ASSOCIATION OF SCHISTOSOMIASIS PREVALENCE WITH SOCIO-DEMOGRAPHIC STATUS MEASURES IN SUB-SAHARAN AFRICA

by

Laurien Sibomana

BS, BA, La Roche College, 2004

Submitted to the Graduate Faculty of

the Graduate School of Public Health in partial fulfillment

of the requirements for the degree of

Master of Science

University of Pittsburgh

2009

UNIVERSITY OF PITTSBURGH

GRADUATE SCHOOL OF PUBLIC HEALTH

This thesis was presented

by

Laurien Sibomana

It was defended on

December 22nd, 2009

and approved by

Clareann Bunker, Ph.D., Associate Professor, Department of Epidemiology

Graduate School of Public Health,

University of Pittsburgh

David Finegold, M.D., Professor, Department of Human Genetics,

Graduate School of Public Health,

University of Pittsburgh

Thesis Advisor: Kristen Mertz, M.D., M.P.H., Assistant Professor,

Department of Epidemiology

Graduate School of Public Health

University of Pittsburgh

Kristen J. Mertz, M.D., M.P.H.

ASSOCIATION OF SCHISTOSOMIASIS PREVALENCE WITH SOCIO-DEMOGRAPHIC STATUS MEASURES IN SUB-SAHARAN AFRICA

Laurien Sibomana, M.S.

University of Pittsburgh, 2009

Schistosomiasis is a water-borne parasitic disease that affects most tropical regions. It is caused by infection with parasitic worms of the genus Schistosoma and poses a big public health threat to affected communities and individuals. More than 200 million people are infected worldwide, and 85 percent of the burden is concentrated in sub -Saharan Africa. It is important to recognize the risk factors which favor development of infection and to focus on countries which are at high risk.

In this thesis, sub- Saharan African (SSA) countries with high prevalence of schistosomiasis infection (living in endemic areas) were identified. Risk factors were also identified and their association with schistosomiasis prevalence was assessed. The results indicate that high literacy rates are associated with low schistosomiasis infection rates. Such results are of great public health significance because neglected tropical diseases like schistosomiasis could be prevented by increasing literacy in at- risk populations.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENT

I would like to express my gratitude to all those who gave me the possibility to complete this thesis; I would like to thank my academic advisor and member of thesis committee Dr Clareann Bunker for her help and guidance during my time at University of Pittsburgh. I would like also to thank Dr Finegold for his help and his sense of humor in any circumstances.

I am deeply indebted to my thesis Chair Dr Kristen Mertz for her patience and help in offering me suggestions for improvement.

Especially, I would like to give my special thanks to my lovely wife Christiane whose patient love enabled me to complete this thesis. Thanks to our daughter Laura and son Christopher for keeping me awake to complete this work.

1.0 INTRODUCTION

Schistosomiasis is an infection with trematode parasites and is a prevalent tropical disease, ranking second to malaria and posing a great public health and social economic threat in sub-Saharan Africa (SSA) [Molyneux 2004; Hotez et al.2007]. More than 200 million people in 76 countries have these parasites; 85 percent live in sub –Saharan Africa [WHO 2008].A recent World Health Organization (WHO) report estimates that more than 600 million people are at risk for schistosomiasis [WHO 2002].

Among those infected, 120 million are symptomatic and 20 million have severe clinical disease. Mortality was estimated at more than 250, 000 deaths per year, making it the most deadly neglected tropical disease (NTD) [Chitsulo et al.2002]. According to the Global Burden of Disease (GBD)[1][WHO], schistosomiasis caused the loss of 1.7 million disability-adjusted life years (DALYs) worldwide in 2001, of which 82%(1.4 million DALYs) were lost in sub-Saharan-Africa(SSA)alone. In 2002, WHO reported that schistosomiasis caused one quarter of the tropical disease cluster burden (WHO 2002).

---

[1] The WHO global burden of disease (GBD) measures burden of disease using the disability-adjusted life year (DALY). This time-based measure combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health. The DALY metric was developed in the original GBD 1990 study to assess the burden of disease consistently across diseases, risk factors and regions (WHO).

1.1 THE BURDEN OF DISEASE

Infection with urinary schistosomiasis in Africa results in approximately 18 million cases of bladder wall pathology and 20 million cases of hydronephrosis, and African intestinal schistosomiasis results in about 8.5 million cases of hepatomegaly [Van der Werf 2003].By extrapolation from these figures, the mortality attributable to urinary schistosomiasis could be as high as 150,000 per year , and the number dying as a result of intestinal schistosomiasis could be as high as 130,000 per year[Fenwick 2003]. The poverty promotes higher worm burdens, yet poor health induced by schistosomiasis can lead to lower incomes. Poverty attributable to schistosomiasis results from disfigurement or other sequelae of long-term illness, impaired childhood growth and cognitive development, and reduced productive capacity [Ross et al, 2002, King et al. 2005; Hotez& Ferris 2006, Hotez et al.2006].

This disease is listed among the 13 diseases classified by the WHO as "Neglected Tropical diseases" [Hotez et al.2007].They are named so because they persist in the poorest and marginalized people who are often subsistence farmers, essentially living on no money and stuck in poverty, with no education. Because they arise mainly in rural areas where families depend on subsistence agriculture, they impair agriculture productivity. Despite the severe pain and life-long disabilities they cause, these diseases are given a low priority alongside high mortality diseases (HIV-AIDS, TB and Malaria) also known as "big three".

The neglected diseases often receive less attention by healthcare providers, national governments and international agencies than they merit. That is partly because not everyone infected becomes ill. However the disability caused by their morbidity remains a serious public health problem. Schistosomiasis infection is often asymptomatic and that is why incidence is not known. Prevalence is the only available epidemiological parameter and in most areas, this measure is also incomplete.

1.1.1 Causative Agents and Geographic Distribution

There are five species that cause schistosomiasis in humans, namely *S.mansoni*, the most pathogenic located in tropical Africa, South West Asia, South America and Caribbean Islands; *S. Haematobium* found in Tropical Africa and South West Asia; *S.japonicum*, previously found in Japan and now mainly in China and Philippines; *S. intercalatum* (West Africa); and *S.mekongi* around the Mekong river in Asia, mostly Laos and Cambodia.

The most common species are *S.mansoni* and *S.japonicum* found in the mesenteries around the intestine causing intestinal schistosomiasis characterized by granuloma formation in the intestine and liver. *S.haematobium* primarily affects the urinary tract resulting in inflammation of the bladder, ureteral obstruction leading to hydronephrosis, stone formation, etc. The five species also differ in size and shape of their eggs and egg production (*S.haematobium* and *S.mansoni* produce 20 to 300 eggs and *S.japonicum* produce 2500 eggs per worm pair per day) [Jordan 1993].

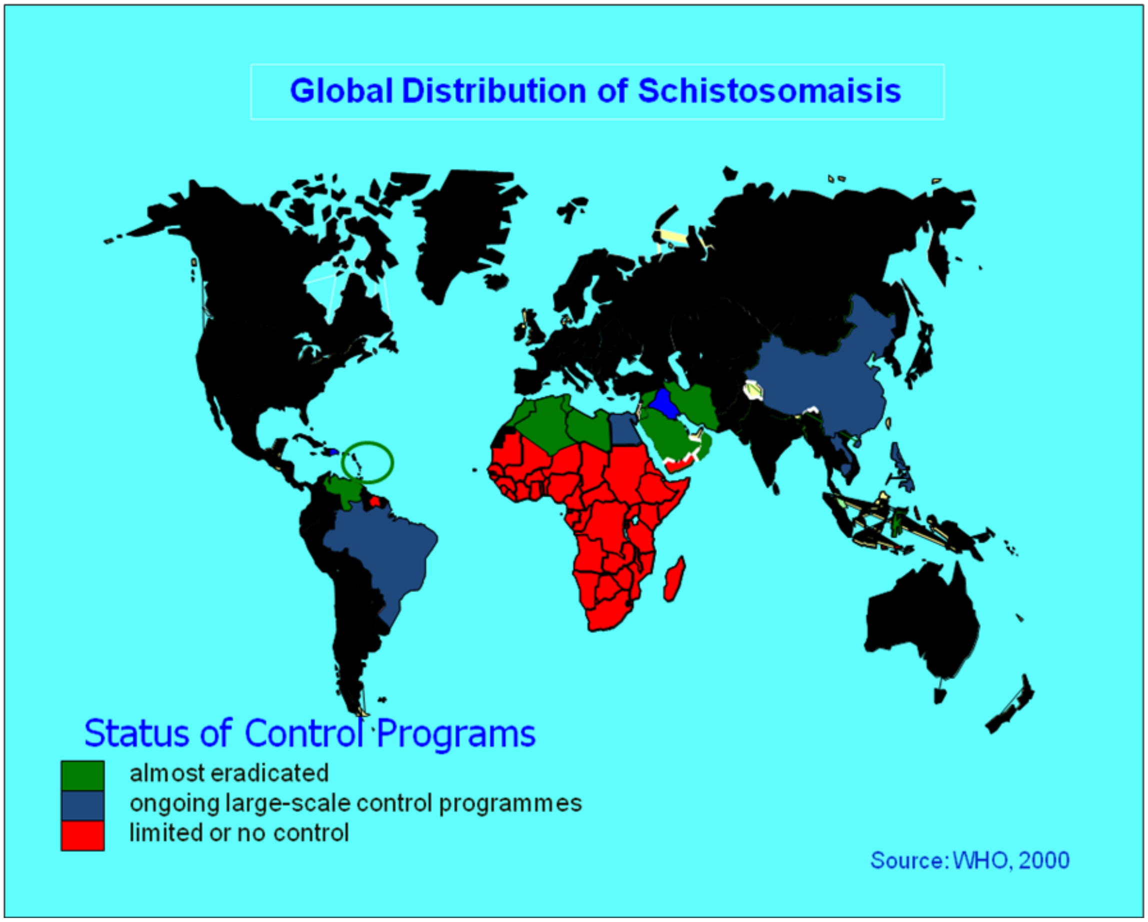

Figure 1: Global Distribution of Schistosomiasis

1.1.2 The Life Cycle of Schistosomiasis

Schistosomiasis has a complex life cycle, which takes place in humans, and in an intermediate host of a freshwater snail. Humans become infected when they come into contact with the cercaria in water, where the snail hosts are found [CDC]. Different species have very similar patterns of human –snail life cycle. Figure 2, the diagram from the Center for Disease Control and Prevention (CDC), shows the life cycle of schistosome infection. The cercariae penetrate the skin of the host, finding their way into the blood circulation to heart, lungs, and eventually to the liver where they grow and form male- female pairs, then migrate to final destination: the mesenteric veins in the wall of the intestines or bladder. The flukes copulate and lay eggs. Through the intestinal walls, the eggs get inside the gut and are passed out in the feces (S.mansoni) or through urine (S.haematobium). Once they reach water, the egg hatch into miracidia which will now seek the snail, thus repeating the cycle [CDC]

Schistosomiasis disease is characterized by general malaise; abdominal pain; headache; enlarged liver; spleen and lymph nodes; and blood; mucus and pus in stool [Ruberanziza et al.] Although the disease has a low mortality rate it can be debilitating and cause a high level of morbidity [Kabatereine 2006]. Long-term infections can lead to severe damage to human body and can sometimes be deadly [Kabatereine 2004, 2006]. Host immune response to eggs of schistosome parasites causes development of organ fibrosis and portal hypertension [Engels et al.2002]. The lesions can lead to blockage of blood flow. The portal hypertension can create collateral circulation that directs eggs into other parts of the body such as lungs and brain. In the case of intestinal schistosomiasis, the worms reside in the blood vessels lining the intestine. In urinary schistosomiasis, they live in the blood vessels of the bladder. Only about half of the eggs are excreted and the rest stay in the body, damaging other vital organs. In chronic hepatic schistosomiasis, bleeding from gastro-esophageal varices constitute the most serious also fatal complication [Ross et al.2002, Koukounari et al.2007]

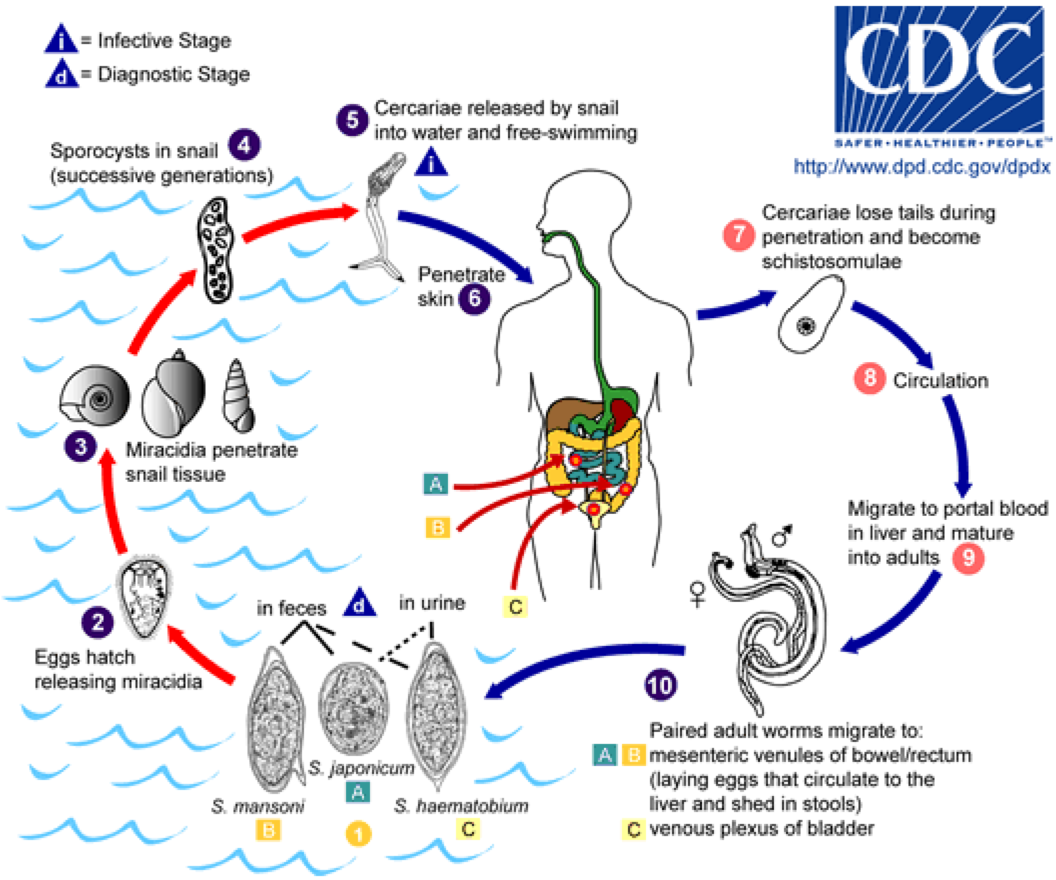

Figure 2: Life Cycle of Schistosomiasis

1.1.3 Risk Factors

Schistosomiasis is widespread among the poor populations in less developed countries, who live in conditions that favor transmission and who have no access to proper health care or effective prevention measures. Infection is predominant in school- age children between 10 and 15 years old. Difference in the peak age-related prevalence of disease is due to the gradual development of immunity and changes in the extent of freshwater exposure [Barbosa 2006]. Adults who immigrate to endemic areas are as susceptible to infection as young children [Hotez 2008]. Children who practice swimming are particularly at high risk, because of their prolonged and complete body exposure. These endemic areas are often characterized by low socioeconomic conditions and poor sanitary facilities, erroneous habits of the people as regards urination and defecation in canal water, and exposure to this polluted water by bathing, swimming, washing utensils and clothes, walking bare-foot during irrigation in agriculture or fishing. Snails live usually in marginal water and that's why they are present in tertiary canals in high quantities.

1.2 DIAGNOSIS OF SCHISTOSOMIASIS

1.2.1 Stool Examination

The gold standard for diagnosis of schistosomiasis infection is the detection of schistosomiasis eggs excreted in stools for intestinal strains (S.mansoni, S.japonicum) and in the urine for urinary strains (S.haematobium).The number of eggs excreted determines the intensity of infection and these parameters can be easily measured with limited laboratory equipment in resource- limited settings such as sub Saharan Africa where the fecal thick smear or Kato-Katz method [Katz 1972] is commonly used, because it allows quantification of infections by egg counts, usually expressed as per gram of feces . The determination of average number of eggs per gram of feces reflects the intensity of schistosomal infection.

1.2.2 Ultrasonography

Ultrasonography is used to detect schistosomal pathology both at the hospital and field level [Hatz C F; 2001]. It has been established as a safe, rapid non-invasive and relatively inexpensive technique for assessing schistosomiasis –related lesions in individual patients and in community surveys, according to the same author. It can also be used to validate laboratory tests, to measure morbidity, and provides an opportunity to visualize the evolution of pathological lesions after treatment.

Ultrasonography has been useful in revealing the fibrotic liver during chronic hepatic schistosomiasis [Utzinger et al.2000]. Schistosomiasis infections are considered to be the most frequent cause of liver fibrosis worldwide [Warren KS.1984]. Although portal hypertension syndrome (hepatomegaly, splenomegaly, ascites), is commonly said to be cirrhotic, schistosomiasis should be considered too. [Doumenge 1987].

1.3 PREVENTION AND CONTROL

Different control initiatives have been applied to reduce worm infections and the disease caused by schistosomiasis parasitic infections. However, the effects of those initiatives are quite uneven because of the regional and country-specific differences in available resources and political commitment. With combined approaches of snail control, chemotherapy, health education and hygiene movement, some countries like China have made substantial progress against schistosomiasis. In Brazil, chemotherapy programs achieved 50 to 70 percent decrease in prevalence. However, schistosomiasis still remains a major public health issue in sub Saharan

Africa where, instead of reduction, there are reports of increased spread in new geographic areas. Furthermore, there are also reports of resistance to praziquantel, the cornerstone of schistosomiasis control ,but because worm reproduction in human host is sexual and generation time is relatively long, resistance is likely to take many years to become an important clinical and public health issue [King 2000,].

Measures for control include chemotherapy using praziquantel, snail control (molluscicide), cercariae and miracidia control, provision of safe water supply, and health education by encouraging healthy behaviors such as use of latrines and change in defecation habits. To achieve optimal benefits from the disease control strategies, it is appropriate to recognize the seasonal factors that affect transmission of the parasitic and environmental heterogeneities of host population. [Kabatereine 2004]

1.3.1 Human Chemotherapy

Due to lack of resources, drug treatment can not cover every infected human host in the area. To achieve the best result of chemotherapy, one generally needs to identify the high-risk groups and concentrate on them.

1.3.2 Age-based Treatment

School-age children constitute a high-risk population and as children, they typically have the highest intensity of schistosomiasis infection of any age group. Chronic infection negatively affects all aspects of children's health, nutrition, cognitive development, learning, and educational access and achievement [World Bank 2003]. In general, children are easier to cover with mass drug treatment because they are readily available to be reached through schools which offer a sustained infrastructure with a skilled workforce that is in close contact with the community. Child-treatment reduces disease transmission; hence infection levels in community decline even for untreated children. The effect is greater because of the behavioral and biological differences between adults and children. By reducing transmission of schistosomiasis infections, deworming can improve the health and school participation of both treated and untreated children, both in treatment schools and in neighboring schools [Miguel and Kremer 2003].

Not only school-age children are at risk but also preschool children are vulnerable to the developmental and behavioral deficits caused by iron deficiency anemia ,and according to Booker and Hotez [2004] worms are an important contributor to anemia in that age group. Women at reproductive age are particularly susceptible to iron deficiency anemia because of iron loss during menstruation and because of increased need during pregnancy [Savioli 1995]. The severe iron-deficiency anemia that can arise from schistosomiasis disease during pregnancy can have adverse results for the mother, the fetus, and the neonate. [Savioli 2000]

2.0 OBJECTIVE

The objective of this thesis is to examine the country-level association between the estimated prevalence of schistosomiasis and indicators of socio-demographic status in Sub Saharan Africa.

3.0 METHODS

3.1 DATA SOURCES

An online World Health Organization (WHO) report was used to identify the population at risk of schistosomiasis and those infected in Sub Saharan African countries at mid -2008[WHO, 2008]. The World Health Statistics report was also used to identify the total population of each individual country included in this thesis. [WHO, 2008]. From this same report, other useful country-level parameters were used: adult literacy, infant mortality rate, percentage of children under 15 years old, percentage of population living in rural area, percentage of population living under two dollars per day, number of physicians and nurses per ten thousand population . Also the percentage of population with no access to clean water by country was obtained from a UNICEF website [WHO/UNICEF 96].

3.2 DATA ANALYSIS

Given the total population (TP) of each individual country and the number of persons infected (PI), prevalence of infection (PREV) was calculated by dividing the population infected (PI) by total population (TP) times 100. Countries were categorized as "high" prevalence if prevalence of infection was greater or equal to 30 percent and "low" prevalence if less than 30 percent. Then t-test was also used to assess the difference between mean levels of each variable in "high" and "low" prevalence countries.

A Correlation coefficient matrix was used to determine correlations between all social - demographic variables and outcome (Table 3).Scatter plots were also used to assess relationship between each risk factor and prevalence of infection (PREV).

Linear regression was used to identify measures independently associated with schistosomiasis prevalence and 3 risk factors were initially included (PR15, ADLIT, MD). Stepwise backward elimination method was used.

All statistical analyses were performed using version 9.2 of SAS software (SAS Institute, Cary, NC, USA).

4.0 METHODS

4.1 POPULATION

As presented on Table 1, the median percentage of young people (%Y15) in endemic sub-Saharan African countries is 43 percent and young persons are at high risk for schistosomiasis. The median percentage of rural population (%Rul.) is 63 percent and this group is mostly poor without access to basic infrastructures such as clean water, in other words, it is at high risk for schistosomiasis and other diseases of poverty. A median of 77 percent of the population (%$2) lives in extreme poverty, on less than two dollars per day, in disease conditions, struggling for the most basic necessities. The median child mortality rate (CM5) is 126 per thousand. The median number of physicians (MD) is 1 per ten thousand and the median number of nurses (NUR) is 6 per ten thousand population. The median percentage of literate adults (ADLIT) is 65 percent and the median percentage of those without clean water (NWAT) is 36 percent

Table 1: Country_ Level Socio-Demographic Measures

Country	Infected	At Risk	Tot.Pop.	%Y15	%RI	PRE\	%Rul.	%$2	CM5	ADLI	MD	NUR	NWAT
Angola	7,777,514	10,499,644	18,020,668	46	58	43	43	73	158	67	1	14	49
Benin	3,300,594	7,447,494	8,662,086	44	86	38	59	75	123	41	0	8	35
Botswana	190,552	476,379	1,904,991	35	25	10	40	49	40	83	4	27	4
Burkina Faso	4,563,995	12,170,652	15,208,586	46	80	30	84	81	191	29	1	5	28
Burundi	1,180,830	3,936,099	8,074,254	41	49	15	90	93	180	59	0	2	29
Cameroon	4,296,174	16,188,893	18,897,957	42	86	23	44	58	148	68	2	16	30
Central African Republic	442,429	3,760,650	4,423,452	41	85	10	62	82	172	49	1	4	34
Chad	4,816,218	8,759,279	11,067,437	46	79	44	73	83	209	26	0	3	52
Congo	1,316,922	2,693,032	3,615,152	42	74	36	40	74	125	87	2	10	29
Côte d'Ivoire	7,849,695	18,624,238	20,591,302	41	90	38	52	47	127	49	1	6	19
Democratic Republic of the Congo	18,275,470	50,468,820	64,205,366	47	79	28	67	80	161	67	1	5	54
Equatorial Guinea	10,394	103,939	659,197	42	16	2	61		206	87	3	5	57
Eritrea	361,521	2,655,791	4,996,204	43	53	7	79		70		1	6	40
Ethiopia	6,043,909	45,163,108	80,713,434	44	56	7	84	78	119	36	0	2	58
Gabon	613,706	675,077	1,448,159	35	47	42	16	20	91	86	3	50	13
Gambia	526,220	1,403,254	1,660,200	41	85	32	44	57	109		1	13	14
Ghana	17,364,943	22,459,043	23,350,927	40	96	74	52	54	115	65	2	9	20
Guinea	2,465,526	9,572,042	9,833,055	43	97	25	67	87	150	30	1	5	30
Guinea-Bissau	523,751	1,396,668	1,575,446	43	89	33	70	78	198	65	1	7	43
Kenya	8,864,989	30,839,766	38,534,087	43	80	23	81	40	121	74	1	12	43
Liberia	946,132	3,153,772	3,793,400	47	83	25	42	95	133	56	0	3	36
Madagascar	11,125,739	16,172,162	19,110,941	43	85	58	70	90	112	71	3	3	53
Malawi	6,123,589	11,430,699	14,278,404	46	80	43	83	90	111	72	0	6	24
Mali	3,814,824	10,172,864	12,711,140	45	80	30	69	77	196	23	1	6	40
Mauritania	877,520	2,562,917	3,200,288	40	80	27	60	44	119	56	1	6	40
Mozambique	15,214,927	17,450,040	21,780,614	43	80	70	69	90	168	44	0	3	58
Namibia	12,613	262,067	2,114,161	37	12	1	65	62	68	88	3	31	7
Niger	1,988,657	11,784,635	14,668,743	49	80	14	83	86	176	30	0	2	58
Nigeria	35,154,357	121,182,498	151,319,500	45	80	23	53	84	189	72	3	17	53
Rwanda	594,262	1,000,862	9,720,694	44	10	6	72	90	181	64.9	1	4	35
Sao Tome and Principe	6,161	29,571	160,954	41	18	4	42		99	88	5	19	14
Senegal	1,940,460	10,150,100	12,211,181	42	83	16	59	60	114	43	1	3	23
Sierra Leone	3,552,693	5,257,985	5,559,853	43	95	64	63	76	262	38	0	5	32
Somalia	1,612,081	4,478,002	8,953,890	44	50	18	63		142		0	2	71
South Africa	5,295,051	30,275,051	48,687,000	32	62	11	39	43	59	88	8	41	7
Sudan	7,165,105	31,556,010	41,347,723	40	76	17	62		109	60.9	3	9	36
Swaziland	293,443	918,606	1,167,834	39	79	25	76	63	91	80	2	63	40
Togo	1,698,852	5,409,938	6,458,605	43	84	26	60	69	100	53	0	4	41
Uganda	5,104,418	25,522,089	31,656,865	49	81	16	87	76	130	74	1	7	36
United Republic of Tanzania	21,348,317	33,171,138	42,483,923	44	78	50	75	97	116	72	0	4	45
Zambia	3,227,578	9,723,578	12,620,219	46	77	26	63	82	170	68	1	20	42
Zimbabwe	5,392,494	10,784,987	12,462,879	38	87	43	63		90	91	2	7	19
Median	3,264,086	9,647,810	11,639,309	43	80	25	63	77	126	65	1	6	36

5.0 RESULTS

5.1.1 T-test Results of differences between "high" and "low" prevalence countries

Analyses of differences between "high" and "low" prevalence countries compare mean values of each variable within "low" and "high" prevalence categories and the results of T-test are shown on Table 2. Mean number of physicians and mean adult literacy rates were significantly different (P=0.015 and 0.0112 respectively) in "high" and "low" prevalence countries.

Table 2: Mean Values of Socio-Demographic Variables by Prevalence of Schistosomiasis

Country-Level Variable	Low Prevalence Countries (<30%) N=25	High Prevalence countries (>=30%) N=17	P-value
%Y15	42	43	0.75
%Rul.	64	60	0.50
%$2	71	73	0.64
‰CM5	130	147	0.24
%ADLIT	64	48	0.011
MD	2	1	0.015
NUR	13	9	0.23
NWAT	37(25)	34	0.53

Variables: %Y15: percentage of persons under 15 years old, %Rul. (percentage of rural population), %$2(percentage of those population living under $2 per day), ‰CM5 (child mortality rate per a thousand),% ADLIT(adult literacy rates),MD(number of physicians per ten thousand), NUR(number of nurses per ten thousand),NWAT(percentage of population without clean water).

5.1.2 Correlation Coefficients and Relationship between Risk Factors and Prevalence of Infection

Correlation coefficients were used to assess correlation between each risk factor and outcome and results are presented in Table 3. The relationship between risk factors and prevalence of infection was also assessed using scatter plots (Figures 2, 3).

Level of adult literacy rates (%ADLIT) is strongly correlated with prevalence of infection (PREV) (θ=-0.46) (Table 3 and Figure 2).Number of physicians (MD) per ten thousand population and percentage of population under 15 years (%Y15) are also significantly correlated with prevalence of infection(Table 3 and Figure 3).

Table 3: Correlation Coefficients between Prevalence of Infection and Risk Factors

Pearson Correlation Coefficients

Prob > |r| under H0: Rho=0

Number of Observations (n)

	PREV	%Y15	%Rul	%$2	CM5	ADLIT	MD	NUR	NWAT
PREV	1.00000	0.30677	0.13213	0.13463	0.21438	-0.46078	-0.38458	-0.25509	0.15375
PREV		0.0482	0.4042	0.4337	0.1728	0.0032	0.0119	0.1030	0.3310
	42	42	42	36	42	39	42	42	42
%Y15	0.30677	1.00000	0.51444	0.68971	0.57748	-0.50108	-0.68947	-0.61531	0.65329
%Y15	0.0482		0.0005	<.0001	<.0001	0.0012	<.0001	<.0001	<.0001
	42	42	42	36	42	39	42	42	42
%Rul	0.13213	0.51444	1.00000	0.56279	0.29731	-0.39479	-0.51267	-0.42343	0.45092
%Rul	0.4042	0.0005		0.0004	0.0559	0.0129	0.0005	0.0052	0.0027
	42	42	42	36	42	39	42	42	42
%$2	0.13463	0.68971	0.56279	1.00000	0.52920	-0.37096	-0.51287	-0.57275	0.56242
%$2	0.4337	<.0001	0.0004		0.0009	0.0282	0.0014	0.0003	0.0004
	36	36	36	36	36	35	36	36	36
CM5	0.21438	0.57748	0.29731	0.52920	1.00000	-0.53815	-0.45458	-0.45870	0.50860
CM5	0.1728	<.0001	0.0559	0.0009		0.0004	0.0025	0.0022	0.0006
	42	42	42	36	42	39	42	42	42
ADLIT	-0.46078	-0.50108	-0.39479	-0.37096	-0.53815	1.00000	0.62257	0.53250	-0.37335
ADLIT	0.0032	0.0012	0.0129	0.0282	0.0004		<.0001	0.0005	0.0192
	39	39	39	35	39	39	39	39	39
MD	-0.38458	-0.68947	-0.51267	-0.51287	-0.45458	0.62257	1.00000	0.59440	-0.49612
MD	0.0119	<.0001	0.0005	0.0014	0.0025	<.0001		<.0001	0.0008
	42	42	42	36	42	39	42	42	42
NUR	-0.25509	-0.61531	-0.42343	-0.57275	-0.45870	0.53250	0.59440	1.00000	-0.42998
NUR	0.1030	<.0001	0.0052	0.0003	0.0022	0.0005	<.0001		0.0045
	42	42	42	36	42	39	42	42	42
NWAT	0.15375	0.65329	0.45092	0.56242	0.50860	-0.37335	-0.49612	-0.42998	1.00000
NWAT	0.3310	<.0001	0.0027	0.0004	0.0006	0.0192	0.0008	0.0045	
	42	42	42	36	42	39	42	42	42

5.1.3 Scatter Plots

Adult literacy rate is indirectly related to prevalence of infection (Fig.3)

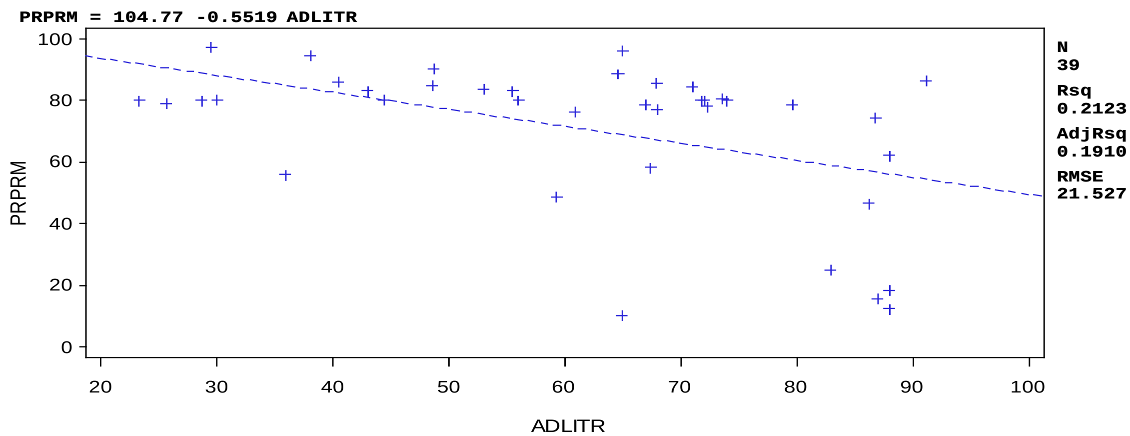

Figure 3: Adult Literacy Rates and Risk of Infection

Low number of physicians is assocated with higher prevelence of infection(Fig.4)

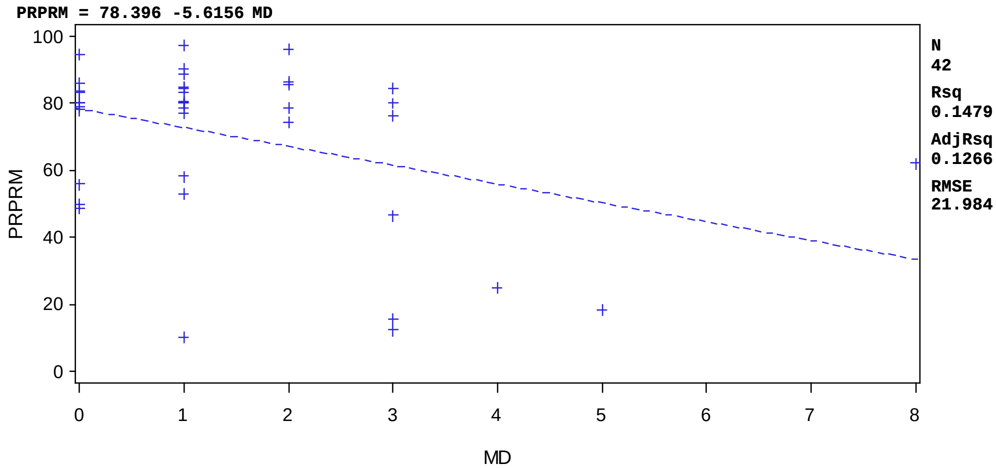

Figure 4: Risk of Infection and Number of Physicians

5.1.4 Linear Regression for Factors Associated with Infection

In order to determine the factors that are associated with infection, the data were analyzed using linear regression.

Initially two factors (ADLIT and MD) were included based on the t-test results and by stepwise backward elimination; adult literacy rates (ADLIT) remained significantly associated with prevalence of infection (P< 0.0032). Table 4 presents the results of linear regression analysis at final stage with adult literacy rates as independent variable: (OR=0.576;95% CI 0.404, 0.820).An Odds ratio less than 1 suggests that as adult literacy increases, prevalence of infection decreases. In other words, literacy is a protective factor.

Table 4: Linear Association of Adult Literacy Rate and Prevalence of Schistosomiasis in Sub-Saharan African Countries

Variable	***Label***	***DF***	***Odds ratio***	***95% Confidence Interval***	
ADLIT	ADLIT	1	0.576	0.404	0.820

6.0 DISCUSSION

Schistosomiasis is a multifactorial disease, prevalent in impoverished and often vulnerable people living in conditions that favor transmission, without proper access to health care or prevention measures. The occurrence is particularly linked to agricultural and water development schemes which paradoxically, by improving water access also increase the habitat of snail, thus extending the areas where schistosomiasis is found.

In this thesis, the following risk factors that may increase likelihood of exposure and transmission were used: young population under 15 years old because of their interaction with unsafe water and lack of immunity against schistosomiasis, rural population without adequate health infrastructure, people living in extreme poverty, child mortality (under 5 years), adult literacy rates, number of physicians, number of nurses, and people with no access to clean water.

Adult literacy rate (ADLIT) was significantly associated with prevalence of infection using country –level data.

Adult literacy may decreases risk of infection because of other implications such as following instructions to protect against potentially contaminated water.

The data used have some limitations. Most developing countries do not have resources to collect data on most of the neglected diseases .They usually put priority on diseases such as HIV-AIDS, malaria, and TB. Some countries in sub-Saharan Africa are involved in continuous wars and violence (Somalia, Republic Democratic of Congo, and Sudan for example) and it is impossible to conduct any survey. It was also reported that some data were just the result of generalization from one country to another [Van der Werf 2003].

In this thesis, the focus was on prevalence of infection which gives notion to potential morbidity but it's not known when those who are infected will be sick because it takes long time depending on other conditions: intensity of infection, length of infection, co-infection, nutrition, immunity, age, gender, climate, altitude, and other factors. Approximately 50-60 % of those infected develop symptoms but people with lighter infection have fewer or no symptoms and severe disease may follow after many years of silent or mildly symptomatic period [WHO 1993].

In addition, national prevalence may hide the real picture of disease in a given population. As a disease of conditions on ground, schistosomiasis should be treated mostly locally (living near rivers, dams, lakes, irrigation ditches) because that is the area which is unevenly impacted by the disease. For example, in Rwanda, the national prevalence is about 6% but it is above 60 % in some areas such as northern region close to the lakes Bulera and Ruhondo [Ruberanziza 2007]

7.0 CONCLUSION

Schistosomiasis like other neglected diseases is a disease of poverty. It is mostly prevalent in Sub- Saharan Africa where not only it overlaps with other low priority (politically) diseases but also high priority diseases such as HIV, malaria, and TB. Schistosomiasis has low mortality but high morbidity rates and because of prioritization, the high mortality diseases are treated first. Thus an integration of schistosomiasis control programs with efforts to curb these high priority diseases has been repeatedly advocated [Molyneaux, 2004; Hotez et al.2006]. It is helpful, not only to recognize the countries with high prevalence in schistosomiasis but also to identify the risk factors. Low literacy increases chances of infection and we believe that increasing literacy rates may decrease infection by schistosomiasis. Information on such disease should be provided to local population by formal and informal education in schools, multimedia (TV, radio, magazine, booklets) and meetings within communities. Education on neglected tropical diseases (NTD) does not only consist in increasing literacy but also increasing hygienic behaviors such as using toilets and avoiding contaminated water.

BIBLIOGRAPHY

1. Arnon, R. Life span of parasite in schistosomiasis patients. *Isr J Med Sci* 1990; 26:404

2. Barbosa CS, Favre TC, Wanderley TN, Callou AC, Pieri OS (2006) Assessment of Schistosomiasis, through school surveys, in the Forest Zone of Pernambuco, Brazil. *Mem Inst Oswaldo Cruz* 101: (Suppl 1)55–62

3. Bethony J, Brooker S, Albonico M, et al. Soil-transmitted helminthes infections: ascariasis, trichuriasis and hookworm. *Lancet* 2006; 367: 1521–32

4. Bleakley H. Disease and development: evidence from hookworm eradication in the American South. *Q J Econ* 2007; 122: 73–117

5. Brooker S, Jardim-Botelho A, Quinnell RJ, Geiger SM, Caldas IR, Fleming F, Hotez PJ, Correa-Oliveira R, Rodrigues LC, Bethony JM. Age-related changes in hookworm infection, anemia and iron deficiency in an area of high Necator americanus hookworm transmission in south-eastern Brazil. *Trans R Soc Trop Med Hyg* 2007;101(2):146-154

6. Center for Disease Control and Prevention(CDC) Schistosomiasis disease;[cited 2009 December 11]; available from :http://www.dpd.cdc.gov/dpdx/html/schistosomiasis.htm

7. Chitsulo L, Engels D. Montesor A, Savioli L. The global status of schistosomiasis and its control. *Acta Trop* 2007; 77:41-51

8. De Silva NR, Brooker S, Hotez PJ, Montresor A, Engels D, Savioli L. Soil-transmitted helminth infections: updating the global picture. *Trends Parasitol* 2003; 19: 547-51

9. Doumenge JP, Mott KE, Chueng C, Villenave D, Perrin MF, Reaud-Thomas G, 1987. *Atlas of the Global Distribution of Schistosomiasis*. Geneva: World Health Organization

10. Engels D. Schistosmiasis mansoni in Burundi: Progress in its control since 1985. *WHO Bulletin* 71(2):207-214

11. Engels, D.; Chitsulo, L.; Montresor, A.; Savioli, L. The global epidemiological situation of schistosomiasis and new approaches to control and research. *Acta Tropica*, May 2002, Vol. 82 Issue 2

12. Hatz C F. The use of ultrasound in Schistosomiasis. *Adv Parasitol*.2001;48: 225-84

13. Hotez PJ, Fenwick A, Kjetland EF (2009) Africa's 32 Cents Solution for HIV/AIDS. *PLoS Negl Trop Dis* 3(5): e430

14. Hotez PJ, Ferris M. The antipoverty vaccines. *Vaccine* 2006; 24: 5787-99

15. Hotez PJ, Molyneux DH, Fenwick A, et al. Control of neglected tropical diseases. *N Engl J Med* 2007; 357: 1018–27

16. Hotez PJ, Molyneux DH, Fenwick A, Ottesen E, Ehrlich Sachs S, Sachs JD. Incorporating a rapid-impact package for neglected tropical diseases with programs for HIV/AIDS, tuberculosis, and malaria. *PLoS Med* 2006; 3: e102

17. Jordan P, Webbe G, Sturrock RF, eds. Human schistosomiasis. Wallingford: *CAB International*, 1993;159-183

18. Kabatereine NB, Brooker S, Tukahebwa EM, & Al. Epidemiology and geography of *Schistosoma mansoni* in Uganda: implications for planning control. *Trop Med Int Health*. 2004; 9:372-380

19. Kabatereine NB, Fleming FM, Nyandindi U, Mwanza JCL, Blair L (2006) The control of schistosomiasis and soil-transmitted helminths in East Africa. *Trends Parasitol* 22(7):332–339

20. King CH, Dickman K, Tisch DJ. Reassessment of the cost of chronic helminthic infection: a meta-analysis of disability-related outcomes in endemic schistosomiasis. *Lancet* 2005; 365: 1561–69

21. King CH. Lifting the burden of schistosomiasis—defining elements of infection-associated disease and the benefits of anti-parasite treatment. *J Infect Dis* 2007; 196: 653–55

22. Koukounari A, Fenwick A, Whawell S, et al.Morbidity indicators of Schistosoma mansoni: relationship between infection and anemia in Ugandan schoolchildren before and after praziquantel andalbendazole chemotherapy. *Am JTropMedHyg*.2006; 75:278-86

23. Molyneux DH. “Neglected” diseases but unrecognized successes – challenges and opportunities for infectious disease control. *Lancet Infect. Dis* 2004; 364: 380-3

24. Ruberanziza E, Gahimbare L, Musemakweri A, Vervoort T, Van Den Ende J, Clerinx J. Schistosomiasis mansoni in children around Lake Ruhondo, Rwanda A Clinico-epidemiological study. *Rwanda Medical Journal* 38th Year ,2007,66:34-53

25. Steinmann P, Keiser J, Bos R, Tanner M, Utzinger J. Schistosomiasis and water resources development: systematic review, meta-analysis, and estimates of people at risk. *Lancet Infect. Dis* 2006; 6: 411-25

26. Stoever, K., Molyneux, D., Hotez, P. & A. Fenwick (2009). HIV/AIDS, schistosomiasis, and girls. *Lancet Infect. Dis*,2009;Jun 13;373(9680):2025-6

27. Stothard JR and Gabrielli A-F (2007). Schistosomiasis in African infants and pre-school children: to treat or not to treat? *Trends in Parasitology*, 23, 83-86

28. The Carter Center Schistosomiasis Control Program.[cited 2009 December 11] Available from: htpp://www.cartercenter.org/health/Schistosomiasis/index.html

29. Utzinger J, N'Goran EK, Ossey YA, Booth M, Traore M, Lohourignon KL, et al. Rapid screening for Schistosoma mansoni in western Côte d'Ivoire using a simple school questionnaire. *Bulletin of the World Health Organization* 2000; 78:389-98

30. Van der Werf M,&Al. Quantification of clinical morbidity associated with schistosome infection in sub-Saharan Africa. *Acta Trop* Volume 86, Issues 2-3, May 2003,125-139

31. Warren KS. The kinetics of hepatosplenic schistosomiasis.*Semin Liver Dis*. 1984; 4:293-300

32. World Health Organization (2001) World Health Assembly Resolution 54.19.Schistosomiasis and soil-transmitted helminthes infections. [Cited 2009 December 11]Available from: http://www.who.int/wormcontrol/about_us/en/ca54r19.pdf

33. World Health Organization (2002) Expert Committee. Prevention and control of schistosomiasis and soil-transmitted helminthiasis. *World Health Organ Tech Rep Ser*. 2002;912:1-57

34. World Health Organization (2004), *World Health Report-Changing history*. WHO, Geneva: 1-157

35. World Health Organization (2004). Burden of disease in DALYs by cause, sex and mortality stratum in WHO regions, estimates for 2002. Geneva: *World Health Organization Bulletin*. 2004;82:844-851

36. World Health Organization / The United Nations Children's Fund / Waterside Capital Corp. *Water Supply and Sanitation Sector Monitoring Report* 1996. WHO/EOS/96.15.

Geneva:WHO;1996[cited 2009 December 12];available from: http://www.africanwater.org/coverage_1996.htm

37. World Health Organization Data Bank [cited 2009 December 11]; available from: http://www.who.int/neglected_diseases/preventive_chemotherapy/sch/en/index.html

38. World Health Organization, the Control of Schistosomiasis: Second Report of the WHO Expert Committee. *WHO Technical Report Series* 830. Geneva: WHO, 1993[cited 2009 December 12]; available from: http://whqlibdoc.who.int/trs/WHO_TRS_830.pdf

39. World Health Organization. Public health impact of schistosomiasis: disease and mortality. WHO Expert Committee on the Control of Schistosomiasis. *Bull World Health Organ*. 1993; 71:657–62