REVIEW PAPER
Ife Journal of Science vol. 18, no. 4 (2016)

SPATIAL DISTRIBUTION OF HELMINTH INFECTIONS IN NIGERIA (2005-2015) AND THE NEED FOR ATTITUDINAL AND BEHAVIOURAL CHANGES IN THE WATER, SANITATION AND HYGIENE INTERVENTIONS

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(Received: 25th July, 2016; Accepted: 27th September, 2016)

ABSTRACT

This study critically reviewed the spatial distributions of helminth infections in Nigeria within the last decade (2005-2015) and the need for urgent interventions in order to protect the susceptible populations against its morbidity and mortality. This study revealed that prevalence of intestinal helminth in the country has not declined since the1970s. *Ascaris lumbricoides* was the most prevalent helminth in the Southwestern (21%) and South-southern (13%) parts of Nigeria. Hookworm was the most prevalent helminth infection in the Southeastern (19%) while multiple infections were highly prevalent in Northern Nigeria (25% in North-central and 19% in the Northeast and Northwest, respectively). Cases of *Taenia sp* and *Schistosoma mansoni* infections were high in the Northeast and Northwest of Nigeria (8% and 6%, respectively). Nigeria has benefited from the Water, Sanitation and Hygiene (WASH) programme for over thirty years in the aspects of enhanced capacity building for applying personal hygiene and sanitation, improved water sources and provision of sanitation facilities and the National Emergency Group for coordination of emergency preparedness and response for WASH-related diseases. Despite the WASH interventions, prevalence of helminth infections in Nigeria is still very high and alarming. The factors identified for the high prevalence include socio-economic status, culture and ignorance; attitudes and behaviours toward hygiene and sanitation are also critical.

Keywords: spatial, prevalence, helminthes, water, hygiene, sanitation, Nigeria.

INTRODUCTION

In Nigeria, infections caused by intestinal parasites are of public health concern. Poor socio-economic environment is a major factor facilitating the spread of the disease (WHO, 2002). The prevalence rate of intestinal parasites varies considerably in different parts of Nigeria. Studies had shown *Ascaris lumbricoides* as the most prevalent helminth followed by hookworms, *Trichuris trichiura* and *Strongloides stercoralis* (Asaolu, 2002; Sam-Wobo and Mafiana, 2006). For instance, the study of Taiwo and Agbolade (2000) showed *A. lumbricoides* as the most prevalent parasite (66%) among school children in Oru, Ogun State. On the contrary, published work in some parts of Nigeria had revealed hookworm as the most prevalent helminth (Suswan *et al*., 1992; Anosike *et al*., 2006). Furthermore, *T. trichiura* was reported as the most prevalent in parts of Lagos and Oyo (Ogbe and Adu, 1990). According to Olaniyi *et al.* (2007), unhygienic practices of people dumping excrement or defecating indiscriminately at dumpsites, nearby bushes, traffic highways, river banks and open fields in the 1980s had not changed till date. Little success has been achieved in the introduction of latrines to rural communities in Nigeria (Holland and Asaolu, 1990; Ekundayo *et al*., 2007). It was observed that helminth infections are a disease of poverty, with a strong correlation found between parental socio-economic status and intestinal parasitosis in children (Oston *et al*., 2007). Infection by intestinal helminths thrives and persists in communities lacking better housing, clean water, good sanitation, improved access to health care, education and increased personal income (Crompton, 1999). Sam-Wobo *et al.* (2007) concluded in their study that, the unwillingness to pay for helminth treatment was a factor of ignorance and low economic profile of the community member. These are typical characteristics of many rural communities and urban slums in Nigeria. Also, children raised in these communities are expected to be infected soon after weaning and to be re-infected constantly throughout their life span (Awasthi *et al*., 2003).

Intestinal parasites had been observed to affect children's development and growth. Adekunle

(2002) reported that in Ibadan, Oyo State, children with heavy intestinal parasites were shorter in height and lower in weights than non-infected children. The effects of these intestinal helminths and their public health concerns emphasize the need for continuing assessment of the prevalence to reduce the burden of the disease (Sam-Wobo *et al.*, 2012). Ekpo *et al.* (2008) reported that, the burden of parasitic infections and poor sanitary conditions are of greater public health importance among school pupils in Ikene, Ogun State. The present study reviews critically the spatial distributions of intestinal helminths in the six geopolitical zones of Nigeria in the last decade, the impact of Water, Sanitation and Hygiene (WASH) and the factors responsible for its prevalence.

General Overview of the Water, Sanitation and Hygiene (WASH) Intervention Programme

The UNICEF/WASH programme in Nigeria had been in existence since 1980s with the aim of increasing access of rural areas to water supply and sanitation (/ng_publications_newsletter3_WASH.pdf). One of the goals of the programme is to promote the household use of toilets and elimination of open defecation. The WASH programme had encouraged every house to build an improved latrine for defecation to prevent WASH-related diseases. A high prevalence of WASH- related diseases had been observed in most of the developing nations of the world (WHO/UNICEF, 2010). A report by the World Health Organization (WHO) and United Nations Children Fund (UNICEF) revealed that, about 900 million people (13%) of the world population have no access to potable water (WHO/UNICEF, 2004). An estimated 2.6 billion people (39%) were without basic sanitation like latrines at their homes (WHO/UNICEF, 2010). Important social and economic benefits of WASH interventions include environmental cleanliness, healthy living, poverty reduction and gender equity (Waddington *et al.*, 2009). These benefits act as barriers to transmission of diseases from the environment to the human body (Kosek *et al.*, 2003).

The disease burden that results from poor access to improved source of drinking water is significant; the WHO estimated that more than 9% of the disease burden and 6% of deaths could be prevented by improving the WASH intervention programme. Children suffer the most, as 25% of global mortality of children (1 month – 14 years) was linked with unsafe water and inadequate sanitation or insufficient hygiene, which was polarized in developing countries (WHO/UNICEF, 2010). To overcome the challenge of WASH-related diseases, improved hygiene practices are essential. It is therefore important to sensitize people on the importance of water and sanitation practices through hygiene education. This hygiene education may be incorporated into the curriculum of schools from primary to tertiary institutions. There is also a necessity to incorporate behavioural changes that will lead to appropriate use of water and sanitation facilities (UNICEF/IRC, 1998). Generally, sanitation and hygiene programme should include participatory assessment needs by every member of the community, objective formulation, result and action plan, improved water and sanitation facilities, and hygiene education for all (UNICEF/IRC, 1998).

In Africa, the population using improved sanitation facility increased from 33% in 1990 to 38% in 2006 (WHO/UNICEF, 2008). Efforts were put in place to achieve 45% of improved sanitation facility in 2015 to meet the Millennium Development Goal (MDG). It should be noted that, as at 2006, 589 million people in Africa lack access to sanitation while over 200 million Africans practiced open defecation (WHO/UNICEF, 2008). Nigeria is the largest population with unimproved sanitation in 2006 where 104.3 million people lived below the MDG's access to sanitation (WHO/UNICEF, 2008). The figure represented half of those who were denied access to basic sanitation in the whole of West Africa. In 2006, statistics showed that, open defecation was practiced by 23% of the Nigerian populace while this figure was very high in Eritrea with 89% (WHO/UNICEF, 2008).

WHO (2008) revealed that 55% of children's deaths in the rural areas could be prevented through the WASH interventions. This means that 2.2 million lives could be saved yearly with the WASH intervention programme. The WASH

integrated programme may be achieved through access to safe and effective sanitation through good toilet facilities (World Vision, 2011). It was also observed that deaths through WASH-related illnesses can be reduced by 5-10% and up to 20% through access to good latrines and flush toilets respectively (Jeuland *et al.*, 2013).

It is also worthwhile to note that diarrheal disease is responsible for 15% of children (less than 5 years) annual deaths globally (WHO, 2006). With the WASH interventions, these deaths could be prevented by 65% (0.74 million deaths; World Vision, 2011). Poor hygiene may result into neonatal and pneumonia deaths, which accounted for combined 2.51 million children deaths in 2010 (World Vision, 2011). Generally, WASH-related diseases and malnutrition claim 5 million children's lives annually. Application of WASH interventions could prevent the mortality of at least 4 million out of 5 million children annually (World Vision, 2011). Malnutrition may result from persistent diarrheal and parasitic infections (Guerrant *et al.*, 2008; Schuster-Wallace *et al.*, 2008).

The WASH programme has made significant contributions in improving the well-being and health of Nigerians ((UNICEF, 2013) in the following ways:

1. Enhanced capacity building for applying personal hygiene and sanitation through training programme given to 1,190 officials in 26 States of Nigeria.
2. Provision of improved water resources and sanitation facilities in about 1.2 million schools in four States and the Federal Capital Territory (FCT). Workshops were organized for relevant stakeholders. Environmental Health Clubs were established to promote hygiene and sanitation.
3. Access to improved water and sanitation facilities by people in the lower socio-economic status. Through the UNICEF/WASH intervention, over 5 million people had access to latrines between 2009 and 2013. Sanitation and hygiene messages were disseminated to around 11.7 million people. Important memorable Days (e.g. Handwashing Day, World Toilet Day, National Environmental Day) were promoted. Provision of improved drinking water through water disinfection and purification was also recommended.
4. The UNICEF/WASH intervention programme has strengthened the National Emergency WASH Section Group for coordination of emergency preparedness and response to WASH-related diseases. A great feat has been achieved in this regard to eradication of guinea worm in Nigeria.

Burden and Epidemiological Patterns of Intestinal Parasites

Gastro-intestinal parasites are predominantly protozoans and helminths with over 70 species that infect humans and animals through contaminated food and water (Omalu *et al.*, 2013). They can also be contracted through contaminated soil, domestic or wild animals harbouring the parasites, person to person and auto-infection. These gastro- intestinal parasites are responsible for numbers of prevalent diseases in the developing countries. Disease conditions caused by gastro-intestinal parasites include anaemia, reduced birth weight, intra-uterine growth retardation, poor development and performance in children (Sackey *et al.*, 2003; Rodriguez-Morales *et al.*, 2006). It has been observed that children exposed to soil-transmitted helminths performed low in their educational pursuits (Miguel and Kreme, 2003). Economic loss due to helminth infections on domestic animals had also been reported (Miguel and Kreme, 2003).

Hotez *et al.* (2004) reported that hookworms are an important cause of intestinal blood loss that results in iron deficiency and protein malnutrition. Because of the underlying poor iron status in children, women of reproductive age, and pregnant women, they are frequently the most susceptible to developing hookworm anaemia (Brooker *et al.*, 2006). Iron deficiency anaemia during pregnancy has been linked to adverse maternal-feotal consequences, including prematurity, low birth weight, and impaired lactation (WHO, 2002). Chronic soil-transmitted

helminth (STH) infections can affect physical and mental development in children (WHO, 2002). A study by Stephenson *et al.* (2000) had shown that growth and physical fitness deficits caused by chronic STH infections are sometimes reversible following treatment with antihelminthic drugs.

The most vulnerable groups of gastro-intestinal parasite infections can therefore be summarized as: (1) people with low socio-economic status (2) people living under poor personal and environmental hygiene (3) those living in overcrowding houses (4) those with limited access to safe drinking water and unimproved toilet and waste disposal facilities (Merigitsu *et al.*, 2007).

Spatial Distributions of Parasitic Helminths in Nigeria

Tables 1-5 showed the research works carried out on helminth infections across the six geopolitical zones in Nigeria. Helminth species identified in these studies were *Ascaris lumbricoides,* hookworm, *Trichuris trichiura, S. stercoralis, Taenia* sp, *S. mansoni*, *S. stercoralis, Enterobius vermicularis* and *Hymenolopis nana*. Table 1 highlighted the prevalence (%) of each identified helminth, gender and age prevalence, and the authors' comments on exposure routes. The different methods adopted for identification and characterization of the helminths were reported.

There was high prevalence of *A. lumbricoides* above other helminths in studies reported in Southwestern Nigeria. These studies suggested that the high prevalence of *A. lumbricoides* could be attributed to favourable environmental conditions such as low level of environmental sanitation Awolaju and Morenikeji (2009) and socio-economic conditions, unhygienic nature of the environment, ignorance and poverty (Ojurongbe *et al.*, 2014). The habit of using water and hand to clean up after defecation, which is culturally practiced among the Yorubas and the people of low status might also be responsible for the high prevalence of *A. lumbricoides*. Ugbomoiko *et al.* (2006) suggested that the habit of eating soil known as geophagy and regularly biting or licking fingernails, drinking of well-or cistern-stored water could increase incidence of soil- transmitted helminths.

Table 1: Prevalence of Helminth Infections in Southwestern Nigeria

Author	Study Area	Method of Analysis	Helminth Prevalence (%)	Prevalence by Sex (%)	Prevalence among Age Group (%)	Cause of Infection (%)
Adeoye *et al.*, 2007	Lagos	Kato-Katz	*A. lumbricoides* =29.7 Hookworm = 0.7 *T. Trichiura* = 18.4 *S. stercoralis* =0.3 Total =49.1	Male = 52.8 Female = 45.2	0-2yrs =27.3 2.1-4yrs = 23.4 4.1-6yrs =14.7 6.1-8yrs =13 8.1-10yrs =16 10.1-12yrs =8.2	Toilet Facility and Unhygenic behavior
Awolaju and Morenikeji, 2009	Ilesha Osun	Kato-Katz	*A. lumbricoides* =39.1 Total =39.1 (48.4)	Male = 41.7 Female = 58.3	2-4yrs =0.7 5-7yrs = 6.6 8-10yrs =17.2 11-13yrs =15.9 14-16yrs =33.8 17-19yrs =14.6 20-21yrs =11.3	Poor sanitation
Okonko *et al.*, 2009	Abeokuta Ogun	Haemotoxylin and eosin stain	*A. lumbricoides* =2.6 *S. mansoni* =0.2 Multiple infection =0.4 Total = 3.2(6.6)	Male = 65 Female = 35		Geological location
Sam-Wobo *et al.*, 2012	Odeda Local Governmen t, Ogun	Kato-Katz	*A. lumbricoides* =9.6 Hookworm = 4.1 *T. Trichiura* = 1.8 Total =15.6	Male = 32.3 Female = 67.7	5-19yrs =38.2 20-34yrs =20.6 35-49yrs =17.6 ≥ 50yrs =23.5	Belief, Ignorance and Environmental sanitation
Akingbade *et al.*, 2013	Abeokuta Ogun	Saline, Iodine wet mount, Formol-Ether	*A. lumbricoides* =14.5 Total =14.5 (25.8)	Male = 45.2 Female = 54.8	1-3yrs =32.3 4-5yrs = 67.7	Sanitation problem and Low body immune system
Banjo *et al.*, 2013	Abeokuta Ogun	Formol-Ether & Direct Normal Saline	*A. lumbricoides* =17.2 Hookworm = 3.2 *T. Trichiura* = 5.7 *Taenia* sp =1.6 *S. mansoni* =1.6 Total =27.3	Male = 46.9 Female = 53.1	21-40yrs =37.7 41-60yrs = 35.9 61-80yrs =20	Occupational exposure
Ojurongbe *et al.*, 2014	Ile Ife Osun	Formol-Ether	*A. lumbricoides* =36.4 Hookworm = 5.4 *Taenia* sp = 1.2 *S. stercoralis* =3.7 Multiple infection=1.2 Total =48.2	Male = 59 Female = 41	3-6yrs =39.7 7-10yrs =52.6 11-14yrs =27.7	Socio-economic status and Unhygienic environment
Simon-Oke *et al.*, 2014	Ifedore, Ondo	Saline	*A. lumbricoides* =22.2 Hookworm = 10.6 *S. stercoralis* =12.8 Multiple infection=3.3 Total =48.9	Male = 47.7 Female = 52.3	5-9yrs =54.6 10-14yrs =45.4	Poor sewage disposal, Unsafe water source, Poor sanitary conditions, Poor housing and Lack of awareness by parents
Akinseye *et al.*, 2015	Ifedore, Ondo	Formol-Ether	*A. lumbricoides* =21.9 Hookworm = 3.9 *T. Trichiura* = 3.1 Multiple infection=0.8 Total 28.9	Male = 47.7 Female = 52.3	5-9yrs =54.6 10-14yrs =45.4	Playing activities, Poor hygiene and sanitation and Poverty

Values in bracket indicate analysis of protozoans along helminths

Hookworm is another important helminth that is most frequently diagnosed after *A. lumbricoides* in the studies reported in Southwestern, Nigeria. Hookworm is usually acquired through skin penetration from contaminated soil when walking barefooted (Ezeagwuna *et al.*, 2009). Trichuriasis is also a common infection in some parts of the Southwestern States e.g. *T. trichiura* prevalence value (18.4%) reported by Adeoye *et al.* (2007) was greater than the overall helminth prevalence reported by Okonko *et al.* (2009) and Sam-Wobo *et al.* (2012) in separate studies carried out in Abeokuta, Ogun State.

Sex is an epidemiological factor in assessing prevalence and intensity of parasitic diseases. In the studies reported above, there is no clear line of gender prevalence. While some studies had identified higher prevalence among the male participants; some have reported females as the most infected gender. In the studies identified in Table 1, it appeared that gender dominance in helminth infection is closely associated with age. Female subjects appeared to have higher prevalence of intestinal infection in studies involving adults (14 years and above). This might be linked to exposure through fecal clean-up for

young children and also a personal hygiene issue. Generally, discrepancy in gender helminth prevalence might be attributable to factors including the study locations within the geopolitical zone, people's response during sample collection, type of occupation, age groups, and personal hygiene. Age prevalence in these studies is also not consistent. The study of Adeoye *et al.* (2007) in Lagos has identified age prevalence peak of 0-2 years, Awolaju and Morenikeji (2009) have observed the prevalence peak to be 14-16 years, Banjo *et al.* (2013) reported 21-40 years while Akingbade *et al.* (2013) also reported 4-5 years.

Studies on prevalence of helminth infections in South-eastern Nigeria are highlighted in Table 2. The major identified helminths include *A. lumbricoides*, hookworm, *T. trichiura*, *S. stercoralis*, *H. nana* and *Taenia* sp. A glance at the studies from the Southeastern Nigeria revealed hookworm as the most prevalent helminth (Emmy-Egbe, 2013; Kamalu *et al.*, 2013; Wosu and Onyeabor, 2014). It was observed from these studies that female subjects were more infected by hookworms compared to their male counterparts (e.g. Kamalu *et al.*, 2013). This might be directly linked to farming activities engaged mostly by women in the region (Odurukwe *et al.*, 2006). The study of Emmy-Egbe (2013) contradicted the observation that female subjects were at greater risk of hookworm than male. Emmy-Egbe (2013) argued that men are at the greater risk due to behavioral change, poor sanitation, lack of domestic hygiene and ignorance. The risk factors of hookworm infections in the study of Kamalu *et al.* (2013) were bush defecation, walking barefooted and poor hygiene. The act of geophagy was also common in the Southeastern Nigeria (Izugbara, 2003). This might also be another factor responsible for high prevalence of hookworm in the region.

It was observed that some studies carried out in Southeastern Nigeria showed high prevalence of *A. lumbricoides* similar to the helminthic situation in the southwestern Nigeria. The study of Emeka (2013) on the prevalence of intestinal helminth infections among school children in rural and semi-urban communities in Enugu revealed *A. lumbricoides* as the most prevalent helminth. Ogbuagu et al. (2009) and Kalu *et al.* (2013) in separate studies also reported a high prevalence of *A. lumbricoides* infection. They further observed that men were at greater risks of *A. lumbricoides* than women. Since the major route of entry of *Ascaris* is through fecal-oral contamination, Nduka *et al.* in 2006 pointed scavenging activities mostly practiced by men as the major reason for high prevalence of helminth infections in Southeastern region. *T. Trichiura* infection is also prevalent in some parts of Southeastern Nigeria (Ezeagwuna *et al.*, 2009; Kalu *et al.*, 2013; Wosu and Onyeabor, 2014).

Information on some helminths in South-south Nigeria is presented in Table 3. The overall prevalence of helminths was lower than those observed for Southwest and Southeast. The highest prevalence value in these studies was 59% (Usip and David, 2013). Even though, low helminth infection prevalence was generally observed in this region; many risk factors responsible for helminth infections include fecal contamination, poor personal hygiene and environmental sanitation, lack of protective foot wears, low socio-economic status, malnutrition and lack of toilet facilities. It appeared that people in this region are more hygienic than those of other geopolitical regions in Nigeria. A study showed that 61% of people leaving in south-southern part of Nigeria have access to water closet toilets (Ordinioha and Owhondah, 2008). In the south-south region, the identified helminths were not different from those reported in the Southwest and Southeast regions. Prevalence of *A. lumbricoides* was clearly observed in most of the published studies. Only the study of Usip *et al.* (2013) from Akwa Ibom reported hookworm and *Trichuris* as the dominating helminths. Hookworm (29%) and *T. Trichiura* (17%) were the most prevalent helminths observed in school children within the age bracket 5-13 years. In terms of gender prevalence, males were more exposed than female in most studies.

The published literature work on intestinal helminths in the North-central of Nigeria is presented in Table 4. A very high prevalence helminth infection up to 80% was observed in this region (Ejima and Ajogun, 2011). The helminth classes identified in the reported works are *A. lumbricoides*, hookworm, *Taenia sp*, *Schistosoma*

mansoni, *S. stercoralis*, *E. vermicularis*, *Fasciola sp*, *T. Trichiura* and *Vampirolepis nana*. These helminth classes were greater than those reported in the southern parts of Nigeria. Helminths such as *E. vermicularis*, *Fasciola sp*, *H. nana* and *S. mansoni* were not often diagnosed in the studies from the southern parts of Nigeria. Few studies have diagnosed helminthes like *H. nana* and *S. mansoni*. For example, Kamalu *et al.* (2013) was able to characterize *H. nana* (1.6%) in their study conducted in Owerri, Imo state, Southeastern Nigeria while Okonko *et al.* (2009) reported *S. mansoni* (0.2%) in their studies conducted in Abeokuta. Another vital observation in the distributions of helminth infections in North-central Nigeria is the occurrence of *Taenia sp.* in most of the reported studies. Cases of multiple infections were also high in some of these studies (e.g. Ejima and Ajogun, 2011).

Table 2: Prevalence of Helminth Infections in South-Eastern Nigeria

Author	Study Area	Method of Analysis	Helminth Prevalence (%)	Prevalence by Sex (%)	Prevalence among Age Group (%)	Cause of Infection (%)
Uduka *et al.* , 2006	Abia	Formol-Ether	*A. lumbricoides* =17.8 Hookworm = 14.8 *T. Trichiura* = 2.3 Total =34.9	Male = 51 Female = 49	<10yrs =7.9 11-20yrs =24.9 21-30yrs =32.2 31-40yrs =18.1 41-50yrs=11.3 >50yrs=5.6	Exposure to mining wastes
Ogbuagu *et al.*, 2009	Nnamdi Azikwe Teaching Hospital Anambra	Saline and Iodine Wet Mount	*A. lumbricoides* =27.4 Hookworm = 25.2 Total =52.6	Male = 55 Female = 45		Host r esponse to infection and Nutrition status
Ezeagwuna *et al.*, 2009	Ozubulu Anambra	Formol-Ether	*A. lumbricoides* =15.4 Hookworm = 15.4 *T. Trichiura* = 5.8 Multiple infection=1.5 Total =48.1	Male = 39 Female = 61	5-7yrs =39.7 8-10yrs =52.6 11-13yrs =27.7 14-16yrs =27.7	Walking barefoot
Emmy-Egbe, 2013	Ihiara Anambra	Floatation concentration	*A. lumbricoides* =5.7 Hookworm = 18.9 *T. Trichiura* = 2.8 Total =27.4	Male = 55 Female = 45	3-5yrs =39.8 6-8yrs = 25.6 9-11yrs =16.9 12-14yrs =10.8 15-17yrs =6.7	Fecal disposal and Poor sanitation, ignorance
Kamalu *et al.* , 2013	Owerri Imo	Formol-Ether Saline	*A. lumbricoides* =13.4 Hookworm = 16 *T. Trichiura* = 2.8 *Taenia* sp =3.2 *H. nana* = 1.6 *S. stercoralis* =3.6 Total =43.8	Male = 25 Female = 75	<10yrs =17.2 11-15yrs =15.9 16-20yrs =33.8 21-25yrs =14.6 ⩾26yrs =11.3	Level of education, Personal environmental Hygiene and Social habit
Kalu *et a l.*, 2013	Mbaitoli, Imo	Direct Smear	*A. lumbricoides* =22 Hookworm = 5.0 *T. Trichiura* = 9.0 Multiple infection=6.5 Total =42.5	Male = 49 Female = 51	6-8yrs=54.1 9-11yrs=35.3 12-14yrs=10.6	Playing on contaminated soil, Poor living conditions and hygiene
Wosu and Onyeabor, 2014	Umuahia Abia	Formol-Ether	*A. lumbricoides* =22.7 Hookworm = 33.7 *T. Trichiura* = 34.5 *S. stercoralis* =3.6 Total =75.7	Male = 38 Female = 62	6-8yrs =3.9 9-11yrs =47 12-14yrs =41.7 15-17yrs =7.4	
Chioma *et al.* , 2015	Uga, Anambra	Formol-Ether	*A. lumbricoides* =19.7 Hookworm = 7.7 *T. Trichiura* = 6.5 *Taenia* sp =10.8 Total =44.7	Male = 46 Female = 54	3-5yrs =40 6-8yrs =30 9-11yrs =20 11-14yrs =10	Ignorance, Poverty, Poor environmental Hygiene, Lack of toilet facilities and Lack of health care

Values in bracket indicate analysis of protozoans along helminth

Table 3: Prevalence of Helminth Infections in South-South, Nigeria

Author	Study Area	Method of Analysis	Helminth Prevalence (%)	Prevalence by Sex (%)	Prevalence among Age Group (%)	Cause of Infection (%)
Wagbatsoma and Aisien, 2005	Benin City, Edo	Formol-Ether and Kato-Katz	*A. lumbricoides* =11 Hookworm = 5.8 *T. Trichiura* = 3.8 *S. mansoni* =1.0 *S. stercoralis* =0.5 Multiple infections=5.3 Total =27.4	Male = 34 Female = 65		Fecal-Oral contamination, Lack of education
Oguanya *et al.*, 2012	Ekpoma, Edo	Formol-Ether	*A. lumbricoides* =4.0 Hookworm = 15.0 *T. Trichiura* = 0.5 *S. stercoralis* =1.0 Multiple infections=4.0 Total =24.5	Male = 57 Female = 43	6-10yrs =67 11-15yrs =33	Poverty, Poor Sanitation and hygiene, Lack of potable water
Omorodion *et al.*, 2012	Ekpoma, Edo	Formol-Ether and Kato-Katz	*A. lumbricoides* =4.3 Hookworm = 2.5 *T. Trichiura* = 0.2 *Taenia* sp =0.6 Multiple infections=2.0 Total =9.6 (12.5)	Male = 34 Female = 66		Fecal-Oral contamination
Odu *et al.*, 2013	Obio/Akpor, Rivers	Formol-Ether	*A. lumbricoides* =9.0 Hookworm = 2.7 *T. Trichiura* = 4.0 Total =15.7	Male = 51 Female = 49	5-10yrs =72.3 ≥11yrs = 27.7	Toilet Facility, and Poor environmental Sanitation
Akinbo *et al.*, 2013	Benin City, Edo	Formol-Ether	*A. lumbricoides* =27.8 Hookworm = 5.4 *T. Trichiura* = 2.0 Total =33.4 (35.8)	Male = 81 Female = 19	10-20yrs =11.0 21-30yrs = 45.8 31-40yrs =22.0 41-50yrs =21.2	Source of water, Toilet facilities and Presence of diarrhea
Nwaneri and Omuemu, 2013	Benin City, Edo	Kato-Katz	*A. lumbricoides* =18.6 *T. Trichiura* = 2.1 Total =20.7	Male = 43 Female = 57	0-5yrs =46.6 6-11yrs = 30.7 12-17yrs =25.7	Low s ocio-economic status and malnutrition
Usip and David, 2013	Akwa Ibom	Saline and Brine floatation	*A. lumbricoides* =12.3 Hookworm = 29 *T. Trichiura* = 16.5 *Taenia* sp =0.4 *S. stercoralis* =0.4 Total =59.1	Male = 56 Female = 44	5-7yrs=57.3 8-10yrs=30.8 11-13yrs=11.9	Lack of protecting shoes, playing barefooted
Ogbain-Emovon *et al.* 2014	Benin City, Edo	Formol-Ether	*A. lumbricoides* =6.9 Hookworm = 2.4 *T. Trichiura* = 0.2 Total =9.5	Male = 80.9 Female = 19.1	1-5yrs =51 6-10yrs = 46.8 11-15yrs =18.5	Non-washing of hands after defecation and personal and environmental hygiene

Values in bracket indicate analysis of protozoans along helminths

Table 4: Prevalence of Helminth Infections in North-Central Nigeria

Author	Study Area	Method of Analysis	Helminth Prevalence (%)	Prevalence by Sex (%)	Prevalence among Age Group (%)	Cause of Infection (%)
Damen *et al.,* 2010	Doi, Plateau	Formol-Ether	*A. lumbricoides* =1.7 Hookworm = 5.3 *T. Trichiura* = 0.6 *Taenia* sp =0.4 *S. stercoralis* =1.7 *S. mansoni* = 3.2 Total =12.8	Male = 56.3 Female = 43.7	1-5yrs =31.3 6-10yrs = 43.8 11-15yrs =18.8 16-20yrs =6.2	Poor environmental condition, Insufficient health services, Lack of toilet facilities and lack of public health hygiene
Damen *et al.,* 2010	Doi, Plateau	Formol-Ether	*A. lumbricoides* =13.9 Hookworm = 15.9 *T. Trichiura* = 6.3 *Taenia* sp =0.3 *S. stercoralis* =8.7 *S. mansoni* = 2.4 Total =47.6	Male = 53.8 Female = 46.2	1-5yrs =37 6-10yrs = 45.4 11-15yrs =22.7 16-20yrs =18.5	
Jombo *et al.,* 2011	Jos Plateau	Formol-Ether	*A. lumbricoides* =5.8 Hookworm = 9.2 *T. Trichiura* = 1.6 Total =16.7 (63.3)	Male = 55.3 Female = 44.7	<1yr =1.5 1-2yrs =45 2.1-3yrs =20.8 3.1-5yrs =20.3 >5 yrs =12	Disposal of sewage, Open air defecation, Low educational level and Economic constraint
Ejima and Ajogun, 2011	Federal Poly, Ida, Kogi	Formol-Ether	*A. lumbricoides* =11 Hookworm = 2 *Taenia* sp =9 *S. mansoni* =1 *S. stercoralis* =1 *E. vermicularis* =1 *Fasciola sp*=2 Multiple infection=54 Total =80			Sanitary behavior and Population density
Abaver *et al.,* 2011	Abuja	Formol-Ether	*A. lumbricoides* =2.5 Hookworm = 4.2 *S. stercoralis* = 2.5 *T. Trichiura* = 0.8 *Taenia* sp =0.8 Total =10.7 (36.8)	Male = 46.9 Female = 53.1	21-40yrs =37.7 41-60yrs = 35.9 61-80yrs =20	Favourable tropical environment
Abelau *et al.,* 2011	Plateau	Direct wet mount, Formol-Ether Saline	*A. lumbricoides* =22.4 Hookworm = 20.7 *Taenia* sp =1.3 *H. nana* = 1.6 *E. vermicularis* =0.2 Total =55.2	Male = 56.9 Female = 43.1	0-9yrs =2.5 10-19yrs =14.9 20-29yrs =34 30-39yrs =32.5 40-49yrs =11.9 ⩾50yrs =4.1	Low socio -economic status and Poor hygiene practices, Eating of soil
Omalu *et al.,* 2013	Minna Niger	Wet Mount and Formol-Ether	*A. lumbricoides* =10.6 Hookworm = 9.6 *T. Trichiura* = 3.9 *Taenia* sp =3.9 Multiple infection =18.3 Total =46.3 (89.7)	Male = 41.7 Female = 58.3	10-20yrs =8.3 21-30yrs = 16.7 31-40yrs =20 41-50yrs =50 51-60yrs =8.3 >60yrs =0	Unhygenic behavior by the food vendors
Babatunde *et al.,* 2013	Moro Kwara	Formol-Ether	*A. lumbricoides* =11.3 Hookworm = 15.4 *T. Trichiura* = 8.1 *S. stercoralis* =7.1 Total =41.9	Male = 49.1 Female = 51.9	5-9yrs =44.4 10-12yrs =50.9 13-15yrs =4.7	Poor personal hygiene
Saka *et al.,* 2014	Ilorin Kwara	Formol-Ether	*A. lumbricoides* =22 Hookworm = 4.5 *T. Trichiura* = 1.2 *S. stercoralis* =0.4 Multiple infection =1.6 Total =29.7	Male = 39 Female = 63	5-7yrs = 31.5 8-10yrs =48 11-12yrs =20.5	Toilet Facility and Unhygenic behavior
Eke *et al*., 2014	Karu, Nasarawa	Direct Saline	Hookworm = 39.6 Total =39.6	Male = 58.8 Female = 41.2	0-10yrs =33.3 11-20yrs = 24.6 21-30yrs =14.9 31-40yrs =9.6 41-50yrs = 7.9 51-60yrs =6.1 61-70yrs =3.5	Fecal contamination and Walking barefoot

Values in bracket indicate analysis of protozoans along helminths

Prevalence of helminth infections in Northeastern and Northwestern Nigeria is shown in Table 5. There is no much difference in helminth classes identified in this region with that of north-central except for higher values of *Trichuris* and *Taenia sp.* Also, a very high value of *E. vermicularis* (9%) was also observed in the study conducted by Inabo and John (2010) in Kaduna State; however, *Asacris lumbricoides* (29%) was the most prevalent helminth followed by *T. Trichiura* (14%) and *E. vermicularis* (9%). The studies carried out in Gwagwada, Kaduna has shown high

prevalence values of *Taenia sp.* (Auta *et al.*, 2013; 2014). A higher prevalence value of *S. mansoni* was also observed in the studies reported from the Northeastern and Northwestern Nigeria than any of the regions. As gender prevalence is concerned, the domination of helminth infections by male subjects was clearly noted. This may be attributed to the fact that males are more active in terms of socio-economic activities than their female counterparts in this region.

Eating with unwashed hands has also been indicated as one of the most probable risk factors of helminth contamination in this region (Thomas *et al.*, 2014). High consumption of pork and beef had been identified as major factor that could increase *Taenia* infections (Enimien *et al.*, 2014).

In terms of individual helminth prevalence, most studies had reported a slight higher prevalence of hookworm than *A. lumbricoides*. An elevated prevalence value of 39.3% was observed by Eke *et al.* (2014) in their studies on the prevalence rate of hookworm infection in Panda, Nasarawa State. The age group between 1 and 10 years were shown to be at the greatest risk probably due to walking around without sandal or shoe. The highest *A. lumbricoides* prevalence value was 22% recorded by Saka *et al.* (2013) in a study carried out in Ilorin. Although, some studies had ascribed high prevalence values to *Ascaris* (Ejima and Ajogun, 2011; Saka *et al.*, 2014); but it appeared that hookworm infections were more prevalent.

Table 5: Prevalence of Helminth Infections in Northeastern and Northwestern Nigeria

Author	Study Area	Method of Analysis	Helminth Prevalence (%)	Prevalence by Sex (%)	Prevalence among Age Group (%)	Cause of Infection (%)
Inabo and John, 2010	Kaduna	Formol-Ether	*A. lumbricoides* =28.9 Hookworm = 1.1 *T. Trichiura* = 14.4 *Taenia* sp = 1.1 *E. vermicularis* =8.9 *S. mansoni* =4.4 *V. nana*=4.4 Total =63.3	Male = 54.3 Female = 45.7	<1yr=5.3 1-3yrs=17.5 4-10yrs=43.8 11-15yrs=17.5 >18yrs=15.8	Poor environmental hygiene, Shortage of potable water and indiscriminate defecation
Biu *et al.*, 2012	Mafa Bornu	Formol-Ether Saline	*A. lumbricoides* =3.6 Hookworm = 18.2 *T. Trichiura* = 0.9 *Taenia* sp =3.6 *H. nana* = 3.6 Multiple infection =30 Total =60	Male = 58.3 Female = 41.7	6-7yrs =11.1 8-9yrs =23.6 10-11yrs =29.2 12-13yrs =22.2 14-15yrs =13.9	Poverty, Ignorance, Poor environmental hygiene, Impoverished health services
Biu *et al.*, 2013	Biu Bornu	Direct microscopy, Formol-Ether	*A. lumbricoides* =1.0 Hookworm = 10.0 *S. mansoni* =6.0 *H. nana* = 3.0 Total =20	Male = 60 Female = 40	7-24yrs =65 25-36yrs =25 37-50yrs =10	
Shehu *et al.*, 2013	Maru Zamfara	Formol-Ether	*A. lumbricoides* =6.5 Hookworm = 3.5 *T. Trichiura* = 5.2 *Taenia* sp = 3.2 *E. vermicularis* =1 Multiple infection=7.5 Total =31.2	Male = 39.2 Female = 60.8		Poor toilet facility and Hygiene
Auta *et al.*, 2013	Gwagwada Kaduna	Formol-Ether	*A. lumbricoides* =30.7 Hookworm = 6.4 *T. Trichiura* = 4.9 *Taenia* sp =23 *S. mansoni* =11.7 *H. nana* = 3.9 *S. stercoralis* =4.2 Total =67.1	Male = 59.5 Female = 40.5	<6yrs =41.6 7-9yrs =20 10-12yrs =23.7 13-15yrs =12.6 ≥ 16yrs =2.1	Contaminated drinking water
Auta *et al.*, 2014	Gwagwada Kaduna	Formol-Ether	*A. lumbricoides* =40.1 Hookworm = 6.5 *T. Trichiura* = 4.5 *Taenia* sp =17.6 *S. mansoni* = 7.8 Total =76.8	Male = 60.4 Female = 39.6	7-9yrs =31.1 10-12yrs =26.2 13-15yrs =21.3 ≥ 16yrs =21.3	Poor hygiene and Sanitation
Thomas *et al.*, 2014	Chukum and Kaduna South, Kaduna	Direct wet mount, Formol-Ether	*A. lumbricoides* =8.3 Hookworm = 3.5 *Taenia* sp =3.0 *S. mansoni* =1.0 Total =15.8	Male = 58.1 Female = 41.9	6-7yrs = 8.9 8-9yrs =32 9-11yrs =52.7 12-13yrs =6.5	Poor personal hygiene Eating with unwashed hands
Enimien *et al.*, 2014	Numan, Adamawa	Formol-Ether and Kato - Katz	*A. lumbricoides* =2.0 Hookworm = 3.4 *Taenia* sp =3.7 Total =9.1	Male = 51.9 Female = 48.1	<20yrs=51.9 21-39yrs =37.0 40-69yrs =11.1 >70yrs=0	Consumption of Pork

Figure 1 shows the mean summary of published studies on helminth prevalence across the observed regions in Nigeria. The helminth distributions revealed Southwest as the region with the highest prevalence of *A. lumbricoides* infection while Southeast showed the highest prevalence for hookworm and *Trichuris*. Multiple infections were highest in the North-central while Northeast and Northwest regions showed highest prevalence with *Taenia sp* and *S. Mansoni* infections.

The prevalence of helminth in the North-central was not as high as those reported in the Southern part of Nigeria; however, cases of multiple/mixed infections were very high in this region and call for public concerns. As high as 54% prevalence value of multiple/mixed infections were reported by Ejima and Ajogun (2011). Omalu *et al.* (2013) also reported a prevalence value of 18% for multiple infections among food vendors in Minna, Niger State. The most affected age group was 41-50 years. In the studies from Southwest, Southeast and South-south, the highest prevalence value

reported for multiple infections was 7% (Kalu *et al.*, 2013). Generally, studies conducted across the six geopolitical zones in Nigeria had identified the following risk factors for soil-transmitted helminth infections: lack of toilet facilities, poor personal hygiene and environmental sanitation, ignorance, contaminated water, low socio-economic status and attitude of walking barefoot.

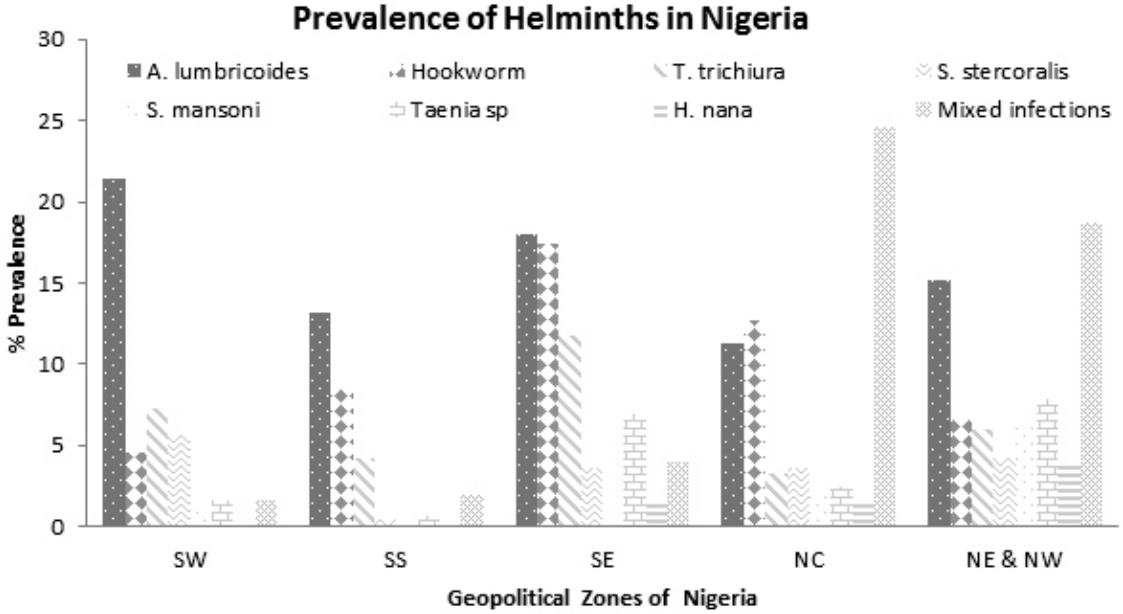

Figure 1: Prevalence of helminths by geopolitical regions in Nigeria. SW-Southwest, SS-South-south, SE-Southeast, NC-North-central, NE-Northeast and NW-Northwest

The observations of this present work were not different from what Ekundayo *et al.* (2007) reported on prevalence of helminths in Nigeria between 1970 and 2005. No significant change had occurred since then till this present work. The work of Ekundayo *et al.* (2007) conducted in ten Nigerian states showed that *A. lumbricoides* was the most prevalent helminth ranging between 7.5% in Enugu State to 88.5% in Osun State. However, in the recent work outlined in Tables 1-5, *A. lumbricoides* prevalence varied from 1.0% in Bornu State (Biu *et al.*, 2013) (Table 5) to 40.1% in Kaduna State (Auta *et al.*, 2014). The highest prevalence of hookworm (39.6%) was observed in Nasarawa (Eke *et al.*, 2014) (Table 4) while the lowest prevalence (2%) was reported in Kaduna State by Inabo and John (2010) (Table 4). Comparing these values with those reported by Ekundayo *et al.* (2007) showed that no laudable progress had been achieved to reduce the hookworm infection compared to *A. lumbricoides*. A lot of effort must therefore be put in place to reduce hookworm infections in Nigeria by the concerned authority.

Control of Helminth Infections and the Intervention Programmes

There are three major interventions for control of helminth infections. These are antihelminthic drug treatment, sanitation and health education. Antihelminthic drug treatment ('deworming') is aimed at reducing morbidity by decreasing the worms burden. Repeated chemotherapy at regular intervals (periodic deworming) in high risk groups can ensure that the levels of infection are kept below those associated with morbidity and will frequently result in immediate improvement in child health and development (Adams *et al.*, 2004). Recommended drugs for use in public health intervention to control STH infection are the benzimidazole antihelmintics, albendazole or mebendazole and levamisole or pyrantel pamoate (WHO, 2002). The public health significance of soil-transmitted helminth infections is now widely accepted, especially in children, for example, in 1993, the World Development Report considered that these infections are a major cause of morbidity in children aged 5-14 years (World Bank, 1993). Available evidence indicates that albendazole and mebendazole (benzimidazole compounds) may be used for treatment of STHs

in children aged 12 months and older provided that the case for their use is established (Albonico *et al.*, 2008). The health benefits of treatment appear to override any risks associated with the correct administration of the drugs (Montresor *et al.*, 2002). The international intervention programmes which necessitated the provision of anti-helminth drugs to the infected population (WHO, 2004) were not effective in reducing prevalence of helminth infections in Nigeria (Auta *et al.*, 2014). The programme has yielded good results in a country like Cambodia who administered anti-helminth drugs to 84% of the infected school children. This programme should be reviewed in Nigeria to drastically reduce helminth infections. Peoples' attitudes and behaviours are needed to change for WASH intervention programme to be effective. Sam-Wobo *et al.* (2005) in their study on intestinal helminth infections among school children in Ogun state recommended that school health programmes in government–owned schools, including deworming, health education and improvement of hygiene conditions must be observed towards control of helminthiasis.

Improved sanitation is another way of controlling transmission of helminths from soil and water contamination to humans. Sanitation is the only definite intervention to eliminate STH infections, but to be effective it should cover a high percentage of the population. Therefore, because of the high cost involved, implementing this strategy is difficult where resources are limited (Asaolu and Ofoezie, 2003). Moreover, when used as the primary means of control, it can take years or even decades for sanitation to be effective (Brooker *et al.*, 2006).

Health education is aimed at reducing transmission and reinfection by encouraging healthy behaviours. This is to reduce contaminations from soil and water by promoting the use of latrines and hygienic behaviour. Without a change in defecation habits, periodic deworming cannot attain a stable reduction in transmission. Health education can be provided simply and economically and presents no contraindications or risks (Hotez *et al.*, 2006). Health education could be done through the provision of information via newspapers, radio or television and health counseling. Health education materials like posters, pamphlets, flip charts and calendars can also be introduced during group community mobilization sessions by teams composed of ministry of health workers and Carter Center personnels for community-directed distributors (CDDs) and community members. Health counseling should be interactive, individualistic and involving the transfer of skills (Breman *et al.*, 2004). The necessary information can be provided by community and voluntary health workers. These persons are extension of the health system and work under the direct supervision of health facility staff or non-governmental organizations (NGOs) and in conformity with standards and norms established by the national government (Gilles, 2002).

Udonsi (1993) in a 30 month-longitudinal study explained that primary health care intervention was effective in reducing the prevalence of three common intestinal nematode infections (*Ascaris lumbricoides, Trichuris trichiura* and *Necator americanus*) in three communities located in Port Harcourt, Nigeria. This was achieved by training school leavers and auxiliary aides as microscopists, health inspectors and field assistants and deploying them to provide screening, surveillance, environmental sanitation and Mass Expulsion Chemotherapy (MEC). Post control surveillance confirmed that the prevalence of these infections had been greatly reduced. The initial decline in prevalence was due to the MEC campaign, but the improved sanitation and health education presumably reduced the rate of reinfection. The study suggested that if the entire population participated, periodic repetition of the mass expulsion therapy campaign at appropriate intervals combined with continual attention to environmental hygiene and prolonged health education could bring these infections under control within a few years.

CONCLUSION

This study has reviewed the spatial distributions of intestinal helminths in Nigeria within the last decade. Studies showed that *Ascaris lumbricoides* is the most prevalent helminth in the Southwestern (21%) and South-southern (13%); hookworm in the Southeastern (19%) and multiple infections in Northern Nigeria (25% in North-central and 19%

in Northeast and Northwest). Cases of *Taenia sp* and *Shistosoma mansoni* infections were also high in the Northeastern and Northwestern Nigeria (8% and 6%, respectively). The Water, Sanitation and Hygiene (WASH) intervention programme has been effective in reducing incidences of helminth infections in the country. However, strong resistance to the programme has largely been attributed to peoples' attitudes and behaviours to sanitation and hygiene. It is therefore necessary that the programme be geared towards working on peoples' attitudes and behaviours through health education and public enlightenment. Potable water should also be provided to the rural dwellers through sinking of boreholes in their communities. Periodic assessment of the intervention programme is also important.

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