RE-HOUSING AND INFECTIONS BY SOIL-TRANSMITTED HELMINTHS IN SINGAPORE

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INTRODUCTION

This is a report on a comparative, retrospective study of prevalence of infections by soil-transmitted helminths in two groups of Chinese children living under different housing and sanitary conditions in Singapore.

PURPOSE OF THE STUDY

To evaluate the influences, if any, of re-housing of families on the prevalence of infections by soil-transmitted helminths in children under the age of 13 in these families.

Rehousing in this context means re-settlement from urban slum and squatter-areas* with unsatisfactory sanitary conditions into flats with modern sanitation.

Beaver[1] recommended that "natural control methods should be applied and evaluated as part of any experimentation with population re-location and village construction".

The findings and the conclusions drawn from this study, which was done in the form of a survey, may be a contribution in the sense of Beaver's recommendation.

SINGAPORE, **a brief account of relevant information[2].**

Singapore is a diamond shaped island with an area of 224·5 square miles.

It lies 85 miles north of the equator and its climate is characterized by uniform temperature (range 75°—87°F.), high humidity (range 65—85%) and heavy rainfall (annual rainfall range 79—95 inches). The wettest months are October, November, December and January.

The population of Singapore is multiracial and is estimated (mid-year 1964) at 1,820,000. The Chinese form the largest ethnic group comprising about 75% of the total population, the Malays (including Indonesians) 14%, and Indians and Pakistanis 8%. Europeans, Eurasians, and other ethnic groups make up the remainder of the population. An estimated 65% of the total population live in the City area. The Crude Death Rate and the Crude Birth Rate for 1964 (mid-year) were estimated as respectively 5·7% and 32·1%.

The overall density for the year 1962 was estimated at 7,718 persons per square mile (range approximately 850—25,000 per square mile.)

Singapore has a housing problem. In a survey on urban income and housing (Social Survey of Singapore, 1953-54 published in 1958)[3] GOH KENG SWEE found in his survey-area: "..., or less than a fifth (of 6070 households, J. K.) enjoy exclusive use of their houses. The great majority have to share houses with others, with nearly a fourth of households sharing II or more to a house". It is not within the scope of this paper to discuss the various factors that have contributed to the existence of this situation.

The present Government of the State of Singapore has acted vigorously and formulated a five year (1960-1965) housing programme in order to solve the housing problem and to deal successfully with slum clearance. When the programme is completed, about 450,000 people will be re-housed[4].

Data on prevalence of infections by soil-transmitted helminths in Singapore have been reported often previously. See papers and reports, numbers 5-18 in the references list. Little is known, however, about the influence of change in environment on the prevalence of helminth infections in Singapore.

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* According to the Shorter Oxford Dictionary (1955), the word "squatter" in United Stated English means: ".... b. An unauthorized occupant of land ....." This definition comes nearest to the meaning of "squatter" in Singapore.

For the purpose of this study, "squatter-area" means *urban* "squatter-area".

THE SURVEY

The area chosen

Re-settlement of the population takes place mainly in the urban area of Singapore. It seemed obvious therefore to plan the survey in this area. With an intensive building programme like that existing in Singapore, it is not difficult to find an area in which two populations are living under difficult housing and sanitary conditions, to be more precise: to find two groups close to each other of which one lives in new flats and the other still in slums or squatter huts.

The *Bukit Ho Swee Area* was chosen (see Map 1) mainly for the following reasons:

1. It is located near the Department of Social Medicine and Public Health (University of Singapore) from which the survey was conducted.
2. Before 1961, the whole area was known as a notoriously unsanitary squatter-area. In 1961, a heavy fire broke out resulting in the destruction of the greater part of the huts.[4,19] The affected people (2,600 families) were temporarily housed with other families, the greater majority of them in flats and tenement houses but not in other squatter-areas. The Housing Board, in a crash programme, erected on the fire site multi-storey flats with modern sanitation giving priority to the victims of the fire to apply for them. Many families returned within ten months to the same location.
3. The population of the Bukit Ho Swee Area consists of families in the lowest income groups, where most cases of infections by soil-transmitted helminths are expected.
4. Nearly all families in the Bukit Ho Swee Area belong to one ethnic group: Chinese.

Boundaries of the survey area. (see Map 2)

The Bukit Ho Swee Area lies within the City limits in one of the most crowded parts of town. For the purpose of this survey, the following boundaries of the area were set: To the North: Havelock Road, to the East: Outram Road, to the South: Tiong Bahru Road, to the West: Lower Delta Road. Total area is approximately 0·2 square miles.

Physical Characteristics of the Survey Area

The lowest part of the area lies just above sea-level, the highest at about sixty feet. Generally the flats are situated on the higher ground. The shortest distance between the flats-area and the squatter-area is about 120 feet. The soil mainly consists of red earth and laterite. Before the flats were built, top layers were bulldozed to level the ground. There is more open space with patches of grass around the flats than in the squatter-area where almost the whole surface is covered by houses, huts and shacks, leaving barely enough space for narrow lanes. There is an efficient drainage system in the flats-area. In contrast, earthen, "natural" drains and pools of stagnant water are no exception in the squatter-area.

HOUSING

a. Flats

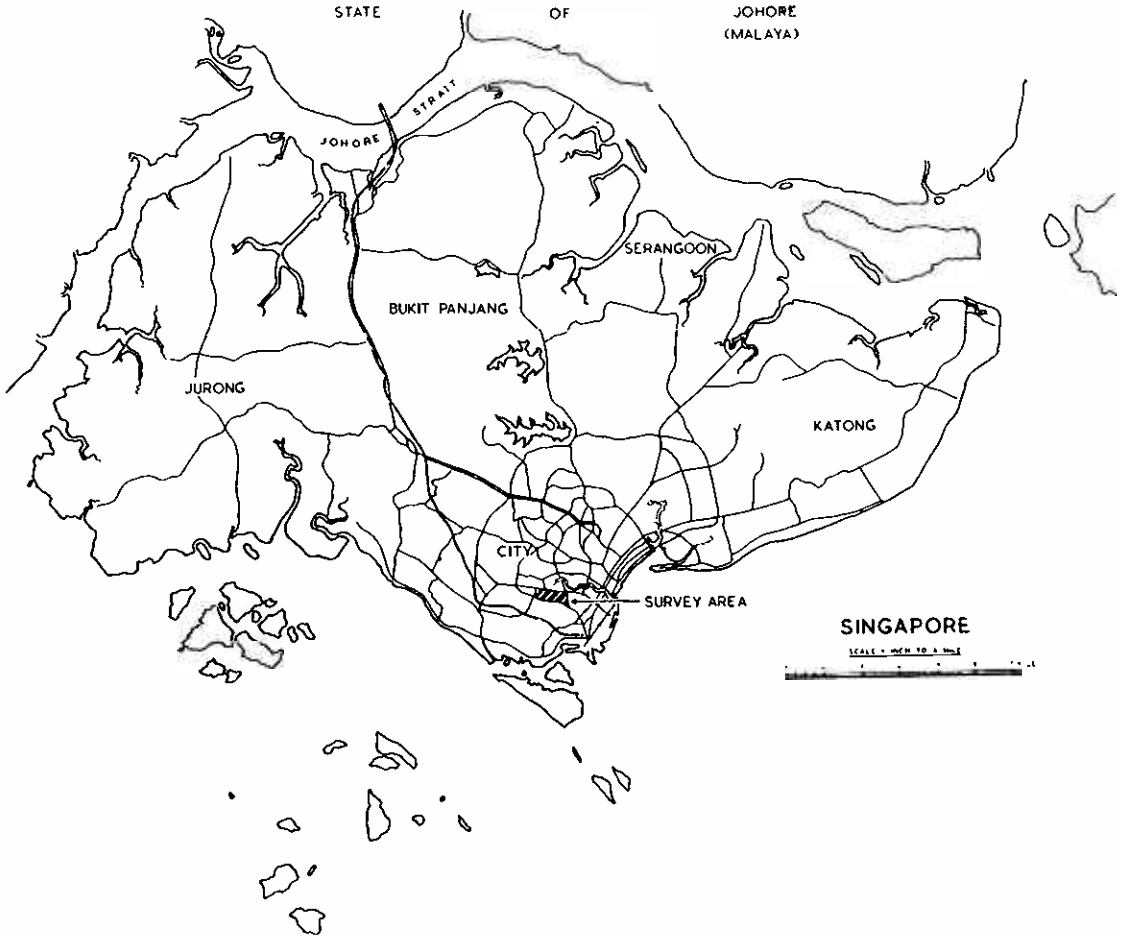
There are three types of flats:

1. One room with kitchen, bathroom/W.C. and balcony, area 240 sq. ft. M$20/— rental p.m.
2. Two rooms with kitchen, bathroom/W.C. and balcony, area 400 sq. ft, M$40/— rental p.m.
3. Three rooms with kitchen, bathroom/W.C., balcony, area 550 sq. ft. M$60/— rental p.m.

Successful application for one of the flats depends mainly on two factors: income and size of family. Generally, a family is only eligible for two- or three-room flats when the family consists of at least five persons, including dependent grandparents. Income is found to be more limiting than family-size in the survey area. Hence large families are found to live in small flats more often than the opposite. Subletting is forbidden in the flats.

b. Squatter-Area

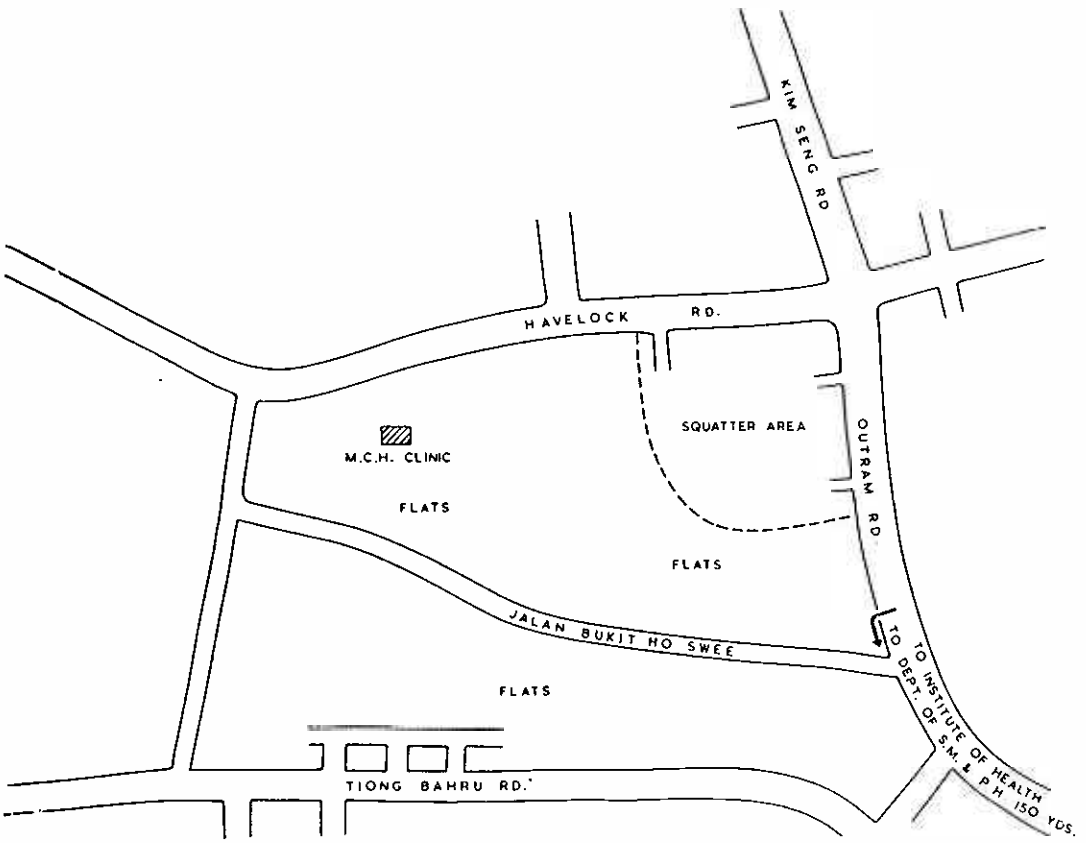
In the squatter-area, rents are on the whole slightly lower but living conditions are poor. Housing is entirely of the temporary type: wooden or partly cemented walls, earthen or cement floor, atap or corrugated zinc roof. In each house, hut or shack ,there are subdivisions in cubicles and bed-spaces which are subrented in most instances.



MAP 1

SKETCH OF THE SURVEY AREA

(NOT TO SCALE)



MAP 2

Sanitary Provisions and Water Supply

As indicated above, each flat has its own watercloset. Squatter families have to share bucket latrines. Indiscriminate defaecation by toddlers and pre-school children was observed in both areas but much more frequently among the squatter population. The removal of full buckets everyday gives rise to another way of soil contamination. Part of the contents is sometimes poured into the drains in order to prevent spilling during manual transport to the lorries.

According to size, a flat contains 1-2 taps, while in the squatter-area, water supply is mainly by communal taps and standpipes. Storage of water in jars, bottles and drums was often observed in squatter homes. Refuse disposal in the flats is by chute-system, but indiscriminate disposal has been observed. In the squatter area, disposal of refuse is by dustbins of many kinds and designs, general collection for the area is at a dustbin-centre. Indiscriminate disposal in drains was seen frequently.

Pests and Vermin

There are plenty of opportunities for mosquito-and fly-breeding in the squatter-area. Especially pools of stagnant water and small dumps of refuse and empty bottles in hidden places between huts are to be mentioned. Cockroaches were frequently seen in abundance in and around squatter homes, while in the flats, their presence was mainly confined to the refuse chutes up to the third floor. Complaints concerning nuisance from rats were heard in every home in the squatter-area, in the flats nobody seems to be bothered by these vermin.

In conclusion, it may be said that living conditions in the flats compared to those in the squatter area are favourable in the following aspects of health:

a) properly constructed housing
b) adequate provision for ventilation
c) safe water available for each family
d) adequate provision for safe excreta disposal
e) adequate provision for proper disposal of refuse
f) considerably less nuisance from pests and vermin

It should be noted that overcrowding per room is not mentioned. In fact, overcrowding was recorded in both areas, but to a lesser extent in the flats where this problem was noted only in families where income was the limiting factor at time of application.

SAMPLING

Sampling was restricted to the younger age-groups (up to 12 years) for the following reasons:

—in the younger age groups, we expected the prevalence of soil-transmitted helminths not to be greatly influenced by factors such as age-immunity, age-resistance, and age susceptibility (Haley 1963).[20] Thus the prevalence in the younger age groups would give a clearer picture of the risks of exposure.

—we expected a very low prevalence of hookworm infections in this urban community, hence it was considered unnecessary to include older age groups, especially in view of the purpose of the study.

—in an urban community, children may be considered to have more frequent and close contacts with the soil as compared with adults, hence they are that part of the population most likely to be infected by soil-transmitted helminths.

—better co-operation from the people was expected when the survey was kept restricted to the children.

Random sampling was considered impractical because of the high percentage of refusals expected. Therefore the following procedure was followed.

In the Maternal and Child Health Clinic situated in the survey area and servicing it, the first families were sampled. During a session in the morning hours, the purpose of the survey was explained to mothers attending. Their co-operation was asked. From the flats-area, 23 families were recorded, from the squatter-area, 3 families.

Further sampling was done by visiting the families at home and in doing so, interest of the neighbours was aroused which resulted in spontaneous requests to be included in the sampling. A pre-coded family record card was completed as well as a personal card for each child of required age. Cups and sticks were

handed out, mothers were shown how to sample the faeces and an appointment was made for the collection of the specimen. The family was offered a gift as a gesture of appreciation from the survey-team*)

A total of 159 families from the flats were included which is approximately 1/15 of all the families living in the Bukit Ho Swee flats area at the time of the survey. In the chosen squatter-area, all families, 169 in total, were included in the survey.

Thus the sampling was done on a family-basis and every attempt was made to include all the children under the age of thirteen in each family. Sampling was continued until a minimum number of 500 in each area was reached, care being taken to ensure that there were sufficient numbers in each group for each year.

The families in the flats-area as well as in the squatter-area were most co-operative, especially after it had been explained by the fieldworkers that only children were needed for the survey and that co-operation would be rewarded by small gifts.

Information on income was in most instances only given reluctantly. Generally, the families in the squatter-area were more suspicious with regards to the intensions of the survey team initially.

Sampling of faeces from children of the age of 6 years and older was sometimes found difficult because these were not easy to persuade to defaecate in a special receptaculum from where a small portion of the faeces could be taken by the mother. (The families used bucket-latrines. Therefore it was considered necessary to use a special receptaculum for defaecation because of the difficulty in obtaining a specimen from a bucket-latrine.)

On some occasions, too small portions of stools were given. Drying made the sample unsuitable for examination.

The time in which the survey was conducted (August—December 1964) has been extended unexpectedly because of two curfew-periods imposed on the population of Singapore because of political disturbances (not in the survey-area).

STAFF

Only one adequately trained laboratory-technician in our Department was available to examine the stools.

He was also engaged in the field in the collection of stool specimen, and he therefore knew from what families and what area he was about to examine the faeces everyday. Otherwise he was not informed about the donors of the stools at all.

Specifically, he was not informed about age, exact address, length of stay at present address, ecological history, or in short, any information that might be of importance in epidemiological considerations.

His diagnostic abilities were above average and regularly checked during the time of the survey.

Three lady field investigators were instructed on how to complete the record forms and obtain other relevant information. They mastered all the main Chinese dialects and were experienced in interrogation-techniques for health surveys. One lady, in addition, was trained in processing of statistical data.

Laboratory Methods Selected

Each stool sample was examined qualitatively and quantitatively (relative wormburden) with the direct smear method (Beaver) and the brine floatation method (Willis-Molloy). In order to obtain an optimum density of the direct smear (2 mg. of faeces), it is recommended that a photoelectric lightmeter be used. Such a lightmeter, however, was not and could not be made available.

To satisfy ourselves that inaccuracies made at microscopy would be of a nature still acceptable in the light of the purpose of the survey, the laboratory-technician was regularly checked on his ability to pick an amount of faeces of approximately 2 mg. of weight. In order to determine the degree of variation in the amount of faecal material examined, the technician

* These gifts were donated by commercial firms and consisted of a wide variety of goods: soap, toys, samples of tea and beverages, chocolate bars, sweets, plastic cups, tumblers, even potato crisps. It is the view of the writer that in a less co-operative people, small gifts may prove of great help, especially if a follow-up for a longer time is considered. These gifts, however, should be more of a "social" nature so as to prevent undesired side-action on the collection of data.

	Very light	Light	Moderate	Heavy
Ascaris lumbricoides	Floatation only *or* direct smear 1-19 eggs/smear	Direct smear: 20-49 eggs/ smear	Direct smear: 50-99 eggs/ smear	Direct smear: 100 and more eggs/ smear
Hookworm & Trichuris trichiuria	Floatation only *or* direct smear 1-9 eggs/smear	Direct smear: 10-24 eggs/ smear	Direct smear: 25-49 eggs/ smear	Direct smear: 50 and more eggs/ smear

was asked to make 100 smears out of each of 10 faeces samples. All these smears were weighed with an electric weighing machine. It was concluded that the degree of uniformity was adequate for the purpose of the survey.

The following scale of relative wormburden was adopted.

Whenever there was any doubt in the diagnosis, advice could be sought from the Department of Parasitology, University of Singapore. (Head: Professor R. S. Desowitz)

The chi-square test was used to test the significant level of the recorded and calculated differences. When P was found to be 0·05 or less, the difference was considered statistically significant, and, when P was 0·01 or less, highly significant.

COMPARISON BETWEEN FLAT AND SQUATTER DWELLERS IN THE SURVEY POPULATION*

Dialect Groups

TABLE 1

FAMILIES ACCORDING TO DIALECT GROUPS (all Chinese)

	Flats-area		Squatter-area	
	No.	%	No.	%
Tot. fam.	159	100	169	100
Hokkien	58	36·5	120	71·0
Cantonese	50	31·5	5	3·0
Teochew	29	18·2	36	21·3
Hakka	8	5·0	2	1·2
Hainanese	2	1·3	1	0·6
Foochow	6	3·8	5	3·0
Other	6	3·8	-	-

The Hokkien, Cantonese and Teochew dialect groups together were the best represented in both areas which is a reflection of the distribution of Chinese language groups in the whole of Singapore.** The explanation for the Hokkien group being the largest in the squatter-area may be found in the fact that these people were less affected by the fire by mere reasons of location.

Income Groups

TABLE 2

FAMILIES ACCORDING TO TOTAL INCOME

(Malaysian dollars per month)

	Flats-area		Squatter-area	
	No.	%	No.	%
Tot. fam.	159	100	169	100
< 50	3	1·9	11	6·5
50-100	13	8·2	24	14·2
101-150	39	24·5	62	36·7
151-200	68	42·7	31	18·3
201-250	15	9·4	9	5·3
251-300	7	4·4	1	0·6
> 300	4	2·6	1	0·6
(Unknown, information not given)	10	6·3	30	17·7

It is appropriate to point out that information on income may not be accurate and complete because it is very easy to conceal sources of income, especially income from work other than in a Government or other legally established organization or company. Thus the accuracy of this information is greatly dependent

* The population studied is described here in greater detail than would appear necessary for the present paper. This is because the present paper is the first of a series of reports on investigations into the effects of re-housing on (communicable) disease patterns.
Subsequent reports will not repeat description of the survey population.

** Compare with GOH KENG SWEE (1958)[3]

on the approach of the field investigator, on her ability to achieve people's confidence and on other subjective factors.

In analysing the above data, we may arrive at the average income per month per family per area for those families that gave information in the following way.

We assume the lowest income-level to be Mal.$50.—and the highest Mal.$325.—.For all the income-level groups in between these extremes, we may take the mid-point values (Mal.$75.—, Mal.$125.—, etc.).

The average income per family per month for the flats-area will then come to Mal.$164·58 and for the squatter-area to Mal.$130·49.

Data on expenditure were not collected but the general impression was that flat-dwellers spent more on water—and electricity—bills as compared to squatters because standpipe-water is provided free and usually the costs of electricity are included in the rent of the room.

Family Size

TABLE 3

FAMILIES* ACCORDING TO FAMILY SIZE

	Flats-area		Squatter-area	
	No.	%	No.	%
Tot. fam.	159	100	169	100
Three	5	3·1	12	7·1
Four	19	11·9	15	8·8
Five	26	16·5	31	18·3
Six	25	15·7	27	15·9
Seven	33	20·8	30	17·7
Eight	22	13·8	18	10·6
Nine	14	8·8	14	8·3
Ten	15	9·4	12	7·1
More than ten	-	-	10	5·9
Unknown	-	-	-	-

* Family in this context means man, wife and children

The majority of families in both areas consisted of four to eight persons.

Accommodation

TABLE 4

FAMILIES ACCORDING TO ROOMS OCCUPIED

	Flats-area		Squatter-area	
	No.	%	No.	%
Tot. fam.	159	100	169	100
1 room**	115	72·2	67	39·6
2 rooms	13	8·2	83	49·1
3 rooms	31	19·5	14	8·3
4 rooms	-	-	4	2·3
More rooms	-	-	1	0·6
Unknown	-	-	-	-

** For the squatter-area, room may mean "cubicle" (see further)

Without further details given, it would seem that families in the flats tend to have less space to live in than families in the squatter-area. However, the criterion when to call a space a room in a squatter-hut is difficult to standardize. In the context of this survey, the same classification was used as in the "Social Survey of Singapore, 1947"†. The sizes of the flats, of course, were all standardized. To indicate roughly the problem of overcrowding, the following table may be useful.

Children Included in the Survey

Mean age for the total number of recorded children in the flats-area was 5·85 years and for the squatter children 6·35 years. Mean ages for the age-groups 1-6 years and 7-12 years were respectively 3·65 years, 9·08 years (flats-area) and 3·68 years, 9·23 years (squatter-area).

Mean ages for the total number of children who responded to the collection of stool specimen 5·76 for the flats-area and 6·49 for the squatter-area.

Response in both areas was extremely satisfactory. Only 5·0% of the registered children from the flats and 5·1% from the squatter-huts did not contribute to the stool sampling.

† By "rooms" or "cubicles" is meant a partitioned space which is used for sleeping purposes, or places like dining rooms or halls which, if not actually used for sleeping, are capable for being so used . . . The distinction between a room and a cubicle was based on the nature of the partition—a room was held to be a cubicle if the partition did not reach the ceiling, except that where the top of the partition consisted of expanded metal frame work, or wooden trellis work, or bars reaching to the ceiling, the place was classified as a room.

TABLE 5

ACCOMMODATION AGAINST SIZE OF FAMILIES IN BOTH AREAS

(F = Flat-dwellers, S = Squatters)

Accommodation / Fam. Size	1 room*		2 rooms		3 rooms		4 rooms		more rooms		Total	
	F	S	F	S	F	S	F	S	F	S	F	S
Three	4	8	-	4	1	-	-	-	-	-	5	12
Four	18	9	-	6	1	-	-	-	-	-	19	15
Five	23	15	2	16	1	-	-	-	-	-	26	31
Six	22	12	1	11	2	3	-	1	-	-	25	27
Seven	26	13	3	16	4	-	-	1	-	-	33	30
Eight	13	4	2	10	7	2	-	1	-	1	22	18
Nine	6	3	2	10	6	1	-	-	-	-	14	14
Ten	3	3	3	5	9	3	-	1	-	-	15	12
More	-	-	-	5	-	5	-	-	-	-	-	10
Total	115	67	13	83	31	14	-	4	-	1	159	169

*For the Squatter-area, room may mean cubicle

TABLE 6

TOTAL NUMBER OF RECORDED CHILDREN BY SINGLE YEARS OF AGE AND RESPONSE TO STOOL SAMPLING

Ages/compl. years	Flats-Area		Squatter-Area	
	No. Recorded	No Response	No. Recorded	No Response
Below 1 year	61	3	31	4
1 year	44	1	42	3
2 years	46	4	43	3
3 years	64	3	44	1
4 years	57	3	48	2
5 years	55	3	57	2
6 years	59	4	53	3
7 years	49	2	49	5
8 years	38	2	62	2
9 years	46	1	39	-
10 years	39	1	41	4
11 years	32	-	46	1
12 years	17	2	29	-
Total:	607	29	584	30

3·0 children under the age of 13 years per family.

3·5 children under the age of 13 years per family.

TABLE 7

DISTRIBUTION OF SEXES IN DIFFERENT AGE GROUPS

Children whose stools were examined only

(F = Flats-area, S = Squatter-area)

Age (years)	<1		1-3		4-6		7-9		10-12		Total	
	F	S	F	S	F	S	F	S	F	S	F	S
Boys	22	15	75	55	89	77	61	81	42	58	289	286
Girls	36	14	77	65	73	73	61	63	38	47	285	262
Total:	58	29	152	120	162	150	122	144	80	105	574	548

Sex Distribution

On the whole, there were more boys included than girls.

Ecological (Sanitary) history of the Families

TABLE 8

SANITARY HISTORY OF THE SURVEYED FAMILIES IN BOTH AREAS

Flats-area

Families which were living in that part of the squatter-area that was destroyed in 1961 - 49·7%

Families which came from permanent housing with approximately equal numbers using W.C. *or* bucket system of nightsoil disposal ("Chinatown")* 47·8%

Families which came from other areas with a complex sanitary history - - 2·5%

* A congested part of the city of Singapore mainly consisting of shophouses often constructed "back to back". The name "Chinatown" was given long ago to indicate that area as being reserved for the Chinese population.

Squatter-area

Families which have been living in the squatter-area under study for a period longer than 3 years *or* which came from other urban squatter-areas.** - - 83·1%

Families which came from permanent housing with approximately equal number using W.C. *or* bucket system of nightsoil disposal. - - 16·9%

** This group is hereafter referred to as: "from" squatter-areas.

FINDINGS†

Infection Rate for all Species Together

The infection rate in each age group is higher for squatters than for flat-dwellers. The differences in rates for children of 1 year and older were all statistically highly significant.

Species-pattern

In both areas, the prevalence of hookworm in the examined group of children was very low. Only the older age groups were slightly affected. Flat-dwellers showed a higher prevalence for *Trichuris* in practically all age groups as compared with *Ascaris*. Among squatters, a higher prevalence for *Ascaris* was recorded in the below 1 and 1—3 years age groups, whereas in the older children, prevalence rates for *Ascaris* and *Trichuris* were of the same order. Both *Ascaris* and *Trichuris* were found in the youngest age group.

The differences in rates between flat-dwellers and squatters for *Ascaris* and *Trichuris*

† For convenience, children from the flats-area and squatter-area will be referred to as "flat-dwellers" and "squatters".

TABLE 9

INFECTION RATE (%) BY SINGLE YEARS
(HOOKWORM, *ASCARIS* AND *TRICHURIS* TOGETHER)

Age in completed yrs.	FLATS-AREA			SQUATTER-AREA		
	Tot. No. Ex.	Pos.	%	Tot. No. Ex.	Pos.	%
below 1 yr.	58	3	5·2	29	3	10·3
1 yr.	44	2	4·5	45	20	44·4
2 yr.	45	5	11·1	36	28	77·7
3 yr.	63	16	25·3	39	26	66·6
4 yr.	55	15	27·3	58	46	79·3
5 yr.	52	20	38·4	44	37	84·1
6 yr.	55	24	43·6	48	42	87·5
7 yr.	45	25	55·5	55	43	78·2
8 yr.	35	18	51·4	46	40	86·9
9 yr.	42	17	40·5	43	32	74·4
10 yr.	35	15	42·8	40	37	92·5
11 yr.	31	14	45·1	38	35	92·1
12 yr.	14	10	71·4	27	24	88·8
Total:	574	184	32·1	548	413	75·4

TABLE 10

INFECTION RATE *PER WORM SPECIES* AS A PERCENTAGE OF THE TOTAL NUMBER OF SPECIMEN EXAMINED PER AGE GROUP

(M = male, F = female)

	Age Groups (years)	Tot. No. Exam.	*Hookworm* Pos.	%	*Ascaris* Pos.	%	*Trichuris* Pos.	%
FLATS	below 1 yr.	58	-	-	1	1·7	3	5·2
	1-3	152	-	-	14	9·2	13	8·5
	4-6	162	-	-	20	12·3	53	32·7
	7-9	122	1	0·8	9	7·4	56	45·9
	10-12	80	5	6·2	7	8·7	38	47·5
	Total:	574	6	1·0	51	8·9	163	28·4
SQUATTERS	below 1 yr.	29	-	-	3	10·3	1	3·4
	1-3	120	-	-	72	60·0	33	27·5
	4-6	150	4	2·6	101	67·3	102	68·0
	7-9	144	2	1·4	90	62·5	97	67·4
	10-12	105	6	5·7	78	74·3	82	78·1
	Total:	548	12	2·2	344	62·8	315	57·5

TABLE 11

RATE OF SINGLE AND MIXED INFECTIONS AS A PERCENTAGE OF SPECIMEN EXAMINED PER AGE GROUP

	Age Groups (years)	Tot. No. Exam.	Hookworm only Pos.	%	*Ascaris* only Pos.	%	*Trichuris* only Pos.	%	Mixed Infections Pos.	%
FLAT-DWELLERS	below 1 yr.	58	-	-	-	-	2	3·4	1	1·7
	1- 3	152	-	-	10	6·6	9	5·9	4	2·6
	4- 6	162	-	-	6	3·7	39	24·1	14	8·6
	7- 9	122	-	-	4	3·3	50	41·0	6	4·9
	10-12	80	-	-	1	1·2	28	35·0	10	12·5
	Total	574	-	-	21	3·6	128	22·3	35	6·1
SQUATTERS	below 1 yr.	29	-	-	2	6·9	-	-	1	3·4
	1- 3	120	-	-	41	34·1	2	1·6	31	25·8
	4- 6	150	-	-	23	15·3	24	16·0	78	52·0
	7- 9	144	-	-	18	12·5	24	16·6	73	50·7
	10-12	105	-	-	13	12·4	18	17·1	65	61·9
	Total	548	-	-	97	17·7	68	12·4	248	45·2

Relative Wormburden (Wormload)

TABLE 12

RELATIVE WORMBURDEN FOR ALL AGE GROUPS

(as a percentage of all positive diagnoses per species*)

Hookworm	**Flats-area**		**Squatter-area**	
very light	100	(6)	100	(12)
Ascaris				
very light	41·2	(51)	27·3	(344)
light	39·2		42·6	
moderate	11·8		15·1	
heavy	7·8		14·8	
Trichuris				
very light	99·4	(163)	93·3	(315)
light	0·6		-	
moderate	-	-	6·3	
heavy	-	-	0·3	

* Actual number given within ( )

TABLE 13

RELATIVE WORMBURDEN FOR ASCARIS ONLY PER AGE GROUP

(as a percentage of all positive diagnoses for *Ascaris*)

Age Groups (years)	below 1		1-6		7-12	
	Fl.	Sq.	Fl.	Sq.	Fl.	Sq.
Very light	-	66·6	47·1	24·4	31·3	29·6
Light	-	33·4	35·3	40·1	50·0	45·5
Moderate	100	-	11·7	14·5	6·2	16·0
Heavy	-	-	5·9	21·0	12·5	8·9

were statistically significant to highly significant with one exception: *Trichuris* below 1 age group.

Infection Type

Among the flat-dwellers *Trichuris* single infections prevailed. Among squatters more single infections for *Ascaris* were recorded in the first two age groups,while in older children mixed infections were predominant.

It is to be noted that none of the hookworm infections were classified as single.

All hookworm infections were classified as "very light". *Ascaris* infections among children from both areas were predominantly "very light" and "light" more "moderate" and "heavy" infections were recorded among the squatters. *Trichuris* infections in both areas were considered "very light" in the great majority of cases.

DISCUSSION

There were only few hookworm infections diagnosed. Those from the flat-dwellers were found in stools of ex-squatters, those from the squatter-area in stools of children who were living in that area for a long period (more than two years). The relative absence of hookworm infections may be explained along different lines for each area.

While low prevalence in flat-dwellers may be attributed to proper sanitary facilities, in the squatter-area the soil composition might be considered unfavourable for the development of the soilstages of hookworm. In an overcrowded area, it is very likely that there will be little soil left for development and the little patches available will be subjected to chemical pollution of various types (laundry water, dish water, urine etc.). In addition, cockroaches, which are supposed to act as "natural enemies" of hookworm eggs,[21] were found in abundance in the squatter-area.

It is abundantly clear that among flat-dwellers the infection rate for *Ascaris* was markedly lower than among squatters. As shown in Table 8, families in flats and squatter-area differed proportionally as regards to their sanitary history.

The flats' population already had an advantage in comparison with the squatter population. The group with the worst possible sanitary history, namely ex-squatters with bucket latrines, is in the flats' population represented by 49·7% of the total while 83·1% stands for the comparable group among the squatter population.

Also it is likely that the length of stay in present habitation may have influenced the rates considerably.

It is diffiult, however, to select a time limit for comparison in rates according to length of stay in present habitation.

It is known that hookworm infections persist many years after the last exposure. Chandler (1926, 1929, 1935, mentioned by FAUST)[22] estimated that in a one year period, the egg count for hookworm drops by 70% in absence of re-infection. *Trichuris*' life span is several years, that of *Ascaris* is much shorter, 9 months to one year.

A one year stay in present habitation seems a convenient limit to set for comparison.

The following table shows how infection rates were related to sanitary history and length of stay in present habitation.

For infections by *Ascaris* we observe that among younger flat-dwellers (up to the 4-6 years age group) a history of "squatter area with bucket latrines" was associated with higher rates. In the older children, higher rates were found in the group with "ex-permanent housing with bucket latrine *or* W.C.". It is doubtful whether any conclusion can be drawn from these observations. The group with "ex-permanent housing" is not uniform as to its qualification for nightsoil disposal, and it may be that the majority of older children came from families with bucket latrines in their history. The differences between prevalence rates (Totals) in the two groups of flat-dwellers was statistically not significant.

Among the squatters it is evident that the group with the most unsatisfactory sanitary history has the highest rates. The differences in rates between the two groups are statistically significant to highly significant for all age groups except the 10—12 years group.

The infection rates for flat-dwellers who came from squatter-areas are significantly lower compared with the infection rates for present squatters. This may be explained by the fact that ex-squatter flat-dwellers were moved to a better environment after the fire and had experienced less exposure risks since.

After division in sub-groups for length of stay in present habitation the numbers of observations in different cells (Table 14) become very small. We should therefore confine ourselves to the totals.

For flat-dwellers in both "sanitary" groups the prevalence rates for children who stayed in present habitation longer than 12 months were lower than for children who stayed shorter than 12 months.

The opposite is true for the comparable rates among squatters.

These findings are not surprising.

Assuming that the flats represent the most satisfactory environment they ever had, we may expect the infection rates for children in the flats who came from a less sanitary environment to show a downward trend in time. On the other hand, we may expect the opposite for squatters who came from a less unfavourable environment.

Except for the first age group the prevalence rates for *Trichuris* among flat-dwellers is lower (statistically significant) than among squatters (Table 10). Flat-dwellers in the first age group show a higher rate than squatters (see further).

For flat-dwellers, the rates found for children from "ex-temporary housing with bucket latrine" (Table 14) were consistently higher up to the age group 7—9 years as compared to those belonging to the group "ex-permanent housing with bucket latrine *or* W.C.". In the 10-12 years age group the picture is the reverse. Although the differences were all statistically significant to highly significant the same restrictions as given for infections by *Ascaris* prevent us from drawing sensible conclusions.

For the squatters the infection rates for *Trichuris* in the group associated with a history of "ex-temporary housing with bucket latrine" were significantly higher compared to those for the group with a less unsatisfactory sanitary history.

Comparing the rates (Totals) related to the different length of stay in present habitation one observes slight differences (statistically not significant) in both "sanitary" groups of flat-dwellers.

Again a reverse pattern is shown for rates related to length of stay in present habitation in squatters.

It is evident that the relative predominance of *Trichuris* infections in flat-dwellers is due to the fast rate at which infections by *Ascaris* were lost.

The same argument may be used in explaining the difference in infection type (single *or* mixed infections) between flat-dwellers and squatters.

It is shown that as far as the physical and biological environment is concerned, children in the flats live under better conditions than children in the squatter-area. Especially the provision of safe excreta disposal, the relatively unlimited availability of safe water and the less chance of contact with soil in the living unit and its immediate environment are factors which make the possibility of contact with the infective stages of soil-transmitted helminths less likely.

Could the observed difference in prevalence rates for *Ascaris* and *Trichuris* be due to factors other than environmental?

The survey was not done on the basis of random sampling, the reasons have been explained.

Some of the non-environmental factors that may have influenced the results are now discussed.

Firstly, it should be remembered that not all families which lost their homes in the fire were rehoused in the same area. Many moved to other parts of the city. What were the reasons that brought the families back or kept them away from the former locality? Would it be likely that these reasons might have significance as far as the infection rate of the group is concerned? Only one piece of information is available: that the majority of the families which came back to the area did this to be near to their place of work.

Families from the squatter-area were predominantly of Hokkien origin while in the flats, almost equal numbers of Hokkien and Cantonese families were recorded. The predominance of Hokkien families may have influenced the prevalence rate for the squatter population unfavourably. This is not shown in the following table.

TABLE 14

Infection rate per age group according to length of stay in present habitation and sanitary history of the families

FLAT-DWELLERS

	Age Groups (years)	EX-PERM. HSG., bucket latr. *or* W.C.								EX-TEMP. HSG., (Squatter area) bucket latr.							
		Tot/Pos	%	> 12 ms.			< 12 ms.			Tot/Pos	%	> 12 ms.			< 12 ms.		
				No.	Pos	%	No.	Pos	%			No.	Pos	%	No.	Pos	%
ASCARIS	< 1	23/-	-	17	-	-	6	-	-	35/1	2·8	23	1	4·3	12	-	-
	1- 3	86/3	3·5	70	2	2·8	16	1	6·2	66/11	16·6	50	4	8·0	16	7	43·7
	4- 6	84/8	9·5	68	5	7·3	16	3	18·7	78/12	15·4	61	8	13·1	17	4	23·5
	7- 9	59/6	10·1	48	6	12·5	11	-	-	63/3	4·7	44	2	4·5	19	1	5·2
	10-12	43/5	11·6	33	3	9·1	10	2	20·0	37/2	5·4	26	2	7·7	11	-	-
	Total	295/22	7·4	236	16	6·8	59	6	10·1	279/29	10·4	204	17	8·3	75	12	16·0
TRICHURIS	< 1	23/-	-	17	-	-	6	-	-	35/3	8·6	23	3	13·0	12	-	-
	1- 3	86/3	3·5	70	3	4·3	16	-	-	66/10	15·1	50	6	12·0	16	4	25·0
	4- 6	84/16	19·0	68	12	17·6	16	4	25·0	78/37	47·4	61	27	44·2	17	10	58·8
	7- 9	59/16	27·1	48	12	25·0	11	4	36·3	63/40	63·3	44	28	63·6	19	12	63·1
	10-12	43/30	69·7	33	21	63·6	10	7	70·0	37/10	27·0	26	8	30·7	11	2	18·2
	Total	295/63	21·3	236	48	20·3	59	15	25·4	279/100	35·8	204	72	35·3	75	28	37·3

SQUATTERS

	Age Groups (years)	EX-PERM. HSG., bucket latr. *or* W.C.								EX-TEMP. HSG., (Squatter area) bucket latr.							
		Tot/Pos	%	> 12 ms.			< 12 ms.			Tot/Pos	%	> 12 ms.			< 12 ms.		
				No.	Pos	%	No.	Pos	%			No.	Pos	%	No.	Pos	%
ASCARIS	< 1	4/-	-	3	-	-	1	-	-	25/3	12·0	24	3	12·5	1	-	-
	1- 3	24/6	25·0	13	5	38·4	11	1	9·1	96/66	68·7	93	66	70·9	3	-	-
	4- 6	26/11	42·3	14	6	42·8	12	5	41·6	124/90	72·6	121	88	72·7	3	2	66·6
	7- 9	23/11	47·8	13	10	76·9	10	1	10·0	121/79	65·3	116	77	66·4	5	2	40·0
	10-12	16/11	68·7	13	8	61·5	3	3	100·0	89/67	75·3	87	65	74·7	2	2	100·0
	Total	93/39	41·9	56	29	51·8	37	10	27·0	455/305	67·0	441	299	67·8	14	6	42·8
TRICHURIS	< 1	4/-	-	3	-	-	1	-	-	25/1	4·0	24	1	4·1	1	-	-
	1- 3	24/1	4·1	13	1	7·7	11	-	-	96/32	33·3	93	32	34·4	3	-	-
	4- 6	26/11	42·3	14	6	42·8	12	5	41·6	124/91	73·4	121	88	72·7	3	3	100·0
	7- 9	23/11	47·8	13	7	53·8	10	4	40·0	121/86	71·1	116	83	71·5	5	3	60·0
	10-12	16/11	68·7	13	9	69·2	3	2	66·6	89/71	79·8	87	70	80·4	2	1	50·0
	Total	93/34	36·5	56	23	41·1	37	11	29·7	455/281	61·7	441	274	62·1	14	7	50·0

TABLE 15

SQUATTER FAMILIES WITH 100% RESPONSE (*all* registered children contributed stools for examination)

Infection rate* by dialect groups

	No.	Pos.	%
Hokkien	99	73	73·7
Other	43	33	76·7

* At least one specimen from the family found to be positive for at least one worm species.

The slight differences in family-size are unlikely to have influenced the prevalence rate in one direction or another.

It is difficult to assess the problem of overcrowding and its influence on the prevalence of soil-transmitted helminths mainly because overcrowding is often associated with other conditions detrimental to the environment, such as low income and shortage of dwellings.

It may be said, however, that as far as living space is concerned, the flats' population lives in better ventilated rooms, but it is unlikely that this can account for the significantly lower prevalence rate among children from the flats.

Although not impossible, it appears unlikely that the slightly higher income of flat-dwellers is a significant factor in causing the difference in prevalence rates.

The overall prevalence rate may be greatly influenced by different age-distribution in the comparable groups. Considerable differences were noted in the under 1 year age group with 29 more children from the flats-area. On the average, the squatters are older than the flat-dwellers. The differences, however, are not large enough to explain the difference in prevalence rates.

Also, the slight sex distribution differences in the population studied do not allow us to put any weight on its importance in explaining the prevalence rate differences.

De-worming practices may have influenced the prevalence rates. The following table shows that there were no significant differences in this respect.

TABLE 16

DE-WORMING EXPERIENCE OF CHILDREN WHO CONTRIBUTED TO THE STOOL SAMPLING

(all age-groups)

De-worming experience	Flat-dwellers	Squatters
Regularly by parents*	42·2%	45·6%
Only on doctor's advice	19·5	17·4
No experience	37·1	32·1
Unknown	1·2	4·9

* In Chinese dispensaries, de-worming "cakes" are available. Usually, these "cakes" contain small doses of santonine and piperason.

It may be assumed that de-worming practices in one sub-group may have more significant results with regard to the infection rate of the whole group.

This is not shown in the following table.

TABLE 17

INFECTION RATE (%) ACCORDING TO DE-WORMING PRACTICES

(all age groups)

	Flat-dwellers	Squatters
Regularly by parents	32·6	70·8
Only on doctor's advice	37·5	85·4
No experience	27·2	76·7
Unknown	57·1	70·4
Infection Rate whole group	32·1	75·4

The fact that on the first day of the survey (which was chosen at random), 23 families from the flats were recorded against only 3 from the squatter-area needs further investigation. It may be an indication of different attitudes towards Health Services provided by the M.C.H. clinics which in turn may indicate a difference in "health consciousness". The following table shows information on the use of M.C.H. Services by the children recorded.

TABLE 18

PERCENTAGES OF THE TOTAL NUMBER OF CHILDREN WHO CONTRIBUTED TO THE STOOL SAMPLING All ages (0-13 years)

	Flats-area	Squatter-area
Occasionally brought to a M.C.H. clinic	96·5%	94·7%
Often brought to a M.C.H. clinic	3·5%	5·3%

Another possibility to explain the area-difference on the first survey day was given by personnel of the M.C.H. clinic in the survey area: Squatter families tend to visit the "old" clinic at the Institute of Health (Outram Road) more often than the new Bukit Ho Swee Clinic. The distance from the squatter-area to either clinic is approximately equal while for the families in the flats, the latter is the nearer.

The flats' population was surveyed first. The time lapse between the last examination of stools from the flats and the first from the squatters was approximately two weeks. The whole survey took place mainly in the dry season, the last batch of stool samples being collected at the beginning of the rainy season.

It is considered unlikely that in "chronic" infections like those by soil-transmitted helminths the time factor will influence the prevalence to a great extent. This is especially true for equatorial regions where conditions for development and transmission are favourable and constant throughout the year.

The laboratory technician who did the stool examinations may have been influenced by knowledge of the origin of the specimen. Regular checks by the author did not reveal any irregularities.

HENCE, with some reservations, it can be stated that the differences in prevalence rates for *Ascaris* and *Trichuris* between the two groups studied are likely to be primarily due to more satisfactory sanitary provision in the flats, and secondly to the more favourable ecological history of the majority of families living in them.

The infection rates in the youngest age group (below 1 year) for *Ascaris* among flat-dwellers and squatters were respectively 1·7% (1/58) and 10·3% (3/29) for *Trichuris* respectively 5·2% (3/58) and 3·4% (1/29).

In both areas, these positives were associated with an ecological history of squatter housing and bucket latrines. It is not difficult to accept that children born in the squatter area run a great risk of becoming infected as soon as they are weaned or when they are artificially fed. As soon as utensils and preparation of food are introduced, the chances for contamination and pollution of the food are great, especially in a group of people with a low standard of personal hygiene.

However, it is not easy to understand the mode of infection in an infant from the flats who has been born when his family had been living in the flats for some time. For all (4) positive infants from the flats were from families which had lived there for a period longer than one year at the time of the survey. The four infants all came from families in which more children were found to be infected. *Ascaris* and *Trichuris* need the soil for development. With the facilities for proper disposal of faeces in the flats and only rare contact with infected soil, the remaining possible source of infection would be not properly washed and cooked vegetables* bought from markets or roadside hawkers. And again, personal hygiene may play an important role. Brothers and sisters with soiled hands from playing outdoors, mothers who do not wash their hands properly after handling the purchased vegetables, all are possibilities. An infection may be acquired during a visit in a heavily infected area. However, the infants did not leave the flat except for visits to the M.C.H. clinic or for a stroll with the mother. The possibility of "dirt eating" could, of course, not be ruled out.

Helminth eggs may be carried over considerable distances with dust but there is doubt whether these eggs would be viable enough to establish an infection[23].

CONCLUSIONS

The findings in this survey strongly suggest that re-housing of Chinese families in Singapore from urban slum—and squatter-areas into

* Most vegetable farms in Singapore use nightsoil as fertilizer.

flats with modern sanitation do have a pronounced reducing effect on the prevalence of infections by soil-transmitted helminths (mainly *Ascaris* and *Trichuris*) in children under the age of 13 years in these families.

The most important contributing factors seem to be the better sanitary facilities in the flats and the less chance of reinfection.

A follow up study is required to determine the continuing rate of decline of the worm population among the flat-dwellers, and whether this is influenced by the remaining indirect means of transmission.

SUMMARY

An attempt was made to evaluate the effect of re-housing of Chinese families in Singapore from urban slum—and squatter areas into flats with modern sanitation on the prevalence of infections by soil-transmitted helminths (hookworm, *Ascaris* and *Trichuris*).

For comparison, children up to the age of 13 years were sampled in a squatter-area and in a flats-area and the prevalence of infections by different soil-transmitted helminths were determined by the direct smear method (Beaver) and the brine-floatation method (Willis-Molloy).

The overall prevalence rate for hookworm, *Ascaris* and *Trichuris* together among flat-dwellers was significantly lower than that among squatters being respectively 32·1% and 75·4%.

Infection rates for hookworm in both populations studied were very low 0·0%—5·7%. Infection rates for *Ascaris* and *Trichuris* in flat-dwellers were influenced partly by a more favourable sanitary history of nearly half of the families.

Evidence is presented regarding the influence of length of stay in a particular habitation on the prevalence of *Ascaris* and *Trichuris*.

There was a predominance of *Trichuris* infections among flat-dwellers. The most obvious explanation for this is the longer life span of *Trichuris* as compared with *Ascaris*.

Difference in life span between *Ascaris* and *Trichuris* is also used to explain the difference in proportions of single and mixed infections between flat-dwellers and squatters.

It is concluded that adequate sanitary provision in the flats is the major contributory factor in explaining the significant differences in prevalence rates for *Ascaris* and *Trichuris* between flat-dwellers and squatters.

Possible modes of transmission in the eelow 1 year age group among flat-dwellers are discussed. It is suggested that indirect contact (e.g. food, soiled hands and toys) may play a part.

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