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Factors Associated with Elimination of Soil Transmitted Helminths in the Maldives.

Raheema Abdul-Raheem[*1], Fazeela Waheed[2], Aishath Majidha Hassan[2], Sana Saleem[3] Shushil Dev-Pant[4], Thimna Latheef[4], Hawwa Afra[1], Rifaath Hassan[1], Fathimath Thohira[3], Ahmed Jamsheed Mohamed[5], Antonio Montresor[6]

[1]The Research Development Office, The Maldives National University, Maldives
[2]Faculty of Health Sciences, The Maldives National University, Maldives
[3]Health Protection Agency, Maldives
[4]World Health Organization Country Office-Maldives
[5]World Health Organization Regional Office for South-East Asia
[6]World Health Organisation

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Abstract

The aim of the study was to find out the effectiveness of the school-based deworming program by determining the prevalence and intensity of STH in children aged 2-14 years by identifying factors associated with Soil Transmitted Helminth (STH) infections. A cross-sectional survey consisting of 1432 participants was carried out. The study adopted a clinical component (examination of stool samples) along with administration of a questionnaire to the selected sample to determine the prevalence and intensity of the worm infestation in the population. The laboratory results show that the presence of STHs was not observed in most of the samples tested. *Trichuris Trichiura* was found in one stool sample from one of the northern islands (Nolhivaram). Pin worms were found in three samples from one of the Southern islands (Isdhoo). The deworming program is effective in eliminating STHs in most of the parts of the Maldives. The current frequency of administration of deworming tablet in the school health programs needs to be revised to treat children with deworming tablets once a year according to WHO guideline.

Introduction

Soil Transmitted Helminth (STH) infections are caused by different types of helminths and worms. These infections are caused by eggs present in human faeces in the soil and are considered to be a major public health problem in many of the tropical and subtropical countries. World Health Organisation (WHO) estimates that there are more than 1.5 billion people who are infected with soil transmitted helminths worldwide [1]. In most areas in Kenya for 2009, there were areas of endemicity of STH ≥20% located around the shores of Lake Victoria and on the coast. The high prevalence of STH in the Kenyan study can be attributed to poor hygiene, lack of proper sanitation facilities and poverty [2]. A study conducted among elementary school children in Ambo town, Western Ethiopia showed that the prevalence of any STHs infection was 12.6%. The respective prevalence of major soil-transmitted helminths in this study is Ascaris (7.8%), Hookworm (2.8%) and *Trichuris* (2.2%). The results of this study show that STHs prevalence varies based on age, sex, latrine use, family size and nail trimming [3]. Although the prevalence of STH is high in some countries, it can be controlled with successful periodical deworming and improved sanitation to reduce the soil contamination. Maldives has been having a school-based deworming programme for 21 years [4] while access to improved drinking water and flushed toilet has increased to 98% [5]. Hence, the aim of this study was to find out the effectiveness of the deworming school program by determining the prevalence and intensity of STH in children aged 2-14 years by identifying factors associated with STH infections. The Maldives has overcome a lot of public health problems which were prevalent in the early 1980-2000 period due to hard work of health practitioners in the community. Much of the burden of the communicable diseases present in early 1980s or 1990s have been eliminated or nearly eliminated since then. In addition, there has been rapid economic transition in the Maldives which has brought about better living conditions and improvement in education over the years. From 1999 onwards, there have been regular deworming intervention programs implemented in the Maldives. In the Maldives, vitamin A and deworming supplementation program was first introduced in 1999 for school aged children between 6-13 years [4]. For pre-school aged children 2-5 years, it was started in 2010 [4]. Both vitamin A and deworming tablets are given twice a year (once every 6 months) and this program has been ongoing throughout the country since 1999 [4]. Based on the National Programme Administrative data, the national coverage rate of deworming was 60% in preschool age children (5 years) and 55% in the primary school age children (6-13 years) in the year 2013 [4]. In the Maldives, deworming program is being conducted as a voluntary program where deworming is provided with parents' consent, as some of the parents give deworming tablets at home with the advice from individual doctors or by parents themselves. This might be the reason that the coverage rate is below 60%. There is very limited research done to evaluate the prevalence of STH in the Maldives. Direct assessment of stool

samples for identification of prevalence rates were conducted for the National Micronutrient Survey in 2007 [6]. According to the National Micronutrient Survey 2007, only 4% of children, from the sample of children aged 6 months to 5 years, were found having any kind of worm infection. This result was based on analysis of the collected stool samples from children aged 6 months to 5 years in the atolls using Kato Katz technique. Breakdown of the analysis showed that majority of the helminth types present in the stool were Whipworms (3.8%) followed by Round Worms (0.38%). No hookworms were present (0.0%) in any of the examined stool samples [6]. In addition to the clinical examination of the stool sample, mothers (with children aged 6 months to 5 years) were asked to recall their diagnosis with any kind of worm infestation. The results showed that overall prevalence was low, with 0.9% of the participants reporting STH infection at the time of data collection and 7.2% of the participants recalled STH infection within 6 months prior to the time of data collection for the survey [6]. A limitation of the National Micronutrient Survey 2007 was that stool sample analysis was not conducted for the participants selected in the capital city of Male'.

World Health Organisation normally recommends regular deworming intervention in areas where prevalence of STH is above 20% [1]. It is estimated by WHO that approximately 840.2 million children across the world require treatment for STH and it has been reported that 27 countries have reached the target of treating at least 75% of school-aged children for STH infection [1]. The scenario of the burden of STH infection in the Maldives is somewhat hazy, considering the limited data available from routine surveillance programmes and the available data from the National Micronutrient Survey conducted more than 10 years back. Since then, a lot of circumstances may have changed, and it is expected that much improvement in the form of improved sanitation and hygiene factors may lead to an expected decline in the prevalence of STH. However, this cannot be deduced without a proper study comprising of adequate coverage and clinical examination of the study population. Hence, as per the recommendation of WHO, it is important to conduct a survey to determine the present status of STH infection and to monitor the impact of the existing programmes. The findings of such a study will assist in making an informed decision regarding the policies related to the control of STH and deworming programme in the country.

Methodology

Ethics Statement

The study was approved by the National Health Research Council. Verbal and written consent were obtained from caregivers of the selected children prior to collecting data indicating that they understood both the purpose of and procedures required for the study, and that they were willing to let their children participate in the study. Every measure was taken to be discreet during interview sessions and reassurance about confidentiality measures were done by enumerators. Research team planned measures to advise survey participants if the results were positive for soil transmitted helminth eggs and if any further intervention is needed or if medical advice is required.

Research Design

The study design recommended for establishing prevalence and associations related to the STH is quantitative in nature, adopting a cross-sectional survey design. The study adopted a clinical component (examination of stool samples) along with administration of a questionnaire to the selected sample to determine the prevalence and intensity of the worm infestation in the population. Quantitative cross-sectional survey approach was used in order to identify the prevalence and to generalise the findings to the selected population. This study was proposed to be carried out in six regions of the country, namely Male', North Region, North Central region, Central Region, South Central Region and South Region.

Sample Population

Sampling Criteria

The following are the sampling criteria for the study:

Inclusion Criteria

- Preschool-Aged Children (PAC) between 2 years and 6years of age enrolled in school
- School-Aged Children (SAC) between 7 years and 14 years of age enrolled in school

Exclusion Criteria

- Pre-School Children aged between 2-14 years enrolled in school who may not be able to participate due to impairment of mental, physical well-being or health of the child

Sampling Technique and Sample Size

A cross sectional survey was proposed to be adopted for the study using multi-stage cluster sampling method. A multistage cluster sampling method was used since there are multiple geographic locations in the Maldives which consists 6, regions divided into 20 atolls which are further divided into small islands (206 inhabited islands). Studies with similar geographies and study settings have used multistage cluster sampling [7, 8]. For the purpose of the study, Male' region, north central region, the central region, south central region and south region were considered as 6 different clusters. Later the sample size was further stratified to take samples from the atolls within those regions. The sample size for the study was calculated based on 95% confidence level with a margin error of 5%. The sample size appropriate for statistical inferences is given in Table 1 below. Table 1, shows the sample required from each geographical region. The target population was children ages <15 years of age who fulfils the inclusion criteria. The number of children per region was obtained from the Census 2014 data [9]. Based on the census data a stratified sample was derived according to figure 1 below and figure 2 is taken from the source: National Bureau of Statistics, the Maldives.

Table 1: *Region-wise distribution of the target population and sample required.*

Locality	Sample size (n)	Atolls	Sample size (n)	Island	Sample size (n)
Cluster 1: Male'	377	Male'	377	Male'	227
				Hulhumale	100
				Villimale'	50
Cluster 2: North	228	Haa Dhaalu	228	Kulhudhuffushi	158
				Nolhivaranfaru	70
Cluster 3: Central Region	344	Noonu	149	Kendhikulhudhoo	65
				Manadhoo	51
		Lhaviyani	228	Naifaru	141
				Hinnavaru	87
Cluster 4: North Central Region	150	Kaafu	150	Guraidhoo	84
				Dhiffushi	66
Cluster 5: South central Region	114	Laamu	114	Gan	63
				Isdhoo	51
Cluster 6: South Region	378	Gaafu Dhaalu	180	Thinadhoo	130
				Fiyoree	50
		Gnaviyani	77	Fuvahmuh	77
		Seenu	121	Hithadhoo	70
				Hulhumeedhoo	51
Total			1624		

Instruments and Materials

A quantitative cross-sectional survey was carried out to study the prevalence of the STH infection in different regions of the Maldives and to establish overall prevalence of STH in the country. Data for the survey was collected using a structured interview questionnaire administered to the caretaker of the selected child. The questionnaire was developed through a consultative process taking into consideration the standard indicators needed to measure the prevalence of STH and to achieve the objectives of the survey.

Pilot testing of the questionnaire was done prior to finalising it. Trained enumerators were used for data collection. Administration Manual was developed which have the standard operating procedures to be followed by the enumerators and Lab technicians who would analyse the stool samples.

Any participant who participated in the pre-test was excluded from the main survey and a minimal number of 10 participants were selected for the pre-test. Based on the pre-test, the questionnaire was finalised and any editing required was brought to the questionnaire. The questionnaire was then entered into izisurvey program and transferred to tablets.

In addition to the administration of the questionnaire, a clinical examination component was included to evaluate the prevalence of STH. Stool samples were collected from the selected children and examined for any STH by a trained clinical pathologists or trained laboratory technician.

Although Kato Katz kits were convenient to use in the field on site during data collection, Kato-Katz technique has the limitation of hookworms not being identified properly. For this reason, it was recommended to use mini-FLOTAC technique for examining the stool, as hookworms can also be identified using mini-FLOTAC. Each stool specimen sample collected was examined by a trained laboratory technician who was asked to register the number of eggs in the mini FLOTAC device in order to identify the number of eggs per gram and assess the intensity of each parasite and categorise accordingly. The intensity of the infection for each case was recorded in accordance with the WHO thresholds classified to light/moderate/heavy. Classification in this manner allows understanding the proportion of children with different levels of STH infection. The classification criteria were also validated using mini-FLOTAC method in studies carried out in Ethiopia, Lao PDR and Pemba Island (Tanzania) [10, 11]. Intensity levels for *Ascaris lumbricoides* are; light intensity infections (1-4999) epg, moderate intensity infections (5000-49999) epg and heavy intensity infections (>50000) epg). Intensity levels for *Trichuris trichiura* are; Light intensity infections (1-999) epg, moderate intensity infections (1000-9999) epg and heavy intensity infections (>10000) epg. Intensity levels for *Necator americanus* are; light intensity infections (1-1999) epg, moderate intensity infections (2000-3999) epg and heavy intensity infections (>4000) epg [12].

Laboratory technicians trained for the purpose was selected from each island so that testing can be done in the field. The training on how to use FLOTAC method was held in Male'. A special trainer trained by the WHO conducted the three-day workshop on FLOTAC method for all the laboratory technicians in this study. It was ensured that the number of samples collected was sufficient to generate regional level statistically significant results and in accordance with the intensity criteria. A mark was made on the collection bottles so that the survey participants were well informed about the amount of stool sample to be submitted. An instructional note in local (Dhivehi) language was given to each participant on how to collect the stool.

The standard protocol of examination was followed by the technicians examining the specimens and findings were recorded on specimen observation sheet. The data collection was followed by checking of the questionnaires and specimen observation sheet for completeness. Any missing information or errors were checked and followed up for completing the data by a second technician.

Data Analysis

Following data collection, the data was checked for completeness and the result of the stool analysis was recorded on pre-developed format and finally linked with the questionnaire

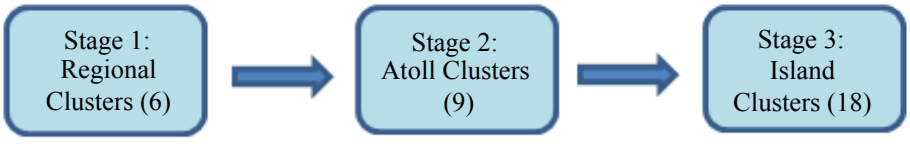

Figure 1: *Clusters at different stages.*

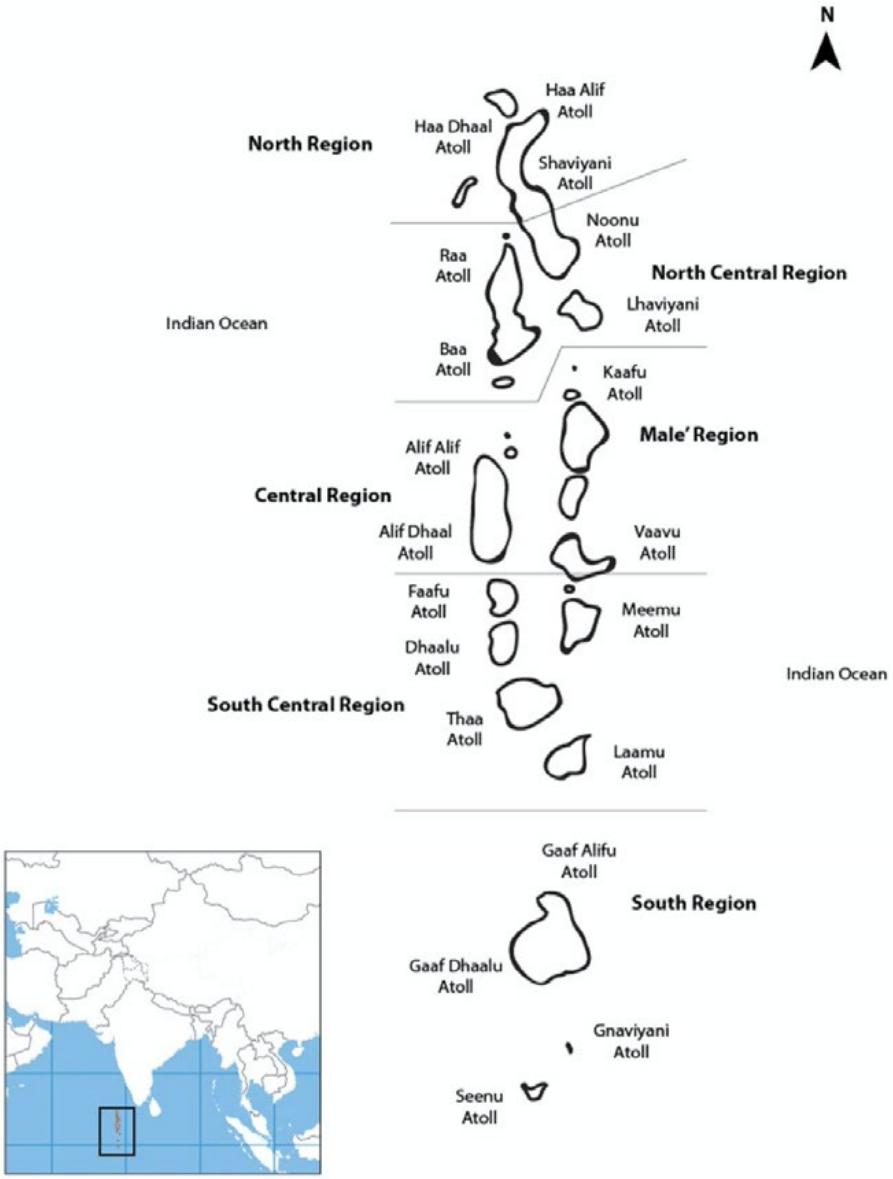

Figure 2. *Map of the Maldives with six regions.*

on the tablet. The data was then uploaded by an automated process and verified for accuracy by comparing it with data in questionnaire by co-researchers. Data was checked for errors and missing values. Statistical Package for the Social Sciences (SPSS) software was used for analysing the data. The following types of analysis were carried out using the dataset.

- Descriptive Analysis: Using frequency tables, univariate analysis for several variables, including, number of eggs and the percentage belonging to each of the variable categories to identify the STH infection
- Bivariate Analysis: Bivariate analysis was done in the form of contingency tables which allows easy comparison of two variables
- Multivariate Analysis: Existence of intervening variables or variables which moderate a relationship could be examined through these techniques
- Chi-square test and correlations: To find out difference between expected and actual values for each cell in the table is calculated and added up to establish whether there is a relationship between variables (e.g.: STH infection and age category)

Results

The gender was equally distributed among the participants with males, 50.3% and females 49.7%. The fathers' education level of the participants was mostly secondary (38.6%). Similarly, most mothers of the participants were educated up to secondary level (48.4%). More than 98% parents have at least basic education. Most respondents who participated in the survey were from the age categories between 2-4 years, followed by 5-7 years. Less than 300 children participated between the ages of 8-10 years and least participated were at the age of 14 years (19 children). It was easier to get samples from younger children as many older participants declined to give stool samples, this observation

confirmed as depicted. Many children were ready to participate but when they were informed about taking stool samples, children who were above 10 years declined to participate. Table 2 shows the number of samples that were collected, number of samples with the presence of soil transmitted helminthiasis, number of inadequate samples and other types of worms that were identified. The FLOTAC laboratory test results show that only one sample was positive for soil transmitted helminths and three samples were positive for pin worms. There were no helminth eggs observed from other samples.

Although the results indicate that the deworming program is quite effective, there were various other issues identified during the survey. These include giving worm medication too frequently without the advice of a medical practitioner or health professional apart from the 6-month deworming in the normal deworming program. Many parents indicated that they give deworming tablets at home bought from pharmacies in addition to the tablets given from school. Figure 3 shows how most people give deworming medication to their children. Most of the children are given worm medication through school program, health centre and privately. Four Percent of the participants were not treated for worms. Some schools stated that they had some difficulties in providing the children worm medicine regularly due to school holidays. A limitation in this study was that the exact frequency the worm medication was given was not captured in this study.

Discussion

The laboratory test results showed that the presence of soil transmitted helminths was negative in all the samples tested except for one sample. Hence, it can be concluded that the deworming program is effective in eliminating STHs in the Maldives since the available data from the National Micronutrient Survey conducted in 2006 showed higher prevalence of STH. In addition, a prevalence threshold less than 50% means that the treatment schedule needs to be changed to once a year from twice a year in the Maldives. In addition to the deworming program, rapid economic transition in the Maldives that has brought about better living conditions, sanitation and improvement in education over the years together must also have contributed to eliminating soil transmitted helminths. The Demographic Health Survey 2016-2017 of the Maldives shows that 98% of the households have access to safely managed drinking water, 98% of the households use flush toilets for sanitation and 98% had essential handwashing agents [5]. This study is important in the field of public health when determining the doses of deworming tablets given in schools in developing island nations. The study has also shown that close to zero

Table 2: *Participant number distribution among islands.*

Cluster	Response rate %	Island	Sample received	Education level of parent			Gender		Presence of STH eggs
				Basic	Primary/Secondary	Tertiary	Male	Female	
Cluster 1 (294)	78	Male'	183	5	65	30	50	50	
		Hulhumale	75						
		Vilimale	48						
Cluster 2 (201)	88	HDh.Kulhuduffushi	133	33	60	7	53	47	*1 (Trichuris trichiura)*
		HDh.Nolhivaranfaru	69						
Cluster 3 (313)	91	N.Kendhikulhudhoo	50	7	83	10	52	48	
		N.Manadhoo	45						
		Lh.Naifaru	127						
		Lh.Hinnavaru	89						
Cluster 4 (155)	100	K.Guraidhoo	86	10	81	8	52	48	
		K.Dhiffushi	67						
Cluster 5 (125)	100	L.Gan	68	11	79	10	44	55	3 (Pinworm)
		L.Isdhoo	56						
Cluster 6 (349)	92	Gh. Thinadhoo	70	13	71	17	51	49	
		GDh. Fiyoree	53						
		Gn.Fuvahmulah	77						
		S.Hithadhoo	96						
		S.Hulhumeedhoo	54						
Total			**1437**						4

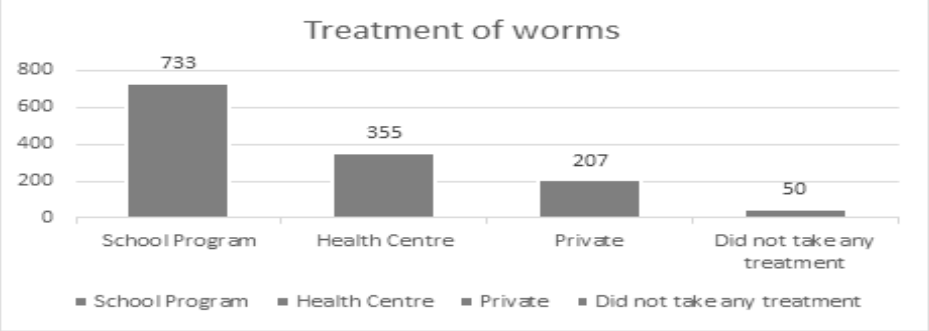

Figure 3: *Place from where parents get worm medication.*

prevalence of soil transmitted helminths can be achieved using school health interventions including deworming and hygiene.

Many studies in other countries had shown that school-based programs alone are not enough to prevent STH transmission in communities. A cross-sectional survey that included 19,684 participants from 120 community clusters that received school-based deworming treatment for three consecutive years in South Coastal Kenya that looked into age-related patterns in prevalence and intensity of STH infection showed that 21.5% of the study population were infected with one STH though school-based deworming was administered for the sampled population. The study highlighted that school based deworming alone is insufficient to reduce community wide elimination transmission [13]. The Kenyan authorities further evaluated the school-based deworming program in a second study and the results showed similar results stressing that additional strategies would be required to sustain the interruption of transmission at community level [14]. These studies highlight the fact that school-based programs alone are not enough to sustain the impact. Thus, adding more value to the argument that living conditions, sanitation and improvement in education over the years in the Maldives must have added to the effectiveness of the school-based deworming program in the Maldives.

The net attendance ratio for the primary school age (6-12 years) is observed as 93.7% and for secondary school age (13-17 years) is recorded as 77.2% [5]. Considering the high school attendance in the Maldives and the negative test results for STH among school age children, the effectiveness of the school deworming program is positive. However, it needs to be noted that it is not a sign that there are no STH infections in the country. Studies in other countries have shown initial success and later decreased effectiveness due to other factors. For example, STH prevalence predictions done on an 8 year-mass drug administration program on school children in Burundi showed initial decrease in prevalence during 2008-2011, but an increase was reported in 2014 [15]. Hence, suggesting a need for continuous evaluation of STH programs even in successful events such as in the Maldives.

Most STH deworming programs are targeted at school age children. However, studies have shown that community-wide treatment programs are more effective. For example, a cluster-randomized controlled trial that looked into annual community-wide treatment group and school-based treatment showed that community-wide treatment was more effective in reducing hookworm prevalence and intensity than school-based treatment [16]. This view was supported by Legge, Kepha [17] in their qualitative study on STH prevention in Kenya. They recommended that in addition to school-aged children, programs must also target adults, potentially through community-wide mass drug administration in order to achieve elimination of STH transmission in communities. Unlike the Kenyan study, the Maldivian school-based program has shown to be effective.

Although the data on how the participants get deworming tablets, whether it is from the school health program, health facility or pharmacy was collected, it was a limitation of the study that the actual frequency of deworming was not collected. While many parents reported that they give deworming medication through the normal six-month programme, many parents indicated that they give medication bought from the pharmacy in addition to what they give through the school health program. The frequency of deworming medication needs to be revised to be once a year since too much medication can have an effect on the gut microbiota. Some parents also indicated that they do not give medication and some indicated that they give medication less frequently if the medications reach schools during school holidays. Even in the instances where parents did not give any deworming medication, the laboratory test results were negative for soil transmitted helminthiasis. The other limitation was that the age distribution of the participants of the study was skewed, so the study can have some bias. The deworming programme was certainly useful to maintain the STH morbidity low, but the economic development end consequent improvement on sanitation is important to maintain the morbidity levels of STH at a lower rate. With such low levels of prevalence and good sanitation, it is not necessary to provide deworming or the frequency of medication needs to be minimized to once a year. A survey should be conducted in two years' time to confirm the absence rebounding infections.

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***Correspondence to:**

Raheema Abdul-Raheem
Research Development Office, The Maldives National University
Maldives
E-mail: raheema.abdulraheem@mnu.edu.mv
Telephone: 9607830994