Soil-transmitted helminthiases in school-age children following more than a decade of control program implementation in Roxas City

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ABSTRACT

Objectives. The study aimed to describe the prevalence and intensity of soil-transmitted helminthiases (STH) as well as the nutritional status of school-age children in non-sentinel public elementary schools in selected barangays in Roxas City, Capiz, the Philippines, a decade after implementation of mass drug administration (MDA). **Methods**. Children in grades one to six were targeted as participants. For the parasitological assessment, stool samples were collected, processed, and examined using Kato-Katz technique to determine the presence of STH. Prevalence of any STH and moderate-heavy intensity (MHI) infections as well as the prevalence of infection and MHI for each parasite species were derived. For the nutritional assessment, anthropometric and hemoglobin measurements were collected. Prevalence of underweight, stunting, wasting, and anemia were derived. Association between STH and nutritional status was determined. **Results**. A total of 251 children underwent parasitological assessment. Of these, 220 participated in the nutritional assessment. High prevalence of STH (66.9%) and MHI STH (39.4%) as well as high prevalence of underweight (22.6%) and stunting (30.4%) were seen, while moderate prevalence of wasting (8.3%) and anemia (12.7%) were observed. Underweight, wasting, and stunting were significantly associated with high prevalence of MHI trichuriasis (p-value <0.035), while anemia was significantly associated with high prevalence of any STH and ascariasis (p-value <0.032). **Conclusion**. STH remains a major public health concern among children in non-sentinel public elementary

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Date received: March 12, 2022
Date revised: July 06, 2022
Date accepted: October 03, 2022

KEYWORDS

soil-transmitted helminthiasis, undernutrition, mass drug administration, WASH, school-age children, Philippines

schools despite implementation of MDA for more than a decade. The findings of high prevalence and intensity of STH as well as the high rates of undernutrition suggest the need to identify and address the underlying causes of these continuing health challenges which may include limited access to MDA as well as water, sanitation, and hygiene (WASH) facilities. Multisectoral collaboration among the STH control, nutrition, and WASH sectors is necessary to help enhance disease control and improve health outcomes.

INTRODUCTION

Neglected tropical diseases (NTDs) are a diverse group of communicable diseases that prevail in tropical and subtropical conditions and mainly affect populations living in poverty with limited access to water, sanitation, and hygiene (WASH). These diseases affect more than one billion people and cost developing countries billions of dollars each year (WHO 2020). Among the specific targets of the United Nations Sustainable Development Goals is to end epidemics of NTDs by 2030 (UN 2015).

Soil-transmitted helminthiases (STH), the most common NTD, affect approximately 1.5 billion people worldwide (WHO 2020). The pathogenic agents include *Ascaris lumbricoides*, *Trichuris trichiura, Necator americanus,* and *Ancylostoma duodenale*, and transmission occurs through ingestion of embryonated helminth ova or skin penetration of infective larvae. School-age children (SAC) are among the at-risk populations for STH (WHO 2012). They bear the highest burden of infections due to their increased nutritional needs, intense development and learning capacities, and lack of awareness in hygiene (WHO 2002). As a result, high-intensity (HI) infections cause detrimental effects on their nutritional status, physical growth, and cognitive development (WHO 2012).

The World Health Organization (WHO) recommends annual or biannual mass drug administration (MDA) of anthelminthics to populations at-risk living in areas where baseline prevalence of STH is $\geqslant$20% as well as improvements in WASH to reduce morbidities caused by the infection (WHO 2017). The WHO targets to achieve $\geqslant$ 75% MDA coverage and reduce the prevalence of moderate-heavy intensity (MHI) STH to <2% (WHO 2020). In the Philippines, the Department of Health (DOH) launched the Integrated Helminth Control Program in 2006 to provide policy guidance for STH prevention and control (DOH 2006). The program aims to achieve <50% prevalence of STH among SAC through MDA of albendazole or mebendazole, covering $\geqslant$85% of the target population.

The WHO (2011) recommends periodic collection of process, parasitological, and morbidity indicators for monitoring the control program. Data of the second indicator, such as prevalence and intensity of infections, are generated through parasitological assessment of target populations. In 2007, the War on Worms (WOW) Project, implemented by the University of the Philippines Manila, promoted school-based teacher-assisted MDA in Capiz province, Western Visayas (Belizario et al. 2014). As part of monitoring the implementation of the control program, parasitological assessment was conducted in selected sentinel public elementary schools (ES) every other year. Results showed significant reductions in the prevalence (64.4% to 24.1%) and intensity of STH (33.3% to 1.7%) from 2007 to 2017 (Belizario et al. 2014). Whether the situation is similar in non-sentinel public ES, where the same MDA approach was implemented, remains undetermined.

OBJECTIVES

This study aimed to describe the prevalence and intensity of STH as well as the nutritional status of SAC in non-sentinel public ES in selected barangays in Roxas City, Capiz, the Philippines, a decade after the initial implementation of MDA.

METHODOLOGY

Study site

The study was conducted in Roxas City, one of the WOW Project sites where biannual school-based teacher-assisted MDA using mebendazole has been implemented for more than ten years. For this study, non-sentinel public ES in one island and three coastal barangays (villages), where access to WASH facilities remains a challenge based on consultation with local officials, were chosen.

Study design and sampling

The study utilized a cross-sectional study design. A total of 200 SAC from Roxas City were targeted following the WHO guidelines (WHO 1998) in evaluating the prevalence and intensity of STH. Due to generally low student population in the selected non-sentinel public ES, SAC in grades one to six were targeted for parasitological assessment, which is a modification of the recommended WHO guidelines. SAC who received anthelminthics within the last three months prior to parasitological assessment were excluded from the study. Targeted participants for the nutritional assessment included SAC who participated in the parasitological assessment.

Parasitological assessment

The study was conducted in June 2018, one month before the scheduled MDA for STH. Stool samples were collected with the assistance of school teachers, processed using the Kato-Katz technique (WHO 1998), and examined microscopically by trained medical technologists for the presence of STH. The number of eggs was determined in each sample and was multiplied by the standard factor of 24 to calculate for the number of eggs per gram (epg) of feces. The resulting number of epg was used to classify the intensity of the infection based on WHO guidelines. For quality control, 10% of slides were re-examined by a reference microscopist from the University who was blinded to the initial results. Discrepant results were resolved as necessary.

Nutritional assessment

Anthropometric and hemoglobin measurements were done by the project staff following the WHO guidelines (WHO 1995; WHO 2011). Height was measured using a mechanical, calibrated height rod and recorded to the nearest tenth of a centimeter. Weight was measured using a mechanical beam scale (DETECTO®, Missouri, USA) and recorded to the nearest tenth of a kilogram. To assess hemoglobin levels, blood was collected through finger prick method using a lancet. A microcuvette was filled with the blood sample and was inserted into a calibrated portable hemoglobin analyzer (HemoCue® Hb 201+, Angholm, Sweden) to measure hemoglobin levels.

Table 1: Prevalence and intensity of soil-transmitted helminthiases and prevalence of co-infections in school-age children by Kato-Katz technique in selected non-sentinel public elementary schools, Roxas City, Capiz, the Philippines, June 2018*

Elementary school	No. Examined	STH+ # (%)	MHI STH+ # (%)	*Ascariasi*+ # (%)	MHI *Ascariasi*+ # (%)	*Trichuriasis*+ # (%)	MHI *Trichuriasis*+ # (%)	*Ascaris*+*Trichuris* # (%)
Paciano Bombaes	44	32 (72.7)	14 (31.8)	23 (52.3)	11 (25.0)	28 (63.6)	8 (18.2)	19 (43.2)
Dumolog	53	38 (71.7)	19 (35.8)	23 (43.4)	13 (24.5)	30 (56.6)	9 (17.0)	15 (28.3)
Olotayan Integrated	103	47 (45.6)	23 (22.3)	41 (39.8)	22 (21.4)	25 (24.3)	1 (1.0)	19 (18.4)
Punta Cogon	51	51 (100.0)	43 (84.3)	49 (96.1)	38 (74.5)	50 (98.0)	26(51.0)	48 (94.1)
TOTAL	**251**	**168 (66.9)**	**99 (39.4)**	**136 (54.2)**	**84 (33.5)**	**133 (53.0)**	**44 (17.5)**	**101 (40.2)**
(95% CI)		***(60.8-72.5)***	***(33.5-45.7)***	***(47.9-60.3)***	***(27.9-39.6)***	***(46.8-59.1)***	***(13.3-22.8)***	***(34.3-46.5)***

**No hookworm infections were observed*
STH: soil-transmitted helminthiases
MHI: moderate-heavy intensity
CI: confidence interval

Data processing and analysis

Results of the parasitological assessment were double-encoded using Microsoft Excel 2016. Prevalence of any STH and MHI infections as well as the prevalence of infection and MHI for each parasite species were determined based on the WHO guidelines (WHO 1998).

Results of the nutritional assessment, particularly the anthropometric measurements, were encoded using the WHO AnthroPlus 2009 software. The height and weight measurements were used to determine nutritional indicators such as weight-for-age (WFA) Z-score, height-for-age Z-score, and body mass index-for-age (BFA) Z-score. These Z-scores were used as a basis for classification of SAC as underweight, stunted, or wasted, based on the WHO growth reference (WHO 1995). SAC whose birth dates were not recorded were excluded in the computation of Z-scores. The WFA Z-score of SAC with ages 10 years old and above was not computed because reference data for WFA are unavailable beyond such age. Hence, BFA percentiles for all SAC were calculated based on the set of growth charts of the Centers for Disease Control and Prevention (CDC 2000), since it provides reference data for SAC with ages 10 years old and above which was not previously available. SAC whose BFA were less than the fifth percentile were considered underweight based on the recommendations of the WHO. A Boolean Operator "OR" was used such that SAC who were classified as underweight based on either the WFA Z-score or the BFA percentiles, were considered underweight for this study. Results of hemoglobin assessment were encoded using Microsoft Excel 2016. The WHO cut-off values for anemia were used to classify hemoglobin levels observed in SAC (WHO 2011). Prevalence of underweight, stunting, wasting, and anemia were derived.

Pearson Chi-square test (χ^2) was used to determine the association of STH and nutritional status. A *p*-value of <0.05 was considered significant. Data analysis was done using STATA version 14.1 (StataCorp®, Texas, USA).

Ethical considerations

The study was conducted as part of monitoring the existing control program in non-sentinel public ES in selected barangays in Roxas City. Consultations with concerned offices of the Department of Education and local government units (LGUs) were done before project implementation. Prior to the conduct of both parasitological and nutritional assessments, parents or guardians and SAC were oriented by school teachers on the benefits and risks of participation in the study. Informed consent and assent were obtained as necessary. Codes were used in place of the study participant's information, and only designated members of the research team had access to the raw data and results to ensure confidentiality. Study participants who tested positive for STH were referred to the rural health unit for appropriate case management according to DOH guidelines.

RESULTS AND FINDINGS

Parasitological assessment

A total of 251 SAC participated in the parasitological assessment, with an average of 63 SAC (range of 44 to 103) per ES. High overall prevalence of STH and MHI infections were observed at 66.9% (95% CI: 60.8-72.5%) and 39.4% (95% CI: 33.5-45.7%), respectively. Highest prevalence of STH (100.0%) and MHI infections (84.3%) were seen in Punta Cogon ES, while lowest prevalence of STH (45.6%) and MHI infections (22.3%) were noted in Olotayan ES.

High overall prevalence of ascariasis and trichuriasis were observed at 54.2% (95% CI: 47.9-60.3%) and 53.0% (95% CI: 46.8-59.1%), respectively. No cases of hookworm infection were found. Overall prevalence of MHI ascariasis and trichuriasis were likewise high at 33.5% (95% CI: 27.9-39.6%) and 17.5% (95% CI: 13.3-22.8%), respectively. *Ascaris-Trichuris* co-infections were also seen in 40.2% (95% CI: 34.3-46.5%) of SAC (Table 1).

Nutritional assessment

Among those who underwent parasitological assessment, only 220 (87.6%) SAC participated in the nutritional assessment. High overall prevalence of underweight (22.6%; 95% CI: 19.5-31.1%) and stunting (30.4%; 95% CI: 24.6-36.9%) as well as moderate overall prevalence of wasting (8.3%; 95% CI: 5.3-12.8%) and anemia (12.7%; 95% CI: 8.9-17.9%) were observed. Highest prevalence of underweight (50.0%), stunting (47.2%), wasting (16.7%), and anemia (25.0%) were seen in Punta Cogon ES (Table 2).

Association of STH and nutritional status

High prevalence of any STH was not significantly associated with underweight, stunting, and wasting, while high prevalence of MHI STH was not significantly associated with underweight, stunting, wasting, and anemia (*p*-value >0.05). Underweight was significantly associated with high prevalence of trichuriasis, MHI trichuriasis, and *Ascaris-Trichuris* co-infection (*p*-value <0.013). Stunting and wasting were only significantly associated with high prevalence of MHI trichuriasis (*p*-value <0.035), while anemia was significantly associated with high prevalence of any STH, ascariasis, and *Ascaris-Trichuris* co-infection (*p*-value <0.032).

DISCUSSION

Consistent with the WHO (2011) recommendations on collection of parasitological indicators to monitor the control program, parasitological assessment was conducted in sentinel

Table 2: Prevalence of underweight, stunting, wasting, and anemia in school-age children in selected non-sentinel public elementary schools, Roxas City, Capiz, the Philippines, November 2018

Elementary school	Underweight		Stunting		Wasting		Anemia	
	No. Examined	No. of cases (%)	No. Examined	No. of cases (%)	No. Examined	No. of cases (%)	No. Examined	No. of cases (%)
Paciano Bombaes	44	3 (6.8)	44	14 (31.8)	44	2 (4.5)	46	7 (15.2)
Dumolog	40	10 (25.0)	40	9 (22.5)	40	3 (7.5)	40	1 (2.5)
Olotayan	97	23 (23.7)	97	26 (26.8)	97	7 (7.2)	98	11 (11.2)
Integrated	36	18 (50.0)	36	17 (47.2)	36	6 (16.7)	36	9 (25.0)
Punta Cogon								
TOTAL	**217**	**54 (24.9)**	**217**	**66 (30.4)**	**217**	**18 (8.3)**	**220**	**28 (12.7)**
(95% CI)		***(19.5-31.1)***		***(24.6-36.9)***		***(5.3-12.8)***		***(8.9-17.9)***

CI - confidence interval

public ES in selected barangays in Capiz province, Western Visayas. Results showed remarkable morbidity control over a ten-year follow-up period after implementation of MDA (Belizario et al. 2014). This study was then conducted to determine whether the situation was similar in non-sentinel public ES, where the same MDA approach was implemented.

Results of the study revealed very high overall prevalence (66.9%) and MHI STH (39.4%), suggesting that morbidity control has remained a challenge among SAC in the selected non-sentinel public ES in Roxas City, despite implementation of MDA for more than a decade. MHI infections are a major source of morbidity (WHO 2017), and their link with undernutrition has been well-established (WHO 1998). Nutritional assessment showed high overall prevalence of underweight (22.6%) and stunting (30.4%) as well as moderate overall prevalence of wasting (8.3%). SAC in Punta Cogon ES, in particular, which recorded the highest prevalence of STH and MHI infections, also had the highest prevalence of underweight, stunting, wasting, and anemia. This is supported by findings of other studies wherein MHI STH was found to be associated with undernutrition among children (Simarmata and Sembiring 2015; Moncayo et al. 2018).

Prevalence of stunting and wasting observed in this study were higher compared to the 2018 national prevalence of 24.5% and 7.6% (FNRI 2019), not meeting the national cut-offs of <21.4% and <5%, respectively (DOH-NNC 2016). Likewise, our results failed to meet the global targets for underweight (<10% prevalence), stunting (<20% prevalence), wasting (<5% prevalence), and anemia (<5% prevalence) (WHO 1995; WHO 2011). Poor nutritional status among SAC should be addressed considering its detrimental effects. Children who are mildly underweight have an increased mortality risk, while severely underweight children are at an even greater risk (WHO 2010). Stunting may lead to delayed mental development, poor school performance, and reduced intellectual capacity. Wasting impairs functioning of the immune system, leading to increased severity and duration of, and susceptibility to infectious diseases. Anemia impairs the physical and cognitive development of children and is associated with mortality.

Results of this study revealed that underweight, stunting, and wasting were significantly associated with high prevalence of MHI trichuriasis, supporting the findings of another study done in Malaysia (Gilman et al. 1983). Children who have MHI trichuriasis may experience nausea, vomiting, bloody diarrhea, abdominal pain, and tenesmus, which can result in decreased food intake and increased nutrient losses, thereby contributing to malnutrition (Stephenson et al. 2000). Anemia was found to be significantly associated with high prevalence of any STH and ascariasis, which was consistent with the results of another study conducted in South Ethiopia (Molla and Mamo 2008). Although high prevalence of any STH was not found to be significantly associated with underweight, stunting, and wasting, other studies have shown otherwise (Shang et al. 2000; Anwar et al. 2018). Helminth infections are considered important contributors to undernutrition (Pullan and Brooker 2008). Likewise, undernourished children have weaker immune system, making them more susceptible to STH (WHO 2015). This allows a vicious cycle of poor nutritional status and infection, which may explain the high rates of STH and undernutrition seen in this study.

The last four rounds of MDA in the non-sentinel public ES reported high coverage, meeting both global (WHO 2020) and national (DOH 2006) targets of 75% and 85%, respectively. However, these were inconsistent with the high prevalence of STH and MHI infections observed in the study. SAC in Punta Cogon ES, in particular, had the highest prevalence of STH and MHI infections while having reported the highest MDA coverage in January 2018. The challenge in morbidity control among SAC suggests the need to validate reported coverages and revisit existing approaches for MDA delivery to identify areas of improvement. In case of low coverage, there may be a need to modify existing approaches to enhance MDA delivery. If the coverage was found to be high, continuous efforts must be made to sustain it. In areas with persistent STH prevalence of >50%, triannual MDA may be implemented as recommended by the WHO (2020). This was found to be more effective in significantly reducing STH among Kenyan children as compared to annual MDA (Kepha et al. 2017).

Continuing major challenges in WASH in the study sites may contribute to persistence of high burden of STH (Strunz et al. 2014). In 2018, the reported sanitary toilet coverages in the four selected barangays (40.3% to 78.3%) in Roxas City were low, not meeting both the global (WHO 2017) and national (DOH 2010) targets of 100%. Access to sanitation facilities is essential to prevent open defecation which is linked to higher incidence of STH in children when compared to those who have toilets at or around their homes (Abossie and Seid 2014). Likewise, availability and use of sanitation facilities are associated with a reduction in prevalence of STH due to a lower risk for transmission and reinfections (Ziegelbauer et al. 2012). The selected barangays, being coastal and island barangays, may have inadequate sanitation facilities due to their geographical location and environmental conditions (Navarro 1994), suggesting the need to revisit the WASH coverages in the selected sites and improve them.

Aside from inadequate sanitation, the high burden of STH may also be due to poor hygienic practices such as improper handwashing, having long or untrimmed nails, and habitually picking up and eating food from the ground, which may be common among children (Gabrie et al. 2014; Kattula et al. 2014). Deficiency in WASH may also contribute to the high prevalence of undernutrition seen among SAC. A study conducted in India

revealed that household access to toilet facilities was associated with a 16-39% lower odds of being stunted.[35] Similar findings of association between poor WASH conditions and undernutrition have also been reported in other developing countries (Fink et al. 2011; Ngure et al. 2014). This link between poor WASH and developmental deficits may be mediated by a key pathway such as environmental enteropathy (Chen et al. 2015). Therefore, improvements in sanitation by increasing access to sanitary toilets, health education campaigns on topics such as risk behavior, transmission, prevention, and control of STH, and promotion of good hygiene behavior alongside implementation of MDA that achieves sustained high coverage, can help lower the prevalence and intensity of STH among SAC (Steinmann et al. 2014) that will, in turn, contribute to improved nutritional status and other health outcomes.

The findings of this study were inconsistent with the results of the monitoring done by the WOW Project in selected sentinel public ES in Capiz province which showed highly remarkable morbidity control over a ten-year follow-up period (Belizario et al. 2014). Regular monitoring and follow-up activities conducted in the sentinel public ES, in contrast to non-sentinel public ES, may have possibly contributed to better program implementation of the LGUs in these sites. This phenomenon is referred to as the Hawthorne Effect, wherein subjects may alter their behavior due to their awareness of being observed. Awareness of the study goals (Chen et al. 2015) as well as direct feedback from observers (Storey et al. 2014) may also influence the performance of program implementers. Since results of the parasitological assessments conducted throughout the years were fed back to the various stakeholders and concerned LGUs of the sentinel public ES, this may have driven them to improve their implementation of the program to meet the desired targets and outcomes of the Project. Thus, there may be a need to consider inclusion of non-sentinel public ES on a minimal scale in future monitoring activities of the program to help identify possible pockets of high endemicity that could provide targeted interventions in highly challenged areas.

As demonstrated by this study, an integrated approach in the collection of both parasitological (i.e., prevalence and intensity of infections) and morbidity indicators (i.e., malnutrition and anemia) among SAC in ES is valuable in monitoring the impact of the control program on the intensity of helminth infections and its effectiveness on improving health status, respectively (WHO 2011). This integrated approach allows optimal use of limited resources which are especially important in developing countries such as the Philippines.

Results of this study cannot be generalized to other non-sentinel public ES of Roxas City. Since a cross-sectional study design was used, a causal relationship between STH and nutritional status could not be established. Secondary data on the MDA and sanitary toilet coverages obtained were dependent on the teachers' and sanitary inspectors' ability, respectively, to accurately record and report these data, potentially affecting validity. Furthermore, there is a discrepancy in the number of SAC who underwent the parasitological and nutritional assessment, with the latter having less study participants due to fear of being finger pricked for the hemoglobin assessment.

CONCLUSION AND RECOMMENDATION

STH remains a major public health concern among SAC in the selected non-sentinel public ES despite implementation of MDA for more than a decade. The findings of high prevalence and intensity of STH as well as high rates of undernutrition suggest the need to identify and address the underlying causes of these continuing health challenges which may include limited access to MDA and WASH facilities. Multisectoral collaboration among the STH control, nutrition, and WASH sectors is necessary to help enhance disease control and improve health outcomes.

ACKNOWLEDGMENTS

The authors would like to acknowledge the Gerry Roxas Foundation, Inc., Capiz Provincial Health Office, and Roxas City Health Office, Capiz, the Philippines for their technical assistance, as well as the Infant Pediatric Nutrition Association of the Philippines for their support in the nutritional assessment of this study. The authors would also like to thank Ms. Audrey Marie D.L. Agustin for her assistance in data collection and manuscript preparation.

CONFLICT OF INTEREST

All authors declare no conflict of interest. This research received funding from the Gerry Roxas Foundation, Inc., Roxas City, Capiz, the Philippines as well as from the Provincial Government of Capiz and the Roxas City Government. The analyses and views expressed in this submitted article are the authors' own.

CONTRIBUTIONS OF INDIVIDUAL AUTHORS

VY Belizario Jr is the principal author and contributed to the conceptualization of research, acquisition and analysis of data, drafting and revising, and final approval of the manuscript to be published. DLPF Cubarrubias contributed to the acquisition and analysis of data, drafting and revising, and final approval of the manuscript to be published, LAD Ong, contributed to the analysis of data, drafting and revising, and final approval of the manuscript to be published. AQ Villarruz and LC Biclar contributed to data acquisition, revising and final approval of the manuscript. All authors agree to be accountable for all aspects of the work. All authors declare that the manuscript's data, figures, graphs, calculations, etc. are authentic.

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