Original article

Rural health in the Progressive Era: revisiting the hookworm intervention in the American South

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Abstract

Objective: In this study, we investigated Progressive Era public health interventions and connected two subsequent efforts to improve outcomes in the American South: the Rockefeller Sanitary Commission’s hookworm eradication efforts in the early 1910s and investments in local health infrastructure between the 1910s and the 1930s. We tested whether hookworm eradication had the largest effects in areas that invested in public health and whether county health organizations—cooperative public-private institutional arrangements—impacted the Rockefeller Sanitary Commission program’s success.

Materials and Methods: The methods used to measure the effects involved estimation of difference-in-difference and triple-difference models across the geographic samples of the Rockefeller Sanitary Commission’s surveyed area, the American South, and the United States. Material on hookworm infection rates and activities by the Rockefeller Sanitary Commission is obtained from the Rockefeller Foundation Annual Reports. Material on the activities, spending, and duration of the different county health organizations is obtained from the Public Health Service Bulletin 222 titled, “A history of county health organizations in the United States: 1908–1933”.

Results: By comparing similar cooperative and independent county health organizations in the American South with the rest of the United States, we find that cooperative efforts are generally important and strengthen the Rockefeller Sanitary Commission’s impact on human capital outcomes in the American South. Simultaneously, independent county health organizations produced negative or non-significant effects.

Conclusion: The Rockefeller Sanitary Commission is important in guiding local health efforts. Our results are robust in both the short and long runs. This study sheds light on the effectiveness of public-private partnerships in rural public health during the Progressive Era.

Key words: county health organizations, hookworm eradication, progressive era, public-private partnerships

Introduction

From 1910 to 1914, the Rockefeller Foundation invested in substantial public health interventions to combat hookworm before World War I in the American South. In the two decades that followed, the Rockefeller Foundation expanded its scope of public health investment. It worked with state and local governments in the US to find local public health institutions called county health organizations (CHOs).

Efforts to eradicate soil-transmitted helminths in the American South have been linked to increased school participation and literacy⁵ and growth in agricultural output and productivity⁶ but have also excluded many at-risk counties⁷. Recent work has questioned the efficacy of this early public health invention⁵, ⁷, and hookworms themselves have resurfaced in some Southern areas⁸. The Rockefeller Foundation’s public health investments have been less scrutinized. This research evaluates its role as a bridge for successive investments in rural public health and estimates the importance of its participation in what was otherwise a government project.
The Rockefeller Foundation’s work in the American South remains an important chapter in American public health history. It has served as both a cautionary tale on the limits of a private foundation’s ability to improve public health5,6, and a positive model of how a focused private program can effect permanent improvements in local health and educational outcomes7. The debate over the impact of private philanthropic organizations continues today.

We revisit the Progressive Era public health period to connect the Rockefeller Foundation investments in the American South to the growth of local health infrastructure over the following decades. We employ a double- and triple-difference estimation strategy to assess the public health effect of CHOs by institutional arrangement and geographic location. Because the Rockefeller Foundation participated in funding and organizing some CHOs but not others, we estimated whether these institutional differences were related to health and educational outcomes. Those funded by the Rockefeller Foundation will be referred to as “cooperative CHOs”. Other CHOs, funded and organized almost entirely by local and state governments, will be referred to as “independent CHOs”. Geographically, the Rockefeller Foundation only implemented its hookworm campaign within the southeastern United States. Hence, we anticipate areas in the rest of the US where the Rockefeller Foundation did not implement its hookworm eradication campaign to have reduced impacts.

Our primary finding is that cooperative CHOs are associated with improvements in human capital outcomes measured by school attendance and literacy, while independent CHOs are not. It follows that cooperative CHOs throughout the US were crucial for reinforcing human capital improvements. We interpret our findings as supporting the importance of public-private partnerships in the provision of public health. The Rockefeller Foundation pushed the expansion of local public health and played an essential role in providing quality, higher levels of human capital and productivity.

The investments in local public health in the American South exist within a larger trend in United States urban and rural public health improvements during the Progressive Era, many of which have been linked to outcome improvements. Previous research has found that the Progressive Era state and municipal investments in public health are associated with declines in infant mortality7,8. Research examining county health organizations found that CHOs are linked to lower mortality in North Carolina9 and the US10. These effects last into adulthood and are more prominent for non-white infants11. However, the institutional structure, level of control, funding, origins, and activities of these county health organizations vary substantially by region. Some counties organized their own health organizations, while others coordinated with the state or federal government12. In other cases, private organizations such as the Rockefeller Foundation provided financial and other forms of assistance. Notably, the Rockefeller Foundation conditioned its assistance on cooperation and funding from both county and state governments. They created a “cooperative plan of county health work” for the county health organizations to which they provided funding13.

Between 1911 and 1916, county and city governments were the sole sources of funding and management for rural public health work through the CHOs. In 1916, external funding was provided by the Rockefeller Foundation in Wilson County, North Carolina, totaling $800 (equivalent to roughly $20,400 adjusted for inflation in 2021)13. Within a year, these funding sources broadened, with 12 different counties receiving funding from state governments, the Rockefeller Foundation, or the US Public Health Service. This accounted for approximately one-sixth of the total funding of county health organizations during the year. This amount grew to over a quarter of the total CHO funding by 1920 and a third by 1932.

Growth in external funding paced the expansion of rural public health across the US and the American South. By 1920, 135 US counties had operating county health organizations, 97 of which resided within a southeastern state, formerly part of the Rockefeller hookworm eradication efforts. By 1920, other states with county health organizations included California (1), Kansas (3), Montana (3), Ohio (27), Oklahoma (1), and Washington (3). By 1933, this number had grown to 715 and included other areas of the US, but Southeastern states continued to hold about 62% of all counties with county health organizations. Although many of these areas now lag in their public health investments, most rural public health work in the US before the New Deal occurred there.

Rural public health activities varied extensively and followed the institutional arrangements of its provision. Some CHOs received funds only from county governments and served as dispensaries and educational centers. State and city governments funded others, which then existed as state or municipal health department outreach stations. Lastly, some CHOs received funding from a combination of organizations and worked toward goals common across their different interests. The most common was the prevention and restoration of polluted soil14. This was inherited from the Rockefeller hookworm campaigns and included the inspection and building of sanitary bathrooms, examining soil specimens for bacteria or parasitic worms, and treating infected soil areas. Funding from the Rockefeller Foundation was almost universally contingent on government participation. These jointly funded CHOs predominantly received funding from a combination of (1) county or state governments and (2) the Rockefeller Foundation1.

Support was conditional on government participation, a stipulation inherited from the Rockefeller hookworm eradi-

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cation program. The broad application of this institutional arrangement to rural public health work beyond hookworms was formalized in 1916. John Ferrell, the associate director of the Rockefeller Foundation’s International Health Board, and Watson Rankin, the North Carolina secretary of the health department in North Carolina, created what was called a “Cooperative Plan of County Health Work”. Between 1916 and 1917, this was tested across a set of North Carolina counties. It began with a three-year plan for 10 counties in North Carolina and initial funding proportions set at one-quarter from the state, one-quarter from the Rockefeller Foundation, and half from county governments. Although the original plan was for three years, most participating counties continued public health investments throughout the 1920s and into the early 1930s. The demand for this public–private partnership in public health appeared to be high. By 1920, the state of North Carolina had more requests from counties for funds than they had funds to distribute, and South Carolina, Tennessee, and Texas had organized similar plans.

This county health cooperative plan was derived from the Rockefeller Foundation’s initial foray into public health with its hookworm eradication program. It mirrored many of its characteristics: cooperation with local governments, improvements in the sanitary environment, public health education, and proselytizing for adoption in other areas. North Carolina was an important partner in this effort because of the relationship history between individuals in the Rockefeller Foundation and the North Carolina Health Department. John Ferrell, for example, began his career as the Superintendent of Health for Duplin County in North Carolina. He was appointed assistant secretary for the eradication of hookworm disease in North Carolina and hired in 1913 by the Rockefeller Foundation as associate director of its hookworm efforts.

The Rockefeller Foundation only engaged with governments willing to coordinate a cooperative plan of public health work but was open to counties outside the Southeastern US. 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 US states as funds for “County Health Work”. Their annual reports also indicate a shift to a broader geographic focus. By 1923 the Rockefeller Foundation changed the language in their reports from “County Health Work for Southern States” to “County Health Work”. From 1920 onward, they provided funds for CHO’s in New Mexico, Wyoming, Minnesota, Oregon, Iowa, and Colorado.

The broadening focus of the Rockefeller Foundation and the connection between its early hookworm efforts and subsequent investments in rural public health was evident in its writings. The Rockefeller Foundation’s hookworm interventions in the US South officially ended in 1921, but with the expectation that CHOs would use Rockefeller funds to continue their efforts. After 1921, the Rockefeller Foundation budget reports only show Alabama receiving any money earmarked for hookworm efforts, with its 1925 appropriation of 25 nominal dollars (paid in 1927). However, the Rockefeller Foundation viewed its investments in rural public health as a successor to its early hookworm programs: “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 transition period was 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.”

As noted by Brinkley and Soskis, the Rockefeller Foundation’s public health efforts in the American South did not end by 1915. County health organizations formed under the Cooperative Plan of County Health Work continued the tradition of hookworm eradication campaigns but with a broader focus on public health. Notably, many counties with hookworm dispensaries have started cooperative rural health centers. This is an important postscript for de-worming campaigns in the American South, representing a successive and complementary intervention in the initial hookworm programs.

This paper is organized as follows. Section 2 describes the data and methodology and maps the growth of investments in local public health during the Progressive Era, emphasizing the American South. In Section 3, we report the results of our empirical investigation on whether the institutional organization of rural public health mattered and whether these impacts were most significant in the Southeast region, given its history with the Rockefeller Foundation partnership. Section 4 discusses our findings and Section 5 concludes the paper.
Materials and Methods

Information on hookworm infection rates and activities by the RSC was obtained from the Rockefeller Foundation Annual Reports. Detailed descriptions of these activities can be found in other sources (e.g., Brinkley3, Farley25, Bleakley6, and Elman et al.3), so we describe them only briefly here. The original hookworm eradication efforts were a collaborative effort between the Rockefeller Foundation and state and local governments. These efforts surveyed hookworm infection rates across the American South and administered treatments of thymol or oil of Chenopodium to infected individuals in selected communities14. The location of RSC hookworm dispensaries depended on the perceived prevalence of hookworms in the communities and 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 taken from the Public Health Service Bulletin 222 titled “A history of county health organizations in the US: 1908–1933”19. We know of no systematic survey of CHOs after 1933; therefore, 26 years is the maximum number of potential years in operation. Although the written record indicates a significant demand for rural public health investments, most counties chose not to invest. Nearly two-thirds of the 1,178 counties in the 11 southeastern states in 1930 had no record of spending distributed to a county’s health organization. Only about 40 percent of counties in North Carolina funded rural public health before 1930. This was a state with exceptionally high hookworm infection rates, where nearly every county had a hookworm dispensary and whose health department had, in Watson Rankin, one of the preeminent proponents of public health in the Progressive Era1.

Figure 1 shows the distribution of county health organization funding by source for the 11 southeastern states, adjusted to 1930 dollars. The vertical axes differ from state to state to highlight the roles of different funding sources, but states are ordered from the highest overall spending to the lowest. Alabama is listed first, with nearly one million 1930 dollars (about $16.3M adjusted for inflation in 2021) invested annually at its peak. Texas, whose counties spent just over 185,000 1930 dollars (about $3M adjusted for inflation in 2021) at its peak in 1933, was listed last.

Figure 1 shows the various sources from which county health organizations received funding. However, with a few exceptions, county governments provided at least some, and often most, CHO funding. This indicates the significant variation across states in rural public health provision and demonstrates the important role county governments played in investment decisions.

The Rockefeller Foundation distributions were relatively small as a proportion of total funding. Only in 1918 was the Rockefeller Foundation responsible for over 10% of CHO funds, and this was a year when funding overall was relatively low. That said, CHO growth occurred most in the eleven Southeastern states with hookworm programs. By 1919, 90% of the 43 counties with county health organizations were in the American Southeast. By 1930, this proportion remained above 60%, despite CHO growth to 629 counties. Furthermore, within these states, about three-quarters of counties that adopted a CHO did so as part of the cooperative plan. Thus, although the private funds distributed through the Rockefeller Foundation were small relative to overall public expenditures, the Rockefeller Foundation distributed them broadly and was an essential impetus to CHO growth.

Apart from a handful of counties, there are no records regarding which CHOs are ‘cooperative’ and which are ‘independent’. We applied the broadest possible definition to bias our models against finding an impact. A CHO is classified as a “cooperative CHO” if it received joint funding from the county government, state government, and Rockefeller Foundation at any point. The geographic distribution of rural public health stations by institutional arrangement is shown in Figure 2.

Figure 2 shows the concentration of county health organizations, both cooperative and independent, in the United States. CHOs operated in nearly every state in the US but were relatively absent in the Mountain West, West North Central, and Northeast areas4. CHOs, particularly cooperative CHOs, were found in the Carolinas, Alabama, and Mississippi River valleys. This mirrored the location of hookworm eradication work in the 1910s. Aside from Florida, the southeastern states included 1,191 counties, of which 618 were surveyed for hookworm infections. Of these 618 counties, cooperative CHOs existed in 25 counties by 1920 and 103 counties by 1933. Start and stop dates varied, but for those with a cooperative CHO by 1933, the average number of active years was approximately 4.5 years.

Data on individuals comes from the 1900–1950 1% samples of the US decennial census available via Integrated Public Use Microdata Series (IPUMS)26. Individual-level information includes school attendance, occupation, literacy, and selected demographic and family characteristics.

5 Records from North Carolina document correspondence between Dr. Rankin and individuals and health departments throughout the US. This included many individuals in New York, also a leader in the development of US public health6.
6 Mountain West states include Nevada, Idaho, Montana, Wyoming, Utah, Colorado, Arizona, and New Mexico. West North Central states include North Dakota, South Dakota, Minnesota, Nebraska, Iowa, Kansas, and Missouri. Northeast states include Pennsylvania, New York, New Jersey, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine.
Figure 1  Horizontal axes range from 1914 to 1933. Vertical axes scales vary; Upper bounds are 1,200,000 for Alabama, 900,000 for Kentucky, 700,000 for Tennessee, 600,000 for North Carolina and Georgia, 500,000 for Mississippi, 450,000 for Louisiana, 400,000 for Virginia, 350,000 for Arkansas, and 200,000 for South Carolina and Texas. “Other” spending includes the Reconstruction Finance Corporation, the Indian Bureau, and other unlisted organizations.
We are interested in the relative importance of cooperative CHOs, both overall and in terms of their impact on the initial hookworm intervention. Due to missing individual-level data, we omitted 1930 and began with just over six million individuals across the five census years. Individuals born outside the US, of an unknown race, or outside the age range of 8–16 years were also excluded. For those analyses specific to the Southeast, we also limited our analysis to individuals residing in one of the 11 southeastern states with hookworm eradication work.

The dependent variables were school attendance, full-time school attendance, and literacy level. Individuals enrolled in school were considered full-time students if they had no recorded occupation. Measures of literacy are not available for individuals in the 1940 or 1950 census; therefore, they are excluded as dependent variables in models that include these samples.

Figure 2 The RSC States include Texas, Louisiana, Mississippi, Tennessee, Kentucky, Georgia, South Carolina, North Carolina, Alabama, Arkansas, and Virginia. Cooperative CHOs are those with recorded funding from the state, the county, and the Rockefeller Foundation at some point between 1910 and 1933. RSC-independent CHOs are those, which never received RSC funding. Grey counties are counties with recorded RSC activities between 1911 and 1915; green counties are those with no recorded RSC activities but located in an “RSC State”. 1933 is the last year of recorded data for the distribution and spending of CHOs in the US. RSC stands for the Rockefeller Sanitary Commission. CHOs stand for Country Health Organizations.

Covariates on health, health policy, education, race and race relations, and agricultural/rural conditions have been included from the publicly available data by David Roodman on his GiveWell website. 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 possibly correlated with both hookworm intervention and human capital.

Methods
To investigate the importance of institutional arrangements and the Rockefeller Foundation’s role in the success of county health organizations in improving human capital outcomes, we estimated a series of difference-in-difference and triple-difference models across the geographic samples of the American Southeast and the US. We expect the pres-

5 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 whom information exists, 138,991 did not attend school while 91,844 did. The small number of observations is likely due to privacy restrictions for the 1950 sample.
ence of CHOs, broadly defined, to be associated with improvements in human capital outcomes. However, we also expect greater impacts for cooperative CHOs.

The triple-difference model is useful in two ways. First, it allows a comparison with earlier estimates of the Rockefeller hookworm program to gauge whether including a CHO proxy reduces the estimated impact of the hookworm intervention. A reduction in the point estimate suggests the original hookworm intervention was less effective without subsequent investments in health infrastructure. This would provide evidence of treatment failure in areas that tried to eradicate hookworms but did not invest in rural public health. Second, the triple-difference model estimates the complementarity between the initial hookworm intervention and secondary CHO intervention. For these reasons, we perform our analysis within Bleakley’s existing sequential cohort analysis framework. Due to shifting county boundaries, earlier analyses used aggregated county groupings, or “State Economic Areas” (SEA), as the geographic unit. We follow that convention.

To evaluate how the presence of independent and cooperative CHOs moderate the relationship between Rockefeller hookworm intervention and human capital outcomes, we include a SEA-level measure of the presence of these local health stations in the sequential cohort analysis framework and interact it with the original hookworm interaction. Where the original analysis represented a diff-in-diff method, this adds another level of variation and represents a “diff-in-diff-in-diff” model. By design, this model attributes the full reduction in hookworm infection rates to the initial intervention. The effectiveness of this reduction was then evaluated across areas with and without county health organizations. Hookworms were not eradicated in 1915, and the eradication efforts shifted to county health organizations starting in 1917. As such, this method underestimates the number of years spent in each county within SEA, averaged over both the number of counties in SEA and the number of years surveyed.

To aggregate the county-level CHO data to the SEA level and account for the years of activity, we estimated the proportion of county-level years a given SEA had an active CHO (or cooperative CHO) as a measure of the intensity of CHO activity. This proportion is equal to the number of years spent in each county within SEA, averaged over both the number of counties in SEA and the number of years surveyed.

\[
CHO_{share} = \frac{1}{K} \frac{1}{T} \sum_{k=1}^{K} \sum_{t=1}^{T} CHO_{share, k, t}, \forall k \neq j
\]

\(CHO_{share, k, t}\) is an indicator equal to 1 if county \(k\) has any spending on a CHO (or cooperative CHO) in year \(t\). \(T\) is equal to either 1920 (the model estimating short-term effects between 1910 and 1920) or 1933 (the model estimating longer-run effects between 1900 and 1940). For a cooperative CHO that began in 1920 and recorded data until 1929 but had no spending data recorded in 1923 and 1924, which existed in a SEA with four other counties with no recorded activity, we calculated the SEA-level CHO share as \((10-2)/24 \times 1/5 = 0.066\). The CHO share variable is correlated with the number of counties in an SEA, and SEAs with fewer counties tend to be more urbanized and economically developed; therefore, we include a variable \(K\) for the number of counties in each SEA in the model specification below:

\[
Y_{i,j,t} = \beta_0 (CHO_{share, \text{all} \times Post}) + \beta_1 (CHO_{share, \text{coop} \times Post}) + \beta_2 K + (\delta_1 + \delta_2) + \delta_3 + \chi_{i,j,t} \Gamma + e_{i,j,t}
\]

\(Y_{i,j,t}\) represents one of the three outcome variables for individual \((i)\) in SEA \((j)\) for census year \((t)\). \(H_{\text{coop} \times Post}\) is the interaction between hookworm infection rates and an indicator for the period after 1915 (hereafter referred to as the “hookworm interaction”), which acts as a proxy for RSC intervention.

\(\delta_1\) are fixed effects for the different census years, \(\delta_2\) are fixed effects for SEA, and \(\chi_{i,j,t}\) is a vector of control variables. We note that the SEA trend interaction \((\delta_1 + \delta_2)\) is applicable only to the long-term model.

\(\text{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. Within two years, another four counties had been included in the cooperative plan, with five more having requested cooperation. Once the General Assembly approved appropriations for these counties, they could start their cooperative CHO. As such, there existed variation with regard to when a specific cooperative CHO began.}

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Table 1: Cooperative versus non-cooperative county health organizations (CHOs) in the American South

| Sample: American South | Person controls | Person and geographic controls |
|------------------------|-----------------|--------------------------------|
|                        | School Enroll. | FT Sch. Attend. | Lit. | School Enroll. | FT Sch. Attend. | Lit. |
| Short Term (1910–1920)  |                 |                   |      |                 |                   |      |
| CHOshare_{ALL}$^\dagger$ $* Post,  | 0.0239 (0.029)  | −0.0158 (0.040)  | −0.00874 (0.160) | 0.0218 (0.018)  | −0.012 (0.040)  | −0.00951 (0.001) |
| CHOshare_{COOP}$^\dagger$ $* Post,  | 0.188** (0.040) | 0.416** (0.064)  | 0.0503 (0.034)  | 0.167** (0.040) | 0.425** (0.064) | 0.0329 (0.035)  |
| Observations Incl. SEAs | 106,188 | 106,188 | 81,474 | 95,106 | 95,106 | 73,016 |
| Long term (1900–1950) W/ SEA trends |                 |                   |      |                 |                   |      |
| CHOshare_{ALL}$^\dagger$ $* Post,  | 0.0226 (0.033)  | −0.0155 (0.034)  | 0.0255 (0.034)  | 0.00325 (0.032) |
| CHOshare_{COOP}$^\dagger$ $* Post,  | 0.0853 (0.160)  | 0.0881 (0.167)  | 0.0552 (0.181)  | 0.0312 (0.186)  |
| Observations Incl. SEAs | 221,144 | 221,144 | 197,937 | 173 | 173 | 173 |

Robust standard errors in parentheses. **P<0.01, *P<0.05, †P<0.1. Presented coefficient estimates are those from the equation (4). This sample is selected to be as close as possible to that selected by Bleakley (2007), where we include individuals only in those areas with surveyed for hookworm infection rates, born in the US, 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, and so it is excluded as a dependent variable for those years. The independent variable for the SEA-level sanitation index is only available for RSC surveyed areas, so is excluded from the set of control variables above.

The full panel is presented in the bottom half of Table 1. The estimated effects from the long-term panel suggest that cooperative CHOs may be important because the coefficient magnitudes for the cooperative CHO interaction are 2× to 10× greater than those for the overall CHO interaction. However, none of the estimated coefficients are statistically significant. A comparison with the earlier panel suggests that the returns diminished over time or that SEAs with a lower intensity of rural public health work in the American Southeast before 1933 tended to converge on those with more public health activity.

Expanding our sample to cover all of the US indicates that the cooperative arrangement was also important across

Regression Equation (2) presents the diff-in-diff-in-diff model with SEA-level trends. Of primary interest is the statistical and economic significance of $\beta_1$ and $\beta_2$. The former will indicate whether these local health stations are independently important. The latter will indicate whether the institutional organization of rural public health was influential in the success of CHOs in improving outcomes.

Results

Table 1 presents the results of Equation (2). The top half of the table includes the estimates from the 1910 to 1920 panel. Only areas with cooperative CHOs correlate with improvements in outcomes for the short-term period. The estimated coefficients of the (CHOshare_{COOP}$^\dagger$ $* Post) interaction are mostly negative and close to zero, and none of the estimated coefficients is statistically significant at the 10% level. In contrast, the estimated coefficients of the (CHOshare_{COOP}$^\dagger$ $* Post) interaction are all positive. For the school attendance variables, they are statistically significant at the 1% level.

This vector of control variables contains different covariates depending on the specification. The ‘basic’ or ‘partial controls’ specification contains individual-level covariates for age, sex, and race. The ‘full controls’ specification includes SEA-level covariates measuring health, health policy, education, race, and agricultural/rural conditions. For health and health 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 of the black population, 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, crop acreage per capita, sharecropped areas per capita, farm value per capita, cotton acreage per capita, and tobacco acreage per capita.

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Cooperative versus non-cooperative county health organizations (CHOs) across the US

Table 2

| Sample: United States                                                                 | Person controls                  | Person and geographic controls |
|--------------------------------------------------------------------------------------|----------------------------------|--------------------------------|
|                                                                                      | School Enroll. | FT Sch. Attend. | Lit. | School Enroll. | FT Sch. Attend. | Lit. |
| Short Term (1910–1920)                                                               | (1)            | (2)             | (3)  | (4)            | (5)             | (6)  |
| CHOshare_{ALL} \* Post,                                                               | 0.0284*        | 0.0505*         | 0.0127 | 0.0259*        | 0.0503*         | 0.0126 |
| (0.015)                                                                             | (0.024)        | (0.009)         | (0.015) | (0.024)        | (0.009)         |      |
| CHOshare_{COOP} \* Post,                                                             | 0.307**        | 0.960**         | 0.216**| 0.289**        | 0.952**         | 0.207**|
| (0.042)                                                                             | (0.087)        | (0.039)         | (0.042) | (0.086)        | (0.039)         |      |
| Observations Incl. SEAs                                                             | 336,942        | 336,942         | 258,454 | 322,074       | 322,074         | 247,113|
|                                                                                      | 467            | 467             | 467   | 430           | 430             | 430   |
| Long term (1900–1950) W/ SEA trends                                                 |                 |                 |       |               |                 |      |
| CHOshare_{ALL} \* Post,                                                               | 0.0377*        | 0.0235          |       | 0.0342†        | 0.0229          |      |
| (0.018)                                                                             | (0.019)        |                 |       | (0.018)        | (0.019)         |      |
| CHOshare_{COOP} \* Post,                                                             | 0.171          | 0.443**         |       | 0.188          | 0.476**         |      |
| (0.221)                                                                             | (0.117)        |                 |       | (0.234)        | (0.124)         |      |
| Observations Incl. SEAs                                                             | 705,354        | 705,354         |       | 677,154        | 677,154         |      |
|                                                                                      | 467            | 467             |       | 430           | 430             |      |

Robust standard errors in parentheses. **P<0.01, *P<0.05, †P<0.1. Presented coefficient estimates are those from the equation (4). This sample is selected to be as close as possible to that selected by Bleakley (2007), where we include individuals only in those areas with surveyed for hookworm infection rates, born in the US, 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, and so it is excluded as a dependent variable for those years. The subset of geographic controls presently available for the entire US include variables for the hookworm examined rate per capita (0 for non-RSC areas), WWI cantonment size per capita, malaria mortality between 1919 and 1921, the change in fertility between 1900 and 1910, change in the return to literacy rates, baseline literacy rates from 1910, the change in urbanization between 1900 and 1910, the fraction black population in 1910, and agricultural variables for crop acreage per capita, share crop acres per capita, farm value per capita, cotton acreage per capita, and tobacco acreage per capita.

The country, as shown in Table 2. Regarding the short-term panel (1910–1920), any county health organization’s presence was associated with increased school attendance and literacy. However, the estimated effect of cooperative CHOs is an order of magnitude larger and statistically significant at the 1% level. This result holds when both personal and geographic controls are added. In SEAs with cooperative CHOs, we observed increases of 28.9%, 95.2%, and 20.7% in school enrollment, full-time school attendance, and literacy, respectively. Regarding long-term outcomes, cooperative CHOs are associated with increased school attendance, full-time school attendance, and literacy. These effects were positive and statistically significant but differed geographically. Cooperative CHOs in the American Southeast region were mostly associated with improvements in school enrollment and literacy. In contrast, cooperative CHOs elsewhere were mostly associated with improvements in full-time school enrollment.

In the long term (1900–1950), cooperative CHO activity was not significantly associated with increased school enrollment. This again suggests that areas with a lower intensity of rural public health work before 1933 tended to converge with those with more public health activities. However, we do note that cooperative CHOs outside the American Southeast are associated with persistent increases in full-time school enrollment of about 21% to 26%.

Table 3 shows the full US sample but includes variables for geographic location (South * Post, and CHOshare_{COOP} * Post, * South). This model splits the impact of cooperative CHOs between those in the US (CHOshare_{COOP} * Post) and those in the American South (CHOshare_{COOP} * Post * South) so we estimate the linear combination of the coefficients across separate variables. Thus, the CHO Joint Test is important, while the coefficients on the separate variables indicate in which geographic area (American Southeast or outside the American Southeast) the effects were strongest. In the short term (1910–1920), cooperative CHOs were associated with increased school attendance, full-time school attendance, and literacy. These effects were positive and statistically significant but differed geographically. Cooperative CHOs in the American Southeast region were mostly associated with improvements in school enrollment and literacy. In contrast, cooperative CHOs elsewhere were mostly associated with improvements in full-time school enrollment.

Table 4 reports the results on independent CHOs across the US, including the Southeast. Immediately evident is the consistently negative and statistically significant relationship between the presence of independent CHOs and human capital outcomes. This is the case for the short-term and long-term effects, with the joint CHO effect estimated to be about a 3% to 5% reduction in schooling attendance and literacy. These effects are a reversal of those seen for the cooperative CHOs. Furthermore, if there are areas that ben-
benefited from the presence of independent CHOs, these areas were in the Southeast. This suggests a residual connection between the early hookworm work. Subsequent investments in public health were undertaken without the cooperation of the Rockefeller Foundation. Over the longer term, the impact of CHOs outside the Southeast is marginally positive, if not statistically significant. However, within the Southeast, SEAs with independent CHOs were associated with an approximately 6.8% reduction in full-time school enrollment.

**Discussion**

The Rockefeller Foundation hookworm eradication campaign ended in 1915, but public health efforts in the United States did not. County health organizations formed under the Cooperative Plan of County Health Work continued the work of hookworm eradication campaigns but with a broader focus on public health. Hookworm dispensaries evolved into rural public health stations, and the Rockefeller Foundation was instrumental in promoting the expansion of rural public health in the US through its relationships and advocacy with public health departments. However, this expansion was uneven and impermanent. County health organizations were mostly found in the American Southeast region, where the Rockefeller Foundation had been active with its hookworm programs. The geographic distribution of these rural health stations is striking, with concentrations in the Carolinas, Alabama, and Mississippi River Valley, where hookworm infection rates in the early 1910s were the highest.

Furthermore, many of the rural health stations did not

| Table 3  | Cooperative county health organizations (CHO) in the American South versus the US |
|-------------------|-----------------------------------------------|
| **Sample: United States** | | **Person controls** | **Person and geographic controls** |
| | | (1) | (2) | (3) | (4) | (5) | (6) |
| **Short Term (1910–1920)** | | | | | | |
| $CHO_{i, t}^{\text{COOP}} \times \text{Post}_t$ | $-1.700^{**}$ | $0.642^{**}$ | $-0.276^{**}$ | $-1.786^{**}$ | $0.760^{**}$ | $-0.237^{**}$ |
| $(0.073)$ | $(0.068)$ | $(0.019)$ | $(0.073)$ | $(0.071)$ | $(0.017)$ |
| $South_j \times \text{Post}_t$ | $0.0217^{**}$ | $0.114^{**}$ | $0.0315^{**}$ | $0.0194^{**}$ | $0.115^{**}$ | $0.0312^{**}$ |
| $(0.003)$ | $(0.004)$ | $(0.003)$ | $(0.003)$ | $(0.004)$ | $(0.003)$ |
| $CHO_{i, t}^{\text{COOP}} \times \text{Post}_t \times South_j$ | $1.916^{**}$ | $-0.236^{**}$ | $0.337^{**}$ | $1.997^{**}$ | $-0.355^{**}$ | $0.294^{**}$ |
| $(0.081)$ | $(0.090)$ | $(0.037)$ | $(0.081)$ | $(0.091)$ | $(0.036)$ |
| CHO joint test | $0.215^{**}$ | $0.406^{**}$ | $0.0614^{*}$ | $0.211^{**}$ | $0.4042^{**}$ | $0.057^{†}$ |
| $(0.0394)$ | $(0.0618)$ | $(0.0337)$ | $(0.0394)$ | $(0.0617)$ | $(0.0337)$ |
| Observations Incl. SEAs | $336,942$ | $336,942$ | $258,454$ | $322,074$ | $322,074$ | $247,113$ |
| | $467$ | $467$ | $467$ | $430$ | $430$ | $430$ |
| **Long term (1900–1950) W/ SEA trends** | | | | | | |
| $CHO_{i, t}^{\text{COOP}} \times \text{Post}_t$ | | $0.0724$ | $0.214^{*}$ | $0.126$ | $0.257^{†}$ |
| $(0.118)$ | $(0.105)$ | | $(0.134)$ | $(0.135)$ |
| $South_j \times \text{Post}_t$ | | $0.0281$ | $0.0920^{**}$ | $0.0272$ | $0.0938^{**}$ |
| $(0.031)$ | $(0.018)$ | | $(0.032)$ | $(0.018)$ |
| $CHO_{i, t}^{\text{COOP}} \times \text{Post}_t \times South_j$ | | $0.0402$ | $-0.151$ | $-0.0153$ | $-0.194$ |
| $(0.160)$ | $(0.191)$ | | $(0.168)$ | $(0.207)$ |
| CHO joint test | | $0.1126$ | $0.063$ | $0.111$ | $0.063$ |
| $(0.1496)$ | $(0.1664)$ | | $(0.1498)$ | $(0.1664)$ |
| Observations Incl. SEAs | $705,354$ | $705,354$ | $677,154$ | $677,154$ | $677,154$ |
| | $467$ | $467$ | $430$ | $430$ | $430$ |

Robust standard errors in parentheses. **$P<0.01$, *$P<0.05$, †$P<0.1$. Presented coefficient estimates are those from equation (4). This sample is selected to be as close as possible to that selected by Bleakley (2007), where we include individuals only in those areas with surveyed for hookworm infection rates, born in the US, 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, and so it is excluded as a dependent variable for those years. The subset of geographic controls presently available for the entire US include variables for the hookworm examined rate per capita (0 for non-RSC areas), WWI cantonment size per capita, malaria mortality between 1919 and 1921, the change in fertility between 1900 and 1910, change in the return to literacy rates, baseline literacy rates from 1910, the change in urbanization between 1900 and 1910, the fraction black population in 1910, and agricultural variables for crop acreage per capita, share crop acres per capita, farm value per capita, cotton acreage per capita, and tobacco acreage per capita.
The cooperative plan of county health work, from which many of these CHOs sprang, was intended as a temporary program where local governments could see the benefits of improved public health and continue their expansion independently. However, many counties stopped funding county health organizations after only a few years. In Georgia, for example, 18 counties had stopped funding county health organizations before 1933.

Overall, the Rockefeller Foundation-led rural public health expansion in the American Southeast and across the US Cooperative CHOs had a positive impact. Under the public-private cooperative plan of county health work and partially supported by Rockefeller funds, it appears to have been effective at improving human capital outcomes, at least while they were in operation.

**Conclusion**

County health organizations grew as public and private institutions pushed for the expansion of rural public health in the US. A significant factor in this expansion was the cooperative plan of county health work formed between the state of North Carolina and the Rockefeller Foundation in 1917. This represents an evolution of these two entities’ more focused public health intervention to eradicate hookworm five years prior. Like the original hookworm campaign, the CHO movement was uneven and impermanent, with only a portion of the counties choosing to invest. However, those which did invest experienced increased human capital outcomes, at least in the short term. The institutional arrangements of these rural public health stations are the
most important aspect. County health organizations formed under the public-private cooperative plan of county health were associated with the largest gains.

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