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Francis Makamu
Oklahoma State University

Mehtabul Azam
Oklahoma State University

Harounan Kazianga
Oklahoma State University

Department of Economics
Oklahoma State University
Stillwater, Oklahoma

339 BUS, Stillwater, OK 74078, Ph 405-744-5110, Fax 405-744-5180

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Francis Makamu,* Mehtabul Azam,† Harounan Kazianga‡

Oklahoma State University

Abstract

Using the rollout of the schistosomiasis campaign in Nigeria as a quasi-experiment, we examine the impact of the disease control program on school age children education outcomes. Schistosomiasis is a parasitic disease caused by infections from a small worm. Its most severe effects hamper growth and cognitive development of children. The mass campaign targeted four states that saw large reduction in the infectious disease afterwards. Using difference-in-differences strategy, we find that the cohort exposed to the treatment in rural areas accumulated an additional 0.6 years of education compared to cohort not exposed to the treatment. Moreover, the impact of the schistosomiasis treatment is mainly on girls residing in rural areas.

Key words: Schistosomiasis, Disease Control, Child Education, Nigeria.
JEL Codes: I15, I18, I26

*Corresponding author. Email: francis.makamu@okstate.edu. Spears School of Business, Oklahoma State University, 001 Classroom Building, Stillwater, OK 74078.

†Email: mazam@okstate.edu. Spears School of Business, Oklahoma State University, 326 Business Building, Stillwater, OK 74078.

‡Email: harounan.kazianga@okstate.edu. Spears School of Business, Oklahoma State University, 324 Business Building, Stillwater, OK 74078.

1 Introduction

Schistosomiasis, a neglected tropical disease (NTD), is an acute and chronic disease caused by parasitic worms.[1] According to the World Health Organization (WHO) at least 258 million people required treatment in 2014. The disease is particularly prevalent among school age children. In general, repeated treatment help reduce and prevent morbidity. We examine a deworming program which provided regular treatment to at-risk population in one of the regions that borne the greatest burden of the disease. We do not find conclusive evidence that treatment increased school enrollment for 6-14 year children. However, we find that cohort exposed to treatment in rural areas accumulated 0.6 years more of education. Moreover, most of the impact is driven by the impact on the girl child.

The importance of resolving the problem of endemic disease is crucial to development in low income countries. Studies in development economics provide evidence on the relationship between overall health environment and long term changes in development outcomes. Although the role of disease reduction in affecting economic growth is found rather weak (Weil, 2010), global improvement in health conditions not only improved lives but also enhanced economic growth (Weil, 2007; Bloom et al., 2004). Albeit the debate on the empirical estimation is still unsettled, the implication for developing world appears to be of significance.[2]

Public policies directed toward the decline in prevalence, morbidity and mortality rates of infectious diseases have not only important regional implications but also implications

[1] The Centers for Disease Control and Prevention (CDC) categorizes the NTDs in endemic infections in tropical regions that not only affect the world's poorest people but also cause disabilities that make it more difficult to succeed in school, care for family, or earn a living. NTDs also predominantly occur among populations that have little or no access to good housing, safe water supply and sanitation, or formal health system.

[2] The decline in mortality from several diseases in the twentieth century positively impacted life expectancy and population growth in the developing countries (Acemoglu and Johnson, 2007) In sub-saharan Africa, for example, infections due to the TseTse fly affected the continent's precolonial prospects in developing agricultural technologies (Alsan, 2014). Regions where the parasite is endemic became less likely to use domesticated animals, to use the plow and ultimately to intensify agriculture.

at the individual level.[3] Better health capital improve the individual return to investment in education and lead to higher future returns. For instance, Bleakley (2010) documents how and the extent to which exposure to endemic disease in early childhood development affects labor productivity in the adulthood. Cutler et al. (2010) review a malaria eradication program in India and report positive impact on cohort's expenditure and per capita household consumption. Venkataramani (2012) studies a nationwide effort to eliminate malaria in Mexico in the 1950's. The author finds that, in the case for men, birth year exposure in treated states led to increase in cognitive test score performance and better schooling outcomes. The model, however, holds smaller and no significant estimates for women. Kazianga et al. (2014) find an increase in rural population and land transaction in Burkina Faso after a campaign against Onchoceriasis run by the WHO. Exposure to the Onchoceriasis control program induced villages to develop and improve local institutions (e.g., land markets) and the provision of public goods (e.g., public markets, primary schools and telephone services).

Bleakley (2007) provides evidence on the benefits of disease control on economic outcomes. He evaluates the impact of the eradication of hookworm, an infection similar to schistosomiasis, in the American south. Hookworm, an intestinal parasite, was responsible for half of the literacy rate gap between northern and southern states. After the program completion, it appeared that the disease accounted for as much as 20 percent of the difference in income between the north and the south. Other findings indicate that hookworm eradication had large positive effects on school enrollment and on years of education completed. Miguel and Kremer (2004) investigate the effects of deworming programs in areas with high helminth infection rates of intestinal worms including hookworm, roundworm and schistosomiasis in rural Kenya. The authors focus on school age children and enrollment in

[3]Implications of large endemic disease on the development of low income countries include inhibition of growth of specific geographic regions, low investment in human capital, missing opportunities in transfer of technologies and agriculture (see, Strauss and Thomas, 1998; Glewwe et al., 2001; Gallup and Sachs, 2001; Becker et al., 2005).

school. They show evidence of substantial increase in school participation and reduced absenteeism in randomly selected treated schools. Although they found no evidence on pupil's test scores, they argue that the deworming program was extremely cost effective in terms of returns to education and human capital investments. Their cost-benefits analysis indicates that the program has sizeable benefits.

Our study exploits a large campaign of drug administration to school age children that has reduced the prevalence of schistosomiasis in Nigeria. The disease causes anemia, stunted growth, cognitive impairment and premature death. The drug distribution started in 1999 and initially covered two states (i.e. Plateau and Nasarawa). By the year 2010, the program had expanded to include four states and over a million children received the treatment each year. A substantial body of the medical literature has examined the effectiveness of the schistosomiasis mass treatment. Most of these studies that have so far investigated student performance response to the treatment have relied on cross sectional techniques comparing the outcome between a control and a test group (Ekanem et al., 1994; Meremikwu et al., 2000; Ayoya et al., 2012).

This paper contributes to and extends the literature on health and education externalities by reporting empirical results of the schistosomiasis control program impact on child's education outcomes. Our estimation strategy uses difference-in-differences to show that efforts to eliminate the disease in developing region had positive impacts on child education outcomes. By taking advantage of the expansion of the Schistosomiasis control program in four states of Nigeria from 1999 to 2013, we show that the reduction in the water-borne disease has contributed in improving the level of education of younger cohorts who were exposed to the program.

The remainder of the paper is organized as follows. Section two offers a description of the disease, the circumstances in which a child might get infected, and the symptoms of the infection. It also discusses the treatment campaign conducted by the carter center and

the effectiveness of the program. Section three provides a description of the data employed. Section four sets out the model specification and the identification strategy used to capture the treatment impact. The findings of our study are presented in section five. The last section concludes.

2 Program Description

2.1 Schistosomiasis

Schistosomiasis is a water-borne disease that mostly affects children in tropical regions especially in developing countries of Africa, Asia and South America. The schistosome parasite, which is a worm, is acquired by contact with unprotected stagnant water. The classical sign of schistosomiasis infection is blood in urine. Once in the blood vessels, the parasite attacks mainly bladder and kidneys and causes fever, pain in the stomach and during urination. The most vulnerable group to the disease are school age children. They are more likely to come in contact with the vector and the disease exposes them to serious deficiency manifested through anemia, inhibited growth, debility and high morbidity. Nigeria is one of the country with the highest prevalence rate of schistosomiasis in the world. Abdulkadir et al. (2017) review a large number of articles in an attempt to estimate the prevalence of schistosomiasis in Nigeria. Amidst the analyzed studies, they find the prevalence of urinary schistosomiasis to vary from 2 to 82.5 percent.

Schistosomiasis is a concern for the developing world because it tends to be endemic in infested rural places and densely populated urban areas as well. As with other neglected tropical diseases, schistosomiasis can hinder development prospects if it is not adequately addressed. Although schistosomiasis is endemic in many regions, there are effective treatment regimens. The most common course of treatment consists of periodic intake of the drug

praziquantel. The drug is highly effective as it can reverse up to 90 percent of the damage at a relatively low cost, between $0.15 to $0.20 per treatment (Hopkins et al., 2008). The WHO is active in raising awareness about schistosomiasis and recommends health education on access to safe water, improved sanitation and hygiene.

Gutman et al. (2008) advocate for preventive mass treatment of all school age children as the cheapest approach to control schistosomiasis. The authors notice that the disease affects the ability of infected children ability to work, by weakening their body. Furthermore, infected children show signs of poor growth and learning difficulty at school. Agi and Okafor (2005) study the epidemiology of schistosomiasis and find a significant negative correlation between age and intensity of infection. Their results suggest that there is a progressive rise in prevalence for children aged 5-9 but the infection rate often peaks for children aged 10-14 and grows weaker as the individual gets older. Similarly, Ezeadila et al. (2015) find the difference in prevalence between children aged 6-9 and 10-13 to be not significant at the 5 percent level.

The paper is connected to a strand of literature that relate the impact of a neglected tropical disease to children education outcomes. Early studies, such as Ekanem et al. (1994), in a cross sectional analysis assess the effect of schistosoma infection children aged 5-15 in southeastern Nigeria to find no significant impact on their physical growth and school performance. Meremikwu et al. (2000) also find no improvement in school attendance following repeated treatment of praziquantel to children aged 8-9 in Adim, Nigeria.[4] Like Ekanem et al. (1994), Meremikwu et al. (2000) employ a simple difference comparing cohort pupils characteristics pre-treatment and post-treatment period without controlling for observed or unobserved factors within child, school or village that could influence the outcome. Ayoya et al. (2012) offer a stronger analysis studying primary school children aged 7-12 in poor urban area in Bamako, Mali. Using a linear regression model they find a significant increase

[4]Attendance is defined as being reported to be enrolled in school at the time of the survey.

in children attendance and school achievement, measured by the pupil's passing rate. They acknowledge that they do not control for unobserved factors that could bias their estimates. By using difference-in-differences, we are able to account for unobserved heterogeneity across time and space in estimating the effects of schistosomiasis control on children educational outcomes.

2.2 Program Intervention

As part of the effort to control the disease, the Carter Center (CC) has provided schistosomiasis health education and drug distribution in Nigeria since 1999 to children aged 5-14. Originally, the CC operated in Nigeria for the treatment of Onchoceriasis. The CC eventually obtained a grant from Smithkline Beecham to begin the treatment of urinary schistosomiasis, the most severe form of the disease. In addition to that, the project was supported by a donation of 50,000 doses of praziquantel from Medochemie and Bayer Pharmaceuticals.

At first, the CC conducted a nationwide postal survey, confirming the presence and the high prevalence of urinary schistosomiasis throughout the country. The rate of infection was particularly high among people living in poor rural areas with little or no access to a safe source of water. Of all age groups, children between 5 and 14 years traditionally responsible for water-related household chores were the most exposed and commonly affected. For instance, in the village of Mungkohot in the Plateau state, a staggering 80 percent of school age children were found infected with the disease. In the first year of the program, the CC assessed the activity of 150 villages to not only determine where the infectious disease was located but also determine communities habits and practices that were used in the preparation of health education material for the schistosomiasis campaign. The control program at its pilot phase reached more than 8,000 people in highly affected villages in the states of Plateau and Nasarawa. The CC schistosomiasis program, in association with the

Federal Ministry of Health, initially launched its global assist program in two states, Plateau and Nasarawa. In 2004, the pilot program expanded into all local government areas in these states and was able to grow to include the state of Delta and Edo.

During the schistosomiasis campaign, the CC distributed treatment doses of praziquantel to the at-risk populations in the states of Plateau, Edo, Delta and Nasarawa (Figure 1). They received medicine for the severely debilitating form of the disease, the urinary schistosomiasis. In 2008, the CC received a donation of 1.1 million doses of praziquantel followed by another donation of 1.5 million drugs in 2009 from WHO and Merck. The contributions made in 2008 and 2009 to the program surpassed the cumulative number of treatment from 1999 to 2007 (1.08 million treatments) to illustrate a significant expansion of the schistosomiasis control program (Figure 2).

The intervention as of today is believed to have considerably reduced schistosomiasis infection in the treated states. The CC reports that blood in schoolchildren's urine has been reduced by approximately 94 percent in Plateau and Nasarawa states and approximately 88 percent in Delta state. The claim has been supported by several studies that documented a reduction in blood in urine in areas targeted by the CC (Hopkins et al., 2002; Agi and Okafor, 2005; Hopkins et al., 2008).

This is pertinent to our study because we assume the treatment was effective in successfully controlling the disease. On the one hand, we have studies not related to the program that collected urine samples among school age children in the CC states and document a low prevalence of the disease (e.g., Ezeadila et al., 2015). On the other hand, there are findings of studies conducted in control states that concluded in high prevalence of urinary schistosomiasis and the endemic state to the infection of many communities (Sam-Wobo et al., 2011; Babatunde et al., 2013).

3 Data

To examine the effect of the program, we use five rounds of the Demographic Health Surveys (DHS) on Nigeria collected in the years 1990, 1999, 2003, 2008, and 2013.[5] The surveys initiated by the National Population Commission (partly funded through the United States Agency for International Development, USAID) were developed to provide accurate information on maternal and child health but also family planning.

Samples of the DHS are drawn to be nationally representative. Administratively, Nigeria is divided into states, local government areas, localities, and enumeration areas (EA). The DHS clusters, or primary sampling unit, were based on census EA. Some clusters combined several EA because the DHS requires a minimum of 80 households for each cluster. The sample includes all the 37 states, including Plateau, Edo, Delta, and Nasarawa where most of the efforts against schistosomiasis by the Carter center have been concentrated. The CC worked closely with the Ministry of Health and, to the best of our knowledge, there were no other similar programs before or concurrently with the CC intervention.

Since the CC program started in 1999, we treat the 1990 and the 1999 survey as pre-program, while the 2004, 2008, and 2013 surveys serve as post-program data. As the program was concentrated in four states of Nigeria, we group these four states (Plateau, Nasarawa, Delta, and Edo) as treated states while the other 33 states serve as comparison states.[6] Moreover, as the main beneficiaries were school going children, we restrict the data to individuals in 6-14 age group.[7] Table 1 provides descriptive statistics for some key variables for individuals in the 6-14 age group by treatment status. School enrollment is a dummy

[5]The 1999 survey is not distributed to the public. Although the 1999 data was collected for women aged 10-49, the indicators were calculated for women aged 15-49. We were able to access the 1999 data under the disclaimer that the DHS do not stand behind the quality of the dataset for that particular reason.

[6]Ebonyi and Enugu states were included the CC program in 2014, however, since our data is up to 2013, these two states are part of non-treated states.

[7]The official entrance age for the lowest level of education in Nigeria is 6 years old, therefore children aged 6 to 14 were not only likely to be enrolled in school at the time of the intervention but also susceptible to receive the treatment.

variable to indicate whether the member reported attending school during the current school year. Enrollment in the treated states were larger compared to the non-treated states in both pre-program and post-program period.

We are also interested in the years of education completed by individuals exposed to the program. For this, we carry out a cohort wise analysis using the 2013 data. For this part of the exercise, we are interested mainly in assessing the stock of education accumulated by the individual exposed to the treatment. Thus, we concentrate on individuals who were exposed to the CC treatment at a younger age and who have likely finished schooling at the time they were surveyed in 2013. This cohort corresponds to individuals born between 1985 and 1993, i.e., they were 6 to 14 year old in 1999 when the program started, and were 20 to 28 year old in 2013. We refer to this group as 'young cohort'. Individuals belonging to this cohort benefited from the treatment if they resided in a treated state. We define a comparison group, referred as 'old cohort' or old that consists of individuals born between 1975 and 1983. These individuals were between 16 and 24 years old in 1999 when the program started, and were 30 and 38 years old in 2013. These individuals would not have benefited from the treatment regardless of their state of residence. Table 2 reports descriptive stats for the data used in the cohort-wise analysis. The young cohort in the CC treatment states received 9.85 years of education while the young cohort in the control states reported 8.79 years. The relative change in education attainment relative to the old cohort after the intervention is 0.54 years.

4 Methodology

To identify the effect of the schistosomiasis treatment, we exploit the fact that the CC schistosomiasis program was restricted to four states to implement difference-in-differences strategy (DID). We define the four states which benefitted from the program as treated, while the rest of 33 states serves as control states. To examine the effect of the treatment of

the disease, we first use the following model:

$$\text{Enroll}_{ijt} = \alpha + \beta\ (\text{Post}_t \times \text{Treated}_j) + \delta\ \text{X}_{ijt} + \text{Age}_i + \gamma_j + \theta_t + \epsilon_{ijt}\ , \tag{1}$$

where Enroll_{ijt} represents the school enrollment for 6-14 aged individual i living in state j in period t (t=1990, 1999, 2003, 2008, 2013). Post_t is a dummy to indicate the time period after the treatment intervention.[8] X_{ijt} represents a set of individual specific controls—indicator for gender of child, area of residence, household head age, head gender, father education. γ_j and θ_t are state and time fixed effects. Age_i is age fixed effects. The interaction term $\text{Post}_t \times \text{Treated}_j$ in the equation capture the DID treatment effect on school enrollment. The DID estimates provides a causal impact of the program under the assumption that without the program both treated and control states would have followed the similar trend. The standard errors are clustered at the state level.[9]

Moreover, in order to identify differences in the impact of CC program by year, we estimate the following model that allows for the impact to vary for each year:

$$\text{Enroll}_{ijt} = \alpha + \sum_{t=1999}^{2013} \beta_t\,(\text{Year}_t \times \text{Treated}_j) + \delta\ \text{X}_{ijt} + \text{Age}_i + \gamma_j + \theta_t + \epsilon_{ijt}\ , \tag{2}$$

where Year_t denotes an indicator for the year t. The parameters β_t capture the effect of child exposure to the campaign for each survey year.

Since the treatment could potentially impact the amount of time spent in school that will be reflected in accumulated years of schooling. To capture the impact of the CC program on the years of education we carry out a cohort analysis using the following equation.

[8]Bertrand et al. (2004) showed that estimates and inference of difference-in-differences are sensitive to serial correlation when the data extended to several periods, and they recommend aggregating the data in two periods of pre- and post- intervention.

[9]Given the concerns about number of clusters, we also report the p-values of zero null hypothesis derived through wild bootstrap clustered at the state-level as proposed by Cameron et al. (2008). We use the Stata program cgmwildboot.ado written by Judson Caskey.

$$\text{Educ}_{ijk} = \alpha + \beta\ (\text{Young}_i \times \text{Treated}_j) + \delta\ \text{X}_{ijk} + \gamma_j + \tau_k + \nu_{ijk}\ , \tag{3}$$

where Educ_{ijk} represents the years of education for individual i residing in state j and born in year k; Young_i is an indicator for young defined as individuals who were in age group 6-14 in 1999; Treated_j is an indicator that takes the value of 1 for the treatment state and 0 otherwise; τ_k is the cohort fixed effects, and ϵ_{ijk} is the error term. The above equation is estimated on the sample that is restricted to individuals who are identified either as young or old, where old is defined as individuals aged between 16 and 24 in 1999. The standard errors are clustered at the state level. The identification exploits the variation of cohort exposure to treatment across time and space. As stated above, the old cohorts were never exposed to the program, regardless of state of residence. The young cohorts were exposed to the program if they lived in a treated states.[10] The coefficient of the interaction term between Young_i and treated states Treated_j captures the impact of program.

Causal interpretation of our difference-in-differences estimates hinges on the identifying assumption that in the absence of the CC intervention, the outcome would have had similar trend in both treated and comparison groups. Although it is not possible to directly test this assumption because the same young cohort who were not exposed to the program are not observed, we perform a falsification exercise by using old cohort as a placebo treatment group while using very old cohort—defined as individuals aged between 26 and 34 years in 1999 (or aged between 40 and 48 years in 2013)—as comparison group. We basically

[10] Assignment of individuals to states is based on the state of residence at the time of survey, i.e. 2013, and not based on the state of residence during school age, i.e. during 1999-2008. This may be problematic in the presence of migration; however, only inter-state migration is a concern, not within state. The inter-state migration in Nigeria (for all population) was about 10 percent in 2006 (National Population Commission, 2010).

estimated the following equation:

$$\text{Educ}_{ijk} = \alpha + \beta\ (\text{Old}_i \times \text{Treated}_j) + \delta\ \text{X}_{ijk} + \gamma_j + \tau_k + \nu_{ijk}\ , \tag{4}$$

This specification is similar to equation (3) except now our estimation sample include individuals who are defined as old along with the very old as the excludable group. Since both old and very old cohort did not benefit form the CC program, we expect the coefficient β in the above equation to be indistinguishable from zero if there were no pre-existing trends differences across the treatment and comparison groups.

5 Results

Table 3 reports the results of the before and after regressions using equation (1). The outcome variable indicates whether the child aged 6 to 14 is currently enrolled in school at the time of the survey. The DID estimate, our parameter of interest, is the coefficient associated with the interaction variable Post-1999 $\times$ Treated. Column (1) contains estimates for a specification that does not control for any X covariates, but includes age dummies, year, and state fixed effects. Column (2) includes additional X covariates. The DID estimate does not change by inclusion of additional covariates (X) suggesting that our results are robust to controlling for additional covariates. While the point estimates are positive, they are statistically insignificant. Hence, we cannot preclude that the program has no impact on the school enrollment of 6-14 years children.

We then estimate equation (1) on sub-samples of our data to investigate the heterogeneity of the program impact by gender and area of residence. Column (3) and column (4) provide estimates for boys and girls separately. We do not find statistically significance impact on either gender. Similarly, we cannot rule out no impact both in urban and rural areas

(column(5) and column (6)). Column (7) and column (8) present the results for boys and girls in rural areas, respectively. The DID estimates are statistically insignificant for both genders in rural area. Hence, we cannot rule out no impact of the program.

The results of equation (2) are reported in Table 4. The year-by-year estimates are presented with and without controls in column (1) and column (2), respectively. The estimate for the baseline 1999 year is zero. This suggests that there were no pre-existing trend differential between treated and non-treated states before the program was implemented. However, the year-wise impact as captured by interaction terms are not statistically significant for either of the post program years.

The CC program could potentially have affected the accumulated years of education even in the absence of impact on enrollment if the treatment enabled students to stay longer in school. Alternatively, if the drugs were distributed mainly in schools, it might not have affected enrollment per se but would have increased years of education completed[11]. Treated children would be more likely to progress through the grades and less likely to dropout of school. Table 5 presents the results of our cohort-wise analysis using equation (3). The first column reports the point estimate for the entire sample. The coefficient on the interaction term is positive and statistically significant at the 1 percent level. In other words, relative to the control states, individuals in the younger cohort gained on average 0.45 additional years of education due to their exposure to the CC treatment. The estimated effect correspond to approximately 5.3 percent increase in education attainment with respect to the control group average education. Column (2) introduces additional X controls, the magnitude of the DID estimates declines but remains statistically significant. The point estimates in column (3) and column (4) show the treatment impact for boys and girls, respectively. The coefficient attached to the treatment interaction with young male-cohort is negative and not

[11] Although we do not have a documentation where the distribution of the drugs took place, almost all the reports we came across are centered around schools and or school children. Thus, it is likely that schools played a central role in the distribution of the drugs.

statistically different from zero. Comparatively, the coefficient on the interaction term for young female-cohort in column (3) is positive and statistically significant.

The results presented in columns (5) and column (6) separate the program impact into urban and rural areas. The point estimate in urban areas is small and not significantly different from zero, implying that the treatment has no detectable effect in urban locations. In contrast, the effect of the program is positive and statistically significant in rural areas. This is not surprising given that the program was concentrated in rural areas. Young cohort in the treatment rural villages gained about additional 0.62 year of education relative to those in control villages. In columns (7) and column (8), we show the estimates for the young male and female residing in rural areas. The estimate in column (7) indicates the years of education for the males increased because of the program. However, the magnitude is small, and the estimate is not statistically significant. Importantly, the females exposed to the treatment in the rural areas gained about one more year of schooling compared to females not exposed to the program residing in rural areas of non-treated states. A possible explanation for the heterogeneity in the treatment impact could be due to the fact that girls were more involved in domestic chores, and thus more likely to be in contact with contaminated water. Hence, girls will be more likely to benefit from the treatment.

6 Robustness Checks

In this section, we report two robustness checks. First, we carried out a placebo test using equation (4). The results are reported in Table 6. None of the point estimates is statistically different from zero at conventional levels, except for the urban sample. It is noteworthy that the sign of the coefficient for the urban sample is negative, and probably the DID estimate for urban area in Table 5 underestimates the impact. However, a mean reversion in urban areas can not be ruled out. Nonetheless, as reported in earlier paragraphs, the DID estimate

for urban area is marginally negative and statistically insignificant precluding any positive impact in the urban sample. While the results presented in Table 6 do not prove the existence of similar trends in the hypothetical case of no program, they indicate that our conclusions are unlikely to be driven by the pre-existing trend differential between treatment and control groups.

Second, the efforts against schistosomiasis coincided with the malaria-lymphatic filaris control program, another large scale health intervention. we demonstrate empirically that our findings are not driven by the malaria control program. The malaria policy intervention to eliminate lymphatic filaris started with a pilot project in 2004 and operated mass drug administration of single dose treatment as well as the distribution of insecticide treated bed nets to households in rural villages in Plateau and Nasarawa states (Blackburn et al., 2006). It could be possible that the program have impacted child health and education and therefore introduce a bias in the estimates reported in Tables 5 and 6. Our data identified households that received treated bed nets. We thus estimate the effect of malaria treatment program on young children education. The results are reported in Table 7. The estimates on the triple interaction term across all specifications are positive but not significantly different from zero at the conventional level. Hence, there is no strong evidence of any additional effects of the malaria campaigns on the schistosomiasis control program.

6.1 Possible Channels

We have argued that this large scale health program has improved health outcomes of eligible children in treated states, and this in turn has allowed these children to accumulate more education. We do not have access to direct measures of health outcomes, especially for the relevant cohorts that we use. The DHS, however, collects height and weight for women aged 15 to 49 years. As we mentioned above, one of the consequences of schistosomiasis if left

untreated is stunted growth. Hence we can use the DHS data to explore the program effects on height for women. Height is largely determined at childhood, and thus would not be sensitive to current economics circumstances.

We use a specification identical to equation (3), except that the dependent variable is height (in centimeters). The results are reported in Panel A of Table 8. The point estimates indicate that in rural areas, women belonging to the treated cohorts gained 0.48 centimeters relative to similar cohorts in the comparison areas. The point estimates is significant at the 1 percent level. Noticeably, none of the estimates in columns 1-3 (especially in urban areas) is statistically different from 0, and the results are quite consistent with those reported in Table 5: the gains are essentially concentrated for females in rural areas. While 0.48 centimeters may appear small in absolute value, it is in range of secular gains in heights reported in the literature (e.g. Cole, 2000; Fudvoye and Parent, 2017).[12]

In Panel B of Table 8, we report robustness check using a placebo tests estimated using equation (4). The point estimates are smaller in magnitude (relative to Panel A), and are statistically not different from 0. Hence, it is unlikely that the increase in height that we detect in Panel A is due to pre-existing differences in trends between treated and comparison states.

7 Conclusion

This paper examines the impact on schooling outcomes for children exposed to the treatment of schistosomiasis, a disease that causes anemia, poor growth, and impaired cognitive function. Schistosomiasis is one of the largest endemic disease around the world. It is estimated that at least 90 percent of those requiring treatment live in Africa (WHO, 2015). Large scale

[12]Cole (2000) mentions heights gains ranging from 3mm per decade in Scandinavia to 30mm/decade in parts of Southern and Eastern Europe during later half of the 20^{th} century. The data reported in Fudvoye and Parent (2017) imply that height gains ranged from 3.7mm per per decade in Portugal to 15.1mm per decade in the Netherlands, between 1880 and 1980.

distribution of drugs is the most effective and low-cost mechanism to control the parasitic transmission, and to reduce and prevent morbidity.

Our research approach takes advantage of the exogeneous variation generated from the Carter foundation rollout of schistosomiasis treatment in four states in Nigeria to implement difference-in-differences (DID) strategy to identify a causal relationship between the schistosomiasis control program and the child's enrollment and education attainment. We do not find evidence that the program has an impact on the enrollment of school going children. However, we find that the cohort exposed to the treatment in rural areas accumulated an additional 0.62 years of education compared to cohort not exposed to the treatment. Moreover, the impact of the Schistosomiasis treatment is mainly on girls residing in rural areas. Consistent with the impact of education, we find that height of females exposed to the treatment in rural areas increased by 0.48 centimeters. Overall, the findings of this research demonstrate substantial gains in health following the mass drug administration of schistosomiasis doses. These gains in health translated, in turn, into more accumulation of education. The gains are the most substantial for females in rural areas.

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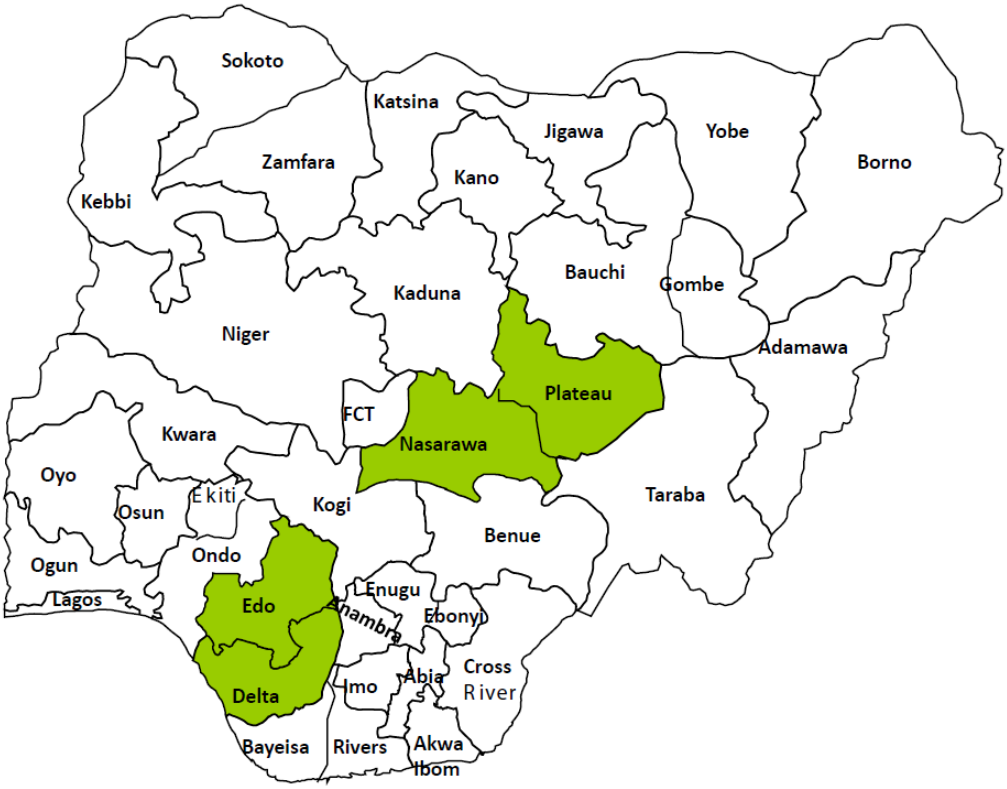
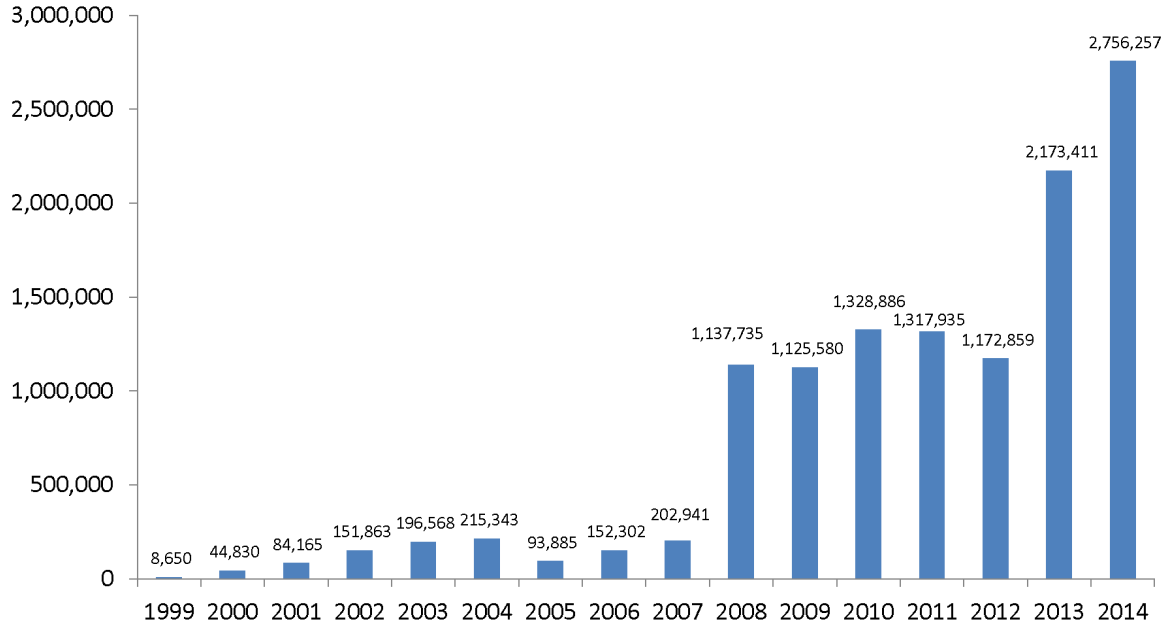
Figure 1. Schistosomiasis Treatment States in Nigeria



Notes: Carter Center-Assisted Schistosomiasis Program treatment states in Nigeria. In 2014, the treatment initiative was extended to the states of Ebonyi and Enugu. Source: The Carter Center.

Figure 2. Annual Praziquantel Treatments, 1999-2014



Notes: Carter Center-Assisted Schistosomiasis Program annual praziquantel treatments. Source: The Carter Center (Disease Data, updated in May 2015).

Table 1. Summary Statistics, Pre- and Post- Program Intervention (6-14, All Surveys)

	All sample	Before treatment		After treatment		Difference in means	
		Treated States	Non-treated States	Treated States	Non-treated States	(4) - (2)	(5) - (3)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
School Enrollment	0.69	0.69	0.63	0.87	0.69	0.18	0.06
	(0.46)	(0.46)	(0.48)	(0.33)	(0.46)	[0.00]	[0.00]
Age (years)	9.56	9.80	9.58	9.66	9.54	-0.14	-0.04
	(2.55)	(2.62)	(2.55)	(2.56)	(2.54)	[0.02]	[0.02]
Gender (male=1)	0.51	0.53	0.51	0.51	0.51	-0.02	0.00
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	[0.22]	[0.67]
Age of Head (years)	48.39	51.24	49.14	48.09	48.17	-3.15	-0.97
	(13.05)	(14.54)	(13.70)	(13.72)	(12.75)	[0.00]	[0.00]
Household size	8.02	10.11	8.32	7.87	7.92	-2.24	-0.40
	(4.08)	(7.57)	(4.59)	(3.89)	(3.82)	[0.00]	[0.00]
Father education (years)	2.45	2.64	2.11	3.14	2.45	0.50	0.34
	(3.04)	(2.63)	(3.08)	(3.16)	(3.01)	[0.00]	[0.00]
Mother education (years)	0.35	0.28	0.26	0.49	0.36	0.21	0.10
	(0.48)	(0.38)	(0.43)	(0.49)	(0.48)	[0.00]	[0.00]
Gender of Head (male=1)	0.87	0.85	0.88	0.83	0.87	-0.02	-0.01
	(0.34)	(0.36)	(0.33)	(0.38)	(0.34)	[0.03]	[0.00]
Observations	112788	2103	19485	9002	82198		

Notes: Standard deviations are displayed in parentheses. The data is restricted to 6-14 age group in each survey year. The before treatment period regroups statistics for the 1990 and 1999 surveys, whereas the after treatment period includes the 2003, 2008, and 2013 surveys. School enrollment is a 0-1 dummy that indicates that the member reported attending school. The P-values for the test in mean difference are reported in brackets in column (6) and (7).

Table 2. Summary Statistics, Young and Old Cohort by Treatement and Comparison States (2013 Survey)

	All sample	Treatment states		Control states		Difference in means	
		Age 6-14 in 1999	Age 16-24 in 1999	Age 6-14 in 1999	Age 16-24 in 1999	(2) - (4)	(3) - (5)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Years of education	7.53	9.85	7.53	8.79	7.01	1.06	0.52
	(5.61)	(4.34)	(5.56)	(5.00)	(5.82)	[0.00]	[0.00]
Age (years)	28.01	23.85	23.80	33.52	33.40	-9.67	-9.6
	(5.49)	(2.69)	(2.70)	(2.69)	(2.73)	[0.00]	[0.00]
Gender (male=1)	0.46	0.48	0.44	0.50	0.48	-0.02	-0.04
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	[0.09]	[0.00]
Age of Head (years)	41.49	44.12	41.27	42.51	41.23	1.61	0.04
	(14.55)	(17.35)	(16.27)	(13.06)	(11.55)	[0.00]	[0.80]
Household size	5.82	5.76	5.69	5.77	5.99	-0.01	-0.3
	(3.66)	(3.84)	(3.83)	(3.38)	(3.44)	[0.95]	[0.00]
Father education (years)	2.90	3.37	2.68	3.60	3.01	-0.23	-0.33
	(2.97)	(4.46)	(2.98)	(2.44)	(2.66)	[0.04]	[0.00]
Mother education (years)	0.58	0.66	0.56	0.70	0.59	-0.04	-0.03
	(0.82)	(0.84)	(0.84)	(0.76)	(0.79)	[0.18]	[0.00]
Gender of Head (male=1)	0.87	0.82	0.85	0.88	0.90	-0.06	-0.05
	(0.34)	(0.38)	(0.36)	(0.33)	(0.30)	[0.00]	[0.00]
Observations	43492	2772	21665	2050	17005		

Notes: Standard deviations are in parentheses. The table uses data from the 2013 survey. The P-values for the test in mean difference are reported in brackets in column (6) and column (7).

Table 3. Schistosomiasis Program Impact on School Enrollment

	All sample (1)	All sample (2)	Boys only (3)	Girls only (4)	Urban areas (5)	Rural areas (6)	Boys in Rural (7)	Girls in Rural (8)
Post-1999 × Treated states	0.06	0.06	0.06	0.05	-0.01	0.08	0.08	0.08
	(0.10)	(0.09)	(0.08)	(0.10)	(0.07)	(0.08)	(0.08)	(0.09)
	[0.45]	[0.46]	[0.44]	[0.46]	[0.88]	[0.42]	[0.33]	[0.45]
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	112943	112788	57373	55415	37324	75464	38635	36829
R-squared	0.30	0.35	0.32	0.38	0.19	0.36	0.33	0.39

Notes: All the models include fixed effects for age, year, and state. The additional control (X) variables include areas of residence, gender, household head age, head's gender and father's education. Treated states indicates the Carter Center assisted states of Delta, Nasarawa, Edo, and Plateau. Post-1999 indicates the period after treatment. See equation 1 for details. Standard errors in parentheses are clustered at the state level. The brackets report P-value for zero null hypothesis derived through wild bootstrap clustered at the state level with 700 repetitions. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Table 4. Schistosomiasis Program Impact on School Enrollment, Year-by-Year Results

	(1) School Enrollment	(2) School Enrollment
Year 1999 × Treated states	-0.01	0.00
	(0.11)	(0.08)
	[0.89]	[0.93]
Year 2003 × Treated states	0.09	0.07
	(0.16)	(0.14)
	[0.45]	[0.49]
Year 2008 × Treated states	0.08	0.07
	(0.15)	(0.12)
	[0.45]	[0.45]
Year 2013 × Treated states	0.03	0.04
	(0.15)	(0.12)
	[0.60]	[0.53]
Controls	No	Yes
Observations	112943	112788
R-squared	0.30	0.35

Notes: All the models include fixed effects for age, year, and state. The additional control (X) variables include areas of residence, gender, household head age, head's gender and father' education. Treated states indicates the Carter Center assisted states of Delta, Nasarawa, Edo, and Plateau. See equation 2 for details. Standard errors in parentheses are clustered at the state level. The brackets report P-values for zero null hypothesis derived through wild bootstrap clustered at the state level with 700 repetitions. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Table 5. Schistosomiasis Program Impact on Years of Education, Young Cohort

	All sample (1)	All sample (2)	Male only (3)	Female only (4)	Urban areas (5)	Rural areas (6)	Male in rural (7)	Female in rural (8)
Treated states × Age 6-14 in 1999	0.45***	0.34***	-0.06	0.70***	-0.07	0.62***	0.08	1.11***
	(0.22)	(0.16)	(0.15)	(0.24)	(0.37)	(0.16)	(0.17)	(0.24)
	[0.01]	[0.00]	[0.76]	[0.00]	[0.78]	[0.00]	[0.13]	[0.00]
Age 6-14 in 1999	0.38*	0.61***	0.03	1.15***	0.58*	0.70***	0.32	1.11***
	(0.20)	(0.16)	(0.21)	(0.23)	(0.29)	(0.18)	(0.25)	(0.27)
	[0.07]	[0.00]	[0.18]	[0.00]	[0.09]	[0.01]	[0.87]	[0.00]
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	43492	43492	20182	23310	17584	25908	11852	14056
R-squared	0.34	0.47	0.45	0.50	0.23	0.48	0.47	0.49

Notes: All the models include fixed effects for age, year, and state. The additional control (X) variables include areas of residence, gender, household head age, head's gender and father' education. See equation 3 for details. Standard errors in parentheses are clustered at the state level. The brackets report P-values for zero null hypothesis derived through wild bootstrap clustered at the state level with 700 repetitions. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Table 6. Schistosomiasis Program Impact on Years of Education, Old Cohort

	All sample (1)	All sample (2)	Male only (3)	Female only (4)	Urban areas (5)	Rural areas (6)	Male in rural (7)	Female in rural (8)
Treated states × Age 16-24 in 1999	0.07	0.12	-0.19	0.21	-0.47**	0.46	0.08	0.54
	(0.23)	(0.22)	(0.32)	(0.27)	(0.23)	(0.30)	(0.37)	(0.38)
	[0.81]	[0.96]	[0.67]	[0.83]	[0.03]	[0.42]	[0.73]	[0.49]
Age 16-24 in 1999	0.86***	1.07***	1.16**	1.23***	1.35***	1.01***	1.08**	1.13***
	(0.23)	(0.21)	(0.29)	(0.28)	(0.36)	(0.21)	(0.30)	(0.27)
	[0.00]	[0.00]	[0.04]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	32232	32232	15943	16289	13060	19172	9451	9721
R-squared	0.31	0.47	0.49	0.46	0.28	0.47	0.53	0.43

Notes: All the models include fixed effects for age, year, and state. The additional control (X) variables include areas of residence, gender, household head age, head's gender and father' education. See equation 3 for details. Standard errors in parentheses are clustered at the state level. The brackets report P-values for zero null hypothesis derived through wild bootstrap clustered at the state level with 700 repetitions. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Table 7. Malaria Campaigns for Insecticidal Net and Schistosomiasis Treatment (Young Cohort)

	All sample (1)	All sample (2)	Male only (3)	Female only (4)	Urban areas (5)	Rural areas (6)	Male in rural (7)	Female in rural (8)
Treated states × Malaria × Age 6-14 in 1999	0.07	0.30	0.07	0.26	-0.31	0.55	0.31	0.61
	(0.52)	(0.49)	(0.46)	(0.52)	(0.39)	(0.68)	(0.55)	(0.72)
	[0.86]	[0.58]	[0.92]	[0.58]	[0.34]	[0.52]	[0.60]	[0.50]
Malaria × Age 6-14 in 1999	-0.15	0.17	0.19	0.17	0.12	0.18*	0.19	0.17*
	(0.20)	(0.14)	(0.18)	(0.15)	(0.18)	(0.14)	(0.22)	(0.13)
	[0.41]	[0.13]	[0.27]	[0.17]	[0.39]	[0.09]	[0.29]	[0.09]
Treated states × Age 6-14 in 1999	0.44**	0.31***	-0.06	0.66***	-0.04	0.56***	0.06*	1.02***
	(0.23)	(0.17)	(0.13)	(0.29)	(0.34)	(0.17)	(0.16)	(0.29)
	[0.03]	[0.00]	[0.70]	[0.00]	[0.86]	[0.00]	[0.10]	[0.00]
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	43492	43492	20182	23310	17584	25908	11852	14056
R-squared	0.34	0.47	0.45	0.50	0.23	0.48	0.47	0.49

Notes: All the models include fixed effects for age, year, and state. The additional control (X) variables include areas of residence, gender, household head age, head's gender and father' education. See equation 3 for details. Standard errors in parentheses are clustered at the state level. The brackets report P-values for zero null hypothesis derived through wild bootstrap clustered at the state level with 700 repetitions. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Table 8. Schistosomiasis Program Impact on Women Height

	All sample (1)	All sample (2)	Urban areas (3)	Rural areas (4)
	Panel A: Young Cohort			
Treated states × Age 6-14 in 1999	0.15	0.13	-0.33	0.48***
	(0.23)	(0.21)	(0.50)	(0.19)
	[0.53]	[0.57]	[0.61]	[0.00]
Age 6-14 in 1999	-1.94***	-1.92***	-1.69***	-2.04***
	(0.29)	(0.28)	(0.37)	(0.38)
	[0.00]	[0.00]	[0.00]	[0.00]
Controls	No	Yes	Yes	Yes
Observations	22592	22592	8930	13662
R-squared	0.06	0.07	0.05	0.05
	Panel B: Old Cohort			
Treated states × Age 16-24 in 1999	-0.30	-0.24	-0.22	-0.25
	(0.26)	(0.26)	(0.44)	(0.38)
	[0.31]	[0.37]	[0.65]	[0.50]
Age 16-24 in 1999	-0.53*	-0.54*	-0.20	-0.71**
	(0.32)	(0.31)	(0.54)	(0.30)
	[0.09]	[0.09]	[0.76]	[0.03]
Controls	No	Yes	Yes	Yes
Observations	15777	15777	6320	9457
R-squared	0.05	0.06	0.05	0.05

Notes: All the models include fixed effects for age, year, and state. The additional control (X) variables include areas of residence, gender, household head age, head's gender and father' education. See equation 3 for details. Standard errors in parentheses are clustered at the state level. The brackets report P-values for zero null hypothesis derived through wild bootstrap clustered at the state level with 700 repetitions. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.