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Geohelminth infection, anemia, and malnourishment in Bawa, Cameroon after ten years of intervention by the Bawa Health Initiative

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ABSTRACT

The Bawa Health Initiative (BHI) was established in 2005 with the goal of initiating a comprehensive public health care program in Bawa, a rural village in the West region of Cameroon. Interventions undertaken include a comprehensive helminth control program, provision of water filters, sanitary latrines, insecticide-treated bed nets, and a health education program. Data gathered from citizens of Bawa during Dec 2017, were obtained from the Sophie Awounke Community Health Center in Bawa, Cameroon. These data including prevalence of geohelminth infection, morphometric data, and hemoglobin concentrations were compared to data gathered in previous surveys conducted by BHI in 2007 and 2010 to assess the effectiveness of interventions implemented by the organization. All metrics indicate substantial improvement in the overall health of the citizens of Bawa, evidenced by decreases in the occurrence of anemia, prevalence of malnourished, undernourished and stunted individuals and in the prevalence and intensity of geohelminths. These data strongly suggest that public health interventions implemented by BHI have been effective in reducing the burden of disease and increasing the overall well-being of the citizens of Bawa, Cameroon and surrounding villages.
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Keywords: Ascariasis, trichuriasis, hookworm infection

INTRODUCTION

The Bawa Health Initiative (BHI) is a 501(c)3 non-profit organization established in 2005 with the goal of initiating a comprehensive public health care program in the village of Bawa and surrounding areas located in the Menoua Division, West Region of Cameroon, Africa. For geographic,

demographic, and climatological descriptions of Bawa and surrounding regions, refer to Smith (2007), Callahan (2010), Tchuinkam et al. (2010), Richardson et al. (2011a, b) and Onana et al. (2019). Included among the interventions implemented by BHI was a comprehensive helminth control program initiated in 2008, consisting of biannual treatments, with single 400 mg doses of albendazole being distributed to all citizens of Bawa over the age of 2 years, excepting pregnant women. In addition, during the summers of 2007 and 2008, insecticide treated bed nets were distributed to all residents to minimize transmission of malaria. The Village Health Committee of Bawa and BHI has continuously maintained an ongoing program of education stressing the importance of continual proper usage of bed nets, including inspection and replacement of nets as necessary. Other public health measures undertaken by BHI in Bawa include the installation of biosand water filters in all family compounds and, beginning in 2014, a program of installation of sanitary latrines since provision of adequate sanitation is essential for human health and well-being (Letah Nzouebet et al., 2019). Richardson et al. (2011b) provided a detailed description of early interventions in Bawa and surrounding villages.

On 4th December 2017, the Sophie Awounke Community Health Center was opened in Bawa. Over a four-day period, all residents of Bawa were asked to visit the clinic to receive a basic health examination. Stool exams were conducted, and basic morphometric data and hemoglobin concentrations were measured as part of this survey. The overall results of these examinations are presented herein and compared to earlier data. The objectives of this study were to assess the efficacies of public health interventions undertaken by BHI over the past ten years and to provide a benchmark for comparison to assess future effectiveness of the program.

MATERIALS AND METHODS

A survey of geohelminth infection was conducted according to Richardson et al. (2011a,b) as follows: Between 4th December and 7th December 2017, 210 stool samples were examined for the presence of the geohelminths *Ascaris lumbricoides, Trichuris trichiura,* and hookworms using the Kato-Katz technique and when sample volume permitted fecal flotation as described by Richardson et al. (2008). All slides were examined within one hour of preparation. Data were divided among age groups and genders as follows: 0-5 years (pre-school children), 6-15 (school-aged children), 16-59 (adults), and $\geq$ 60 (senior adults). All samples were examined using the Kato-Katz technique and approximately 150 samples were examined using fecal flotation. Utilization of fecal flotation failed to reveal any infection not detected by Kato-Katz, thus all data reported in results were determined by the Kato-Katz technique. Additionally, future surveys conducted on this population for comparative purposes need not utilize fecal flotation. Infection intensity was categorized based on Montressor et al. (2002) as described by Richardson et al. (2011b).

Assessment of general health and nutritional status of 247 individuals was conducted by observation of morphometric data [height, weight, and body mass index (BMI)] and hemoglobin levels according to Richardson et al. (2011b) as follows: Height was recorded in cm and weight was recorded in kg. Body mass index was calculated according to the World Health Organization (WHO) (2006) using the formula BMI=mass (kg) / [height (m)]^2. Individuals with a BMI $\leq$ 2 standard deviations (SD) from the WHO growth standards were considered malnourished and individuals with a BMI $\leq$ 3 SD were categorized as exhibiting severe acute malnutrition following universal standards calculated by WHO for children $\leq$ 5 years (WHO, 2006; WHO and UNICEF, 2009) and adolescents 6-19 years (de Onis et al., 2007).

Nutritional status of adults ($\geq$ 20 years) was assessed according to WHO guidelines (WHO, 1995) such that adults with a BMI < 18.5 were considered malnourished. Children and adolescents 5-19 years exhibiting height for age $\leq$ 2SD and $\leq$ 3SD from the WHO standards were considered stunted and severely stunted, respectively (Caulfield et al., 2006). Children, $\leq$ 10 years-of-age, exhibiting weight for age $\leq$ 2 SD and $\leq$ 3 SD from the WHO standards were considered underweight and severely underweight, respectively. Children, 2-5 years-of-age, whose weight for height was $\leq$ 2 SD from WHO standards were considered wasted (Caulfield et al., 2006).

Hemoglobin concentration was recorded in g/dl from a drop of blood procured by dermal puncture. Individuals were categorized as not anemic, anemic, or severely anemic according to standards established by Stoltzfus and Dreyfuss (1998). The hemoglobin concentration (g/dl) cut-off for being considered anemic for children under 5 years was 11.0. For children 5-11 years the cutoff was 11.5, for women the cutoff was 12.0, and for men the cutoff was 13.0. Individuals with a hemoglobin concentration $\leq$ 7 were considered severely anemic. These represent conservative estimates because the standards were established assuming hemoglobin concentration at sea level (Stoltzfus and Dreyfuss, 1998) and the numbers were not adjusted for altitude (Nestle et al., 1999).

Prevalences among cohorts of individuals were compared using contingency table analysis as described by Zar (1999).

RESULTS

Eight (3.8%) of 209 individuals (15 pre-school males, 9 pre-school females, 31 school-aged males, 31 school-aged females, 24 adult males, 55 adult females, 17 senior males, 21 senior females, one male of an undetermined age, and five females of undetermined age) examined for geohelminth infection were determined to be infected with *A. lumbricoides*, *T. trichiura,* or hookworms. All infections were categorized as light. Two (1.0%) individuals, an adult female and a senior male, were infected with *A. lumbricoides*. Infection intensities were 24 and 700 epg respectively. Four (1.9%) individuals, one school-aged male, one school-aged female, one adult male, and one senior male were infected with *T. trichiura*. Infection intensities were 96, 28, 168, and 24 epg respectively. Two (1.0%) individuals, a school-aged female and an adult female were infected with hookworm. Infections intensity was 24 epg in both instances. Data are summarized in Table 1. Chi-square analysis comparing overall prevalence of infection with geohelminths between the 2010 and 2017 data (Richardson et al., 2011 a,b) revealed significant decreases for each species examined and combined geohelminths as follows: *A. lumbricoides* (X^2= 6.34; 1 d.f.; p = 0.12), *T. trichiura* (X^2= 25.41; 1 d.f.; p < 0.00001), hookworm (X^2= 7.19; 1 d.f.; p = 0.0073), and combined geohelminths (X^2= 28.75; 1 d.f.; p < 0.00001). Prevalence data for 2007, 2010, and 2017 are summarized in Figure 1. There were too few infected individuals in the current survey to provide meaningful analysis regarding infection intensities between cohorts and previous years. Nevertheless, a substantial decrease in intensity is evident between 2010 and 2017.

Hemoglobin levels were measured for 210 individuals, of which 62 (29.5%) were anemic. No individual was severely anemic. Data are summarized in Table 2 along with comparative data from earlier surveys (Richardson et al., 2011b).

In 2017, in Bawa, overall 6 (2.4%) of the 247 individuals examined were characterized as malnourished based on BMI, 1 pre-school female, 1 adult female, 2 senior females, and 2 senior males. No individual was categorized as severely malnourished based on BMI. In 2010, 11 (5.0%) of 220 individuals examined were categorized as malnourished, 1

adolescent male, 3 adolescent females, 2 adult females, 3 senior males, and 2 senior females. Likewise, no one was categorized as severely malnourished in 2010. In 2007, 23 (8.6%) of 269 individuals were categorized as malnourished, 2 pre-school females, 4 pre-school males, 4 adolescent females, 2 adolescent males, 4 adult females, 4 senior females, and 3 senior males. Of these, 4 individuals constituting 1.8% of the population were considered severely malnourished, 3 pre-school males, and 1 adolescent male. Chi-square analysis revealed no significant difference in the relative numbers of malnourished individuals between 2010 and 2017. Likewise, Richardson et al. (2011b) detected no significant difference in the relative numbers of malnourished individuals between 2007 and 2010. However, chi-square analysis did reveal a significant decrease in the relative number of malnourished individuals between 2007 and 2017 (X^2= 9.10; 1 d.f.; p = 0.0026). Data are graphically represented in Figure 2.

In 2017, among children and adolescents, 5-19 years of age, 8 (7.8%) of 103 individuals were categorized as stunted based on WHO height for age standards. Five (9.1%) of 55 males and 3 (6.3%) of 48 females were stunted. Chi-square analysis revealed no significant difference in the relative number of stunted individuals (X^2=1.64; 1 d.f.) between genders. Of these, 3 (5.5%) of the 55 males constituting 2.9% of the overall sample were severely stunted. In 2010, 41 (36.3%) of 113 individuals were categorized as stunted. Of these, 20 constituting 17.7% of the sample were severely stunted. Chi-square analysis conducted between the data for 2010 and 2017 revealed significant decreases in the relative number of stunted individuals (X^2=24.9; 1 d.f.; p < 0.00001) and the relative number of severely stunted individuals (X^2=12.38; 1 d.f.; p=0.00043). In 2007, 52 (43.0%) of 121 children and adolescents were categorized as stunted. Of these, 20 constituting 16.3% of the sample were severely stunted. Chi-square analysis conducted by Richardson et al. (2011b) revealed no significant difference in the relative number of stunted or severely stunted children and adolescents between 2007 and 2010. Data are graphically represented in Figure 3.

In 2017, among children 2-10 years of age, 3 (5.9%) of 51 were underweight or severely underweight based on WHO weight-for-age standards. One (2.0%) of the 51 children, a boy, was severely underweight. Chi-square analysis revealed no significant difference between genders in weight-for-age (X^2=0.41; 1 d.f.). In 2010, 23 (41.1%) of 56 children were underweight or severely underweight with 9 (17.6%) of the 51 being severely underweight. Chi-square analysis conducted between the data for 2010 and 2017 revealed significant decreases in the relative number of underweight children (X^2=18.00; 1 d.f.; p < 0.000022) and the relative number of severely underweight children (X^2= 6.27; 1 d.f.; p=0.012). In 2007, 31 (35.6%) of 87 children were categorized as underweight or severely underweight. Chi-square analysis conducted by Richardson et al. (2011b) revealed no significant difference in the relative number of underweight children between 2007 and 2010. Data are graphically represented in Figure 4.

In 2017, none of the 18 children (2-5 years), 12 boys and 6 girls, were categorized as wasted based on WHO standards of weight for height. Likewise, none of 13 children examined in 2010 were wasted; however, in 2007, 2 (5.9%) of 34 children were categorized as wasted.

Table 1: Prevalence [number infected/number sampled (%)], mean intensity±SE given in eggs per gram of feces (epg) of *Ascaris lumbricoides*, *Trichuris trichiura*, hookworm, and combined geohelminths in 2017.

| Cohort		*Ascaris lumbricoides*	*Trichuris trichiura*	Hookworm	Overall Geohelminths
♂ Preschool	# infected/# sampled (%)	0/15 (0.0%)	0/15 (0.0%)	0/15 (0.0%)	0/15 (0.0%)
	Mean intensity (±SE)	---	---	---	n/a------
	Range	---	---	---------	n/a
♀ Preschool	# infected/# sampled (%)	0/9 (0.0%)	0/9 (0.0%)	0/9 (0.0%)	0/9 (0.0%)
	Mean intensity (±SE)	---	---	---	n/a
	Range	---	---	---------	n/a
Overall Preschool	# infected/# sampled (%)	0/24 (0.0%)	0/24 (0.0%)	0/24 (0.0%)	0/24 (0.0%)
	Mean intensity (±SE)	---	---	---	n/a
	Range	---	---	---------	n/a
♂ School-aged	# infected/# sampled (%)	0/31 (0.0%)	1/31 (3.2%)	0/31 (0.0%)	1/31 (3.2%)
	Mean intensity (±SE)	---	96±0	---	n/a
	Range	---	96-96	-------	n/a
♀ School-aged	# infected/# sampled (%)	0/31 (0.0%)	1/31 (3.2%)	1/31 (3.2%)	1/31 (3.2%)
	Mean intensity (±SE)	---	28±0	24±0	n/a
	Range	---	28-28	24-24	n/a
Overall School-aged	# infected/# sampled (%)	0/62	2/62 (3.2%)	1/62 (1.6%)	3/62 (4.8%)
	Mean intensity (±SE)	---	62±34	24±0	n/a
	Range	---	28-96	24-24	n/a
♂ Adult	# infected/# sampled (%)	0/24 (0.0%)	1/24 (4.1%)	0/24 (0.0%)	1/24 (4.1%)
	Mean intensity (±SE)	---	168±0	---	n/a
	Range	---	168-168	---	n/a
♀ Adult	# infected/# sampled (%)	1/55 (1.8%)	0/55 (0.0%)	1/55 (1.8%)	2/55 (3.6%)
	Mean intensity (±SE)	24±0	---	24±0	n/a
	Range	24-24	---	24-24	n/a
Overall Adult	# infected/# sampled (%)	1/79 (1.3%)	1/79 (1.3%)	1/79 (1.3%)	3/79 (3.8%)
	Mean intensity (±SE)	24±0	168±0	24±0	n/a
	Range	24-24	168-168	24-24	n/a
♂ Senior	# infected/# sampled (%)	1/17(5.9%)	1/17 (5.9%)	0/17 (0.0%)	2/17 (11.8%)
	Mean intensity (±SE)	700±0	24±0	---	n/a
	Range	700-700	24-24	---	n/a
♀ Senior	# infected/# sampled (%)	0/21 (0.0%)	0/21 (0.0%)	0/21 (0.0%)	0/21 (0.0%)
	Mean intensity (±SE)	---	---	---	n/a
	Range	---	---	---	n/a
Overall senior	# infected/# sampled (%)	1/38 (2.6%)	1/38 (2.6%)	0/38 (0.0 %)	2/38 (5.3%)
	Mean intensity (±SE)	700±0	8±0	---	n/a
	Range	700-700	8-8	---	n/a
♂ Overall	# infected/# sampled (%)	1/87 (1.1%)	3/87 (3.4%)	0/87 (0.0%)	4/87 (4.6%)
	Mean intensity (±SE)	700±0	96±	---	N2244//a
	Range	24-92,232	24-168	---	n/a
♀ Overall	# infected/# sampled (%)	1/116 (0.86%)	1/116 (0.86%)	2/116 (1.7%)	4/116 (3.4%)
	Mean intensity (±SE)	24±0	28±0	24±0	a
	Range	24-24	28-28	24-24	n/a
OVERALL	# infected/# sampled (%)	2/209* (1.0%)	4/209* (1.9%)	2/209* (1.0%)	8/209* (3.8%)
	Mean intensity (±SE)	362±338	79±34	24±0	n/a
	Range	24-700	24-168	24-24	n/a

*This sample size of 209 individuals includes 1 male and 5 females of indeterminate age, who were not infected with any geohelminths, but could not be verified to a specific cohort.
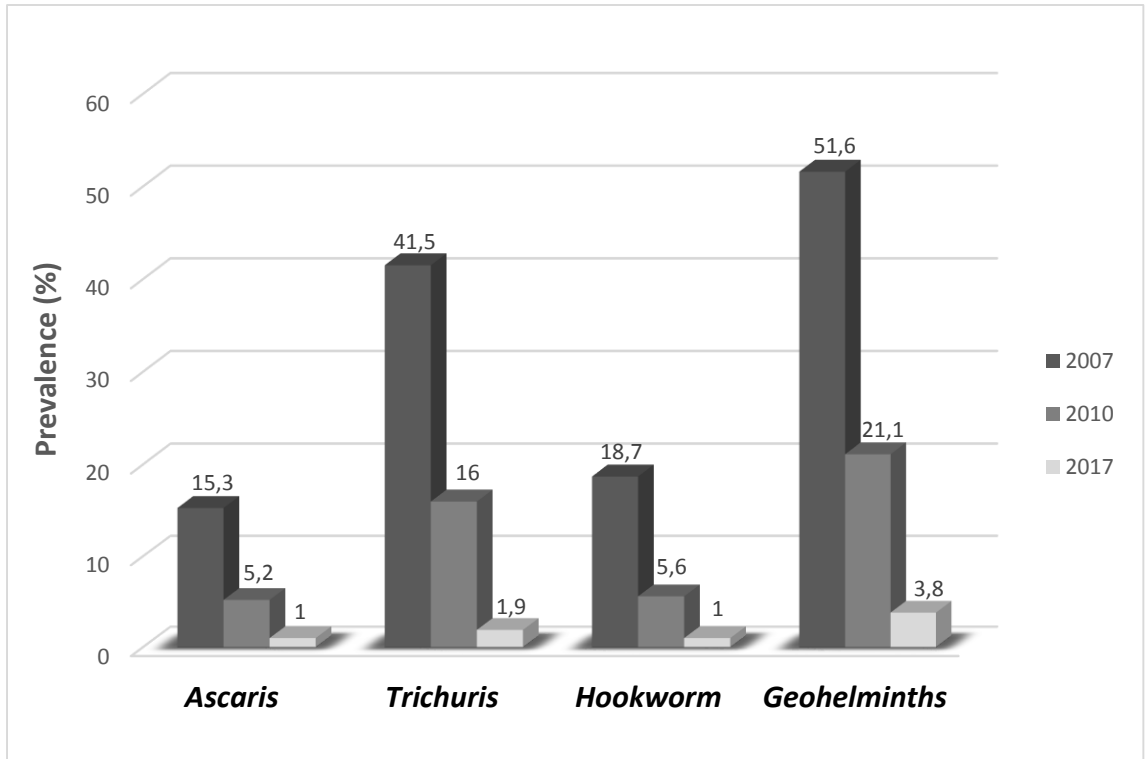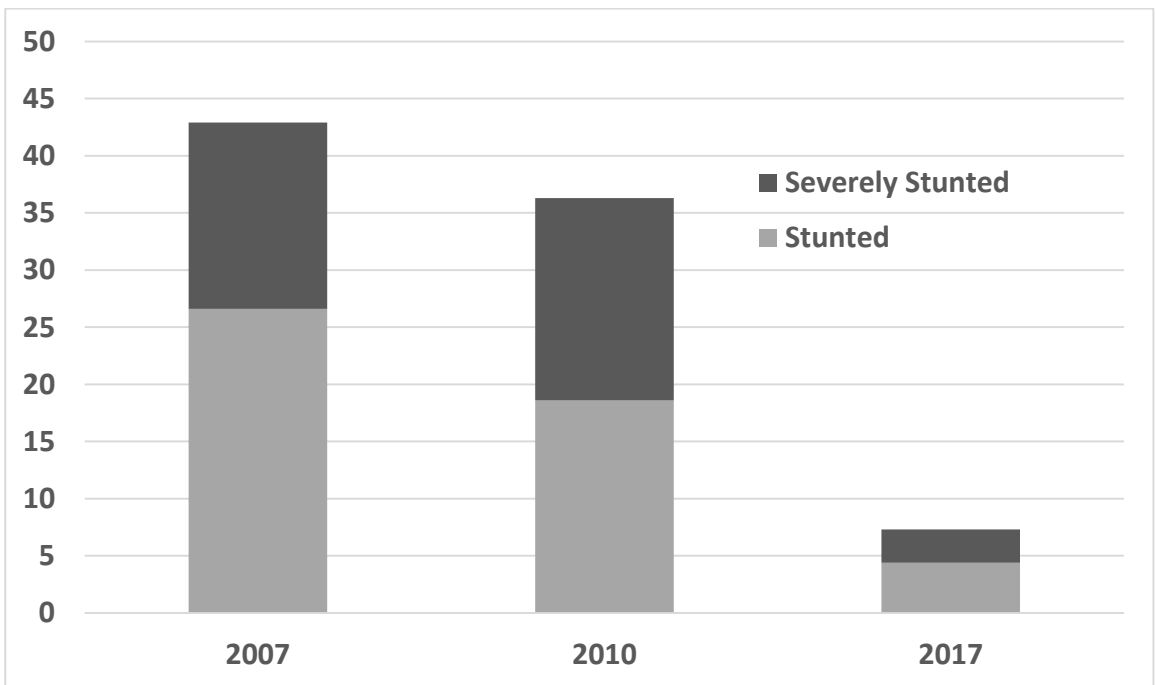
Figure 1: Comparison of prevalences of *Ascaris lumbricoides*, *Trichuris trichiura*, hookworms, and combined geohelminths between 2007, 2010 and 2017 for the combined population of Bawa.

Table 2: Incidence (number anemic/number sampled (%)), mean intensity (±SE) given as hemoglobin/dl of whole blood, and incidence of severe anemia (≤ 7 g hemoglobin/dl) in 2007, 2010, and 2017.

| Age (years)		2007	2010	2017
<5	# anemic/# sampled	26/30 (86.7%)	9/13 (69.2%)	5/20 (25.0%)
	Mean Hbg (±SE)	9.4±0.3	9.5±0.8	9.6±0.6
	# Severely anemic (%)	3 (10.0%)	0 (0.0%)	0 (0.0%)
5-11	# anemic/# sampled	60/67 (89.6%)	36/69 (52.2%)	8/31 (25.8%)
	Mean Hbg (±SE)	9.6±0.2	11.4±0.2	10.8±0.2
	# Severely anemic (%)	4 (6.0%)	0 (0.0%)	0 (0.0%)
>11	# anemic/# sampled	108/159 (68.0%)	60/132 (45.5%)	49/159 (30.8%)
	Mean Hbg (±SE)	11.0±0.2	11.4 ±2	11.3±0.1
	# Severely anemic (%)	2 (1.2%)	1 (0.8%)	0 (0.0%)
Overall	# anemic/# sampled	194/256 (75.8%)	105/214 (49.1%)	62/210 (29.5%)
	Mean Hbg (±SE)	10.5±0.1	11.9±0.1	11.1±0.1
	# Severely anemic (%)	9 (3.5%)	1 (0.5%)	0 (0.0%)
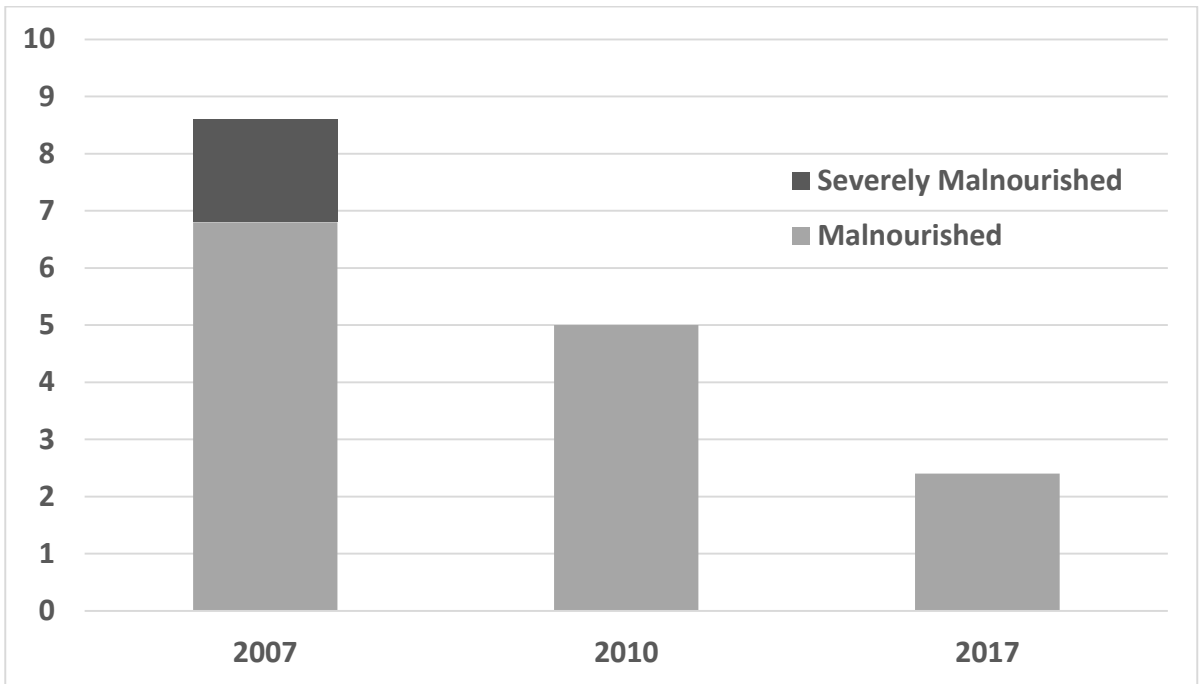
Figure 2: Comparisons of prevalences of malnourishment and severe malnourishment between 2007, 2010, and 2017 in Bawa, Cameroon.

Figure 3: Comparisons of prevalences of stunted and severely stunted individuals (aged 5-19) between 2007, 2010, and 2017 in Bawa, Cameroon.
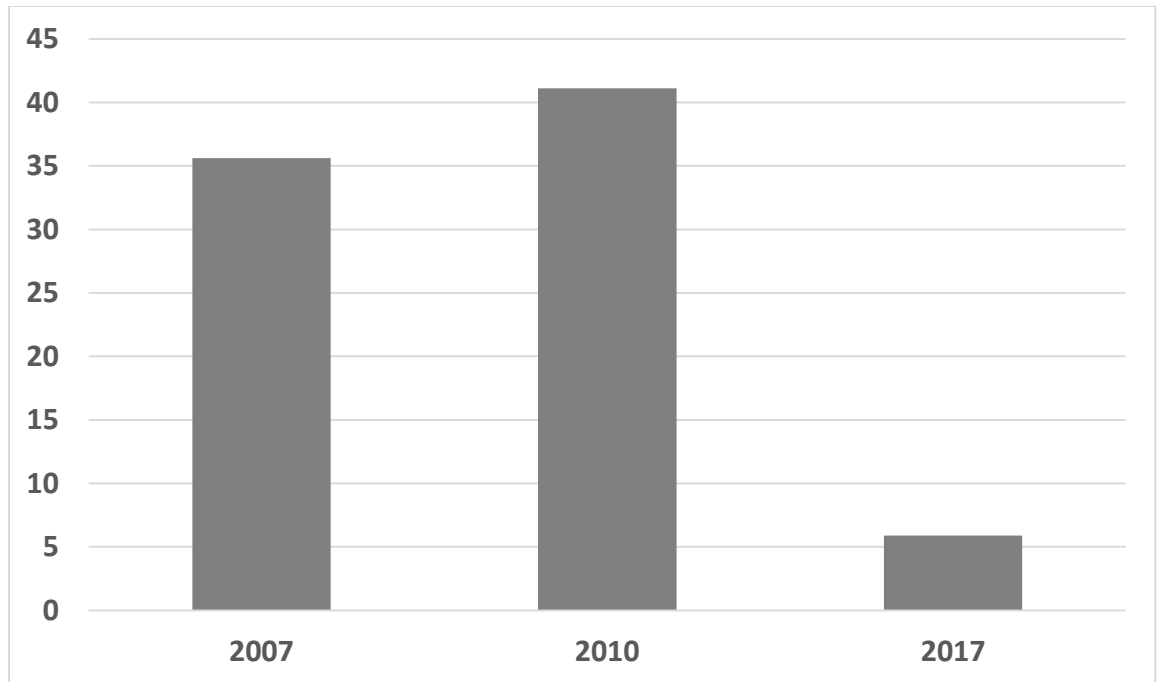
Figure 4: Comparisons of prevalences of underweight individuals (aged 2-10) between 2007, 2010, and 2017 in Bawa, Cameroon.

DISCUSSION

This study provides an assessment of interventions implemented by BHI in Bawa, including provision of insecticide treated bed nets, water filters, sanitary latrines, a geohelminth control program utilizing the anthelmintic albendazole, and a rigorous education program focused on basic matters of sanitation and hygiene. All metrics indicate substantial improvement in the overall health of the citizens of Bawa between 2007 and 2017, evidenced by decreases in the occurrence of anemia (Table 2), and prevalence of malnourished, undernourished and stunted individuals (Figures 2-4). Particularly noteworthy is the reduction in the prevalence and intensity of geohelminths (Figure 1), which may have a profound impact on the overall

health and well-being of persons living in endemic areas (Yapi et al., 2017; Orsot et al., 2018). Given the high degree of success realized in the control of geohelminth infections through the treatment program initiated by BHI, it was determined to reduce the number of treatments from 2 per year (June and December), to once per year (June) based on recommendations of the World Health Organization (2002), beginning in 2018. The general recommendations are that in areas where the prevalence of geohelminth infection is greater than 70% and more than 10% moderate and heavy infections, 2-3 treatments per year are recommended. When the prevalence is between 40-60% and the incidence of moderate and heavy infections is less than 10%, treatment is recommended once

per year. Advantages of optimizing the number of treatments to the minimal level required to achieve community control of geohelminth infection, include reduced cost, reduced logistic complexity, and foremost, reduced risk of development of resistance to anthelmintics (Albonico et al., 2003; Hotez et al., 2006; Richardson et al., 2011b).

Conclusion

These data strongly suggest that public health interventions implemented by the Bawa Health Initiative have been exceedingly effective in reducing the burden of disease and increasing the overall well-being of the citizens of Bawa, Cameroon and surrounding villages. Additionally, these data provide an important hallmark in continuing to monitor the effectiveness of the activities of the Bawa Health Initiative subsequent to opening the Sophie Awounke Community Health Center in December 2017.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

DJR designed the study and directed data acquisition, data analyses, and wrote the text of the manuscript. JG worked with DJR in data acquisition. PT is the Chief Medical Officer of BHI and oversees and coordinates all treatment and surveillance efforts. BD has been an integral part of the design and conduct of this entire disease control program since its inception in 2005. He was instrumental in acquiring funds and arranging logistic support making this work possible. BD critically revised the manuscript.

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