02)	62 (40.2)	0
1	6 (5.4)	6 (6.5)	5 (6.7)	10 (13.0)	6 (11.1)	9 (9.4)	2 (4.3)	0 (0.9)	0 (0.4)	0 (0.1)	0 (0.08)	44 (57.9)	44
2	—	1 (1.5)	2 (3.1)	1 (8.9)	7 (10.2)	5 (10.8)	4 (6.0)	2 (1.4)	1 (0.8)	1 (0.2)	0 (0.18)	24 (43.1)	48
3	—	—	0 (0.5)	5 (2.7)	7 (4.7)	6 (6.6)	2 (4.6)	2 (1.3)	0 (0.8)	0 (0.3)	0 (0.25)	22 (21.8)	66
4	—	—	—	1 (0.3)	3 (1.1)	6 (2.3)	3 (2.1)	1 (0.8)	1 (0.6)	0 (0.2)	0 (0.23)	15 (7.6)	60
5	—	—	—	—	1 (0.1)	0 (0.4)	1 (0.6)	0 (0.4)	0 (0.3)	0 (0.1)	1 (0.15)	3 (2.1)	15
6	—	—	—	—	—	1 (0.1)	1 (0.1)	0 (0.1)	0 (0.1)	0 (0.05)	0 (0.07)	2 (0.52)	12
7	—	—	—	—	—	—	1 (0.01)	0 (0.01)	0 (0.0)	0 (0.01)	0 (0.0)	1 (0.03)	7
Total	17	15	15	32	32	33	19	5	3	1	1	173	252
Total No. family members	17	30	45	128	160	198	133	40	27	10	11	796	

Table 6. The *result of statistical test for familial aggregation of *A. lumbricoides* reinfection

No. reinfec. members in a family	No. households observed (O)		No. households expected (E)		$\frac{(O-E)^2}{E}$
0	62		40.2		11.82
1	44		57.9		3.34
2	24		43.1		8.46
3	22		21.8		0.00
4	15		7.6		7.21
5	3	6	2.1	2.65	
6	2		0.52		4.23
7 & over	1		0.03		
Total	173		173.25		$x^2=35.06$

* The probability for identity of two kinds of values: $p<0.001$

observed and expected values, which confirms that reinfection occurred never randomly but preferably to certain family members (Table 6).

DISCUSSION

In *A. lumbricoides* epidemiology, it has been commented that young children are more frequently infected or reinfected by playing on the contaminated ground near their houses and this makes the prevalence or reinfection peak in this age group (Cort, 1931; Headlee, 1936; Beaver, 1952; Seo, 1978). Furthermore, according to them, the promiscuous defecation by children near their houses becomes in turn the subsequent reinfection source to themselves and to their family members through direct hand-

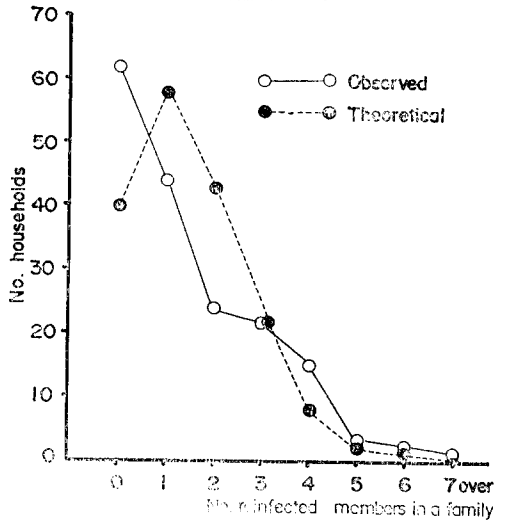

Fig. 3. Observed and theoretical number of households with 'n' reinfected members.

to-oral route or through contaminated vegetables and fruits cultivated there. This type of *A. lumbricoides* transmission has been described by many authors (Headlee, 1936; Beaver, 1952; Seo, 1978) as 'dooryard infection'.

Therefore, the higher reinfection rate and intensity in children and the familial aggregation tendency of reinfected cases observed in this study are not of unexpected. It was suggested that the higher reinfection rate in children might be due to poor hygienic status, dooryard behaviour, or even due to insufficient development of immunity in children (WHO, 1981). However, it was strongly suggested that in ascariasis as well as other helminthic infections, the acquired immunity is not a significant feature both in children and in adults (Jung, 1954; Croll *et al.*, 1982; Anderson *et* May, 1982). It was reported that where infection rate is high and transmission intense, children and adults were equally infected, hence, the age prevalence pattern was not marked (Morishita, 1972; Croll *et al.*, 1982).

For the above reason, it is more probable that the infection chance itself is greater in children and in certain family members, and therfore, the concept of 'dooryard infection' is much appropriate to explain such age-related and household-family related reinfection incidences observed in this study.

The age-specific reinfection curves in the present study were a little different between male and female inhabitants. In case of male, the younger the age the more marked the reinfection rate, while in female, the age pattern was generally less prominent. Both in male and female inhabitants, a small peak in reinfection rate was observed among the middle-aged (30～49) adults in this study. Since it is acceptable that young boys play near their houses more frequently than young girls and middle-aged men and women work more frequently near their houses in this country, such feature seems another phenomenon due to 'dooryard type' reinfection.

Based on egg examinations, the age and family-related difference in prevalence has been reported in this country. The higher prevalence of *A. lumbricoides* was observed in children (Soh *et al.*, 1961; Seo *et al.*, 1969; Kim *et al.*, 1971; MHSA & KAPE, 1971 & 1976) and a significant peak was observed between 30～55 aged women during nationwide survey (MHSA & KAPE, 1981). Furthermore, the familial aggregation tendency of egg positive cases was also reported in a rural area (Cho *et* Loh, 1973). In this connection, it was postulated that the principal mode of *A. lumbricoides* transmission may be of 'dooryard type' in rural and suburban areas (Yun *et al.*, 1979; KSP, 1982), which is confirmed by this study.

The higher reinfection rate in children observed in this study is a good rationale for the current student-directed nationwide mass control activity by KAPE (1982). However, the highest reinfection rate was observed in preschool children group instead of students. Among them, 4～5 year group was more highly reinfected than 0～3 year group. According to the reports made by egg surveys, it was also noted that the prevalence of *A. lumbricoides* among preschool children significantly increased by age up to 5～6 years in rural areas (Kim, 1962; Yang, 1969; Lee *et* Loh, 1974). In this respect, as stated by KSP (1982), close attentions should be paid to preschool children, if ascariasis eradication is aimed in endemic areas by means of mass chemotherapy schemes.

SUMMARY

Epidemiological studies on the reinfetion pattern of *Ascaris lumbricoides* were undertaken by means of blanket mass chemotherapy and worm collection in a rural village in Korea, during 1977～1980. The study objectives were to determine the age(sex)-specific reinfection rate during 2, 4, 6 and 12 months through repeated mass chemotherapy with pyrantel pamoate, and to observe the familial aggregation tendency of the reinfected cases.

The results obtained are as follows:

1. The age (sex)-reinfection curve revealed that the reinfection rate is much higher in younger individuals than in olders in all of 4 kinds of interval chemotherapy groups. The highest reinfection rate and the highest burden of reinfected worms were observed in preschool children, followed by primary school students. Such fluctuation in the age-specific reinfection rates was more pronounced in males than in females.

2. There was noted a significant tendency of familial aggregation among the reinfected cases. It is suggested that reinfection occurs never randomly but preferably to the members of certain household families.

From these reinfection analyses, it is inferred that the principal mode of *A. lumbricoides* transmission in the surveyed rural area is likely to be of 'dooryard type', in which case children and certain family members are more preferably reinfected. It is also suggested that the preschool children should be included in the primary targets of mass control programme.

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=國文抄錄=

韓國 農村地域의 蛔蟲再感染에 대한 疫學的 調査研究

II. 年齡別 再感染率 및 再感染의 家族集積性

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우리나라 農村地域의 蛔蟲感染에 있어서 年齡에 따른 再感染率의 차이 및 再感染의 家族集積性에 주안점을 두고 再感染의 特性을 파악하고자 하였다. 1977年부터 1980年까지 京畿道 華城郡의 11個 마을 全住民에 대하여 2, 4, 6 및 12個月 간격으로 pyrantel pamoate를 사용하여 反覆集團投藥하면서 각 投藥間隔동안 발생한 누적재감염율을 蟲卵陽性與否 및 投藥後 2日間 全大便內에서의 蟲體陽性與否를 綜合하여 구하고 比較分析하였다. 結果를 요약하면 다음과 같다.

1. 年齡別 再感染率은 모든 投藥간격 群에서 小兒가 成人에 비해서 월등히 높은 것으로 나타났다. 가장 높은 再感染率 및 再感染量은 學齡前 兒童群에서 관찰되었고 그 다음은 國民學生 年齡群이었다. 또, 이러한 年齡別 再感染率의 差異는 女子보다 男子에서 훨씬 뚜렷하였다.

2. 再感染者는 어느 特定家族에 集中的으로 발생하는 강한 家族集積性이 관찰되었고 이 결과는 蛔蟲의 再感染이 무작위로 일어나는 것이 아니고 同一한 환경을 가진 特定家族간에 빈발하고 있음을 의미하고 있었다.

이상의 再感染 特性을 감안할 때 우리나라 農村의 蛔蟲 再感染은 이른바 庭園感染(dooryard infection)에 의한 것으로 추측되었으며, 또 보다 효과적인 集團管理를 위해서는 學齡前 兒童이 반드시 管理對象에 포함되어야 할 것으로 생각되었다.