

BEHAVIORS ASSOCIATED WITH WATER CONTACT AND *SCHISTOSOMA JAPONICUM* INFECTION IN A RURAL VILLAGE, THE DONGTING LAKE REGION, CHINA

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Abstract: Although identification of water contact patterns is one of the most important factors for the prevention of *Schistosoma japonicum* infection, it is still insufficient for clarifying specific high-risk behaviors and their implications. Parasitological studies and behavioral observations were carried out in a rural village, the Dongting Lake region, China. A time-allocation study conducted by a time-saving spot-check method was implemented to quantify the behavioral risks. Of the 122 participants, 18 (14.8%; 95% confidence interval: 8.5, 21.0) were positive for *S. japonicum*. Among those diagnosed, the median (25 - 75% quartile) eggs per gram was 8 (8 - 16). A significant positive correlation with worm intensity was found among people who repair ships on the marshland ($p < 0.001$), and this potential risk was consistent with previous suggestions. Although the parasitological techniques and study design require further improvements, our observational methods may be of use to explicitly identify behaviors at the local level that could be relevant to prevention.

Key words: *Schistosoma japonicum*; Schistosomiasis; Water microbiology; Environmental exposure; Behavior; China

1. INTRODUCTION

Schistosomiasis japonica, which is caused by the helminth *Schistosoma japonicum*, is a parasitic zoonosis with more than 40 species acting as definitive hosts [1]. The World Health Organization (WHO) estimates the global number of cases of schistosomiasis due to *Schistosoma* spp. at 200 million, among which 120 million are symptomatic. Moreover, the report states that about 600 million individuals may be at risk worldwide [2]. Since *Oncomelania* snails are still present in numerous areas, and because cattle and buffaloes frequently harbor the infection, schistosomiasis control is a serious challenge even in the 21st century [3].

In mainland China, schistosomiasis japonica remains a major public health problem in eight provinces. Although schistosomiasis gradually decreased after the 1950s and four of 12 provinces succeeded in eliminating the disease, *S. japonicum* was still endemic in 240 counties, with 44 million individuals estimated to be at risk as of 1989 [4]. According to a more recent survey in 2001, 0.8 million humans and 31,500 buffaloes were still infected in China, where the snail habitat area covers 3,436 km² [5].

As the disease is mainly transmitted through contact with infected water, it is of practical importance to identify the most risky behaviors and adopt specific preventive measures. In particular, identification of specific water contact at the local level will contribute to reducing the potential risks. Previous studies explored behaviors associated with water contact by means of questionnaires [6,7] and activity diaries [8-10]. But these do not sufficiently clarify behavioral characteristics, and more detailed quantifications, based on direct observation, are required. In this study, we conducted a cross-sectional behavioral study in a rural village, the Dongting Lake region, and analyzed the behavioral risk factors for *S. japonicum* infection that would be relevant for the design of local lifestyle-oriented prevention programs.

2. MATERIALS AND METHODS

2.1. Study area

Parasitological studies and behavioral observations were carried out in a rural village located in the area called the Dongting Lake region, Hunan Province. Located about

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120 km from the capital city of Changsha, the village lies northeast of Dongting Lake (Junshan district) where the broad marshland (i.e. a type of wetland, a transition zone between land and water) appears in the dry season. The village is in the vicinity of Dongting Lake (Figure 1). Climatologically, the lake has unique characteristics in that the range of water coverage and water level vary dramatically by season [11]. Human habitation is observed near the dike, where floods were often experienced during the wet season. The village is populated by 1,200 individuals (village leader, personal communication) consisting of three distinct groups. Our study focused on a group of 210 persons. Almost all adults make a living as fishermen, and they are officially allowed to catch shrimp and fresh water fish in the Dongting Lake only between July and October. During other seasons, the villagers find jobs in a distant city and work as migrants or continue fishing under special permission from the government.

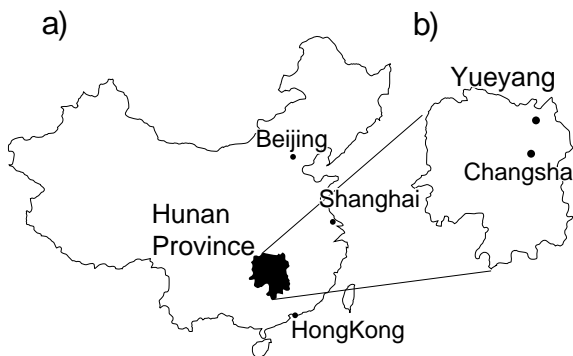


Figure 1. Map of the study area

- a) Hunan province is located in the southeast inner area of mainland China.
- b) The study area, Junshan district in Yueyang city, is the northern-most part of the province, approximately 120 km from the capital city of Changsha.

2. 2. Methods

2. 2. 1. Study preparation

With the assistance of researchers from the Hunan Institute of Parasitic Diseases, we first identified the climatic and environmental conditions in the study area. According to study members from the local Anti-Schistosomiasis Station, the study area has a higher prevalence of *S. japonicum* infection than other villages, averaging three percent of the population throughout the year. Other areas have succeeded in reducing water contact, mainly as a result of the prevention of floods by dike construction. Since the marshland has been recognized as a particularly high-risk location for potential exposure, we decided to explore behaviors at this location. A previous study also documented that the marshland as well as the lake region were specific areas of risk [6].

In other words, we selected this study area because we could expect characteristic high-risk behaviors to be more obvious here than at other sites.

2. 2. 2. Collection of specimens and ethical considerations

This study was approved by the Ethics Committee at the University of Tokyo and the Hunan Institute of Parasitic Diseases. Before commencement of the study, we informed participants that enrollment was voluntary and gave them the right to withdraw at any time. Each subject was informed as to how the information would be used and assured of the confidentiality of responses. The purpose of the study was explained in Chinese, and written informed consent was obtained from participants.

Subsequently, 137 (65.2%) of the individuals approached agreed to participate in the study and detailed survey. Before conducting the behavioral survey, interviews in Chinese were used to obtain demographic information (i.e. age, sex and occupation). The age of subjects ranged from 6 to 87 years. Single stool specimens were collected from the subjects. The Kato-Katz thick smear technique with 41.7 mg of stools (three slides per participant) was used to measure infestation with *S. japonicum* (eggs per gram of feces; epg). The participants, who clearly remembered having received previous treatment, had been given a single oral dose of praziquantel, 40 mg/kg, in 2000 and 2001.

2. 2. 3. Behavioral survey

To explore the behavioral characteristics, time-saving spot-check observations [12] were conducted in October and November 2004. This method records in great detail the time engaged in certain activities and checks the activities of respondents at a scheduled interval in the day. The first author visited the houses of all participants according to a planned time schedule and observed and recorded the activity and location of each participant. The time between 5 am and 7 pm was divided into 14 one-hour intervals and visits were made every other interval on the first day. The intervals not examined on the first day were examined on the second day (Figure 2). Fourteen spot-check records were collected for each individual, or 1708 spot-check observations in total. If a participant was not seen in or around his house when the researcher made a visit, household members or neighbors were asked for his whereabouts. Then, the researcher went to the place to observe his activity there. If the participant had gone to town, no direct observation was made. Continuing this task for two days, almost all activities within the village, including the marshland, had been observed. All observed behaviors were recorded in detail and classified later into 60 categories. In this study, the fol-

lowing 12 behaviors were thought to be particularly high-risk behaviors on the basis of a literature review and discussions in the study location: fishing on the marshland, preparation for fishing on the marshland, repairing ships on the marshland, breeding ducks on the marshland, manual separation of ducks on the marshland, feeding ducks on the marshland, collection of firewood on the marshland, electrical facility fishing, washing, preparation for fishing on dry land, repairing ships on dry land, and working near the fishpond. Electrical facility fishing is defined as an in-river fish sampling method that involves capturing fish using an electric shock technique. As for the last behavior, the fishpond is located outside the dike and has been believed to be safe. The first seven behaviors involve exposure on the marshland, while the latter five are on dry land. Most of the behaviors on the marshland except those related to breeding ducks are conducted when the water level is low and the marshland appears. Therefore most behaviors on the marshland can be observed between October and May, and the villagers had started the behaviors on the marshland about one month before our survey.

	Day (1st)	Day (2nd)
5:00-6:00	observation	
6:00-7:00	data entry	observation
7:00-8:00	observation	data entry
...		
17:00-18:00	observation	data entry
18:00-19:00	data entry	observation
		data entry

Figure 2. Design of the time-allocation study

Each person was observed for two consecutive days, or 14 hours in total. We repeated observations every other hour. On the second day, we reversed the time for observing and entering the data.

2. 3. Statistical analysis

First, associations between infection and demographic or behavioral variables were examined. Except sex, which is a dichotomous variable, age and time allocations for each of the examined behaviors were measured as continuous variables. Thus, to examine the univariate associations, either the χ^2 test or the non-parametric Mann-Whitney test

was used. Second, intensity was used as a dependent variable referring to the geometric mean egg in the population sampled. As the distributions of egg counts were extremely skewed, geometric egg (logarithmic transformation of $\text{egg} + 1$) was used instead. To examine univariate association and correlations between the intensity of infection and other explanatory variables, the Mann-Whitney test (for sex) and the Spearman's rank correlation (for other continuous variables) were used, respectively. We used the non-parametric tests because the distributions of both intensity after the logarithmic transformation and the time allocations were skewed to the right. The level of statistical significance was set at $\alpha = 0.05$. Then, a multiple regression model was used to determine risk factors significantly associated with intensity of *S. japonicum* infection and to eliminate confounding variables. In the multiple regression, we selected the set of variables to be included in the model by the stepwise method. Since there were many potential predictor variables concerning the intensity of *S. japonicum* infection, we selected sex, age, and only variables that were significantly associated or correlated with *S. japonicum* in the univariate analysis.

3. RESULTS

3. 1. Study population and demographic variables

We completed observations for 122 (89.1%) of the 137 individuals who agreed to participate. Nearly one-half were female ($n=58$; 47.5%). The mean age (and standard deviation; SD) of the individuals investigated was 42.1 (19.5) years. Among these, 18 (14.8%; 95% Confidence Interval (CI): 8.5, 21.0) were positive for *S. japonicum*. Two-thirds ($n=12$) of those infected were male, although the Mann-Whitney test showed no significant influence of sex on infection ($p=0.08$). Figure 3 shows the age distributions strati-

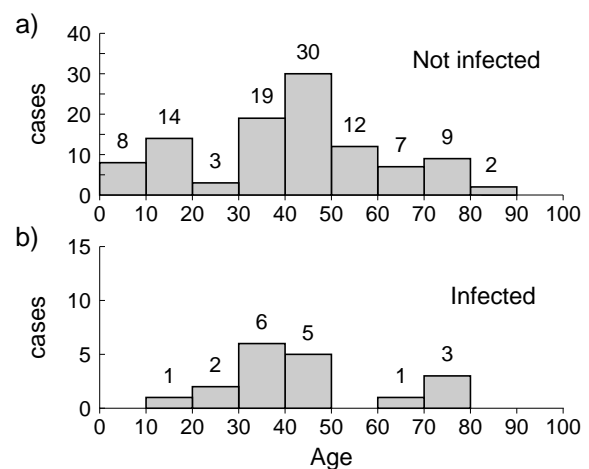


Figure 3. Age distribution by infection with *S. japonicum*
Top: Not infected ($n=104$; 85.25%). Bottom: Infected ($n=18$; 14.75%).

fied by infection. Due to the poverty of the community, many young villagers in their twenties had out-migrated to major cities to seek work. As a result, there were only five villagers in their twenties in this village as shown in figure 3. Age was also not associated with infection ($p=0.91$). Among those diagnosed, the median (25-75% quartile) epg was 8 (8 - 16). The minimum and maximum epg were 8 and 280, respectively. The geometric epg was neither associated with sex ($p=0.49$) nor correlated with age ($p=0.62$).

3. 2. Description of high-risk behaviors

Figure 4 shows distributions of the time-allocation for each behavior by *S. japonicum* infection. Five of a total of seven behaviors on the marshland were performed by participants who were either positive or negative for *S. japonicum*. The participants spent the longest time washing (0.33 hours; 95% CI: 0.22, 0.44), followed by electrical facility fishing (0.25 hours; 0.04, 0.47). On the marshland, fishing (0.12 hours; - 0.02, 0.26) and preparation for fishing (0.12 hours; - 0.05, 0.29) were the behaviors allocated the long-

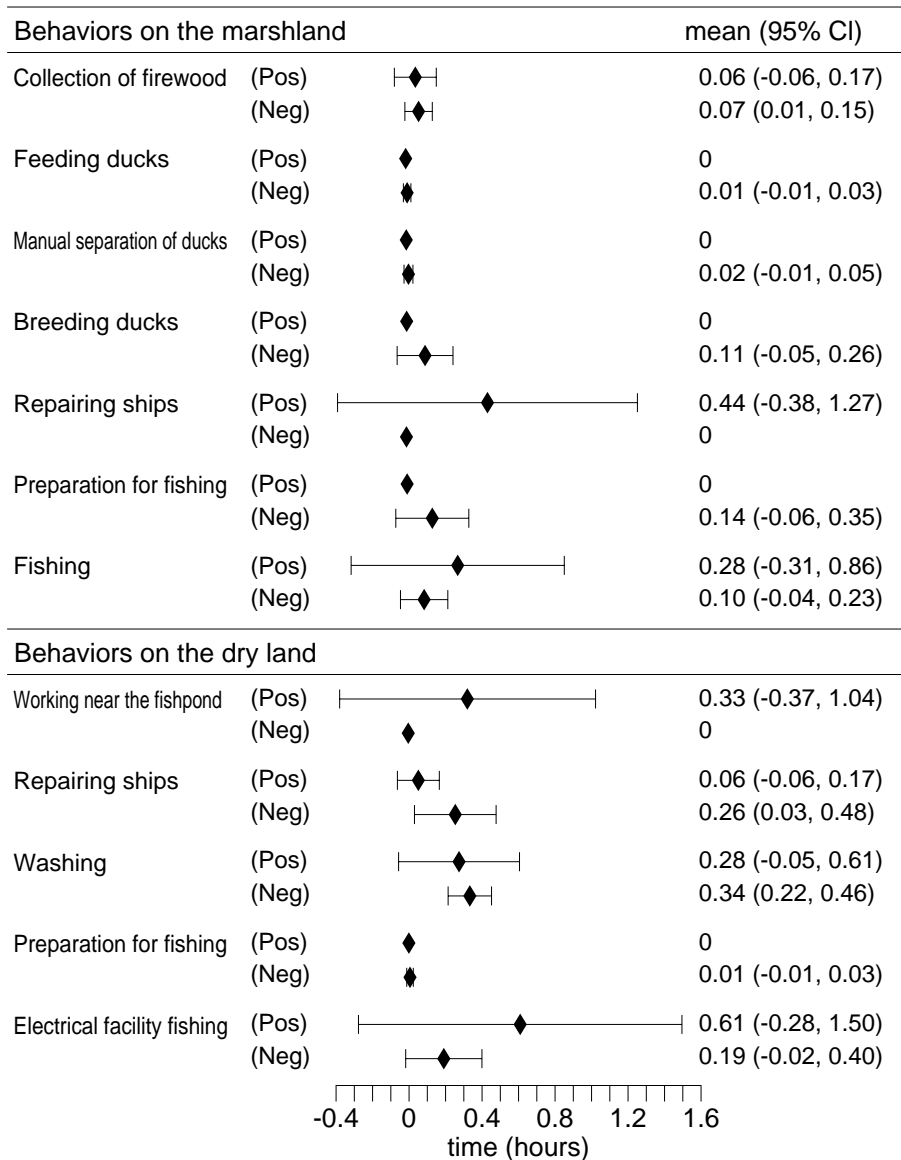


Figure 4. Distribution of time allocated for behaviors on the marshland and dry land
 The upper seven behaviors were those observed on the marshland; the lower five were in other areas. Each time-allocation for the observed behaviors was stratified by infection (i.e. ‘Pos’ and ‘Neg’ refer to infection and not by means of the single Kato-Katz thick smear method). Diamonds represent the mean time allocated for each behavior. The whisker extends from lower to upper 95% confidence limits.

est times. As a whole, the high-risk behaviors observed were performed for only a few hours per day.

3. 3. Univariate analysis of behavioral factors associated with infection and intensity of *S. japonicum* infection

The Mann-Whitney test revealed that the frequency of infection was significantly higher among those who repaired ships on the marshland ($z=3.40$, $p<0.001$). A similar tendency was seen among those who worked near the fishpond ($z=2.38$, $p=0.02$). Moreover, significant positive correlations with intensity of infection were observed for participants who repaired ships on the marshland (Spearman's $\rho=0.32$, $p<0.001$) and those who worked near the fishpond (Spearman's $\rho=0.20$, $p=0.02$).

3. 4. Multivariate analysis of behavioral factors associated with intensity of *S. japonicum* infection

A multiple regression model (Table 1) shows an overall weak model for predicting *S. japonicum* intensity. This model identified repairing ships on the marshland as the only variable significantly associated with the intensity of *S. japonicum* infection ($p<0.001$). Working near the fishpond and sex were not useful predictors of worm intensity.

Table 1. Multiple regression analysis for *Schistosoma japonicum* worm intensity and behavioral factor-related exposure

Independent variables	Parameter coefficient	S.E.	t	p-value
Intercept constant	0.36	0.09	4.11	<0.001
Sex	0.15	0.09	1.69	0.09
Repairing ships on the marshland	0.75	0.14	5.49	<0.001
Working near the fishpond	0.28	0.16	1.74	0.08

From the results of the univariate analyses, repairing ships on the marshland and working near the fishpond were examined with age and sex by stepwise multiple regression analysis. Then sex, repairing ships on the marshland and working near the fishpond were selected for the final model of the predictor of *S. japonicum* intensity (log [epg+1]). $R^2=0.24$, (F value =12.7, $p<0.001$).

4. DISCUSSION

This study investigated specific behaviors associated with water contact and examined the relationship between the behaviors and infection and intensity of *S. japonicum* in a rural village near Dongting Lake. The study location was unique with regard to the variation in water level by season, which could influence the temporal and spatial spread of the disease [13]. The participants in this study were particularly at risk for potential water contact behaviors on the marshland. According to the local Anti-Schistosomiasis Station, the average prevalence in Junshan district was around three

percent (personal communication). The prevalence in this village was higher than the average, but the intensity of *S. japonicum* was low as a whole. The prevalence might be largely influenced by different occupations (which can create heterogeneous patterns), the period of our survey (i.e. seasonal changes in vector ecology and exposure) and mass treatment [14, 15]. Statistical analyses overall did not reveal significant correlations between intensity and the potentially risky behaviors examined. The correlation between working near the fishpond (probably no risk of infection) and *S. japonicum* intensity was significant in the univariate analysis but not significant ($p=0.08$) in the multivariate analysis. Villagers who worked near the fishpond during the survey were fishermen who worked on the marshland on other occasions. Therefore, an apparent correlation was observed between working near the fishpond and *S. japonicum* intensity because working near the fishpond distorted the outcome as confounding factor. In both univariate and multivariate analyses, repairing ships on the marshland was identified as a predictor of *S. japonicum* intensity.

In our direct observation of behaviors, we used a time-saving spot-check method for data collection because it seemed difficult to visit the village, which is located in rural Hunan, to perform repeated observations. Time-allocation observations enabled us to quantify the behavioral data in more detail than questionnaires, 24-hour recall methods or activity diaries. Moreover, a simple questionnaire survey may not be suitable for the identification of behavioral characteristics in detail, because over-reporting of 'correct' behavior (what participants thought they should do) has been claimed in a questionnaire survey related to sanitation and hygiene [16]. With regard to precision and validity, there is a trade-off between exactness of the data and the willingness of subjects to participate in the survey. Since the habitation of the villagers was particularly aggregated, and because their overall participation in the survey was sufficiently high, use of the spot-check method was most suitable for data collection within a limited time period. Consequently, quantifications of the time-allocations for each behavior were reasonable, successful and supported by a valid methodology.

Although the significantly higher risk among participants who repair ships on the marshland may be a straightforward result, it is necessary to discuss the reasons why the other behaviors did not reveal particular relationships with infection and intensity. We attribute this to the following four factors. First, although our study examined infection and intensity by means of the single Kato-Katz thick smear method, it is widely accepted that mild and moderate schistosomiasis japonica can be easily missed when multiple Kato-Katz is not employed [14, 17]. Since it is essential to

measure the relationship between intensity and potential factors, and because *Schistosoma* spp. are macroparasites [18], the low sensitivity of single-field evaluation must be kept in mind [19]. Second, repairing ships on the marshland included the removal of matter clinging to the bottom and side of ships. This activity requires a lot of water. Because of this, repairing ships on the marshland was conducted near water. This is a reason why repairing ships on the marshland was related to both the infection and the intensity. Third, this study differs from previous epidemiologic investigations in that the behaviors were measured in terms of time-allocation (continuous variables); i.e., the statistical correlations between the intensity of infection and exposure doses were examined on the basis of a rough assumption that the dose is proportional to the time-allocation. This anthropological measure enables us to evaluate behaviors quantitatively and qualitatively [12]. But it was extremely difficult to obtain further specific answers in the present setting because of statistical conditions (we examined, not ‘associations’, but ‘correlations’ with intensity, which are far less efficient in elucidating detailed relationships) and because most individuals had experienced exposure on the marshland. Finally, the intensity of schistosomiasis is heavily influenced by genetic heterogeneity [20] and acquired immunity [21]. Considering the potential confoundings among the parasitological factors, future epidemiologic studies should incorporate more biological variables in addition to socio-cultural and socio-behavioral factors.

In conclusion, this study attempted to evaluate the details of high-risk behaviors associated with water contact, and it demonstrated a consistent correlation between the intensity of *S. japonicum* infection and exposure on the marshland. In future studies, several key factors as described above should be taken into account to improve understanding of the epidemiologic process of this disease. By elaborating the details of our investigations at both parasitological and anthropological levels, our methodology may be useful to explicitly identify behaviors at the local level which could be relevant to specific prevention.

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