Freie Universität Berlin

A Rural Health Supplement to the Hookworm Intervention in the American South

Jonathan F. Fox
Theocharis Grigoriadis

School of Business & Economics
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A Rural Health Supplement to the Hookworm Intervention in the American South[1]

Jonathan F. Fox[*]
FU Berlin

Theocharis Grigoriadis[2]
FU Berlin

Abstract: This project re-investigates the hookworm eradication efforts of the Rockefeller Foundation's Sanitary Commission (RSC) in the American South during the Progressive Era. The RSC worked to eradicate hookworm across 11 southern states between 1911 and 1915, efforts that have been linked to dramatic short- and long-term increases in human capital and labor productivity. Although useful from an identification standpoint, these single-shot interventions, in the absence of cooperative efforts to improve underlying conditions, have a mixed record of long-term effectiveness across public health research. The efficacy of deworming campaigns in particular has come under extensive scrutiny. The experience of the American South had stood as example of how a single-shot hookworm eradication program has improved outcomes; however, the robustness of this result has also recently come into question. A replication of the Bleakley (2007) seminal work investigating hookworm eradication finds faults with the robustness and interpretations of the results (Roodman 2017), and an investigation into the activities of the RSC has determined them unevenly distributed across hookworm-affected areas (Elman et. al 2013). Perhaps not coincidentally, the RSC's hookworm eradication program was not the only public health intervention that occurred in the rural South during the Progressive Era. Rural public health centers spread throughout the American South during this period, partially backed by the Rockefeller Foundation. Given the use of difference-in-difference methods using decennial census data, and the participation of the Rockefeller Foundation in the funding of these rural health centers, this is a potentially critical omission in the evaluation of the RSC efforts. In this project, we investigate the connection between these rural health centers and the Rockefeller Foundation's hookworm eradication efforts, consider whether their presence explains effects attributed thereto, and examine their importance as a follow-up program to the initial hookworm intervention.

Keywords: Rockefeller Sanitary Commission, hookworm eradication, Deworming, EconomicDevelopment, County Health Organizations, human capital, Progressive Era

JEL Codes: I15, I18, N32, O15, O51, P51

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[*] Freie Universität Berlin, School of Business & Economics & John F. Kennedy Institute of North American Studies, Lansstr. 7-9, D-14195, Berlin, Germany, jfox@zedat.fu-berlin.de, T: +49-30-838-59503, F: +49-30-838-4-59503.

[2] Freie Universität Berlin, School of Business & Economics & Institute of East European Studies, Garystr. 55, 14195, Berlin, Germany, theocharis.grigoriadis@fu-berlin.de, T: +49-30-838-57037, F: +49-30-838-4-50925.

I. Introduction

Few public health interventions have received the praise lavished on deworming campaigns. Reductions in soil-transmitted helminths (STH; parasitic worms including hookworm, roundworm, and ringworm) have been linked to increases in nutrition (Croke et al. 2016), school participation (Nokes et. al 1992, Miguel and Kremer 2004; Bleakley 2007), and agricultural output (Brinkley 1997). However, the actual efficacy of single-shot interventions, in the absence of corresponding investments in other areas of public health, is a topic of controversy. Specific to STH interventions, new meta-studies question whether large-scale deworming campaigns pass the cost-benefit test (GiveWell 2011, Taylor-Robinson et al. 2015). The robustness (or lack thereof) of two key studies has fueled the recent debate. Garner et. al (2015) claim the discovery of various coding and analysis errors within the Miguel and Kremer (2004) study leading to differences in some of the results, and question whether "the process of observation influenced outcome reporting, and this was different in control and intervention groups" (Garner et. al (2015, pp. 1599). Roodman (2017) takes aim at Bleakley (2007) and argues an over-reliance on coefficient point estimates and that the results are not robust to controlling for covariates using the IPUMS 100 percent sample. On the other hand, Croke et. al. (2016) argue that deworming campaigns remain among the most cost effective of public health interventions. Aside from potential methodological flaws within the studies in question, at issue is not whether treatment (or treatments) for a single individual is effective at eliminating their infection and improving outcomes for that person, but whether these campaigns are effective community-wide and drive substantial improvements in nutrition without other accompanying programs (Taylor-Robinson 2015).

A single intervention may temporarily lower hookworm infection rates, but, absent corresponding improvements in nutrition, income, health, and the ecological environment, improvements are likely to be short-lived. Multiple rounds of treatment may be necessary to rid an individual of parasitic worms. The World Health Organization (WHO) recommends, for everyone, treatments across 10 regular intervals to eliminate STH in high-risk communities (World Health Organization 2010, pp 3). As such, treating individuals for STH may not eliminate STH in the treated community and the probability of (re)infection.[3]

[3] Without an accompanying improvement in sanitary conditions, parasitic worms, whose eggs can exist in feces-contaminated soil, are likely to remain a threat to communities no matter how many rounds of treatment occur. Furthermore, even given a successful deworming campaign and the complete eradication

The most effective deworming campaigns are appropriate in length with iterative treatments, combined with improvements in the sanitary conditions of the surrounding environment, and if implemented in impoverished areas, executed concurrently with nutritional programs. Although the importance of these factors is recognized (WHO 2010, Sakti et. al 1999), the evaluation of deworming programs rarely extends beyond the initial intervention and is limited to the chemical deworming treatments. As such, the estimated effectiveness of deworming may be constrained to those populations which fit the necessary criteria. Furthermore, impacts attributed to deworming may be at least partly due to concurrent efforts to improve the sanitary environment and nutrition of the population.

The hookworm eradication intervention in the Progressive Era American South has existed as an influential piece of evidence in support of STH eradication campaigns.[4] In response to substantial hookworm infection rates across southern communities, the Rockefeller Foundation's Rockefeller Sanitary Commission (RSC) undertook a broad campaign of eradication in cooperation with state and local governments. Importantly, the RSC did not limit their intervention to chemical treatments of infected individuals. They surveyed community environments and worked with those communities improve sanitary conditions, and distributed pamphlets to educate the population (an important feature given the dearth of basic hygienic knowledge). In 1914, the RSC declared the campaign "successful," and the RSC and their hookworm eradication efforts officially ended in 1915.[5]

The RSC hookworm eradication campaign has been linked to improvements in schooling attendance (Bleakley 2007), agricultural productivity (Brinkley 1994), and has been used as an instrument for education in its effect on voting patterns (Henderson 2014). However, the effectiveness of these programs has also been questioned, with Horton (2003) stating that "By the

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of STH, if nutrition remains poor there may be no observable improvement in schooling or other outcomes for the treated community. STH affects education, productivity, and health through its effects on nutrition, specifically iron (World Health Organization 2002). Infected individuals are more prone to iron anemia, and thus become lethargic. If iron deficiencies exist in the population due to poor nutrition, eradicating STH from that population may have no observable effects on schooling or other outcomes.

[4] The traditional narrative is that the hookworm parasite infected a great number of individuals in American South unknowingly at the turn of the 20th century. A doctor with European experience identified the symptoms, and the first hookworm infection survey took place just prior to 1910.

[5] The RSC and Rockefeller Foundation had a different definition of success than most contemporary aid organizations, as described below.

end of the first five-year period, prevalence rates of hookworm were little changed, and it was recognized that either population-wide treatment was needed or there had to be an improvement in sanitation" (Horton 2003, pp 406). Although the RSC ended in 1915, it was reborn as the Rockefeller Foundation's International Health Board. The rebirth accompanied a wider focus and outreach into developing countries in Africa, Central, and South America, but the efforts against hookworm in the American South continued. The Rockefeller Foundation provided funds for hookworm efforts until 1921 through local health stations, at which point they fully transferred responsibility for hookworm testing and treatment to state and local governments.

The local health stations supported by the Rockefeller Foundation were part of a broader trend of growth in rural public health that spread throughout the American South during the Progressive Era. They represented a cooperative effort between county and state governments and the Rockefeller Foundation and played a potentially important role as a follow-up program to the original hookworm intervention. Although referenced in the Rockefeller Annual Reports and mentioned briefly in Brinkley (1995), this study represents the first time these health stations have been explicitly tied to the RSC hookworm eradication efforts. Using the framework developed in Bleakley (2007), we find the presence of these rural health centers significantly amplified the effects of the original intervention in the long-run. Specifically, treated areas with a cooperative health stations saw improvements in educational outcomes an order of magnitude greater than treated areas without, and the estimated effect of the original intervention becomes non-significant.

The paper is structured as follows. In section 2 we offer the historical background on hookworm eradication efforts and the emergence of rural public health in the American South. Section 3 provides our data and methodology. In section 4, we offer our empirical results in the light of the Bleakley paper (2007) and the Roodman replication (2017; 2018). Section 5 concludes.

II. Hookworm Eradication & Rural Public Health in the American South

The Rockefeller Foundation acknowledged in their annual reports that hookworm infections remained as the RSC ended, and yet nevertheless deemed the intervention a success. Their writings on the subject in the 1920 Annual Report are enlightening, and we quote at length:

"The time has now arrived when one may say the object which the [Rockefeller Sanitary] Commission had in mind has been accomplished, and the arrangement, so far as this disease is concerned, may be brought to a satisfactory close. These states have not been freed of hookworm.

Far from it. The accomplishment of that result, it was understood and stated in the beginning, is a thing that no outside commission could do if it would and that no such organization should do if it could. This is a work for permanent agencies operating over long periods of time. Nevertheless, the object which the Commission set out to accomplish has been achieved. The disease has been greatly reduced in both severity and prevalence; the people have been enlightened as to its importance, its relief, and the means of its final control; permanent agencies rooted in the soil are committed to the task; and a sustaining public sentiment has been created in the interest of more general measures for the better protection of health (Rockefeller Foundation 1920, pp. 111-112)."

From their written reports, the Rockefeller Foundation was less interested in eradicating hookworm than in using its effective treatment to "awaken" the public to the benefits of public health. They emphasized meaningful participation of the state and local governments and identified their efforts as being associated with increased state public health expenditures across the American South (Rockefeller Foundation 1920). From state financial statistics, health expenditures did increase more than 5 fold between 1912 and 1932, however health expenditures in non-Southern states also increased by about 4.5 times (Sylla et al. 1995). Furthermore, the RSC efforts excluded many at-risk counties (Elman et al. 2013), and health spending in the Southern county governments grew slower than health spending in the U.S. overall (Fox and Grigoriadis 2017). Contemporary deworming campaigns, with their singular focus on eradicating STH in affected communities through chemical treatments are narrow in comparison with the RSC hookworm eradication campaign. The Rockefeller Foundation required the participation of state and county governments, prioritized broad demonstrations of effective treatment over concentration on STH eradication, continued hookworm work in affected areas 5 years after the original intervention ended, and supported the expansion of rural public health centers to continue improving the surrounding ecological environment.

Despite this relatively unique approach of the Rockefeller Foundation in combatting hookworm, its impact has been assessed using program evaluation methods developed for targeted, time-bounded interventions. The first econometric analysis of the South's hookworm infection problem and its eventual treatment occurred in Garland Brinkley's graduate dissertation (Brinkley 1995). Linear regressions investigated the impact of county-level hookworm infection rates on differences in income across Southern counties.[6]

[6] Results indicated that hookworm infection lowered income by almost 30 percent, and its reduction could explain up to half of the 16.33 percent increase in southern agricultural output between 1910 and 1920 (Brinkley 1995).

Bleakley (2007) undertook a similar, if more econometrically complex analysis. Using the 1 percent U.S. Census samples from IPUMS (Ruggles 2017), Bleakley (2007) applied difference-in-difference methods to sequential cross-sections of the treated State Economic Areas (SEAs) and to cohorts born in the affected states.[7] Since RSC hookworm dispensaries were potentially endogenously located, the effect of the RSC intervention is identified using the pre-intervention hookworm infection rates as proxy. This assumes that the outcomes of interest – namely literacy and school attendance – do not affect the probability of hookworm infection, as well as that there were no other activities/interventions occurring that may have reduced hookworm infections. As did Brinkley (1995), Bleakley (2007) finds strong effects of the RSC intervention on both short and long-term outcomes.

Roodman (2017) replicates the original Bleakley (2007) study, and determines the timings of improvements in schooling, literacy, and income do not align well with the RSC intervention that occurred between 1911 and 1915. Specifically, Roodman (2017) argues that convergence of areas with high hookworm infection rates to those with lower infection rates began decades before the initial intervention and continued for decades after, with no discernible acceleration due to the 1911-1915 RSC intervention.

Directly after the official end of the RSC, the Rockefeller Foundation supplied a strong push for local health stations, organized at the county level and oriented towards rural public health. The earliest county health organization (CHO) on record is that of Jefferson County, Kentucky, which began funding a full-time public health officer in 1908. Guilford County in North Carolina and Yakima County in Washington initiated CHOs in 1911, and by 1914 Walker County in Alabama, and New Hanover, Robeson, and Sampson counties in North Carolina had joined them. However, until 1916, county governments were the sole sources of funding and organization for these rural health stations. In 1916 external funding appeared from the Rockefeller Foundation and the state of North Carolina totaling $1,100 in 1916 dollars across two different counties. In 1917, 12 different counties received funding from external sources, which accounted for approximately 1/6 of total funding on county health organizations during the year. In 1920, external funding comprised over a quarter of total CHO funding, and a third in 1932.

[7] State Economic Areas (SEAs) are groups of counties, usually consisting of 5 different bordering counties. The median number of included counties is 5, about 50 percent of SEAs have between 2 and 10 counties, and a small number of SEAs include over 20 counties.

The growth in external funding, much provided by the Rockefeller Foundation and state governments, paced the expansion of rural public health across the United States and the American South in particular. By 1920, 135 US counties had operating county health organizations, 97 of which resided within a southern state formerly part of the Rockefeller Sanitary Commission hookworm eradication efforts (henceforth referred to as a RSC State). Other states with county health organizations in 1920 included California (1), Kansas (3), Montana (3), Ohio (27), Oklahoma (1), and Washington (3).[8] By 1933, this number had grown to 715, and included other areas of the U.S., but with RSC State counties continuing to constitute about 62% of all counties with county health organizations. States in the American South were responsible for the majority of the growth of rural public health work in the United States prior to the New Deal.

Activities at the CHOs varied but tended to fall into one of six categories. Education was the first of these, and included public meetings, letter mailings, and the publishing of bulletins and press articles. The second was the quarantining of individuals found to have measles, typhoid or influenza. School visits by either a doctor or nurse constituted the third, and during these visits they gave lectures, checked for conditions such as enlarged tonsils or adenoids, and vaccinated against smallpox. Vaccinations in non-school settings constituted the fourth group of activities for the CHOs, and these were given for smallpox, whooping cough, and typhoid fever. The fifth type of activity is listed as reviews of urban conditions, which essentially consisted of sanitary reviews. The final type of activity was the prevention and restoration of polluted soil and was a distinctive characteristic of the rural public health programs. These types of activities followed in the tradition of the RSC hookworm campaigns and consisted of the inspection and building of sanitary bathrooms, the examination of soil specimens for bacteria or parasitic worms, and the treatment of infected soil areas.

Which of the above activities were emphasized, and the scope of CHO operations, funding levels, and funding sources, varied extensively by county. Some CHOs were funded entirely by county governments and served as dispensaries and educational centers. Others were funded entirely by state governments and essentially served as state health department outreach stations. Others were funded by a combination of organizations and worked toward goals common to

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[8] The 27 counties in Ohio all started their operations the same year (1920) with high levels of funding from the county and state government.

those different interests. We distinguish between CHOs funded entirely by the county government or towns and cities within that county, and those that represented a combination of county funds with external contributions. It was under this "cooperative plan" that the Rockefeller Foundation continued their support of hookworm eradication programs and public health provision at the county level in the American South. Wickliffe Rose, the director of the Rockefeller Sanitary Commission between 1913 and 1916 and The International Health Board between 1916 and 1923, had no experience or knowledge of hookworm prior to 1911. Rose was in fact less concerned with eliminating hookworm than with using it to show the effectiveness of public health work and 'arousing the demand of communities' for investments in public health towards the eradication of disease (Farley 2003). This was to happen not through engaging with individuals directly, but through engaging with governmental entities. It was in part due to this reliance on local government cooperation that hookworm was not eradicated in 1915 (Elman et. al 2013).

Despite the unfulfilled goals of the RSC, Frederick Gates, a member of the Rockefeller Foundation executive committee, wrote a letter to John D. Rockefeller which stated not only had the Rockefeller Sanitary Commission successfully eradicated hookworm in the American South, but that the communities in which the activities occurred had been fully awakened to the benefits of public health investments and had taken up the torch themselves (Farley 2003). Untrue, and likely intended to subvert any effort to continue the hookworm programs in the American South, this forced Rose's hand. It was shortly thereafter that the Rockefeller Foundation began its support of county health organizations and their transition to assume the efforts against hookworm infections (Rockefeller Foundation 1925, pp. 290-291). For at least those CHOs part of the cooperative plan of county health, their efforts can be seen as a continuation of the RSC's program: treatments to the population for hookworm, improvements in the sanitary environment, and working to demonstrate the effectiveness of rural public health work and encourage other counties to engage in public health themselves. North Carolina was an important partner in this effort due to the relationships between individuals in the Rockefeller Foundation and in the State Health Department. The associate director under Rose, John Ferrell, began his career as the Superintendent of Health for Duplin County in North Carolina. He was then appointed assistant secretary for the eradication of hookworm disease in North Carolina, which he held until 1913 when the Rockefeller Foundation hired him to be their associate director.

It was Ferrell and Watson Rankin, the North Carolina secretary of the health department in North Carolina, who created a 'Cooperative Plan of County Health Work' in 1916 and 1917. It began with a three-year plan for 10 counties in North Carolina, with funding for the first year being one quarter from the state, one quarter from the Rockefeller Foundation, and the counties paying half at the beginning and increasing amount in later years (Washburn 1966). Although the original plan was for 3 years, these counties tended to continue their public health investments throughout the 1920s and early 1930s. It was believed other counties would observe the success of these efforts and want their own plan of cooperative public health. At least according to the North Carolina State Board of Health, by 1920 the state of North Carolina had more requests from counties for funds than they had funds to distribute (Washburn 1966). South Carolina, Tennessee and Texas organized similar plans (Farley 2003). Cooperative county health departments in South Carolina received $9,650 combined from the state government and the Rockefeller Foundation, with the county governments to provide an additional $6,000 in funds. In Tennessee, the cooperative plan began with the state and Rockefeller Foundation each contributing $10,000 in aggregate, with the county governments allocating a similar amount. The state of Texas appropriated approximately $16,500 annually between 1917 and 1919 for intensive county health work, an amount matched by the Rockefeller Foundation and supplemented by county contributions of a total of $12,000. (Rockefeller Foundation 1917, pp. 90-91).

The Rockefeller Foundation only engaged with those areas willing to coordinate on a cooperative plan of public health work but was open to counties outside of the original RSC states and broadened their focus from hookworm to public health in general. This shift is reflected in the 1921 budget reports, where the Rockefeller Foundation stopped referring to "Hookworm Work: Southern States" and began classifying funds distributed to these states as funds for "County Health Work." The focus also broadened beyond the original RSC States. Although still classified in their reports as "County Health Work for Southern States" until 1922, from 1920 onward Rockefeller Foundation provided funds for CHOs in New Mexico, Wyoming, Minnesota, Oregon, Iowa, and Colorado, among other states.

The broadening focus of the Rockefeller Foundation and their connection to the CHOs in the US was evident in their writings as well. The Rockefeller Foundation's hookworm interventions in the U.S. South officially ended in 1921, but with the expectation that CHOs would use Rockefeller funds to replace their efforts. In 1921, they write that "*Termination of the Board's* *participation in measures directed specifically to the control of hookworm disease does not disturb working relations with these states. It makes possible rather a transfer of funds to the further development of the more general county health program, to the fight against malaria, and to the training of personnel for the technical and administrative positions which are being created."* The Rockefeller Foundation budget reports only show Alabama as receiving any money earmarked specifically for hookworm efforts after 1921, with their appropriation of 25 dollars in 1925 that was then paid in 1927. However, it is clear from the Rockefeller reports they expected the cooperative CHOs to continue treating communities for hookworm and its ultimate causes. A footnote from the 1925 annual report states that 1925 *"In September 1917, the hookworm work in the Southern States began to be absorbed in the programs of the rapidly developing county departments of health. The period of transition being longer in some states than in others, it was not possible to announce until the end of 1920 that in all the states the county health departments would henceforth assume as one of their regular functions, responsibility for all efforts directed toward the relief and control of hookworm and other soil-borne diseases"* (Rockefeller Foundation Annual Report 1925, footnote on pp. 290-291).

As noted by others, the Rockefeller Foundation's public health efforts in the American South did not end in 1915. CHOs, in particular those formed under the Cooperative Plan of County Health Work, continued the tradition of the hookworm eradication campaigns but with a broader focus on public health through education and the improvement of sanitary conditions. Many counties with RSC hookworm dispensaries also invested in CHOs, so the measured effectiveness of the deworming campaigns in the American South may be at least partially due to the local health organizations that came after. Furthermore, the local health organizations may have provided a synergistic impact, as they continued work in the affected communities years after the original deworming campaigns ended.

We argue that the hookworm programs of the Rockefeller Sanitary Commission and the CHOs installed in the second half of 1910s constitute two policy initiatives of the same continuum of rural public health and local human development in the American South. With the introduction of cooperative CHOs, we underscore the long-run developmental effects of the Rockefeller Foundation's activities and indicate why hookworm eradication programs have been uniquely effective in improving outcomes, while nevertheless ambiguous regarding the specific timing of improvements. In this paper, we stress the mediating effect of CHOs in that direction. We reiterate that although the RSC ended in 1915, the public health efforts of the Rockefeller Foundation did not. From the RSC sprang the International Health Board, headed by the same administrators. Many of the efforts of the International Health Board were focused abroad, but a significant amount was concentrated on the Southern States.

One of the principal criticisms of Roodman (2017) relates to the timing of the improvement in schooling, and that it does not align well with the 5 years between 1911 and 1915, nor is it coincident across areas. Moreover, he suggests that Bleakley's difference-in-difference estimations rely on the effects of a product of two factors: a non-exogenous variation of the baseline hookworm spread and a short-term timing of the hookworm intervention (Roodman, 2018). Hence, in the absence of a historical narrative that accounts for these discontinuous changes and critical junctures, there is significant doubt as to the robustness of the Bleakley results with regards to both the short- and long-term impact of hookworm eradication on human development. By emphasizing the Cooperative Plan of County Health and introducing the CHOs organized under it, we fill in for this missing historical pattern and provide an institutional explanation that allows for a long-term explanation of the RSC hookworm intervention.

III. Data & Methodology

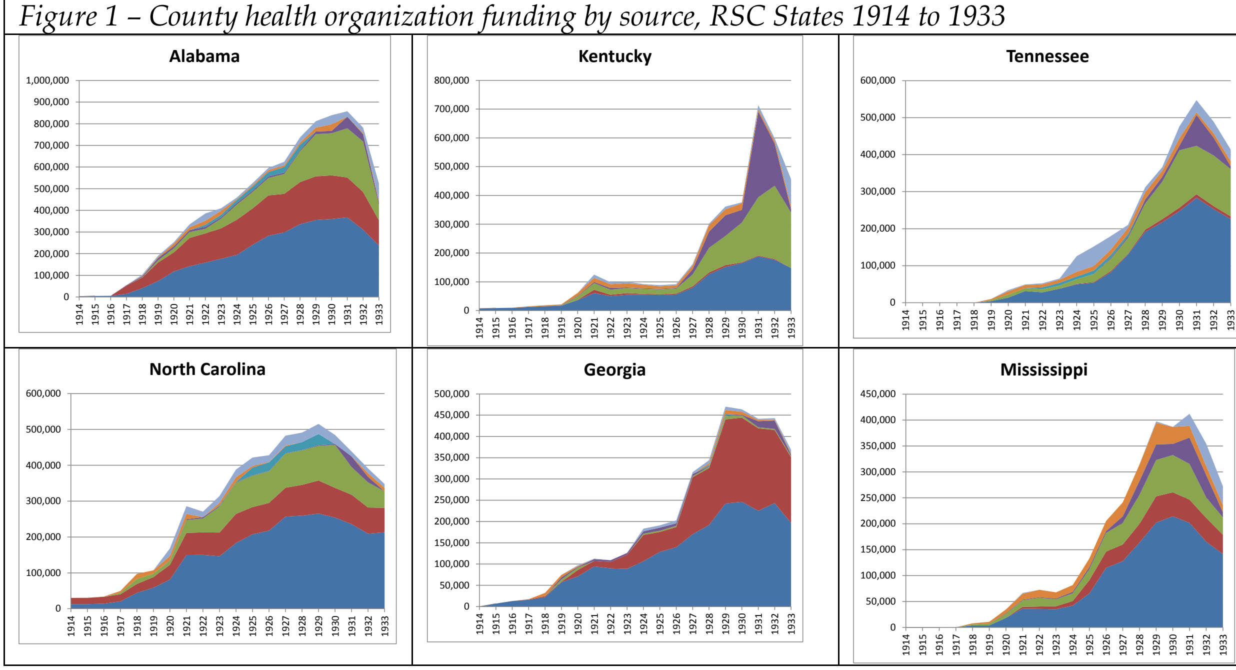
Data

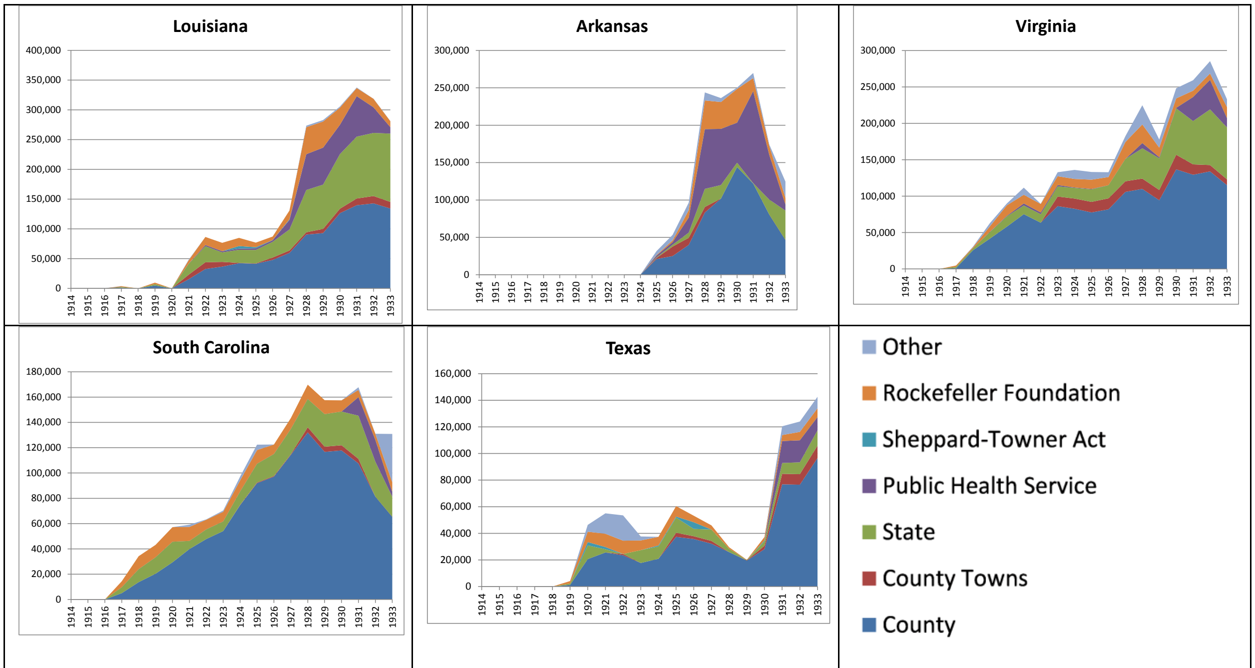
Information on hookworm infection rates and activities by the Rockefeller Sanitary Commission (RSC) comes from the Rockefeller Foundation Annual Reports. Detailed descriptions of these activities can be found in other sources (e.g. Brinkley 1994, Farley 2003, Bleakley 2007, Elman 2013), so we describe them only briefly here. The original hookworm eradication efforts were a cooperative effort between the Rockefeller Sanitary Commission and the state and local governments. The RSC surveyed hookworm infection rates across the American South and administered treatments of thymol or oil of Chenopodium to infected individuals in selected communities. These treatments were generally administered by the local health department and accompanied by written or printed instructions from the health officer (Hookworm 1915). The location of RSC hookworm dispensaries depended on the perceived prevalence of hookworm in the communities, as well as the reception of necessary cooperation from the different levels of government.

Information on the activities, spending, and duration of the different county health organizations is from the Public Health Service Bulletin 222 titled "A history of county health organizations in the United States: 1908-1933." There are no known records of a systematic survey of CHOs after 1933, so our analysis henceforth assumes the existing CHOs in 1933 persisted throughout the rest of the 1930s. This assumption biases against the likelihood of finding an effect for those areas which may have ended their CHOs prior to that point. Although the written evidence indicates there existed significant demand for rural public health investments, most counties chose not to invest. Of the 1,178 counties in the 11 RSC states in 1930, nearly 2/3s had no record of spending distributed to a county health organization. Even within North Carolina, whose counties exhibited exceptionally high hookworm infection rates, for which nearly every county had a RSC dispensary, and whose health department had, in Watson Rankin, one of the preeminent proponents for public health in the Progressive Era, only about 40 percent of the counties initiated a county health organization before 1930.

Figure 1 shows the distribution of county health organization funding by source for the 11 RSC states individually. To highlight the roles of different funding sources in the states, the vertical axes differ from state to state, but states are ordered from highest overall spending to lowest. Alabama, with over 800,000 dollars being spent on county health organizations at its peak, is listed first, while Texas, whose counties spent just over 140,000 dollars at its peak in 1933, is listed last. Evident from Figure 1 is the variety of different sources from which county health organizations received their funding.

Figure 1 – County health organization funding by source, RSC States 1914 to 1933





Notes: The horizontal axes range from 1914 to 1933 for all the different states. Vertical axes are not to the same scale. The vertical upper bounds are 1,000,000 for Alabama, 800,000 for Kentucky, 600,000 for Tennessee and North Carolina, 500,000 for Georgia, 450,000 for Mississippi, 400,000 for Louisiana, 300,000 for Arkansas and Virginia, 180,000 for South Carolina, and 160,000 for Texas. The category 'other' includes spending from the Reconstruction Finance Corporation, the Indian Bureau, and other unlisted government agencies or private organizations.

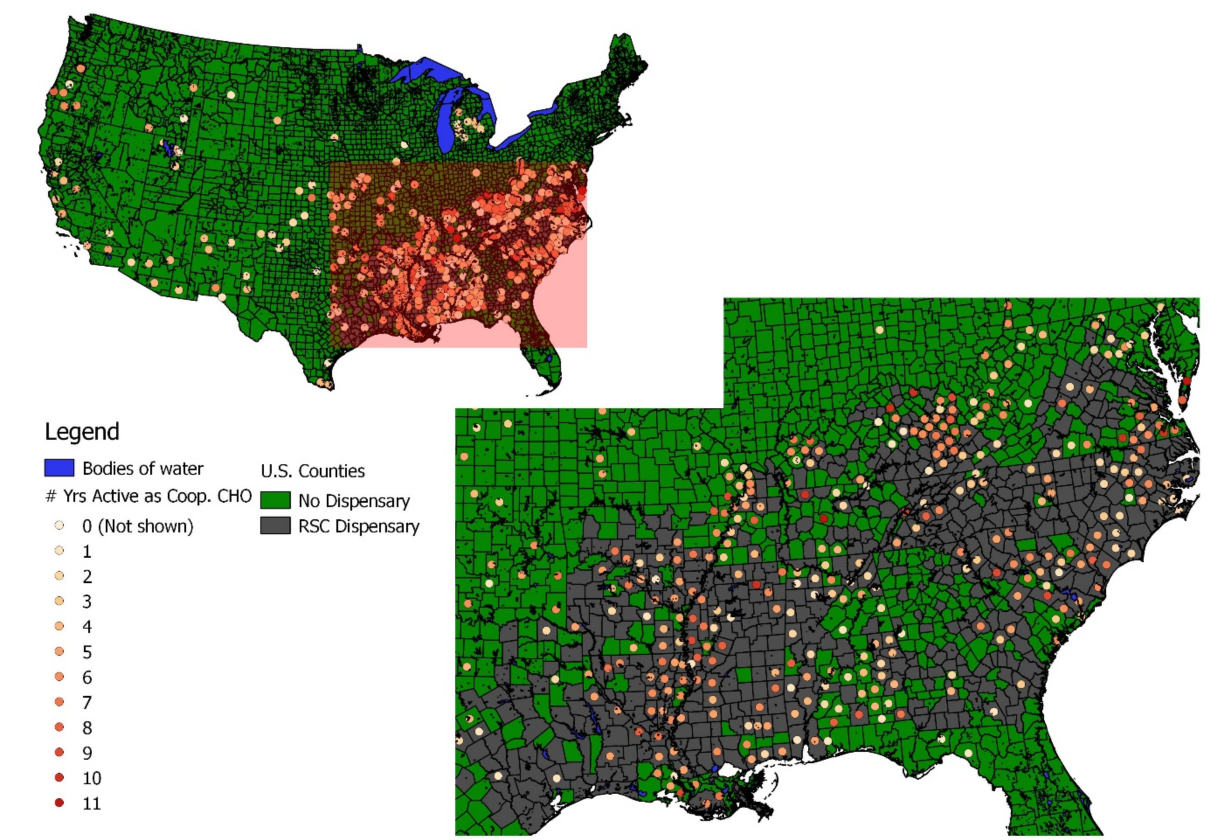
With few exceptions, county governments were responsible for at least some proportion of spending on the county health organizations. This gives some clue as to the significant variation within states in rural public health provision and shows the important role county governments played in decisions to invest or not.[9] Also interesting are the roles private organizations and the different levels of government played across the different states. Small towns were important sources of county health organization funds in Alabama, North Carolina, and Georgia, but less important in the other RSC states. State governments were a major source of funds in Alabama, Kentucky, Tennessee, North Carolina, Louisiana, and Virginia, but had a reduced role in Georgia, Arkansas, and Texas. Spending from the federal government, indicated by those funds from the Public Health Service and the Sheppard-Towner Act, existed, but constituted an important source of funds only in Arkansas, and to a lesser extent in Louisiana,

[9] Of the 715 county health organizations active at some point between 1910 and 1933, only 17 had years for which the county government distributed no funding towards the operation of the county health organization. Of these 17, 9 were counties in Delaware and Pennsylvania where the all the funds were distributed through the state governments. Only two of these 17 counties, Cherokee county, Texas in 1922 and Metcalf county, Kentucky in 1933 existed in an RSC State.

Kentucky, and Mississippi. Given its relatively prominent role in the Progressive Era public health story, it is worth emphasizing that funds distributed through the Sheppard-Towner Act were never a large source of county health organization funding, even though some states allocated most of those funds towards their CHOs. North Carolina and Georgia, for instance, sent over 2/3 of their appropriated funds to their county health organizations, but these never constituted more than 5-10% of total expenditures on the county health organizations. As a proportion of funding, the Rockefeller Foundation distributed relatively little. Only in 1918 were they responsible for over 10 percent of funds distribute to county health organizations, and then just marginally. However, that CHO growth occurred most in those eleven states part of the original RSC area is not a coincidence. Of the 43 counties that had adopted county health organizations by 1919, 90% were in one of the former RSC states. By 1930, 629 counties had a CHO, of which 60% were in former RSC States. Furthermore, within these states, nearly 3/4s of the counties that adopted a CHO did so as part of the cooperative plan.

Due to the variance in funding sources and activities, we focus our analysis on CHOs formed under this cooperative plan. With the exception of a handful of counties, there is no statement regarding which CHOs were 'cooperative' CHOs and which served some other purpose. As such, we consider a CHO to be a 'Cooperative CHO' if it received funding jointly from the county government, the state government, and the Rockefeller Foundation. Figure 2 maps the eleven RSC states, along with the counties that had hookworm dispensaries and those that had a cooperative county health organization.

Figure 2 – Distribution of Rockefeller Sanitary Commission dispensaries and Cooperative County Health Organizations in the American South, 1910 to 1933



Notes: RSC States include Texas, Louisiana, Mississippi, Tennessee, Kentucky, Georgia, South Carolina, North Carolina, Alabama, Arkansas, and Virginia. We consider counties with recorded funding from the state, the county, and the Rockefeller Foundation as active cooperative CHOs for that year. Tan counties are counties with recorded RSC activities between 1911 and 1915. Counties with red dots indicate those with an existing county health organization in 1933. 1933 is the last year of recorded data for the distribution and spending of CHOs in the United States.

Of the 1,191 counties in Figure 2, 573 were not part of the RSC hookworm survey. Of the 618 that were, had no record of RSC dispensary activities. 25 had a cooperative CHO in 1920, and 103 a cooperative CHO by 1933. Start and stop dates varied, but for those that had a cooperative CHO by 1933, the average number of active years was about 4.5. These county-level data are aggregated to the SEA-level, which is discussed in more detail below.

Data on individuals comes from the 1900, 1910, 1920, 1930, 1940, and 1950 1 percent samples of the U.S. census available via IPUMS (Ruggles et. al 2010). This includes individual level information on school attendance, occupation, and literacy, as well as selected demographic and family characteristics. We select the sample to be as close as possible to that selected by Bleakley (2007) in his baseline estimates using the sequential cross section data. This sample was used in estimates for Tables II and III in the original publication, and forms the basis for his conclusions regarding the RSC hookworm eradication programs. To this end, we exclude 1930 and we begin with just over 6 million individuals across the five different census years. 776,805 Individuals born outside the U.S. are excluded, as are an additional 31,122 individuals not classified as either of the white or black race. We also limit to children between the ages of 8 and 16 and to individuals residing in one of the 11 RSC states. This cuts the sample to 327, 360. Another 50,961 persons are excluded due to not having been born in an area with a hookworm infection survey. For our base sample, this leaves 39,885 observations in the 1900 census, 43,495 in 1910, 47,977 in 1920, 55,664 in 1940, and 89,378 in 1950. The dependent variables of interest are school attendance, full-time school attendance, and literacy. Individuals enrolled in school are considered full-time students if they also have no recorded occupation.[10] Measures of literacy are not available for individuals in the 1940 or 1950 census, so it is excluded as a dependent variable in those models which include those samples.

SEA-level covariates on health, health policy, education, race and race relations, and agricultural/rural conditions have been collected from the data made publicly available by David Roodman on his GiveWell website (GiveWell 2018). These include measures for county health spending, sanitary indices, malaria mortality rates, changes in fertility, school and school district characteristics, lynchings per capita, sharecropped acres, and many other variables possible correlated with both the hookworm intervention and human capital. Further descriptions of these and the other included variables can be found in Roodman (2017) and Bleakley (2007).

In the original Bleakley (2007) formulation, the SEA geographic level is chosen over that of the county. This was justified due to the propensity of counties being born and dying, and that

[10] For 1950, most of the population does not have information on school attendance. Of the 1,922,198 individuals captured by the IPUMS 1950 1 percent sample, information on school attendance is missing for 1,691,363. Of those for which information exists, 138,991 did not attend school while 91,844 did. The small number of observations is almost certainly due to privacy restrictions for the 1950 sample.

some saw their boundaries change. However, the decision to aggregate to the SEA was likely driven by data requirements. With the U.S. Census' '72-Year Rule,' it was not until 2012 that individuals in the 1940 census could be tied to their county of residence, and this information remains private for individuals in the 1950 census. Furthermore, using the 1 percent samples of the U.S. census provides a large sample of individuals, but relatively few across SEAs, and even fewer across counties. Although the base sample described above includes 276,339 individuals, only about 300-600 appear in a given year for the median SEA. This number drops in half if using the county geographic level, and for many counties the number of individuals included is in the double or single digits. Thus applying the 1 percent IPUMS sample and controlling for counties may be tainted by small sample problems from the number of available observations for a given county.

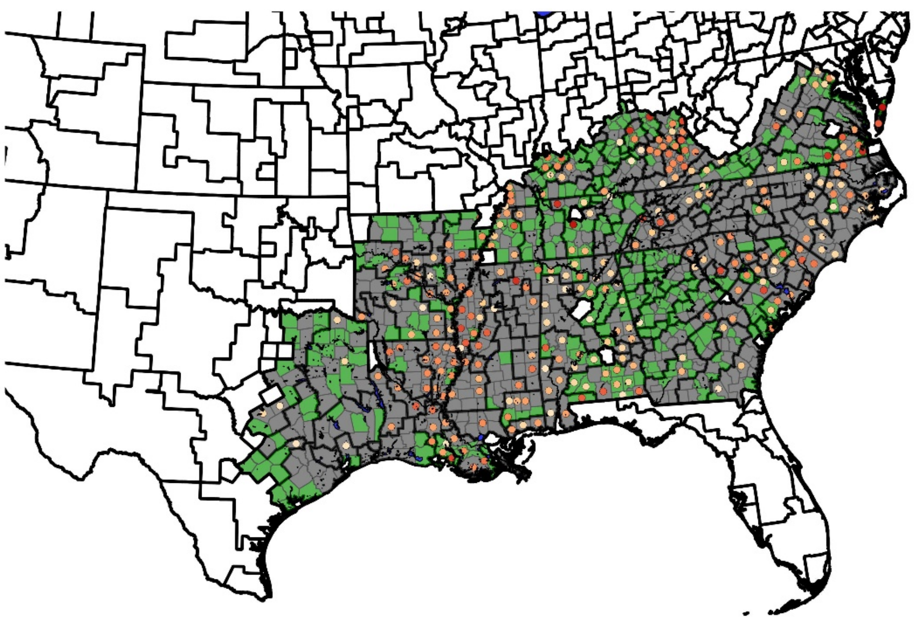
Given these issues with using the county level, utilizing the SEA geographic level was an appropriate methodological decision for the original analysis in Bleakley (2007). However, the SEA level comes with its own challenges and decisions in how to aggregate counties. Many SEAs had counties both with and without RSC dispensaries, and with and without hookworm infection surveys. As such, there is no method of aggregation unambiguously correct. A SEA 'hookworm infection rate' is possible to construct by averaging the given infection rates across the counties in the SEA, but if some of these counties were not surveyed by the RSC, the average of infection rates of the other counties is applied to these non-surveyed counties. For the years prior to 1950, it is then necessary to decide whether to include individuals who lived in non-surveyed counties but 'surveyed' SEAs. We have decided to include these persons to keep consistency across the census years, but given the differences in sample sizes between our analysis and that of Bleakley (2007) and Roodman (2017), they may have been excluded in the prior studies.

A second methodological challenge from use of the SEA geographic level is the tradeoffs regarding small sample sizes. The use of the SEAs mitigates the small sample problems in the identification of the individual characteristics, but exacerbates small sample problems in the identification of geographic-level characteristics. The number 276,339 is somewhat misleading as a sample size, since these persons are distributed across only 117 SEAs. With the inclusion of SEA-level Fixed Effects, the sample of 276,339 persons collapses into a sample of 585 observations

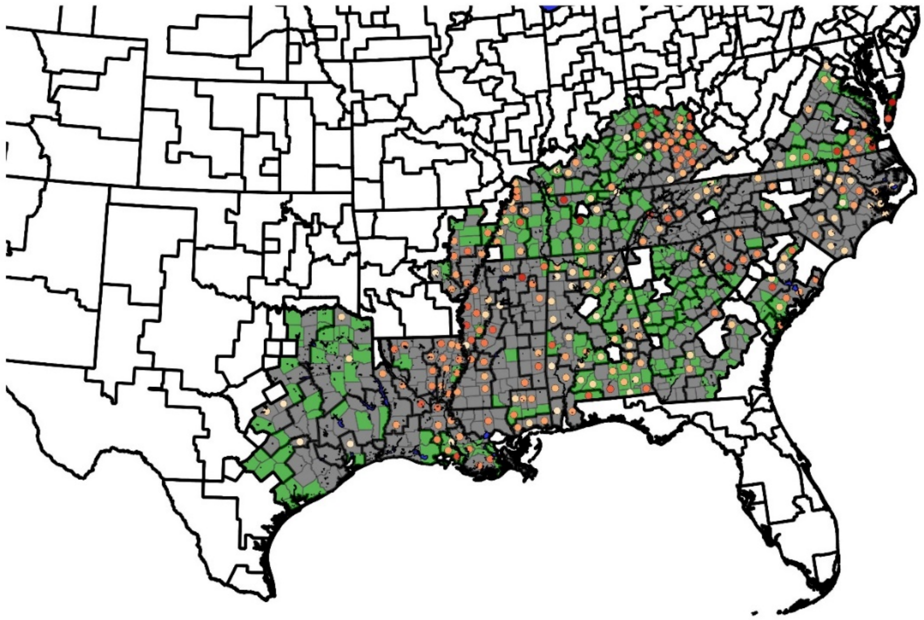
(117 SEAs across 5 census years). Changes in that sample of SEAs can thus result in significant differences in the estimated effects.

Our base sample of included SEAs, as well as a further selected sample, is given in Figure 3 below. The latter is applied to models including additional covariates which are not available for all SEAs. It our model results below, we consider it important to separate the effect of the covariates from the sample necessary to estimate them, since their inclusion necessitates the omission of SEAs across the different states, in particular within North Carolina, Arkansas, and Georgia.

Figure 3 – Sample of Included State Economic Areas



Panel (a): Base sample, 117 SEAs



Panel (b): Further selected sample, 93 SEAs

Methodology

To investigate how CHOs formed under the Cooperative Plan of County Health Work may affect the association between the RSC hookworm eradication program and human capital outcomes, we place a measure for the presence of these cooperative CHOs within the Bleakley (2007) Sequential Cohort Analysis framework. Specifically, we consider whether the inclusion of this variable and its interaction with the proxy for hookworm eradication affects the statistical and economic significance of the variable for hookworm eradication, and whether there are important interaction effects between the two. Because we derived our data slightly differently than in original study, we begin with a walkthrough and re-estimation of the original estimates given in Tables II and III to provide a baseline comparison. Equation (1) (reproduced from Bleakley 2007, pp. 80) considers, within a diff-in-diff framework, the outcomes of school attendance, full-time school attendance, or literacy as function of hookworm eradication interacted with an indicator for the time period after the RSC intervention, time and area fixed effects, and a matrix of covariates and their interactions.

$$Y_{ijt} = \beta\left(H_j^{pre} * Post_t\right) + \delta_t + \delta_j + X_{ijt}\Gamma + \varepsilon_{ijt} \quad (1)$$

Y_{ijt} represents one of the three outcome variables for individual i in SEA j for census year t. $H_j^{pre} * Post_t$ is the hookworm interaction (henceforth referred to as such), which acts as proxy for the RSC intervention. δ_t are fixed effects for the different census years, δ_j are fixed effects for the SEA, and X_{ijt} is a vector of control variables. This vector of control variables contains different covariates depending on the specification. The 'basic' specification contains covariates for age, sex, and race, while the 'full covariates' specification includes covariates measuring health, health policy, education, race, and agricultural/rural conditions.[11] The errors are represented by ε_{ijt} and are assumed to have a conditional mean of zero and a constant variance within each of the different SEAs. The short-term effects of the RSC hookworm efforts are determined by estimating equation (1) over the constrained sample of 1910 to 1920. Long-term effects are determined by estimating it over the full sample of 1900 to 1940.

A second specification includes SEA-specific trends, given in equation (2). In the specification below, differences in trends at the SEA level are controlled for, with β capturing the effect of changes in outcomes due to reductions in hookworm infection rates.

$$Y_{ijt} = \beta\left(H_j^{pre} * Post_t\right) + \delta_t * \widetilde{\delta_j} + \delta_t + \delta_j + X_{ijt}\Gamma + \varepsilon_{ijt} \quad (2)$$

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[11] For health and healthy policy, these variables include measures for the number of persons examined by the RSC per capita, the RSC sanitary index of the area, an indicator for whether a county/SEA had a full-time health officer, the amount of county spending per capita on health, the WWI cantonment size per capita, malaria mortality between 1919 and 1921, and the change in fertility between 1900 and 1910. Educational variables included measures for the log change in school term length between 1905 and 1925, the log change in average monthly salaries for teachers, the log change in school density, the log change in the number of teachers per school, the log change in the pupil-teacher ratio, the log change in the value of school plant and equipment, the log change in county spending on education per pupil, the change in returns to literacy for adults between 1910 and 1920, and county-level literacy rates. Variables for race and race policy include measures for the fraction black, the number of Rosenwald schools per capita, and the number of lynchings per capita. Agricultural and rural controls include measures for the change in urbanization between 1900 and 1910, the crop acreage per capita, the sharecropped areas per capita, farm value per capita, cotton acreage per capita, and tobacco acreage per capita. In the original study, these groups of controls are included sequentially to determine their respective importance in affecting the relationship between hookworm eradication and human capital outcomes. Since we are only interested in the joint importance, we present only the model including all of these covariates.

To evaluate the how the presence of cooperative CHOs may moderate the relationship between the RSC hookworm intervention and human capital outcomes, we include an SEA-level measure of the presence of these local health stations in the above regression equations and interact it with the original hookworm interaction. This strategy, with its attribution of the full reduction of hookworm infection rates to the initial intervention, is likely to underestimate the impact of cooperative CHOs on measurable outcomes. As discussed above, hookworm eradication efforts shifted to the county health organizations starting in 1917, so these health stations were almost certainly important in reducing hookworm infection directly. However, it is difficult to parse the relative importance of the initial intervention against the subsequent CHOs, so we attribute the full impact of reductions in hookworm infection to the initial RSC intervention.

Our primary goal in this analysis is to evaluate whether inclusion of a measure for cooperative CHO presence affects the previously estimated relationship between hookworm eradication and human capital outcomes. Thus, we are most concerned with how the presence of a cooperative CHO moderates the relationship between hookworm eradication and human capital outcomes. However, we argue these cooperative CHOs are plausibly exogenous as they were joint decisions between the county, state and Rockefeller Foundation that rested primarily on the financial situations of the counties and the timing of the state appropriations. To return to our example of North Carolina, ten counties began under the Cooperative Plan in 1917, which started after Watson Rankin was able to secure $15,000 in funding from the North Carolina General Assembly. These counties had sent committees to a health training center in the year or years prior, and using this as evidence of demand, Rankin was able to convince the assembly of the need (Washburn 1966). Within two years, another four counties had been included on the cooperative plan, with five more having requested cooperation. When the General Assembly approved appropriations for these counties, they could start their cooperative CHO. As such, there was random variation for when a specific cooperative CHO began. Of course, counties could start their own health organization without participation of the state or Rockefeller Foundation, but we do not consider these cooperative efforts and so omit them from the analysis. Higher rates of hookworm incidence is associated with the presence of CHOs, could serve as a potential proxy for their existence. However, as we follow the methodology of Bleakley (2007), hookworm incidence is used to proxy for the initial RSC hookworm eradication program. Since this paper investigates the ability of cooperative CHOs to moderate the relationship between that initial program and human capital outcomes, such a strategy is not useable.

Since some counties added local health stations and later dissolved them, the number of active years varied substantially from county to county. Furthermore, it is necessary to aggregate this county-level measure to the SEA-level. We are interested in the intensity of local health activity, so focus on the proportion of county-years a given SEA had an active cooperative CHO. As such, to measure the presence of a CHO in a SEA, we calculate the proportion of years spending occurs over the relevant sample period for each county within that SEA and average over both the number of counties in the SEA and the number of years surveyed.

$$CHO\ share_j = \frac{1}{K}\sum_{k=1}^{K}\frac{1}{T}\sum_{t=1}^{T} CHO_{k,t}\ , \forall\ k \in S \quad (3)$$

Where $CHO_{k,t}$ is an indicator equal to 1 if county k showed evidence of cooperative CHO in year t. T is equal either to 1920 or 1933 depending on whether we are considering the short run effects between 1910 and 1920 or the longer run effects between 1900 and 1940 (sample length thus being either 10 years in the case of the 1910-1920 period or 24 years in the case of the full period sample). For a cooperative CHO which began in 1920 and had recorded data until 1929, but no spending data recorded in 1923 and 1924, and which existed in a SEA with four other counties with no recorded activity, we calculate the SEA-level CHO share as $\frac{10-2}{24} * \frac{1}{5} = 0.066$. One drawback to this approach is the correlation of the $CHO\ share$ variable with the number of counties in a SEA. Since SEAs with fewer counties also tend to be more urbanized and economically developed, the $CHO\ share$ variable may be correlated with the literacy and schooling outcomes in ways unrelated to the presence of a cooperative CHO. As such, our model specifications also include a variable (K_j) for the number of counties in a given SEA. We include our CHO share variable both as an independent variable interacted with an indicator for the post-1910 time period, as well as an interaction with the Bleakley hookworm variable in equations (1) and (2). Equation (1) is then expressed as follows:

$$Y_{ijt} = \beta\left(H_j^{pre} * Post_t\right) + \gamma(CHOshare_j * Post_t) + \eta\left(H_j^{pre} * Post_t\right) * CHOshare_j + \theta K_j + \delta_t + \delta_j + X_{ijt}\Gamma + \varepsilon_{ijt} \quad (4)$$

From regression equation (4) and its counterpart including the SEA-level trends, of initial interest is whether any change in the magnitude to the coefficient estimates on the hookworm variable in comparison with equation (1). If the variable is strongly affected by the inclusion of our measure for CHO presence, this indicates the estimated impact of initial hookworm campaigns of the Rockefeller Sanitary Commission are at least partly a result of the supplementary CHOs. Of primary interest is statistical and economic significance of η . Given the abbreviated time frame, we do not expect much impact of the CHOs between 1910 and 1920. Only 20 SEAs had any cooperative CHO presence, and for most, this was limited to only one county within them for a period of 2 years or less. In the long-run, we expect the presence of a County Health Organization to improve the measured effectiveness of the hookworm eradication campaign beyond the initial RSC intervention, and a significant and positive effect would indicate it had done so.

IV. Results

Table 1 presents our results for equations (1) and (2), along with their counterparts in the original Bleakley (2007) paper and the Roodman (2017) replication. As mentioned above, our data derivation process differed to some extent from that of the previous two studies, so we present our own 'replication' to provide baseline estimates as comparison to those from the model including our measure for the presence of CHOs. For the models with the partial set of controls, although the number of included SEAs in our sample is the same as those of Roodman (2017) and likely Bleakley (2007), there are more person-level observations.[12] This results in slight differences across the given coefficient estimates, but they are consistent with and very close to those in the prior studies. Inclusion of the full set of covariates reduces the available SEAs to 93, a shift visually depicted in Panel (a) versus Panel (b) in Figure 3. The sample of Roodman (2017) consists of 105

[12] We were unable to determine the number of SEAs included in the original Bleakley (2007) analysis, and it has been reported that the code from the original manuscript is lost (Roodman 2018).

SEAs, and includes areas in Arkansas, North Carolina, and Virginia omitted from our sample. Nevertheless, those differences in which SEAs are included do not seem to drive the differences between our estimates and those of Roodman (2017). Limiting the model with only the set of partial covariates to a sample with those 105 SEAs resulted in coefficient estimates similar in statistical and economic magnitude to those presented from our estimates from the full covariate model. Interestingly, while the number of observations is more similar between the original Bleakley (2007) and Roodman (2017) studies, our coefficient estimates more closely approximate those of Bleakley (2007).

Table 1: Baseline Estimates - Replication of Hookworm and Human Capital

Baseline estimates	Bleakley (2007)			Roodman (2017)			New Estimates		
	School enrollment	Full-time school attendance	Literacy	School enrollment	Full-time school attendance	Literacy	School enrollment	Full-time school attendance	Literacy
Partial controls									
$H_j^{pre} * Post_t$									
Time period									
Short-term (1910-1920)	0.0883***	0.1591***	0.0587***	0.0986***	0.1670***	0.0675***	0.0727***	0.137***	0.0496***
	(0.0225)	(0.0252)	(0.0186)	(0.0223)	(0.0243)	(0.0174)	(0.0109)	(0.0137)	(0.0090)
Observations	64,676		49,476	65,436	65,396	50,028	91,472	91,472	70,163
Included SEAs				117	117		116	116	116
Long-term (1900-1950)	0.0608**	0.1247***		0.0724***	0.1188***		0.0728***	0.126***	
W/O SEA specific trends	(0.0261)	(0.0286)		(0.0230)	(0.0237)		(0.0105)	(0.0116)	
Observations	140,161			141,329	141,329		201,663	201,663	
Included SEAs				117	117		117	117	
Long-term (1900-1950)									
W/ SEA specific trends	0.0954***	0.1087***		0.1087***	0.1618***		0.0864***	0.140***	
	(0.0233)	(0.0294)					(0.0329)	(0.0321)	
Observations	140,161			141,329	141,329		201,663	201,663	
SEAs				117	117		117	117	
Full controls									
$H_j^{pre} * Post_t$									
Time period									
Short-term (1910-1920)	0.0850***	0.1026***	0.0513**	0.0029	0.0553**	-0.016	0.0752***	0.133***	0.0573***
	(0.0224)	(0.0325)	(0.0213)	(0.0221)	(0.0229)	(0.0220)	(0.0118)	(0.0156)	(0.0097)
Observations				61,027	61,027	46,695	78,161	78,161	59,980
Included SEAs				105	105		93	93	93
Long-term (1900-1950)	0.1014***	0.1408***		0.0256	0.0909**		0.0947***	0.143***	
W/ SEA specific trends	(0.0349)	(0.0421)		(0.0416)	(0.0393)		(0.0323)	(0.0367)	
Observations				131,062	131,062		172,248	172,248	
Included SEAs				105	105		93	93	

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Presented coefficient estimates are those from the interaction of hookworm infection rates with a post-Rockefeller Sanitary Commission dummy as specified in equation 1: $Y_{ijt} = \beta(H_j^{pre} * Post_t) + \delta_t + \delta_j + X_{ijt}\Gamma + \varepsilon_{ijt}$. The sample is selected to be as close as possible to that selected by Bleakley (2007), were we include individuals only in those areas with surveyed for hookworm infection rates, who were born in the U.S., between the ages of 8 and 16, and of either white or black ethnicity. Measures of literacy are not available for individuals in the 1940 census, so it is excluded as a dependent variable for those years.

Table 2 presents results from equation (4) and the analogous model including SEA specific trends. The top half of the table presents those estimates from the 1910 to 1920 panel. For the short time period, inclusion of our CHO did not substantially impact coefficient on the hookworm interaction relative to the baseline estimates. In fact, the magnitude of the estimated coefficient increased slightly across the different outcomes when controlling for the full set of covariates. As for the CHO variable itself, across all but school enrollment in the model with partial controls, the presence of cooperative CHOs were associated with improvements in schooling and literacy. However, only the CHO coefficient in column 5 was statistically significant at the 10 percent level.. Although the coefficients are economically significant (magnitude greater than that of the of the coefficient on the hookworm interaction variable), we believe the lack of a consistent statistically significant effect to result from the combination of a relatively short identifying time-period and the small sample problems associated with the use of the SEA level. As such, it seems that the impact of the cooperative CHOs is not identifiable for the 1910 to 1920 time period.

Table 2: County health organizations, hookworm, and human capital

Cooperative county health organizations						
	Partial controls			Full controls		
	School enrollment	Full-time school attendance	Literacy	School enrollment	Full-time school attendance	Literacy
	(1)	(2)	(3)	(4)	(5)	(6)
Short-term (1910-1920)						
$H_j^{pre} * Post_t$	0.0652***	0.138***	0.0496***	0.0777***	0.141***	0.0583***
	(0.011)	(0.015)	(0.010)	(0.012)	(0.017)	(0.010)
Change from Table 1 Baseline	-10.3%	0.7%	0.0%	3.3%	6.0%	1.7%
$CHOshare_j * Post_t$	-0.138	0.584	0.0443	0.406	1.005**	0.0671
	(0.240)	(0.374)	(0.209)	(0.291)	(0.396)	(0.239)
$\left(H_j^{pre} * Post_t\right) * CHOshare_j$	0.687	-0.522	-0.0301	-0.521	-1.427*	-0.129
	(0.508)	(0.787)	(0.437)	(0.600)	(0.842)	(0.494)
Observations	91,472	91,472	70,163	78,161	78,161	59,980
	117	117	117	93	93	93
Long-term (1900-1950)						
W/ SEA specific trends						
$H_j^{pre} * Post_t$	0.0189	0.0627		0.0389	0.0896	
	(0.039)	(0.048)		(0.041)	(0.056)	
Change from Table 1 Baseline	-78.1%	-55.2%		-58.9%	-37.3%	
$CHOshare_j * Post_t$	-0.327**	-0.388**		-0.303**	-0.321	
	(0.128)	(0.166)		(0.140)	(0.193)	
$\left(H_j^{pre} * Post_t\right) * CHOshare_j$	1.109***	1.259***		0.902**	0.848	
	(0.348)	(0.480)		(0.409)	(0.564)	
Observations	201,663	201,663		172,248	172,248	
SEAs	116	116		93	93	

Notes: Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Presented coefficient estimates are those from the equation (3). The sample is selected to be as close as possible to that selected by Bleakley (2007), were we include individuals only in those areas with surveyed for hookworm infection rates, who were born in the U.S., between the ages of 8 and 16, and of either white or black ethnicity. Measures of literacy are not available for individuals in the 1940 census, so it is excluded as a dependent variable for those years.

Although a strong effect of the cooperative CHOs was not detectable during the short time period, use of the full panel, presented in the bottom half of Table 2, indicates their importance as a moderating impact on long-term human capital outcomes. In comparison to estimates presented in Table 1, coefficient estimates on the hookworm interaction variable are attenuated by 55-75 percent when controlling for the partial set of covariates, and by 35-60 percent when controlling for the full set of covariates. And although the coefficient for the CHO share variable is negative, its interaction with hookworm is large and positive. This indicates that the effectiveness of the RSC hookworm campaigns, when measured at the SEA level, were substantially magnified when investment in a cooperative CHO occurred. That the coefficient on the CHO variable was negative and significant suggests that SEAs which contained counties that implemented a CHO, but which were not strongly affected by hookworm, tended to do poor relative to those with high hookworm infection rates in the period prior. Thus, while the coefficient on the hookworm interaction term in those models was neither statistically significant at the 10 percent level nor economically significant, the presence of the initial intervention remained important for improving outcomes. The attenuation of its statistical and economic significance may simply be due to collinearity resulting from the relatively few SEA observations.

That the coefficient on the interaction term between hookworm and the cooperative CHOs was generally statistically significant at the 5 percent level and economically important is striking. Although we load the entirety of the impact of hookworm eradication onto the hookworm interaction term, thereby ignoring the role CHOs may have played in further reducing hookworm infection rates, the role of the cooperative CHO remains important. Taking as example a SEA in which half of its counties had a cooperative CHO for 12 of the possible 24 years yields an estimated effect twice that of the baseline coefficient estimates.

V. Conclusions

With his letter to John D. Rockefeller in 1914, Frederick Gates proclaimed that hookworm had been successfully eradicated in the American South, and that the communities in which the activities occurred had been fully awakened to the benefits of public health investments and had taken up the torch themselves. As indicated by Figure 2, and as has been documented elsewhere (Elman et. al 2013), this was clearly not true, and continued to not be true throughout the Progressive Era and beyond. However, hookworm infection rates did improve because of the efforts of the Rockefeller Sanitary Commission between 1910 and 1915 and continued to improve throughout the Progressive Era. Furthermore, while it took some time for the county and state governments to act on any 'public health awakening,' many eventually did so, investing substantially in local public health stations across the United States.

Much has been made of the RSC hookworm eradication campaign and their positive impact on human capital and economic outcomes (or, alternatively, the lack thereof). However, comparatively little attention has been given to the subsequent county health organizations, and even less to the connection between the original RSC hookworm campaign and the cooperative plan of county health work that followed. Ironically, Gates' effort to stop the hookworm campaign in the American South, itself likely a result of his opposition to Wickliffe Rose's goal of stimulating public interest and investment in public health broadly defined, seems to have led to a continuation of them in a different form and under a different name. It was only after Gates' letter than Rose and John Ferrell began work with Watson Rankin to organize their cooperative plan of county health work and help propagate the spread of county health organizations across the American South throughout the Progressive Era.

For their part, these local health organizations seem to have been an immensely important follow-up program to the RSC hookworm campaign. Areas in which both existed saw significantly greater gains in school enrollment and full-time school attendance than areas in which only the deworming occurred. The CHO movement, like the original RSC hookworm campaign, was also not complete and fell short in many ways. However, areas in which these health stations existed saw continuing efforts to treat, not only infections of hookworm, but the underlying ecological environment driving hookworm prevalence. These efforts resulted in important gains in human capital production which would not have otherwise occurred with only the initial intervention.

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