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Mass drug administration and the sustainable control of schistosomiasis: Community health workers are vital for global elimination efforts

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ABSTRACT

Objectives: Schistosomiasis control is centred on preventive chemotherapy through mass drug administration (MDA). However, endemic countries continue to struggle to attain target coverage rates and patient compliance. In the Philippines, barangay health workers (BHWs) play a vital role in the coordination of MDA, acting as advocates, implementers, and educators. The aim of this study was to determine whether BHW knowledge and attitudes towards schistosomiasis and MDA is sufficient and correlated with resident knowledge and drug compliance.
Methods: A cross-sectional survey was conducted in 2015 among 2186 residents and 224 BHWs in the province of Northern Samar, the Philippines using a structured survey questionnaire.
Results: BHWs showed good familiarity on how schistosomiasis is acquired and diagnosed. Nevertheless, both BHWs and residents had poor awareness of the signs and symptoms of schistosomiasis, disease prevention, and treatment options. There was no correlation between the knowledge scores of the BHWs and the residents ($r = 0.080$, $p = 0.722$). Kruskal–Wallis analysis revealed significant differences in BHW knowledge scores between the low (3.29, 95% confidence interval 3.16–3.36), moderate (3.61, 95% confidence interval 3.49–3.69), and high (4.05, 95% confidence interval 3.77–4.13) compliance village groups ($p = 0.002$), with the high compliance areas having the highest mean knowledge scores.
Conclusions: This study highlights the importance of community health workers in obtaining the World Health Organization drug coverage rate of 75% and improving compliance with MDA in the community. Investing in the education of community health workers with appropriate disease-specific training is crucial if disease elimination is ultimately to be achieved.

Introduction

Schistosomiasis, also known as bilharzia, is a neglected tropical disease (NTD) that ranks only second to malaria in terms of human suffering in the tropics. It is endemic in 78 countries, with an estimated global burden of 3.514 million disability-adjusted life years (DALY) in 2015 (WHO, 2016a; WHO, 2016b). Schistosomiasis control is centred on preventive chemotherapy through mass drug administration (MDA) with 40 mg/kg praziquantel, as endorsed by the World Health Assembly in 2001. This control strategy aims to reduce morbidity and mortality, and prevent new infections by limiting transmission through the reduction of the human reservoir (Humphries et al., 2012).

More than 15 years after that endorsement, endemic countries still struggle to meet the target coverage of at least 75% of school-age children. In 2015, only 12 out of 40 reporting countries had achieved coverage rates greater than 75% (WHO, 2017). Adequate drug coverage is necessary for morbidity control, reducing transmission, and ultimately disease elimination (Worrell and

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Mathieu, 2012). Studies on lymphatic filariasis and onchocerciasis have shown that if coverage rates fall below 65%, it is still possible to achieve disease elimination if MDA is extended for several years (Bockarie et al., 2013). In order to achieve sustainable disease control, community awareness and involvement is vital (Sady et al., 2015). In countries such as Tanzania and Yemen, where inadequate knowledge on schistosomiasis continues, the prevalence of the infection remains high despite the implementation of MDA (Sady et al., 2015; Mazigo et al., 2010).

Several studies have assessed awareness among adult and school-age populations in schistosomiasis endemic areas. Although a high level of familiarity with the name of the infection has been shown, this awareness has often been limited to just having heard the name (Sady et al., 2015; Dawaki et al., 2015; Mwai et al., 2016). Poor knowledge of disease transmission, prevention, and treatment has been observed in Nigeria, Mozambique, and Kenya (Dawaki et al., 2015; Mwai et al., 2016; Rassi et al., 2016). The most common misconception is that schistosomiasis is acquired by drinking or eating contaminated food and water (Acka et al., 2010; Kabatereine et al., 2014; Musuva et al., 2014; Odhiambo et al., 2016; Person et al., 2016). Others believe it is transmitted through sexual contact (Rassi et al., 2016; Mwanga et al., 2004).

Community health workers (CHWs) are a common source of schistosomiasis information in rural communities. Unfortunately, insufficiency of such manpower is a problem and may limit the coverage of health education campaigns (Leonardo et al., 2016a). Community members, specifically neighbours, family members, and friends, are other common sources of information in countries such as the Philippines, China, Mozambique, and Nigeria, where more than 70% of respondents to a recent survey identified them as key informants (Dawaki et al., 2015; Rassi et al., 2016; Ferlyn et al., 2015; Zeng et al., 2011). CHWs are generally defined as non-professional lay health workers, who are originally from the community, and who are requested to provide promotional, preventive, and sometimes even curative health care services to their own community (Ma et al., 2017). The use of CHWs in Nigeria to disseminate information on tuberculosis has improved overall knowledge and attitudes of the community about the disease (Balogun et al., 2015). In Uganda, CHWs have been involved in promoting health for children under 5 years of age, and this has resulted in reduced malnutrition and morbidity, and improved child health practices (Brenner et al., 2011). CHWs have also been found to be effective in disseminating information in control programmes for NTDs such as trypanosomiasis and onchocerciasis (Corley et al., 2016).

In the Philippines, barangay health workers (BHWs) are the counterpart of CHWs. The Department of Health describes a BHW as a person who has undergone training programmes under any accredited government or non-government organization, and who renders primary health care services after having been accredited to function as such by the local health board (Philippines DoH, 2017). In the implementation of schistosomiasis MDA activities, BHWs are tasked with assisting in listing the eligible population and mobilizing the community to participate in the MDA. It is necessary for the community to have adequate and correct information in order for them to participate in such activities (Parker et al., 2008). However, an assessment of the capability of BHWs to carry out their role as community advocates and educators has not been performed. Similarly, there has been no study to determine whether BHW knowledge and attitudes has had any impact on the residents of the community. The aim of this study was to determine whether BHW knowledge and attitudes towards schistosomiasis and MDA are sufficient and correlated with resident knowledge and patient drug compliance.

Methods

Study design and study area

In 2015, a cross-sectional survey was conducted among residents and local MDA service providers in the endemic municipalities of Laoang and Palapag, in the province of Northern Samar, the Philippines. Northern Samar was ranked fourth among the poorest provinces in the country, with a poverty incidence of 47.9% in 2015 (Philippine Statistics Authority, 2016). Most household heads are engaged in rice farming, and family incomes are lower than the national average. A national prevalence survey conducted in 2008 estimated the prevalence in endemic provinces to range from 0.08% to 6.3%, and Northern Samar ranked fourth with a prevalence of 2.4% (Leonardo et al., 2012). A 2012 parasitological survey at the study site found a human schistosomiasis prevalence of 27% (Ross et al., 2015). Acute respiratory infections, diarrheal diseases, and other communicable diseases are also very common (Ross et al., 2015).

Study procedures

The survey was conducted among 22 endemic barangays. Residents aged 18 years and older were selected randomly from a list of all eligible residents for each village using the 'sample' command in STATA SE version 13.1 (StataCorp, College Station, TX, USA). The number of selected individuals from each barangay was proportionate to the size of the population. All BHWs were also interviewed. Prior to the start of the survey, intensive training covering the overview of the protocol, methods of inviting study participants, obtaining informed consent, and administering the interview questionnaire was given to local interviewers. During the data collection period, the interviewers visited the households of the selected residents to obtain their consent and to conduct the interview. The BHWs were interviewed at their local barangay health stations.

An extensive review of previous studies on knowledge and attitudes towards schistosomiasis was conducted and used as the basis in developing the structured questionnaires, which were then translated into the local dialect Waray. This was back-translated into English to ensure that the meaning of the questions remained the same after translation into Waray. The questionnaire was pre-tested among a subset of residents who did not participate in the survey. The section on 'knowledge' included questions on the signs and symptoms of schistosomiasis, and how schistosomiasis infection can be acquired, diagnosed, treated, and prevented. The respondents were not given the answers to choose from, but were encouraged to give their own answers. In the 'attitudes' section, respondents were asked to rate their own risk, as well as the community's risk of becoming infected, with possible answers of none, low, moderate, or high risk. They were also asked to rate the severity of the disease as low, moderate, or high. Their perceptions of the benefits of MDA were also assessed by asking them to rate their agreement to various statements.

Data management and analysis

A customized Microsoft Office Access 2007 data entry system was developed for data processing. Field supervisors reviewed all completed questionnaires before the data were encoded using a double-entry system. Data were cross-checked for errors after encoding. The software STATA SE version 13.1 (StataCorp, College Station, TX, USA) was used for data checking and analysis. Comparison of the knowledge and attitudes between residents and BHWs was done using mixed-effects logistic regression analysis, with random barangay effects in the model to account

for correlation among observations within barangays. Education was also included in the analysis as a fixed-effect factor.

Knowledge was scored by giving one point for a correct answer in each of the following categories: signs and symptoms, diagnosis, how the infection was acquired, disease prevention, and treatment, for a possible score of zero to five points. The Kruskal–Wallis test was used to compare the BHW and resident knowledge scores between low (<70%), moderate (70–84%), and high (≥85%) compliance barangays. The cut-off for high drug compliance was based on the 85% target coverage rate set by the Department of Health. Dunn's test with Holms–Šídák adjustment was used to perform post-hoc pairwise comparisons. The correlation between BHW and resident knowledge scores was determined using Spearman correlation.

Ethical considerations

The study protocol was reviewed and approved by the institutional review boards of the Research Institute for Tropical Medicine – Department of Health (IRB Protocol Code 2014-22-0), the Philippines and Griffith University, Australia. Written consent was obtained from all survey respondents. There was no direct benefit to the survey participants; however, the results of the study, as well as the recommendations, will be given to local and national schistosomiasis control programme coordinators to help improve the implementation of MDA in endemic communities.

Results

A total of 2410 individuals were interviewed, of whom 2186 were residents and 224 were BHWs. The mean age of the residents was 42.8 (±12.8) years. The majority were female (52%) and had an elementary education (61%), and almost half were unemployed (48.5%) (Table 1). The BHWs had a mean age of 47.5 years (± 11.5). All were female (100%) and the majority had at least a high school education (53%).

Table 1
Profile of residents and barangay health workers (BHWs) of Northern Samar, Philippines ($N = 2410$).

Profile	Residents		BHWs		Overall	
	n	%	*n*	%	*n*	%
Age, years						
18–30	455	20.8	15	6.7	470	19.5
31–40	568	26.0	44	19.6	612	25.4
41–50	533	24.4	81	36.2	614	25.5
>50	630	28.8	84	37.5	714	29.6
Mean	42.76		47.50		43.12	
SD	12.80		11.50		12.75	
Sex						
Male	1050	48.0	0	0.0	1050	43.6
Female	1136	52.0	224	100.0	1360	56.4
Education						
None	26	1.2	0	0.0	26	1.1
Elementary	1336	61.1	80	35.7	1416	58.8
High school	640	29.3	125	55.8	765	31.7
Vocational	10	0.5	1	0.5	11	0.5
College/post-graduate	174	8.0	18	8.0	192	8.0
Occupation						
None/student	1059	48.7	0	0.0	1059	44.1
Farmer	587	27.0	0	0.0	587	24.5
Barangay employee/volunteer	5	0.2	224	100.0	229	9.6
Service worker	181	8.3	0	0.0	181	7.5
Sales/business	118	5.4	0	0.0	118	4.9
Fisherman	83	3.8	0	0.0	83	3.5
Skilled worker	83	3.8	0	0.0	83	3.5
Professional	35	1.6	0	0.0	35	1.5
Transportation	24	1.1	0	0.0	24	1.0
Other	7	0.3	0	0.0	7	0.3

SD, standard deviation.

As shown in Table 2, all BHWs had heard of schistosomiasis, while 99% of residents had heard of it as well ($p = 0.986$). Knowledge of the signs and symptoms of intestinal schistosomiasis was poor among both local residents and BHWs. Abdominal enlargement was the most frequently identified symptom, and it was reported by 64% of the BHWs and 41% of the residents ($p < 0.001$). Only 18% of the residents identified abdominal pain as a symptom, which was significantly lower than the response of the BHWs (31%, $p < 0.001$). Only a tenth of residents said blood in the stool was a sign of schistosomiasis, but the proportion who gave this answer among BHWs was three times higher ($p < 0.001$).

Overall, there was a moderately high level of knowledge on how the infection could be acquired, with 76% of the respondents saying it is by farming in infected rice fields. The proportion of BHWs who gave this response (93%) was significantly higher than that of the residents (74%, $p < 0.001$). More than half of the BHWs responded that infection can also be acquired through freshwater contact compared with only 39% of residents ($p < 0.001$). Other responses given were open defecation, the consumption of unclean water or food, fishing in infected areas, poor sanitation, and contact with human or animal stool.

There was a moderate level of knowledge that schistosomiasis can be prevented among BHWs (72%) and residents (58%, $p = 0.123$). However, despite the high level of awareness on how the infection is acquired, knowledge of the specific disease prevention strategies was very poor. Overall, the most common response was avoiding contact with infected water, which was given by 29% of residents and only 32% of BHWs ($p = 0.396$). Preventing new infections by participating in MDA campaigns was answered correctly by 43% of BHWs, which was twice the rate for local residents (20%, $p < 0.001$). Almost twice as many BHWs (17%) as residents (9%) responded that the use of protective clothing was protective ($p < 0.001$). Avoiding open defecation, bathing in dirty water, and drinking or eating unclean water or food, and sanitation were the other common answers. BHWs also showed better knowledge about the diagnosis of *Schistosoma japonicum* infection, with 93% of them being familiar with the stool test required, as compared to 64% among residents ($p < 0.001$). Significantly higher proportions of BHWs also cited that physical examination, blood tests, and ultrasound were other methods of diagnosing schistosomiasis.

Among the BHWs, 97% knew that schistosomiasis can be treated, but only 68% of the BHWs knew that praziquantel was the drug of choice for the treatment of the disease. Moreover, 17% of BHWs expressed that they did not know what praziquantel was used for. Residents also showed high awareness that schistosomiasis can be treated (89%, $p = 0.001$). However, the majority did not know of the use of praziquantel (56%) and only a quarter knew that praziquantel is the drug used for schistosomiasis treatment.

The attitudes towards schistosomiasis and MDA of residents and BHWs were also compared; the results are shown in Table 3. Three-quarters of residents and BHWs expressed that they had a moderate to high risk of becoming infected with Schistosoma ($p = 0.471$). A larger proportion of BHWs (89%) than residents (80%) believed that the community also had a moderate to high risk of infection ($p = 0.036$). Schistosomiasis was perceived as a moderate to highly severe infection by 86% of BHWs and 72% of residents ($p < 0.001$). The proportions of BHWs who agreed that MDA is beneficial to participants ($p = 0.008$) and to the community ($p = 0.004$), and that its benefits are greater than the possible adverse reactions ($p = 0.002$) were also higher when compared to the local residents.

Table 2
Knowledge on schistosomiasis of residents and barangay health workers (BHWs) of Northern Samar, Philippines ($N = 2410$).

Knowledge	Residents		BHWs		Overall		Wald test p-value
	n	%	n	%	n	%	
Have heard of schistosomiasis?							
Yes	2162	98.9	224	100.0	2386	99.0	0.986
Signs and symptoms							
Abdominal enlargement	885	40.5	144	64.3	1029	42.7	<0.001
Abdominal pain	403	18.4	69	30.8	472	19.6	<0.001
Blood in stool	214	9.8	67	29.9	281	11.7	<0.001
Diarrhoea	64	2.9	7	3.1	71	3.0	0.802
How is schistosomiasis acquired?							
Farming in infected areas	1619	74.1	208	92.9	1827	75.8	<0.001
Freshwater contact	848	38.8	118	52.7	966	40.1	<0.001
Open defecation	548	25.1	77	34.4	625	25.9	0.010
Consumption of unclean water or food	210	9.6	18	8.0	228	9.5	0.359
Fishing in infected areas	125	5.7	17	7.6	142	5.9	0.258
Poor sanitation	110	5.0	25	11.2	135	5.6	<0.001
Contact with human or animal stool	75	3.4	7	3.1	82	3.4	0.549
Can schistosomiasis be prevented?							0.177
No	689	31.5	58	25.9	747	31.0	
Yes	1277	58.4	162	72.3	1439	59.7	
Don't know	220	10.1	4	1.8	227	9.3	
How can schistosomiasis be prevented?							
Avoid contact with infected water	641	29.3	72	32.1	713	29.6	0.590
Participate in MDA	429	19.6	96	42.9	525	21.8	<0.001
Avoid open defecation	272	12.4	27	12.1	299	12.4	0.613
Use protective gear like boots	185	8.5	39	17.4	224	9.3	<0.001
Avoid bathing in dirty water	177	8.1	23	10.3	200	8.3	0.403
Avoid unclean drinking water and food	164	7.5	15	6.7	179	7.4	0.598
Sanitation	79	3.6	47	21.0	126	5.2	<0.001
How is schistosomiasis diagnosed?							
Stool test	1397	63.9	208	92.9	1605	66.6	<0.001
Physical examination	495	22.6	115	51.3	610	25.3	<0.001
Blood test	263	12.0	49	21.9	312	13.0	<0.001
Ultrasound	148	6.8	48	21.4	196	8.1	<0.001
Can schistosomiasis be treated?							0.021
No	127	5.8	4	1.8	131	5.4	
Yes	1955	89.4	218	97.3	2173	90.2	
Don't know	104	4.8	2	0.9	106	4.4	
How can schistosomiasis be treated?							
With drugs for schistosomiasis, don't know the name	887	40.6	40	17.9	927	38.5	<0.001
With praziquantel	546	25.0	153	68.3	699	29.0	<0.001
See a doctor	96	4.4	17	7.6	113	4.7	0.049
Traditional medicine	118	5.4	2	0.9	120	5.0	0.008
Other medicine	75	3.4	3	1.3	78	3.2	0.104
Don't know	333	15.2	10	4.5	343	14.2	0.002
What is praziquantel used for?							
Don't know	1232	56.4	37	16.5	1269	52.7	<0.001
Schistosomiasis	904	41.4	135	60.3	1039	43.1	<0.001
Deworming	74	3.4	103	46.0	177	7.3	<0.001

MDA, mass drug administration.

Figure 1 shows a scatterplot at the barangay level of the mean knowledge scores of BHWs versus those of the local residents. Higher BHW knowledge scores did not correlate with an increase in resident knowledge scores with respect to disease or treatment ($r = 0.080$, $p = 0.722$). In Figure 2, it can be seen that BHW knowledge corresponded with the level of drug compliance, with higher scores in barangays with high drug compliance compared to low drug compliance. In low compliance barangays, BHWs had a mean knowledge score of 3.29 (95% confidence interval (CI) 3.16–3.36), while they had a score of 3.61 (95% CI 3.49–3.69) in moderately compliant villages. The highest mean knowledge score of 4.05 (95% CI 3.77–4.13) was for BHWs from barangays with the highest MDA compliance rates. Kruskal–Wallis analysis revealed a significant difference in knowledge scores between the three groups ($p = 0.002$). Dunn's test showed similarly significant findings between the scores in low and high compliance areas ($p = 0.001$), and between the scores in low and moderately compliant barangays ($p = 0.014$). Resident knowledge scores were 2.22 (95% CI 2.13–2.19), 2.26 (95% CI 2.19–2.27), and 2.30 (95% CI 2.19–2.31) in low, moderate, and high compliance barangays,

Table 3
Attitudes on schistosomiasis of residents and barangay health workers (BHWs) of Northern Samar, Philippines ($N = 2410$).

Attitudes	Residents		BHWs		Overall		Wald test *p*-value
	n	%	*n*	%	*n*	%	
What do you think is your risk of becoming infected with schistosomiasis?							0.434
No to low risk	415	19.0	48	21.4	463	19.2	
Moderate to high risk	1652	75.6	169	75.5	1821	75.6	
Don't know	119	5.4	7	3.1	126	5.2	
What do you think is the risk of the people in your community becoming infected with schistosomiasis?							0.039
No to low risk	304	13.9	21	9.4	325	13.5	
Moderate to high risk	1747	79.9	199	88.8	1946	80.8	
Don't know	135	6.2	4	1.8	139	5.8	
How severe do you think schistosomiasis is as a disease in your community?							0.001
Not severe to low severity	473	21.6	29	13.0	502	20.8	
Moderate to high severity	1570	71.8	192	85.7	1762	73.1	
Don't know	143	6.5	3	1.3	146	6.0	
Schistosomiasis is a significant public health problem in the Philippines							0.628
Agree	2103	96.2	217	96.9	2320	96.3	
Disagree	38	1.7	6	2.7	44	1.8	
Don't know	45	2.1	1	0.5	46	1.9	
Schistosomiasis is a significant public health problem in Northern Samar							0.376
Agree	2131	97.5	216	96.4	2347	97.4	
Disagree	24	1.1	7	3.1	31	1.3	
Don't know	31	1.4	1	0.5	32	1.3	
MDA is beneficial to those who participate							0.013
Agree	1989	91.2	215	96.4	2204	91.6	
Disagree	55	2.5	6	2.7	61	2.5	
Don't know	140	6.4	2	0.9	142	5.9	
MDA is beneficial to the community							0.006
Agree	2011	92.1	218	97.8	2229	92.6	
Disagree	39	1.8	3	1.4	42	1.7	
Don't know	134	6.1	2	0.9	136	5.7	
The benefits of MDA are greater than the possible adverse reactions							0.002
Agree	1989	91.1	218	97.8	2207	91.7	
Disagree	89	4.1	5	2.2	94	3.9	
Don't know	106	4.9	0	0.0	106	4.4	

MDA, mass drug administration.

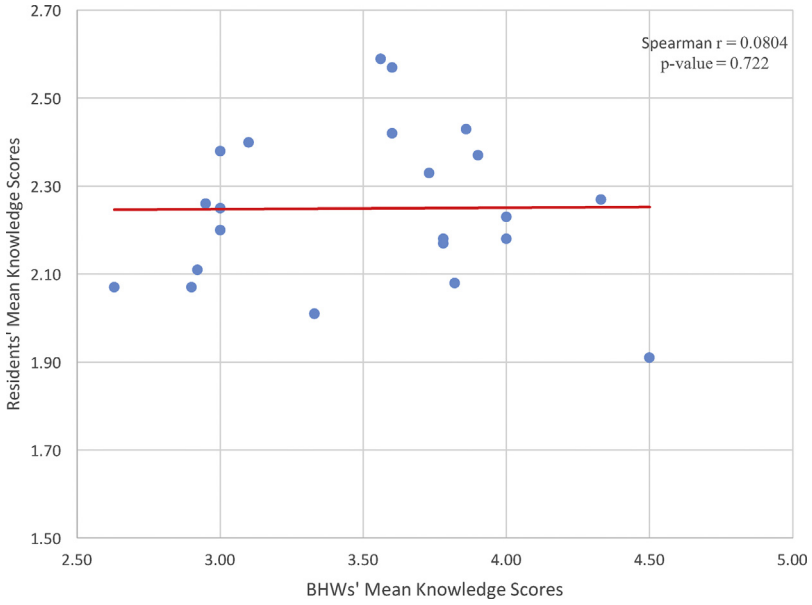

Figure 1. Scatterplot of barangay health worker (BHW) mean knowledge scores versus residents' mean knowledge score in the 22 villages under study.

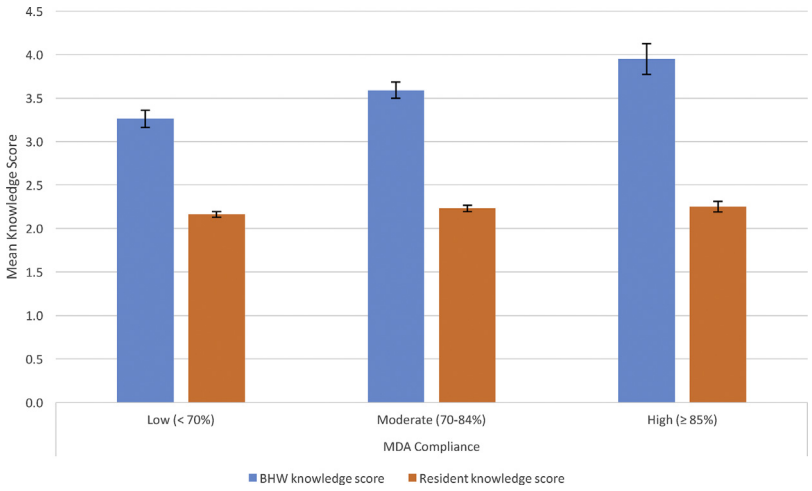

Figure 2. Mean (±standard error) knowledge scores of barangay health workers (BHWs) and residents by barangay (village) MDA compliance in Northern Samar, the Philippines.

respectively. There was no significant difference between the residents' mean knowledge scores ($p = 0.551$) and barangay compliance.

Discussion

Preventive chemotherapy through MDA has been endorsed as the main schistosomiasis control strategy globally. At present, countries implementing MDA for schistosomiasis control are still struggling to attain the ideal level of coverage (75%). Increased awareness, understanding of disease, and treatment options have been linked to good coverage rates and compliance with MDA for other NTDs (Aswathy et al., 2009; Gunawardena et al., 2007; Hussain et al., 2014). The Philippines is one of the countries with below-target national coverage rates at 43.5% in 2015. Given this fact, the present study aimed to determine the knowledge and attitudes of the residents and the BHWs, who are disseminators of disease-specific information prior to an MDA campaign.

Almost all of the respondents had heard of schistosomiasis. This should be expected in highly endemic areas that have been treated repeatedly since the 1980s. The study area has also been the site of a schistosomiasis integrated control trial for the past 5 years, thus exposing the residents and health staff to these activities. This finding is similar to those of studies performed in Kenya, Yemen, Mozambique, and Swaziland in which more than 90% of the survey populations were observed to have an awareness of schistosomiasis (Sady et al., 2015; Mwai et al., 2016; Rassi et al., 2016; Maseko et al., 2016). However, awareness is often limited to just being familiar with the name of the disease. In this study, the community residents and the BHWs demonstrated poor knowledge of the symptoms and signs of the disease, disease prevention, and treatment options. Poor awareness of the signs and symptoms of schistosomiasis was also observed in similar studies in Cote d'Ivoire, Yemen, and Nigeria (Sady et al., 2015; Dawaki et al., 2015; Acka et al., 2010). This may ultimately impact their health-seeking behaviour and compliance with free treatment.

Most of the residents and BHWs knew that Schistosoma infection can be acquired while farming in infected rice fields, engaged in fishing, or in contact with infected freshwater. However, becoming infected with Schistosoma through contact with infected water was not a very common response in surveys conducted in China and Swaziland (Maseko et al., 2016; Liu et al., 2014). Similar to the present study findings, the misconception that the infection can be acquired by the consumption of contaminated water or food was also found to be a common response in African surveys (Acka et al., 2010; Odhiambo et al., 2016; Mwanga et al., 2004; Maseko et al., 2016).

Knowledge of disease prevention has been a problem in many endemic countries. Similar to the findings presented here, avoiding contact with infected water was identified by only a small proportion of endemic populations in Kenya, Tanzania, Yemen, and Swaziland (Sady et al., 2015; Mazigo et al., 2010; Odhiambo et al., 2016; Mwanga et al., 2004; Maseko et al., 2016). There was also poor awareness of preventive chemotherapy as a means of disease prevention, which is consistent with the findings in Yemen and Uganda (Sady et al., 2015; Kabatereine et al., 2014). This indicates a lack of understanding of the purpose of MDA, which may lead to poor drug compliance. In MDA programmes for lymphatic filariasis, treatment knowledge has been shown to increase patient compliance (Aswathy et al., 2009; Gunawardena et al., 2007; Hussain et al., 2014). Overall, BHWs were found to have better disease-specific knowledge than the residents of the community in which they served. However, their knowledge may be insufficient for them to be effective sources of disease-specific information for members of their community. Only 72% of the BHWs believed that the disease can be prevented and only 43% knew that participating in MDA can prevent future infections. Only 19% of BHWs reported that they had attended a training workshop on schistosomiasis and only 4% had been trained in the past year.

A significant finding of this study was the association between higher BHW knowledge and areas with higher patient drug compliance. A similar association was noted in an MDA campaign for lymphatic filariasis in India, wherein health workers with better knowledge compared to non-health workers were able to achieve better coverage and compliance rates when working as drug distributors (Lahariya and Tomar, 2011). In Kenya, where CHWs were used as community drug distributors and were given training on schistosomiasis (physiopathology, symptoms, diagnosis, prevention, treatment, and complications) and MDA (praziquantel, eligibility, drug reactions, and management of reactions), coverage in all communities was at least 75% (Omedo et al., 2012). These studies reaffirm that the knowledge of CHWs is crucial for elimination efforts.

An inadequate number of healthcare professionals is a significant problem in low- and middle-income countries (LMICs). There is a projected shortage of 15 million health workers by 2030, especially affecting LMICs of Asia and the Pacific (Liu et al., 2017). The Philippines is one of the LMICs that suffers from an unbalanced distribution of health professionals. The migration of health professionals to work in developed countries has worsened the

problem in rural areas and has left the remaining health workers with increased workloads (Castro-Palaganas et al., 2017). One of the findings in the evaluation of schistosomiasis control programmes is that the insufficiency of manpower compromises the activities needed for mass treatment, faecal surveys, and monitoring of snail sites (Leonardo et al., 2016b). Tapping into the services of community volunteer health workers is a system being deployed by many countries to augment their healthcare workforce. Their effectiveness in disseminating information has been shown in programmes for trypanosomiasis, onchocerciasis, tuberculosis, and malaria, as well as in promoting the overall health of children under 5 years old (Balogun et al., 2015; Brenner et al., 2011; Corley et al., 2016; Lwin et al., 2014). However, volunteer health workers are often not adequately trained and monitored, which makes them ineffective in carrying out such duties. In Ghana, volunteers felt intimidated when they could not answer questions asked by residents and had difficulty convincing community members to take the drugs (Biritwum et al., 2017). BHWs (or CHWs) are familiar with the language, customs, and culture of the community, which can enable them to deliver health information in a sensitive manner that is easy to understand.

Global control strategies for schistosomiasis are failing largely due to poor drug coverage rates (28%) and poor drug compliance (WHO, 2016a). In order to improve these rates, CHWs are vital. However, they must be given appropriate training and payment if they are to serve effectively in community education, mobilization, and improving community participation, so that disease elimination can ultimately be achieved.

Conflict of interest

All authors: no reported conflicts. All authors have submitted the ICMJE Form for Disclosure of Potential. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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References

Acka CA, Raso G, N'Goran EK, Tschannen AB, Bogoch II, Séraphin E, et al. Parasitic worms: knowledge, attitudes, and practices in Western Cote d'Ivoire with implications for integrated control. PLoS Negl Trop Dis 2010;4(12):e910.

Aswathy S, Beteena K, Leelamoni K. Mass drug administration against filariasis in India: perceptions and practices in a rural community in Kerala. Ann Trop Med Parasitol 2009;103(7):617–24.

Balogun M, Sekoni A, Meloni ST, Odukoya O, Onajole A, Longe-Peters O, et al. Trained community volunteers improve tuberculosis knowledge and attitudes among adults in a periurban community in southwest Nigeria. Am J Trop Med Hyg 2015;92(3):625–32.

Biritwum NK, Garshong B, Alomatu B, de Souza DK, Gyapong M, Kyelem D. Improving drug delivery strategies for lymphatic filariasis elimination in urban areas in Ghana. PLoS Negl Trop Dis 2017;11(5)e0005619.

Bockarie MJ, Kelly-Hope LA, Rebollo M, Molyneux DH. Preventive chemotherapy as a strategy for elimination of neglected tropical parasitic diseases: endgame challenges. Philos Trans R Soc Lond B Biol Sci 2013;368(1623)20120144.

Brenner JL, Kabakyenga J, Kyomuhangi T, Wotton KA, Pim C, Ntaro M, et al. Can volunteer community health workers decrease child morbidity and mortality in southwestern Uganda? An impact evaluation. PLoS One 2011;6(12)e27997.

Castro-Palaganas E, Spitzer DL, Kabamalan MM, Sanchez MC, Caricativo R, Runnels V, et al. An examination of the causes, consequences, and policy responses to the migration of highly trained health personnel from the Philippines: the high cost of living/leaving-a mixed method study. Hum Resour Health 2017;15(1):25.

Corley AG, Thornton CP, Glass NE. The role of nurses and community health workers in confronting neglected tropical diseases in sub-Saharan Africa: a systematic review. PLoS Negl Trop Dis 2016;10(9)e0004914.

Dawaki S, Al-Mekhlafi HM, Ithoi I, Ibrahim J, Abdulsalam AM, Ahmed A, et al. The menace of schistosomiasis in Nigeria: Knowledge, attitude, and practices regarding schistosomiasis among rural communities in Kano State. PLoS One 2015;10(11)e0143667.

Ferlyn V, Logronio FV, Demayo C. Awareness of and knowledge about the prevalence of schistosomiasis in 15 endemic villages of Lala, Lanao del Norte. J Sci Res Dev 2015;2(14):47–52.

Gunawardena S, Ismail M, Bradley M, Karunaweera N. Factors influencing drug compliance in the mass drug administration programme against filariasis in the Western province of Sri Lanka. Trans R Soc Trop Med Hyg 2007;101(5):445–53.

Humphries D, Nguyen S, Boakye D, Wilson M, Cappello M. The promise and pitfalls of mass drug administration to control intestinal helminth infections. Curr Opin Infect Dis 2012;25(5):584–9.

Hussain MA, Sitha AK, Swain S, Kadam S, Pati S. Mass drug administration for lymphatic filariasis elimination in a coastal state of India: a study on barriers to coverage and compliance. Infect Dis Poverty 2014;3:31.

Kabatereine N, Fleming F, Thuo W, Tinkitina B, Tukahebwa EM, Fenwick A. Community perceptions, attitude, practices and treatment seeking behaviour for schistosomiasis in L. Victoria islands in Uganda. BMC Res Notes 2014;7:900.

Lahariya C, Tomar SS. How endemic countries can accelerate lymphatic filariasis elimination? An analytical review to identify strategic and programmatic interventions. J Vector Borne Dis 2011;48(1):1–6.

Leonardo L, Rivera P, Saniel O, Villacorte E, Lebanan MA, Crisostomo B, et al. A national baseline prevalence survey of schistosomiasis in the Philippines using stratified two-step systematic cluster sampling design. J Trop Med 2012;2012:936128.

Leonardo LR, Chigusa Y, Kikuchi M, Kato-Hayashi N, Kawazu S, Angeles JM, et al. Schistosomiasis in the Philippines: challenges and some successes in control. Southeast Asian J Trop Med 2016a;47(4):651–66.

Leonardo L, Chigusa Y, Kikuchi M, Kato-Hayashi N, Kawazu S, Angeles JM, et al. Schistosomiasis in the Philippines: challenges and some successes in control. Southeast Asian J Trop Med 2016b;47(4):651–66.

Liu L, Yang GJ, Zhu HR, Yang K, Ai L. Knowledge of, attitudes towards, and practice relating to schistosomiasis in two subtypes of a mountainous region of the People's Republic of China. Infect Dis Poverty 2014;3:16.

Liu JX, Goryakin Y, Maeda A, Bruckner T, Scheffler R. Global health workforce labor market projections for 2030. Hum Resour Health 2017;15(1):11.

Lwin MM, Sudhinaraset M, San AK, Aung T. Improving malaria knowledge and practices in rural Myanmar through a village health worker intervention: a cross-sectional study. Malar J 2014;13:5.

Ma Y, Kim H, Cho Y, Lee J, Degley JK, Adam AG, et al. Effects of community health volunteers on infectious diseases of children under five in Volta Region, Ghana: study protocol for a cluster randomized controlled trial. BMC Public Health 2017;17(1):95.

Maseko TS, Mkhonta NR, Masuku SK, Dlamini SV, Fan CK. Schistosomiasis knowledge, attitude, practices, and associated factors among primary school children in the Siphofaneni area in the Lowveld of Swaziland. J Microbiol Immunol Infect 2016;(January), doi:http://dx.doi.org/10.1016/j.jmii.2015.12.003 pii: S1684-1182(16)00004-9, [Epub ahead of print].

Mazigo HD, Waihenya RK, Mkoj GM, Zinga M, Ambrose EE, Jahanpour OF, et al. Intestinal schistosomiasis: prevalence, knowledge, attitude and practices among school children in an endemic area of North Western Tanzania. J Rural Trop Public Health 2010;9:53–60.

Musuva RM, Awiti A, Omedo M, Ogutu M, Secor WE, Montgomery SP, et al. Community knowledge, attitudes and practices on schistosomiasis in western Kenya–the SCORE Project. Am J Trop Med Hyg 2014;90(4):646–52.

Mwai J, Njenga S, Barasa M. Knowledge, attitude and practices in relation to prevention and control of schistosomiasis infection in Mwea Kirinyaga county, Kenya. BMC Public Health 2016;16(1):819.

Mwanga JR, Magnussen P, Mugashe CL, Gabone RM, Aagaard-Hansen J. Schistosomiasis-related perceptions, attitudes and treatment-seeking practices in Magu district, Tanzania: public health implications. J Biosoc Sci 2004;36(1):63–81.

Odhiambo GO, Musuva RM, Odiere MR, Mwinzi PN. Experiences and perspectives of community health workers from implementing treatment for schistosomiasis using the community directed intervention strategy in an informal settlement in Kisumu City, western Kenya. BMC Public Health 2016;16:986.

Omedo MO, Matey EJ, Awiti A, Ogutu M, Alaii J, Karanja DM, et al. Community health workers' experiences and perspectives on mass drug administration for schistosomiasis control in western Kenya: the SCORE Project. Am J Trop Med Hyg 2012;87(6):1065–72.

Parker M, Allen T, Hastings J. Resisting control of neglected tropical diseases: dilemmas in the mass treatment of schistosomiasis and soil-transmitted helminths in north-west Uganda. J Biosoc Sci 2008;40(2):161–81.

Person B, Ali SM, A'Kadir FM, Ali JN, Mohammed UA, Mohammed KA, et al. Community knowledge, perceptions, and practices associated with urogenital schistosomiasis among school-aged children in Zanzibar, United Republic of Tanzania. PLoS Negl Trop Dis 2016;10(7)e0004814.

Philippine Statistics Authority. 2015 full year official poverty statistics of the Philippines. Quezon City, Philippines: Philippine Statistics Authority; 2016 27 October 2016.

Philippines DoH. Barangay health workers. 2017 Available at: www.doh.gov.ph [Accessed 20 July 2017].

Rassi C, Kajungu D, Martin S, Arroz J, Tallant J, Zegers de Beyl C, et al. Have you heard of schistosomiasis? Knowledge, attitudes and practices in Nampula Province, Mozambique. PLoS Negl Trop Dis 2016;10(3)e0004504.
Ross AG, Olveda RM, Chy D, Olveda DU, Li Y, Harn DA, Gray DJ, et al. Can mass drug administration lead to the sustainable control of schistosomiasis?. J Infect Dis 2015;211(2):283–9.
Sady H, Al-Mekhlafi HM, Atroosh WM, Al-Delaimy AK, Nasr NA, Dawaki S, et al. Knowledge, attitude, and practices towards schistosomiasis among rural population in Yemen. Parasites Vectors 2015;8:436.
WHO. Schistosomiasis and soil-transmitted helminthiases: number of people treated in 2015. Wkly Epidemiol Rec 2016a;91(49/50):585–600.
WHO. Global health estimates 2015: disease burden by cause, age, sex, by country and by region, 2000-2015. In: GHE2015_DALY_WHOReg_2000_2015.xlsx. Geneva, Switzerland: World Health Organization; 2016.
WHO. Crossing the billion. Lymphatic filariasis, onchocerciasis, schistosomiasis, soil-transmited helminthiases and trachoma: preventive chemotherapy for neglected tropical diseases. Geneva: World Health Organization; 2017.
Worrell C, Mathieu E. Drug coverage surveys for neglected tropical diseases: 10 years of field experience. Am J Trop Med Hyg 2012;87(2):216–22.
Zeng H, Yang X, Meng S, Wang H, Tang X, Tang W, et al. Awareness and knowledge of schistosomiasis infection and prevention in the “Three Gorges Dam” reservoir area: a cross-sectional study on local residents and health personnel. Acta Trop 2011;120(3):238–44.