



Impact of Environmental Education on Water Pollution and the Prevention of Urinary Schistosomiasis in the Sofia Region, Madagascar

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Abstract

Background: Urinary schistosomiasis remains a major public health challenge in Madagascar, particularly in the Sofia Region. While chemotherapy is the standard treatment, sustainable control requires effective health and environmental education.

Objective: This study evaluated the impact of an integrated environmental and health education program on the knowledge, attitudes, and behaviors of populations in endemic villages in the Mandritsara district.

Methods: A cross-sectional survey was conducted in March 2023, comparing 400 individuals from four intervention villages (beneficiaries of educational activities) with 100 individuals from a control village. Data were collected via structured questionnaires and analyzed using chi-square tests.

Results: Knowledge of the disease was significantly higher in the intervention area (82.0% awareness) compared to the control village (6.0%, $p < 0.001$). However, significant gaps remain: 46.6% of respondents in sensitized areas could not cite a single preventive measure, and 42.0% were unaware of the intermediate snail host's role. While modern treatment seeking was higher in the intervention group (63.2% vs 35.9%), high-risk water-contact behaviors persisted. Only 33.0% of respondents in intervention villages reported adopting preventive behaviors, although home-based bathing increased significantly (21.7% vs 8.3%, $p < 0.001$).

Conclusion: Environmental education significantly improves theoretical knowledge of schistosomiasis, but behavioral change is slow. Integrated strategies combining sustained health education with improved access to safe water and sanitation are essential for disease elimination.

Keywords: Schistosomiasis, Environmental Education, Water Pollution, Behavioral Change, Sofia Region, Madagascar, Public Health.

1. Introduction

Urinary schistosomiasis is a parasitic disease of major public health importance, particularly in tropical countries such as Madagascar (World Health Organization, 2013) ^[8]. Globally, the disease is endemic in 76 countries and affects approximately 200 million people. In Madagascar, it shows one of the highest prevalence rates worldwide, with an estimated 52% of the population potentially infected, and transmission reported in more than 74% of administrative districts (World Health Organization, 2023; Ministry of Public Health Madagascar, 2018) ^[8, 4].

Urinary schistosomiasis is closely associated with contact with contaminated freshwater. In the Sofia Region, particularly in the district of Mandritsara, limited access to safe drinking water, frequent use of natural water bodies, water pollution, poor

sanitation, and inadequate hygiene practices considerably increase the risk of infection (Ministry of Public Health Madagascar, 2018).

Effective control of schistosomiasis requires not only chemotherapy but also sustained changes in water-related behaviors and improved knowledge of prevention and treatment. The World Health Organization emphasizes the integration of health education with medical treatment as a key component of schistosomiasis control strategies (Rollinson *et al.*, 2013) [6].

However, despite the implementation of these strategies, few studies have assessed the specific impact of environmental and health education on population knowledge and behaviors related to water use. Therefore, this study aims to evaluate the impact of environmental education on water pollution and the prevention of urinary schistosomiasis in the Sofia Region of Madagascar, focusing on knowledge and behavioral changes among exposed populations (Rollinson *et al.*, 2013; World Health Organization, 2013) [6, 8].

2. Materials and Methods

2.1. Overview of the Urinary Schistosomiasis Control Project in the Sofia Region

The urinary schistosomiasis control project was implemented in the Sofia Region as part of national and international efforts to reduce the burden of schistosomiasis in endemic areas (World Health Organization, 2013; Ministry of Public Health Madagascar, 2018) [8, 4].

The project pursued two main objectives: to reduce morbidity due to urinary schistosomiasis among populations exposed to contaminated water, and to integrate schistosomiasis control activities into basic health services (World Health Organization, 2013) [8].

The project's intervention area was located in the Sofia Region, particularly in the district of Mandritsara. It covered several rural villages characterized by the presence of natural water bodies used for daily activities. The population of the intervention area was estimated at approximately 250, 000 to 300, 000 inhabitants, distributed across more than 200 villages (Ministry of Public Health Madagascar, 2018) [4].

Chemotherapy, health education, training in schistosomiasis control, and environmental sanitation were selected as the main intervention strategies to achieve the project's objectives in the Sofia Region, especially in the district of Mandritsara, in accordance with WHO recommendations for integrated schistosomiasis control (World Health Organization, 2013; Rollinson *et al.*, 2013) [8, 6].

Surveys conducted by the project showed that 80–100% of school-aged children were infected and that up to 45% of pupils presented definite or probable ureterorenal dilatations (Ministry of Public Health Madagascar, 2018) [4]. Baseline data collection identified 52 primary schools and 6, 993 pupils, of whom approximately 25% did not attend school regularly. In the region, illiteracy rates among individuals over 15 years of age were estimated at 88% for women and 78% for men (National Institute of Statistics Madagascar, 2019) [5].

The intervention area included 12 health facilities (dispensaries). Only 15% of villages had at least one functional television set, and 40% relied exclusively on non-potable water sources such as ponds for their water supply (Ministry of Public Health Madagascar, 2018) [4].

A follow-up survey conducted one year after project implementation showed a reduction in the prevalence of heavy infections (≥ 50 eggs per 10 ml of urine) from 88% to 40%, demonstrating the impact of combined control strategies (Ministry of Public Health Madagascar, 2018) [4].

2.2. Health Education Strategy Implemented in the Sofia Region

Awareness-raising activities constituted the core of the intervention strategy, in line with WHO recommendations emphasizing health education as a key pillar of schistosomiasis control (World Health Organization, 2013) [8].

Several educational methods were used:

1. Screening of an educational video by the project team, with up to five sessions per village, followed by discussions.
2. Community discussion groups held twice monthly, facilitated by local health and hygiene workers acting as health educators. These sessions included presentations using illustrated flipcharts followed by open discussions with villagers.
3. School-based information sessions for pupils, using educational materials specifically developed for this purpose, including:
 - an educational film in the local Malagasy language produced with community participation;
 - flipcharts;
 - slide presentations;
 - posters illustrating urinary schistosomiasis;
 - a hygiene education booklet for Grade 5 pupils and a guide for teachers.

The educational messages focused on water-related behaviors, modes of transmission, and methods of prevention and treatment of urinary schistosomiasis (World Health Organization, 2013; Rollinson *et al.*, 2013) [8, 6].

2.3. Study Method

A questionnaire-based cross-sectional survey was conducted to compare outcomes in the intervention area with those of a hyperendemic control village not exposed to awareness-raising activities, located near natural water bodies. The survey was carried out from March 10 to March 20, 2023.

Village selection followed a purposive sampling approach, commonly used in community-based public health studies (Kumar, 2019) [3]. Given the size of the intervention area (>200 villages), a representative sample of villages and households was selected. Four rural villages (Marotandrano, Antrramidola, Andohajango, and Ambodimanga) were chosen due to their high exposure to surface water. A control village with similar environmental conditions and water-use practices but without project interventions was also selected. The study population consisted of 500 individuals: 400 from intervention villages and 100 from the control village. Household selection was based on data from the most recent national population census (National Institute of Statistics Madagascar, 2019) [5]. Households were randomly selected, and all individuals aged over 10 years within selected households were interviewed.

In the intervention area, 80 households were surveyed across the four villages (approximately 20 households per village).

Data were collected using structured questionnaires during face-to-face interviews, entered into a computer database, and analyzed using statistical software. Comparisons between groups were performed using the chi-square (χ^2) test.

2.4. Ethical Considerations:

Permission to conduct the study was obtained from the Regional Health Authorities of the Sofia Region. Participants were informed about the objectives of the survey and their right to withdraw at any time. Informed consent was obtained from all respondents prior to the interview. For minors, consent was provided by their legal guardians. To ensure confidentiality, no personal identifiers were recorded in the database.

3. Results

3.1. Characteristics of the Surveyed Population

Across all villages included in the survey, 500 individuals were interviewed. A predominance of females was observed (approximately 55%).

Surveyed participants were aged 10 years and older, with a mean age estimated at 23 ± 7 years.

The majority of households consisted of 5 to 10 members (approximately 57%).

The educational level of the surveyed population was generally low. Illiterate individuals accounted for approximately 85% of all respondents.

Extended households constituted the majority of the households surveyed.

Table 1: Distribution of Respondents by Age and Sex

Village	10–14 (M)	10–14 (F)	15–19 (M)	15–19 (F)	20–29 (M)	20–29 (F)	30–39 (M)	30–39 (F)	≥40 (M)	≥40 (F)	Total (M)	Total (F)
Marotandrano	10	14	15	20	18	24	8	11	4	6	55	75
Antratramidola	9	15	16	22	17	23	7	10	5	6	54	76
Andohajango	8	13	14	19	16	21	6	9	6	8	50	70
Ambodimanga	9	16	15	21	14	22	6	11	3	7	47	77
Control village	11	17	18	23	20	25	7	12	3	9	59	86
Overall total	47	75	78	105	85	115	34	53	21	36	265	235

Total number of respondents: 500, M = male, F = female

Table 2: Status of Respondents During the Survey

Village	Number of Households Surveyed	Average Number of Persons per Household	Residents (%)	Visitors (%)
Marotandrano (n = 130)	20	6.5	98.5	1.5
Antratramidola (n = 130)	20	6.5	98.7	1.3
Andohajango (n = 120)	20	6.0	99.0	1.0
Ambodimanga (n = 120)	20	6.0	98.8	1.2
Total sensitized villages (n = 400)	80	6.3	98.8	1.2
Control village (n = 100)	20	5.0	98.0	2.0
Overall total (n = 500)	100	5.9	98.6	1.4

3.2. Sources of Information Used by the Population (Diagram)

In the intervention area, project activities constitute the main source of information for the population regarding urinary schistosomiasis, followed by community health workers and schools. In contrast, in the control village, the population has very few structured sources of information on the disease; other means of information have a limited impact and account for less than 5% of the sources cited across both areas.

Other sources of information mentioned mainly include health facilities and, to a lesser extent, community meetings organized by other local initiatives.

3.3. Awareness of the Project and Its Activities

In the sensitized area, 82.0% of respondents reported being aware of the existence of the urinary schistosomiasis control project, compared with 6.0% in the control village ($p < 0.001$). Project activities are significantly better known in villages that benefited from awareness-raising actions.

Among the activities cited, awareness-raising is the most widely known (62.0%), followed by sanitation actions, particularly latrine construction (26.0%), and then screening

activities (12.0%). Outside the intervention area, 54.0% of respondents reported being aware only of awareness-raising activities, while 18.0% stated that they had participated exclusively in community discussion activities and 14.0% in both awareness-raising actions and community exchange sessions.

3.4. Knowledge of the Clinical Manifestations of Urinary Schistosomiasis

Overall, in the study area, 56.0% of respondents referred to urinary schistosomiasis by its most commonly used local name, while 41.0% used another local designation. The correct term for the disease was used both by sensitized populations (58.0%) and by those in the control village (52.0%).

Clinical manifestations of urinary schistosomiasis other than hematuria remain largely unknown, both in the sensitized area and in the control village. Among all respondents, painful urination was the most frequently cited symptom (45.0%), followed by burning during urination (17.0%) and general weakness (16.0%).

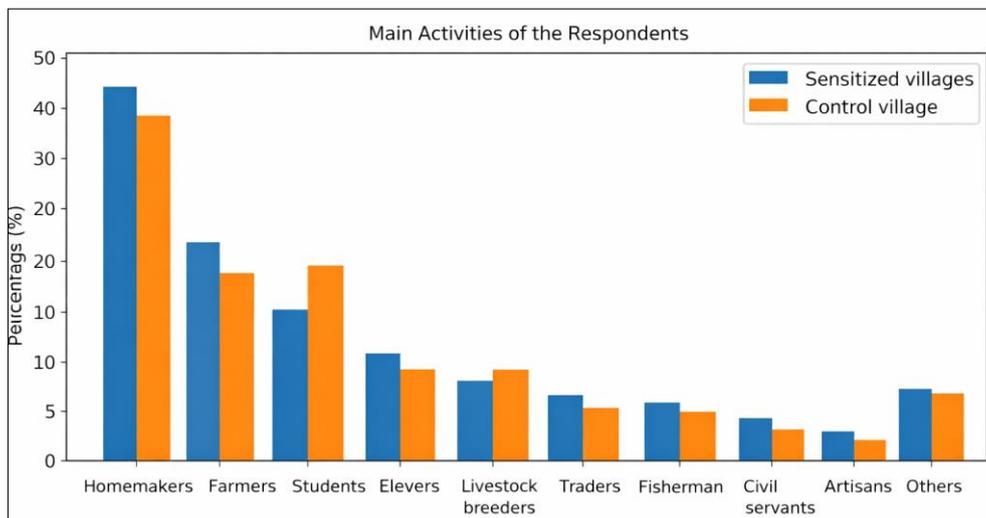


Fig 1: Main Activities of the Respondents

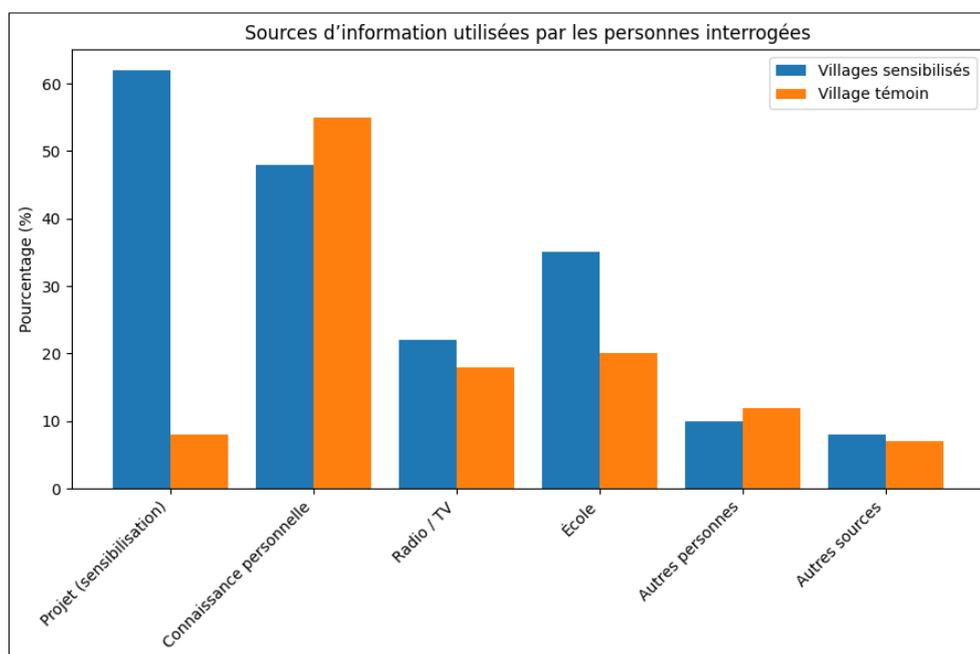


Fig 2: Sources of Information Used by the Respondents

3.5. Knowledge of Disease Transmission

In the sensitized villages, 71.0% of respondents reported knowing at least one route of transmission of urinary schistosomiasis, compared with 57.0% in the control village ($p < 0.001$). The main transmission sites identified were natural water bodies, particularly rivers, ponds, and stagnant water areas used for daily activities (Table 3).

In the control village, 32.0% of respondents stated that they did not know the modes of transmission of urinary schistosomiasis.

Overall, the concept of an intermediate host remains poorly understood both in the sensitized area and in the control village. In the intervention area, 42.0% of respondents were unaware of the existence of an intermediate host in the transmission of the disease, compared with 84.0% in the control village ($p < 0.001$).

Across all surveyed villages, 12.0% of respondents correctly identified the intermediate host of urinary schistosomiasis. However, this knowledge was significantly higher in the sensitized area (20.0%) than in the control village (2.0%) (p

< 0.001).

3.6. Perception of the Role of Humans in Disease Transmission

In the intervention area, 69.0% of respondents reported knowing at least one behavior that promotes the transmission of urinary schistosomiasis, compared with 40.0% in the control village ($p < 0.001$).

The main activities cited as favoring the transmission of urinary schistosomiasis were bathing in natural water bodies, washing clothes or dishes in water, and agricultural activities in flooded environments, particularly rice cultivation (Table 4). These behaviors were significantly better identified by populations in the sensitized villages than by those in the control village.

In addition, 6.0% of all respondents incorrectly attributed urinary schistosomiasis to poor dietary habits, such as excessive consumption of fatty or sugary foods.

Finally, 40.0% of respondents stated that they were not aware of any behavior favoring the transmission of urinary

schistosomiasis, with this proportion being higher in the control village than in the area that benefited from awareness-

raising activities.

Table 3 : Knowledge of Transmission Sites of Urinary Schistosomiasis (%)

Transmission sites	Ponds / Pools	Rivers	Irrigation canals	Rice fields	Other sites	Know at least one site	Do not know
Sensitized villages (n = 400)	22.0	19.0	21.0	10.0	12.0	71.0	17.0
Control village (n = 100)	5.0	42.0	5.0	6.0	11.0	57.0	32.0
Total (n = 500)	18.0	24.0	17.0	9.0	12.0	65.0	24.0

Table 4: Knowledge of Conditions Favoring the Transmission of Urinary Schistosomiasis (%)

Conditions favoring transmission	Poor dietary habits	Bathing	Washing clothes / dishes in water	Rice cultivation	Sun exposure	Fate	Other	Do not know	Know at least one cause
Sensitized villages (n = 400)	6.0	53.0	6.0	8.0	1.0	4.0	4.0	14.0	69.0
Control village (n = 100)	1.0	34.0	2.0	4.0	0.0	0.0	22.0	39.0	40.0
Total (n = 500)	5.0	46.0	5.0	7.0	1.0	3.0	10.0	25.0	56.0

3.6. Knowledge of Transmission Conditions of Urinary Schistosomiasis

Assessment of Knowledge of Control Measures

Among all respondents, 95.0% of inhabitants of the sensitized villages reported being aware of the existence of a treatment for urinary schistosomiasis, compared with 79.9% in the control village ($p < 0.001$). This general awareness of the existence of a treatment, including in the control village, reflects the influence of informal sources of information such as personal experience or community exchanges, independently of project activities.

In contrast, knowledge of modern treatment was significantly higher in the sensitized area (63.2%) than in the control village (35.9%) ($p < 0.001$). Conversely, knowledge of traditional treatment remained markedly more frequent in the control village (52.7%) than in the sensitized area (13.3%) ($p < 0.001$), reflecting the impact of awareness-raising activities in guiding populations toward modern healthcare practices (Diagram 3).

In the project intervention area, 42.4% of respondents

reported having already received modern treatment for urinary schistosomiasis, compared with 9.8% in the control village. Among those who had received modern treatment, 86.2% reported being satisfied. Those who were not satisfied (13.7%) mainly cited the persistence of habits and activities favoring disease transmission (35.7%) as well as the perceived inefficacy of the treatment (19.2%).

Knowledge related to control measures against urinary schistosomiasis is presented in Table 5. The proportion of individuals reporting no knowledge of any control measure remained high in both areas, with 46.6% in the sensitized area and 50.4% in the control village ($p = 0.34$; not significant).

However, among respondents who reported knowing at least one control measure (53.4% in the sensitized area versus 49.6% in the control village), the measures cited differed markedly. In the sensitized area, responses mainly referred to the use of modern treatment, avoidance of contact with contaminated water, and sanitation actions, whereas in the control village, responses were largely based on vague perceptions or traditional practices.

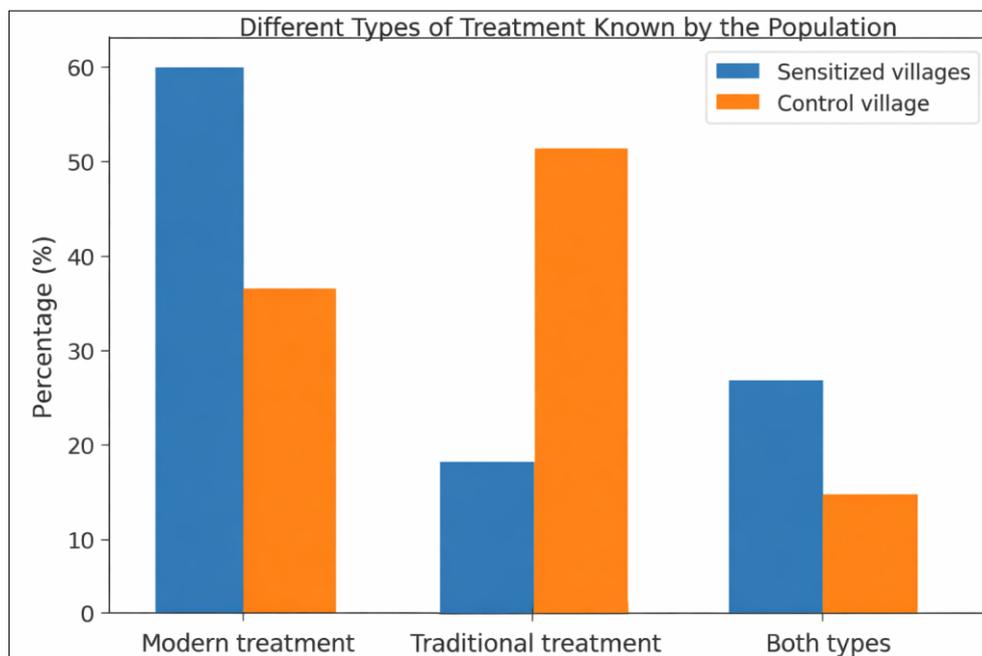


Fig 3 : Different Types of Treatment Known by the Population

Avoiding bathing in natural water bodies and seeking treatment were the control measures most frequently cited by respondents. Other means of control were mentioned in

15.0% of cases and mainly included drinking safe water, washing with soap, consuming herbal teas, and avoiding certain foods considered harmful, such as sugary, oily, or

spicy foods.

3.7. Behavioral Changes

Overall, 33.0% of respondents in the intervention area reported having adopted at least one behavior favorable to the prevention of urinary schistosomiasis, compared with 12.2% in the control village ($p < 0.001$), reflecting a significant impact of awareness-raising activities.

Bathing sites used by respondents are presented in Table 5. Across the entire surveyed population, the proportion of individuals washing outside transmission sites remains low: 15.8% reported bathing at home and 1.2% used a bucket at the edge of water points.

In contrast, transmission sites remain widely frequented, with 62.6% of respondents bathing in natural water bodies and 19.6% in canals or stagnant water areas.

However, the proportion of individuals bathing at home was significantly higher in the sensitized area (21.7%) than in the control village (8.3%) ($p < 0.001$), indicating a positive behavioral change associated with environmental and health education activities.

4. Discussion

Although the results show a significant improvement in

knowledge and certain behaviors in sensitized villages compared with the control village, these improvements remain partial and insufficient to induce sustainable behavioral change at the community level. The measures most frequently cited in the intervention area were avoidance of bathing in natural water bodies (31.7%) and seeking treatment (21.7%), reflecting the impact of the health education actions implemented.

However, a substantial proportion of respondents, both in the sensitized villages (46.6%) and in the control village (50.4%), reported no knowledge of any control measure against schistosomiasis. This situation highlights the limitations in the appropriation of educational messages by the population, despite awareness-raising efforts.

Moreover, certain essential preventive measures—such as cleaning irrigation canals, avoiding washing clothes or dishes in water bodies, and using personal protective equipment—remain poorly known, even in the sensitized area. These findings suggest that while health education has led to partial improvements in knowledge, strengthening and diversifying educational strategies are still necessary to promote better understanding and sustained adoption of preventive behaviors.

Table 5: Bathing Sites of Respondents in the Sofia Region (%)

Bathing sites	At home	In irrigation canals	In rivers / natural water bodies	In ponds	Using a bucket at the edge of canals	Other places
Sensitized villages (n = 400)	21.7	35.0	40.0	0.9	2.1	0.3
Control village (n = 100)	8.3	0.0	91.3	0.0	0.0	0.4
Total (n = 500)	15.0	17.5	65.7	0.5	1.0	0.4

Places where the people interviewed bathed.

The low representation of men over 40 years of age in our sample may be explained by seasonal or long-term migration of young men to urban or mining areas, a phenomenon frequently observed in the Sofia Region. Indeed, a significant proportion of young men leave rural villages for economic reasons, which influences the demographic structure of the surveyed populations.

Interpersonal communication, particularly within families and the community, constitutes the main source of health-related information in the study area. The media and health facilities also play a non-negligible role in information dissemination. Schools appear to be an essential relay for the transmission of knowledge, especially in villages with limited access to health services, thus confirming the importance of school-based education in community awareness.

Urinary schistosomiasis is relatively well known among the populations under various local names, reflecting cultural representations of the disease. Some local terms associate the disease with natural factors such as the sun or heat, a perception previously reported in other African contexts. These representations indicate a partial understanding of the disease and its actual causes.

The concept of an intermediate host in the transmission of schistosomiasis remains largely unknown among the surveyed populations. Although the link between water contact and the disease is generally recognized, many individuals believe that contamination occurs mainly through the ingestion of contaminated water. This erroneous perception, also reported in several studies conducted in Africa, explains why drinking safe water is frequently cited

as the main preventive measure.

Moreover, certain beliefs attributing schistosomiasis to the consumption of sugary, oily, or spicy foods persist within the population. Such representations have also been described in other African studies and reflect confusion between the biological causes of the disease and dietary factors.

Despite the health education activities implemented, knowledge of schistosomiasis control measures remains generally low. For the population, avoidance of contact with water appears to be the main preventive measure, whereas schistosomiasis control relies on an integrated approach combining treatment, improved sanitation, and sustained behavioral change.

Finally, the population resorts to both modern and traditional treatment methods. Individuals who benefited from modern treatment within the framework of the project reported high levels of satisfaction, highlighting the perceived effectiveness of therapeutic care when it is accessible.

5. Conclusion

Thanks to the environmental and health education activities implemented in the Sofia Region, a notable improvement in knowledge about urinary schistosomiasis was observed in villages that benefited from awareness-raising actions compared with the control village. These results confirm the relevance and importance of health education in endemic areas.

However, behavioral changes remain slow and limited despite increased knowledge levels. The adoption of preventive practices is still insufficient, particularly with regard to reducing contact with contaminated water. This situation highlights that health education is a long-term

process requiring continuous engagement, appropriate resources, and sustained support for populations.

Information disseminated within communities—particularly through schools and trained teachers—represents a key lever for knowledge diffusion and long-term reduction of transmission. As school-aged children play a central role in transmission dynamics, their involvement in educational activities is especially strategic.

Although schistosomiasis control relies primarily on chemotherapy to reduce morbidity, health education activities remain essential to encourage regular use of modern treatment, improve understanding of the disease, and promote sustainable preventive behaviors.

In conclusion, environmental and health education should be integrated as a permanent component of urinary schistosomiasis control programs in the Sofia Region. Its effectiveness will be strengthened by complementary actions aimed at improving access to safe drinking water and environmental sanitation, which are essential conditions for a sustainable reduction in disease transmission.

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