Public Health Movements, Local Poor Relief and Child Mortality in American Cities: 1923-1932

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Abstract

This paper examines the effectiveness of the public health education and poverty relief programs prior to the New Deal. Prior researchers have speculated that these programs contributed to the declining mortality rates during the 1920s, but have been unable to econometrically estimate their impact. This paper uses new data on municipal health education expenditures, as well as data on spending to relieve poverty, to separately estimate how effective each of these different types of programs were at reducing child mortality. A panel of 67 cities over 10 years is created, and the effects are identified using the variation within cities over time, after controlling for nation-wide shocks to the system. Fixed effects estimations suggest that spending on both health education and poverty relief were relatively low cost ways to reduce mortality for infants and school age children. Additionally, spending on public health education was extremely cost effective at reducing infant and child mortality rates, with about $27,000 2007 dollars associated with an infant death averted. This supports assertions by prior researchers that education and changing behaviors was the primary reason for falling infant and child mortality in the early twentieth century.

1. Introduction

During the early 20th century, infant mortality and child mortality declined substantially both in urban and rural areas. Prior to 1910, for every 1,000 babies born in the United States, 165 died before their first birthday, and the rate was even worse in rural areas (Newmayer 1911). However, by 1920 the infant deaths fell to about 85 deaths per 1,000 live births, and by 1930 dropped to 65. Child mortality experienced similar declines. Municipal sanitation and water projects explain a substantial part of this decline in the 1910s (Cutler and Miller 2005), but there is still a great deal of variation left unexplained. This is true especially for the 1920s when all major cities already had clean water and sanitation, yet were still gradually improving their health outcomes. Public health historians suggest that one reason for the decline was improvements in the education of the population about simple health procedures like hand washing and boiling water. This paper investigates these early public health education programs in the large municipalities and estimates their influence on declining mortality among children and infants. From an historical perspective, this will inform on the potential causes behind the health transition that occurred in the United States in the early twentieth century. Additionally, the educational programs of the state, municipal, and county health departments were much more cheaply implemented than the large scale public works projects developed in the cities in the decade prior. It is important to evaluate the success of these programs because they are inexpensive relative to the large sums needed for sanitation and water filtration works. In settings where locales have limited access to the necessary capital to build the sanitation and filtration infrastructure, these programs are potentially low cost ways to reduce mortality while waiting to build the larger public works. They may also be low cost and complementary ways to lower mortality even after the works are built.

While the U.S. experienced great reductions in infant and child mortality in the first few decades of the twentieth century, there was also a great deal of inequality in the improvements. The adjustments were uneven, and there existed substantial variation across locations in the mortality trends, as well as in the type and extent of public health and poverty relief programs. Before the New Deal of the 1930s, few federal welfare or public health programs existed, and those that did were either investigative bodies or mandated states to distribute benefits to certain classes of people. As was the case for decisions about poverty assistance, most health spending decisions were made at the state, city or county level. For this reason, this paper focuses on the period prior to the introduction of the New Deal in 1932. By choosing the decade of the 1920s, I can analyze the effectiveness of state and local public health and poverty assistance programs at saving the lives of children without them being confounded by large-scale changes associated with the New Deal.[1] And this was not only a period of fairly stable growth in American municipalities, but major medical technological advances were largely absent.

Given the concurrence of the declines in child and infant mortality with the growth of public health work, it is natural to think the two related. Many believe that the public health education played an important role in improving outcomes (Ferrell et al 1932, Vincent 1921, Blackburn 1927, Ewbank and Preston 1989, Preston and Haines 1991), although there has yet to be an econometric estimate of their impact. Preston and Haines (1991) attribute a lack of know-how rather than a lack of resources as being primarily responsible for poor health outcomes in the late nineteenth and early twentieth centuries. And in summarizing their points regarding the effects of behavioral changes encouraged by these early public health education programs in the first few decades of the United States, Ewbank and Preston state that "While the case is hardly air-tight and perhaps can never be made so, we believe this

[1] The analysis is constrained to those years after 1923 because the level of financial detail necessary is not available between the years 1920-1922

evidence suggests that personal health practices, especially those which reduced children's exposure to pathogens, were a major contributor to the declines in infant and child mortality" (Ewbank and Preston 1989, page 143).

Without data on the state and local health and education programs, researchers studying determinants of the early twentieth century mortality decline have either controlled for the influence of the public health education movement using the timing of major water and sanitation installments in a difference-in-differences model (Cutler and Miller 2005), year and geography fixed effects (Troesken 2004) or inferred its effects by comparing differential mortality trends across occupational groups (Ewbank and Preston 1989). New data on municipal health education spending allows separate estimation of the effects of public health education from those of other city spending, and evidence to inform whether or not a city's emphasis on personal behavioral changes positively affected their health outcomes.

2. Public health education and poverty relief in the early 20th Century

Public health and poverty assistance programs first started gaining support in the early 20th century as birth and death registration areas grew. As these areas expanded, data collected on births and deaths were gathered on a more consistent basis and became more reliable for comparisons. Demographers began to have a clearer picture of the how poorly children fared in the United States compared with other developed countries, and public health advocates began to question if perhaps the U.S. could possibly do better (see, for instance, Newmayer, 1911). Research by scientists such as Louis Pasteur in the late 1800s on the relationship between sanitation and health, and by Paul Karrer on the importance of vitamins and nutrients offered ways in which these issues could be addressed. Public health

education, through dissemination of this new knowledge regarding germs and vitamins, had the opportunity to improve health outcomes and lower mortality.

Several public programs were designed with the goal of reducing child mortality rates. Child and woman advocacy groups (Skocpol et. al, 1993) influenced politicians to pass legislation such as mothers' pensions, form organizations such as the Children's Bureau, and encourage state and city departments of health to form child hygiene divisions and distribute information about how to improve health outcomes.

The Children's Bureau, formed in 1912, was charged with investigating and reporting on all matters pertaining to the welfare of children and child life. Through its publications and political presence, the bureau helped bring attention to the exceptionally high mortality rates in some U.S. cities and for certain classes of people. Although its mandate included investigation of the "whole child," a limited budget, reluctance to duplicate work by other federal agencies, and desire to minimize conflict with the American Medical Association induced the bureau to limit its initial focus to the causes and potential solutions of the high infant mortality rates. An inquiry into these causes and solutions in the city of Johnstown, PA was the first field study done by the Children's Bureau and for the first two years absorbed almost its entire attention (Department of Labor, 1915). Other cities were chosen for case studies to isolate factors associated with different types of industrialization.[2]

The studies led the Children's Bureau to conclude that high infant mortality rates were not only the result of poor hospital care or ignorance among birthing mothers but also the result of a range of socioeconomic factors related to poverty. In 1916, Julia Lathrop, chief of the Children's Bureau, mentions the “coincidence of a high infant mortality rate with low

[2] By 1918, the field studies included a steel city (Johnstown, PA), two textile cities (Manchester, N.H. and New Bedford, MA), a center for the manufacture of high grade shoes (Brockton, MA), a manufacturing city with no one dominant industry (Saginaw, MI), a city with the production of brass as its dominant industry (Waterbury CT), a rubber manufacturing center (Akron, OH) and lastly, a large cosmopolitan area (Baltimore, MD) (Lathrop, 1918).

earnings, poor housing, mother's work and large families (Department of Labor, 1916)." She expanded on these ideas in her contribution to the 1920 Report of the Department of Labor:

> "From the findings in Baltimore certain facts stand forth to which we as a Nation can no longer close our eyes. Without qualification - regardless of color, race or nationality - the infant death rate varies inversely with the father's income. When the father's income represented the ability to insure care and comfort ($1,850 a year or more) the infant death rate was one-fourth as high as when the father's earnings fell into the lowest wage group.[3]"

The bureau's findings stressed the importance of socioeconomic conditions and emphasized a middle class family ideal, for the most part ignoring the impact of medical causes. Since the Children's Bureau did not have a physician on staff for the initial field studies and in any case wanted to avoid stepping on the toes of the American Medical Association, factors like the importance of proper medical care, clean milk and other sanitation related variables were left up to the Public Health Service to study (Lindenmeyer 1995).

The Children's Bureau did, however, encourage the development of maternal and child hygiene divisions within city and state health departments and lobbied strongly for the Sheppard-Towner act, which passed Congress in 1921. This act constituted the first federal public health program and had its primary focus on health education. Federal matching grants were distributed to states with specific instruction in their use. Recipients were prohibited from using the money for any form of capital improvements, purchases or stipend payments (U.S. Children's Bureau 1924). Instead, the money was intended to pay for the operation of health centers to instruct mothers in hygienic ways and to distribute pamphlets to new mothers about how best to care for their baby (Thompson 1921).

The Sheppard-Towner grants consisted of an initial grant, $5,000 denominated nominally, and additional money in the form of matching grants up to some specified

[3] This $1,850 refers to nominal wages in 1920

maximum based on a state's population. If a state chose to accept the Sheppard-Towner appropriations, it was required to designate a maternity and infant hygiene division within their health department to disburse the funds. Although most states accepted some level of the available federal Sheppard-Towner funds, many only took a portion and Connecticut, Illinois, and Massachusetts chose not to participate at all.[4] Of those states not participating, Connecticut did not engage in county health work, but sent out literature on baby hygiene to new mothers and held "well-child" conferences in various towns throughout the state. Illinois had established 6 county health organizations between 1922 and 1929 (although these all had been discontinued by 1930), subsidized clinics for treatment of indigents, and promoted maternal and infant hygiene through distribution of prenatal literature and sending out nurses for personal instruction to mothers. Massachusetts set up "well-child" conferences and had a law requiring the medical examination of all school children.

Localities within participating states had to be prosperous enough to be able to match the grants, although counties and cities that did not directly receive Sheppard-Towner funds still the effects of the educational awareness promoted by it. Many of the maternal and child hygiene divisions arose in the state and municipal health departments shortly after the Act's passage (Ferrell et al. 1932, U.S. Public Health Service 1923), and in at least one state, North Carolina, the funds were the primary support for its Bureau of Maternity and Infancy.

The Children's Bureau studied the reasons behind the high child mortality rates because they knew that information was essential in designing policy to combat them. This perspective still holds. If poverty was the primary cause, then welfare-type social programs would be most effective at reducing the number of child deaths. Alternatively, if a general absence of hygiene, nutritional, and birthing information was the issue, then spending on health and mother's education would be more effective. This paper uses data on two different

[4] For a good analysis of the political economy of state adoption of the Sheppard-Towner act, see Moehling and Tomasson, 2010.

types of social programs, one educational and another directed towards transfer payments, to separately estimate how effective each of these different types of programs were and give an empirically rigorous answer to whether it was the public health education programs or the poverty relief programs which drove the mortality declines in American cities. The effects are identified using a panel data set that controls for city-level time-invariant factors as well as annual nationwide shocks. Once these effects are identified, the differences regarding how these types of variables affect mortality is explored. Specifically, a model controlling for city-specific trends is used to control for differential trends within the municipalities. It is possible that public health education programs and poverty relief programs act in different ways to improve health. For education, the aggregate amount of spending may be the important variable; annual flows are less important than the total amount of education disseminated. Conversely, for poverty relief programs it may be that annual increments are more important than the total amount distributed. Controlling for city-specific trends will help illuminate for each of these programs whether it is simply the aggregate amount of spending that is important, or whether annual flows are necessary to sustain health improvements.

3. The data and basic correlations

The panel data set is composed of annual information from 67 cities with populations over 100,000 during the period 1923-1932. Those years were chosen both for data availability reasons and to eliminate the effect of any New Deal programs enacted after 1932.[5] City financial data, including spending on sanitation, health, mothers' pensions, and other forms of poverty relief were collected from the *Financial Statistics of Cities* volumes, published by the Department of Commerce. Per capita summary statistics adjusted to 2007 dollars for each of

[5] Fishback, Haines, and Kantor (2007) examine the time period from 1929 through 1940 to examine the role of the New Deal in influencing infant deaths, noninfant deaths and births.

the spending variables are given in the top panel of Table 1. Population data were also collected from the *Financial Statistics of Cities* volumes, and when missing, estimated between the nearest two years.[6]

The two financial variables of primary interest are the spending on public health education in a city, and the spending on poverty assistance. Spending on public health education includes spending on the medical inspection of school children and spending for education about proper hygiene, milk preparation techniques and other things that could be done to conserve child life. Money distributed under the "medical inspection for school children" category helped pay for physician and nurse visits to distribute information and perform physical examinations. School children were not treated, but their parents were informed if any defects were found. Spending on poverty assistance includes spending on mothers' pensions, funding for almshouses and orphanages and other charitable spending for children. "Outdoor care" of the poor who lived outside almshouses generally comprised the largest portion of poverty assistance.[7] This was especially true for cities with populations between 100 and 300 thousand, since many of those did not provide aid in the form of mothers' pensions.[8] Adjusted to 2007 dollars, an average city in the dataset spent about $3.15 per person on health programs for children and about $16.23 per person on poverty assistance.

[6] The cities interpolated were: Los Angeles, CA, 1924-1927; Seattle, WA, 1924-1927; Portland, OR 1925-1927; Akron, OH 1924-1927; Bridgeport CT, 1924-1927; New Bedford, MA, 1926-1927; Norfolk, VA , 1924-1925; Lowell, MA, 1926-1927; Lawrence, MA, 1926-1927; Elizabeth, NJ, 1924-1927; Erie, PA, 1924-1927; Waterbury CT, 1924-1927; Jackson, FL, 1926-1927; Hoboken, NJ, 1923-1925; Brockton, MA, 1926-1927; Davenport, IO, 1926-1927; Haverhill, MA, 1926-1927; Wheeling, WV, 1923-1927; Superior, WI, 1923-1927; Auburn, NY, 1926-1927; Newport, VA, 1923-1924.

[7] This typically involved relief to individuals or families that due to unemployment, illness, accident, or for perhaps some other reason, were temporarily dependent. It also sometimes involved the giving of aid more or less permanently, when it seemed desirable to keep a family together instead of scattering its members among institutions.

[8] 24 out of the 67 cities in the panel did not provide aid in the form of mothers' pensions.

The city spending data were matched with city mortality data entered from the Mortality Statistics volumes, published by the Department of Commerce. Figure 1 plots the crude death rates for infants, as well as for children aged 1 to 4, 5 to 9 and 10 to 14. What is first clear is that there is more variation in mortality for the younger age groups during this period than for the older age groups. However, every child age group experienced mortality declines between 1923 and 1932. This is particularly interesting given that, except for Milwaukee, every city in the sample had developed their water and sewer systems prior to the start of the panel. The crude death rate for infants in sample cities declined from about 1.8 in 1923 to about 1 in 1932. Infant mortality rates for cities in the Birth Registration Area (BRA), calculated as the number of infant deaths per 1,000 live births, saw similar declines. Averaged across those sample cities in the BRA, infant mortality decreased from over 90 deaths per 1,000 live births to fewer than 56 deaths per 1,000 live births. This paper does not use the more conventional infant mortality rate in its primary analysis because the size of the BRA in 1923 was much smaller than the size of the death registration area. Specifically, usage of the more conventional infant mortality rate requires dropping cities in Alabama, Georgia, Louisiana, and Texas that are currently in the sample. Most importantly, those states and cities that chose not to participate in the BRA were also states and cities at the bottom of the spending distribution for both health education and poverty relief. Eliminating non-BRA participating states from the analysis would result in a selection bias as well as a reduction in the identifying variation in health education and poverty relief spending across areas. However, it is likely that public health education and poverty relief programs also reduced fertility rates within municipalities. Section 5 re-estimates the primary model using two measures to control for the number of births in cities to examine this.

Mortality rates for children aged 1-4 also decreased considerably over this period, dropping nearly 60 percent from their level in 1923. Meanwhile, mortality rates for children

aged 5-9 decreased only slightly. Both in absolute terms, and relative to the other child age groups, mortality rates for infants experienced the greatest improvement. In 1923 the mortality rate for infants was at least twice as large as the mortality rate for any of the other child age groups, but by 1932, the gap had fallen significantly.

Figure 2a plots the annual mean-differenced crude infant death rate within cities for groups of cities in the bottom and top quartiles of aggregate health education spending between 1923 and 1932. The trends show that cities that spent a relatively large amount on health education generally had crude infant mortality rates much greater than other large cities in the early 1920s. However, by 1932 these cities were performing better than the average.[9] Figure 2b plots the annual mean-differenced death rates for children aged 1 to 4 for the same sets of cities, and a similar story occurs. Cities that spent more on health education between 1923 and 1932 on average experienced worse death rates in the early 1920s, while cities that spent less on average had child death rates below the mean. However, by 1926, the positions of the bottom and top quartiles had reversed.

Figures 2c and 2d perform the same exercise for cities at the top and bottom quartiles of poverty relief spending. Stratifying the cities by their level of poverty relief spending reveals an even greater difference in trends. The crude infant mortality rate fell substantially relative to the average within cities in the top quartile of poverty relief spending. However, cities that chose not to invest in this experienced a growing gap between them and the average large city in the United States. Figure 2d illustrates similar trends.

The information plotted in figures 2a through 2d suggests that in the case of small children and infants, both spending on public health education and spending on poverty assistance were associated with improving health outcomes in the cities. Taking this a step further, figures 3a and 3b plot the number of infant deaths per thousand people against per

[9] Plotting the infant mortality rate for the top and bottom quartiles for the subset of cities with birth data reveals similar patterns.

capita public health education spending (Figure 3a) and per capita poverty relief spending (Figure 3b). Figures 3a and b also include the basic regression estimates between the crude death rate for infants and the amount of different types of spending. These estimated regression lines display the raw correlations and show what conclusions would have been drawn from the data with a method often used to evaluate the success of the policies in the 1920s and 1930s.[10]

The coefficient of -0.046 in the regression line in Figure 3a implies that a reduction of one infant death would have been associated with an additional 21,645 2007 dollars of per capita public health education spending. The coefficient of -0.0049 on poor relief spending in Figure 6b is an order of magnitude smaller. About 204,000 2007 dollars of poverty relief spending was associated with the reduction of one infant death. Figures 3c and 3 d plot the health education and poverty relief spending against the death rates for children aged 1-4. The coefficients for the older age group are negative, but smaller in magnitude than those for the infants and small children. From these basic correlations it appears that smaller amounts of health education spending than of poverty relief spending are associated with lower mortality rates for each of the different age groups. Additionally, infant death rates are most sensitive to changes in either type of spending.

For these basic correlations to represent a causal effect, spending on public health education and poverty relief would need to have been completely uncorrelated with any other factors that may have influenced the crude death rates. This is a strong assumption since it, among other variable relationships, assumes elements such as per capita income or general schooling do not influence mortality and public health education jointly. If charitable and public health spending levels were greater in cities with more per capita income and per capita income was correlated with lower mortality rates, then failing to include a measure of

[10] See, for instance, the Department of Labor Annual Reports, as well as Lathrop 1919, Abbot 1922, Tobey 1925, Vaughn 1922, and Levy 1920

income would lead to estimating a much larger effect of the spending than was actually the case.

To control for the potential biases, various measures of income and other correlates that likely influenced child mortality were collected. The income measure is average annual earnings from the manufacturing sector. To control for differences in the distribution of income, an additional measure of the number of tax returns filed as a share of the municipal population in a year was collected. This gives the number of jointly filing couples in each city with incomes above $5,000 (about $60,000 in 2007 dollars), and individual filers with incomes over $2,000. Although this is a measure of the income share held by the highest income people, it also provides indirect information about the share in the bottom tail of the distribution because I am simultaneously controlling for average manufacturing earnings. County demographics, which includes information on urbanization, minority concentrations and literacy rates are included, as are municipal spending on hospitals, sanitation and other activities, and other data that could be related to both spending and mortality. These variables and their sources are explained in Data Appendix.

4. Econometric model and results

The panel data set is used in the following estimation equation:

$$UMR_{i,t}^{a} = \beta_1 PHE_{i,t-1} + \beta_2 CPR_{i,t} + \sum_{j=1}^{J} \beta_{j+3} X_{j,t,t} + \beta_{J+4} C_i + \beta_{J+5} Y_t + \varepsilon_{i,t}^{a}$$

Where $UMR_{i,t}^{a}$ is the crude urban mortality rate for age group *a* in city *i* and year *t*. $PHE_{i,t-1}$ is the amount of spending on public health education occurring during the prior year in city *i*. This includes spending on the medical inspection of school children and spending distributed towards educating persons about proper hygiene, milk preparation techniques and other things that could be done to preserve child life. The lagged term is included as it likely took some amount of time for people to implement the information they learned about pre and

post-natal practices and caring for young children.[11] $CPR_{i,t}$ is the amount of current year per capita poverty relief spending on children in city *i*. This variable includes spending on mothers' pensions, spending on almshouses and orphanages and other poverty relief spending directed towards children. $\sum_{j=1}^{J} \beta_{j+3} X_{j,t,t}$ is a set of J covariates that include the county demographic variables percent black, percent illiterate, percent rural, and percent foreign born, as well as other city spending on sanitation, hospitals, education, health other than child health, and other charitable spending. It also contains the income and income distribution measures, as well as variables controlling for the amount of pollution within a city and the mortality rate of adults aged 20-29 to control for trends in mortality common across age groups. The errors are assumed to have mean zero, conditional on the covariates in the mortality equations and defined as the unobserved characteristics affecting mortality in city *i*, year *t* for each of the different age groups. The error terms are allowed to be correlated between the different age groups, but because the mortality rate is regressed on the same covariates in each of the different models, this reduces to a basic OLS with covariates model (Wooldridge 2002). Finally, C_i and Y_t are vectors of city and year effects, respectively.

The year fixed effects are used to control for nationwide, annual shocks associated with macroeconomic policy, widespread epidemics or other factors common across the sample cities in a specific year. The city fixed effects control for unmeasured factors that did not vary through time but did vary across cities. The most important feature that fits this definition is the quality of water treatment and sanitation infrastructure. Annual city sanitation spending is included among the set of covariates, but most of this spending was devoted to street sweeping, trash collection and some maintenance. As a result, the city

[11] Other distributed lag structures were estimated, both with respect to spending on public health education and spending on poor relief. The different lag structures estimated were t, t-1, and t-2 and all permutations across the public health education and poverty relief spending variables. The estimated coefficients were consistent across the different specifications.

annual spending is not well correlated with infrastructure quality. In 66 of the 67 cities there were no major capital improvements to the water treatment and sanitation infrastructure over the period; therefore, absent depreciation, the quality of the infrastructure over the period was likely time-invariant in each city.[12] Better infrastructure would have tended to reduce death rates, implying a negative relationship between the sanitation and water treatment facilities and death rates. If the fixed effects to control for these major facilities were left out, the sign of the omitted variable bias will be determined by the relationship between sanitation and water treatment and a city's choice about public health education. If cities with better sanitation and water treatment infrastructure saw them as substitutes for public health education, they would have spent less on public health education. The combination of the negative relationship between infrastructure and death rates and the negative correlation between infrastructure and health education would impart a positive bias to the public health education coefficient. On the other hand, if cities with better infrastructure saw the public health education as a complement to the infrastructure, they might have invested in more public health education. This would then lead to a negative bias for the coefficient of public health education in the regressions without city fixed effects.

The coefficient of the poverty relief variable might also be affected by the quality of sanitation and water treatment infrastructure. If areas with better sanitation infrastructure were areas with more poverty relief spending, the combination of this positive correlation and the negative correlation between infrastructure and death rates would have led to a negative omitted variable bias for the coefficient on poverty relief.[13] Given this, using a fixed effects model will likely be necessary to obtain unbiased coefficient estimates.

[12] Milwaukee added a water treatment plant in 1926. Estimations excluding Milwaukee from the analysis yielded very similar coefficient estimates

[13] After controlling for income, income distribution, various types of city spending, and city and year fixed effects, much of the potential endogeneity has been controlled for. In the possibility that some remains, attempts at different instruments have been made. However thus far, a variable sufficiently correlated with health or poverty spending to get past weak instrument problems has not been found. Some of the potential

Table 2 presents estimates from equation 1 for the infant age group, and Table 3 the estimates for the children aged 1 to 4. Column 1 in both Tables 2 and 3 give the conditional correlations between the spending variables and mortality without controlling for any fixed effects or covariates. Column 2 includes city and year fixed effects and Column 3 adds the covariates controlling for other types of spending. This column represents the primary model used for analysis. Column 4 includes an interaction term between public health education spending in year *t-1* and poverty relief spending in year *t*. Comparing the public health education and poverty relief coefficients in Table 2 across the different specifications, it is first clear that differences across municipalities and time explain a large portion of the variation in mortality during this period. The R squared in Model 1 is only 0.0815, while in Model 2 is 0.8757. After including the covariates in Model 3, the coefficients on public health education and poverty relief both become more negative. This indicates that areas which spent more on public health education and poverty relief also tended to be areas that had higher mortality. This is not all that surprising and is also apparent in Figures 2a-d.

Once the full set of covariates and fixed effects are included, public health spending is associated with reductions in infant deaths, as well as deaths of children aged 1-4 (p-value of 0.12). The negative relationship was much stronger for public health education spending than it was for city welfare spending for children. Including an interaction term caused only mild attenuation in the public health education coefficient, but greatly attenuated the poverty relief coefficient. This further supports the idea that it was a lack of know-how that led to the poor health outcomes in early twentieth century American cities.

Other statistically significant coefficients in Table 2's Column 3 include those on other charitable spending (positive), education (positive), percent black (negative), percent illiterate (positive), and the drought variable (positive). The directions of the coefficients for

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instruments tried and shown little strength are state-level voting patterns, the timing of a state's women's suffrage enactment, and whether or not a state chose to participate in the Sheppard-Towner Act.

number of months of drought and percent illiterate are fairly intuitive. Years with extreme drought led to poorer health outcomes, due perhaps to increases in food prices or the local economic shocks they may have caused in areas more dependent on agriculture. Lower literacy rates were associated with higher mortality, likely a result of the lower incomes lower literacy implies or because illiterate people were less able to take advantage of the improvements in knowledge surrounding health and hygiene. Spending on education across the different cities included spending on both schools and libraries, and positive coefficient estimate may indicate that sickness spread more effectively in areas where more children and adults interacted via public schools and libraries. Other charitable spending was spending directed towards almshouses and other charitable institutions, as well as administrative costs, and likely indicates the same effect as the positive coefficient on educational spending; concentrating individuals in institutions allowed sickness to spread easier. The negative coefficient on the percent black in the surrounding county is likely a result of the fixed effects netting out those factors that led to the poor health outcomes for black populations in the United States. During the sample period black migration occurred into the North and out of the South. New York, Philadelphia and Baltimore had the largest percent increases in black populations, while Norfolk, Nashville and Birmingham had the largest percent decreases. While a rigorous answer to the factors behind this and its effects on American cities is outside the scope of this paper, the negative coefficient indicates that migrating black families from the South into the North, whether due to a selection from the best and fittest families from these Southern cities, families choosing to migrate into areas with the best possible social services and resources, or other factors, was positively correlated with improving health outcomes in the municipalities.

Using the coefficient estimates in Model 3, one additional dollar per capita spent on child health education related activities in the prior year was associated with a 0.0358 point

reduction in the mortality rate for infants. This implies that about an additional 28,000 2007 dollars were associated with one infant death avoided. This value was about 122,000 2007 dollars in the model using children aged 1-4 as the dependent variable.

An additional dollar spent per capita on poverty relief for children, which included funds distributed outside almshouses, mothers' pensions and other spending for the aid of children was associated with a 0.00142 point reduction in the mortality rate for infants, implying that about 700,000 2007 dollars were associated with one infant death avoided. Compared to the estimates of the statistical values of life calculated in Costa and Kahn (2004) for 1940 (about 1 to 1.5 million in 2007 dollars), allocating money to either charitable spending or public health education would yield benefits much greater than the costs.[14] Additionally, comparing these estimates to the results in Fishback, Haines, and Kantor (2007) suggests that the public health and poverty assistance programs prior to the 1930s saved a statistical infant life at a much lower cost than New Deal relief. Converted to 2007 dollars, about $2.3 million was the estimated relief cost per infant death prevented. It does need to be noted, however, that the New Deal relief was not specifically targeted at saving infant lives like the public health and poverty assistance spending in the 1920s were. I expect the reasons for this are that (1) much of this public health education was aimed at the reduction of infant and maternal mortality and likely did not affect deaths from homicides and suicides as the New Deal relief spending did, and (2) there were more opportunities for changes in behavior and hygiene to positively affect health. But while both public health and poverty relief appeared to reduce mortality at a good cost-benefit ratio, the spending on public health education resulted in the largest estimated benefits.

[14] According to a 1912 County Health Organization pamphlet distributed in North Carolina, Irving Fisher also calculated the net worth of an American infant life and found it to be worth about $90 in 1912 (about $2,150 2007 dollars).

5. Robustness Checks: Alternative Measures of Infant Mortality

Although the model in Section 4 controls for city and year fixed effects, it is possible that health education and poverty relief spending shocks are correlated with changes in fertility. More babies necessarily imply more exposure risk and therefore potentially more infant deaths. This section experiments with alternative infant mortality measurements to the crude death rates. The fixed effects model is re-estimated for the entire set of sample cities using the number of infant deaths per women aged 15-44 in city *i*. It is also re-estimated for only those cities in the Birth Registration Area in order to include the standard infant mortality rate as the dependent variable.

The results from these models are included in Table 4. Columns 1 and 2 give results using the number of infant deaths per 1,000 women of child bearing age and columns 3 and 4 display results for those cities in the BRA using the infant mortality rate at the dependent variable.[15] Columns 1 and 3 are analogous to the Column 3 in tables 2 and 3. Columns 2 and 4 include the interaction term between the amount of public health education spending and poverty relief spending and are analogous to Column 4 in tables 2 and 3.

It is clear from Column 1 that adjusting for the number of women of childbearing age did little to affect the coefficients on public health education or poverty relief spending. Adjusted to 2007 dollars, about $10,500 of per woman of child bearing age spending on public health education was associated with reducing the number of infant deaths by 1. About $220,000 dollars of poverty relief spending generated the same effect. So the coefficient estimates are of a similar magnitude to those displayed in tables 2 and 3. As was the case in Table 2, inclusion of an interaction term differentially affected the public health and poverty relief coefficients.

[15] The number of women between the ages 15 to 44 is gathered for each city in 1920, 1930 and 1940 and interpolated for the inter-census years.

Columns 3 and 4 report results using the infant mortality rate as the dependent variable and for only cities part of the BRA. Using the infant mortality rate as the dependent variable, when estimated separately, the public health education and poverty relief variables no longer have statistically significant coefficients. They are, however, still negative and economically significant. Also, estimating the joint effect of the two still leads to an economically and statistically significant coefficient. This is displayed in the fourth column of Table 4. Adjusted to 2007 dollars, about $11,363 spent jointly on public health education and poverty relief was associated with eliminating one infant death for every ten live births. This is smaller in magnitude than the coefficient estimate on public health education in column 3 of Table 2, but is still economically significant. The estimates from columns 3 and 4 in Table 3 suggest that when limiting the analysis to those cities in the Birth Registration Area and using the infant mortality rate as the dependent variable there is not enough separate variation between public health education and poverty relief spending to separately identify the variable coefficients. However, even acknowledging this, joint spending on public health education and poverty relief was still effective at improving health outcomes within American municipalities.

6. Stocks of Education and Flows of Poverty Relief

This section looks at whether controlling for trends affects the coefficient estimates for the poverty relief and public health education spending variables. Doing so will help inform whether, for each of these variables, it is a sustained flow of annual spending that is important or it is instead the aggregate amount of spending across the years that matters.

To try to get at the different ways in which spending on public health and poverty relief may affect health outcomes, a model that includes a random trend variable $g_{i,t}$ is estimated. Other than the inclusion of this city-specific trend variable, the estimating equation

is identical to that expressed in Section 4. The inclusion of this variable removes the trend in mortality in each of the different cities, thereby identifying the effect of public health education and poor relief spending off of deviations within that trend.

The coefficient estimates are given in Table 5. Column 1 includes only the spending variables of interest, city and year fixed effects and the random trend variable. Column 2 includes the covariates and Column 3 adds in the interaction term. The coefficient estimates for public health education spending are no longer statistically significant in any of the columns. Because the model is now identifying off of deviations in the trends, it may be that nearly all of the relevant variation in the public health education variable is absorbed by the trends. Examining this, after controlling for city and year fixed effects, the variation in $PHE_{i,t-1}$ is reduced by about 70 percent, while the variation in $CPR_{i,t}$ is reduced by about 30 percent. Controlling for city fixed effects and city-specific trends, the variation in $PHE_{i,t-1}$ is reduced by about 92 percent, while the variation in $CPR_{i,t}$ is reduced by about 68 percent.

The attenuation of the public health education spending coefficient potentially suggests that with public health education, it is the stock of knowledge that is important, not a sustained flow of marginal increases. Given that individuals do not likely forget that which they have learned, once a certain amount of spending on public health education is allocated and certain number of people have been reached, a sustained flow of dollars is not particularly important. Poverty relief appears to affect child and infant mortality much differently. The effect of poverty relief on child and infant mortality remains in the model that controls for mortality trends using a city-specific trend variable suggesting that in the case of poverty relief, a sustained flow of income is important in continuing to reduce child and infant mortality rates.

7. Concluding remarks

Besides the collecting of birth and death registration certificates and treating cases of malaria and tuberculosis, public health education was the primary method of interaction between state health departments and the public in the early 20th century. During the 1920s, many different states and cities engaged in educating the public about proper ways to care for infants and how to keep children healthy. Many municipal health departments held "well-child" conferences set up infant-welfare stations to observe the health of newborns and sent out bulletins and newspaper press releases (American Public Health Association 1923). During the same period, infant and child mortality rates fell drastically. With the cities in the sample, all of the age groups studied experienced declines of at least 25 percent in their mortality rates, with infants and children aged 1-4 respectively showing even greater drops of 50 and 60 percent.

In this analysis I examine the extent to which these mortality declines can be explained by expanded spending on public health education and poverty relief in the 1920s and 1930s. Using a model with city and year fixed effects, the analysis shows that both types of programs contributed to reductions in infant mortality. Using a fixed effects model, public health education was more cost effective than poverty relief. Adjusted to year 2007 dollars, approximately $28,000 spent on public health education was associated with the prevention of an infant death. Meanwhile an additional $700,000 in poverty relief spending was associated with the same effect. These cost figures are much lower than those found in modern studies of Medicare expenditures and studies of the impact of work relief during the 1930s.

Use of a random trend variable to control for trends within the cities greatly attenuated the estimated effects of public health education, but did not affect the estimated effects of poverty relief spending. Interestingly, this suggests that the two types of spending affect health outcomes and mortality in much different ways. With public health education,

this suggests it is the stock of knowledge that is important, not a sustained flow of marginal increases. On the other hand, for poverty relief, it is a sustained flow of income that is important in reducing the number of deaths.

Although prior scholars could not directly measure these changes, they hypothesized that the simple lessons taught in the public health programs were very effective. That changing behaviors and dispersion of knowledge regarding health and hygiene were of primary importance in improving health outcomes in the early twentieth century. The analysis supports the inferences made by Ewbank and Preston (1989) and Preston and Haines (1991) and that education played a large role in the United States' health transition in the early 1900s. And it shows that, while not diminishing the importance of poverty relief efforts, the public health programs instituted prior to the New Deal have been among the most cost effective programs in American history.

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Figure 1 Mortality Trends

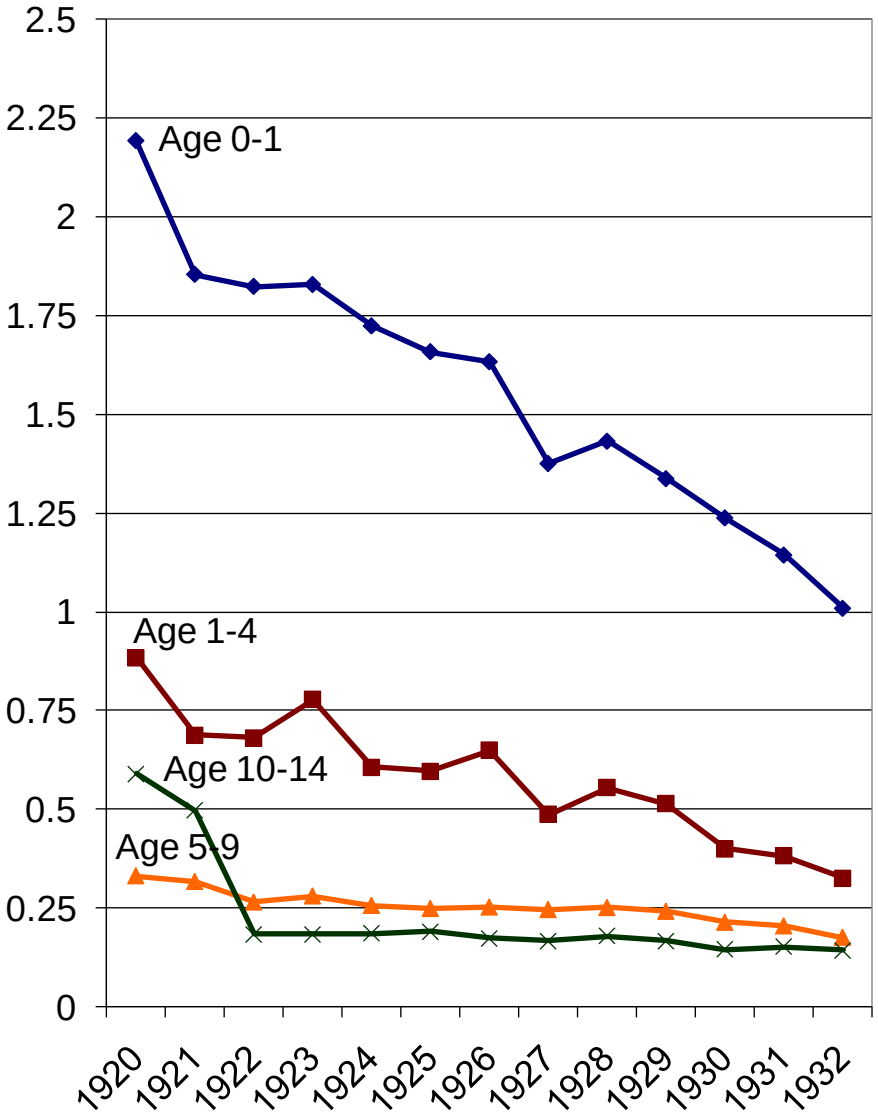

Figure 2 A - Infant Death Trends in Cities with More and Less Public Health Education Spending

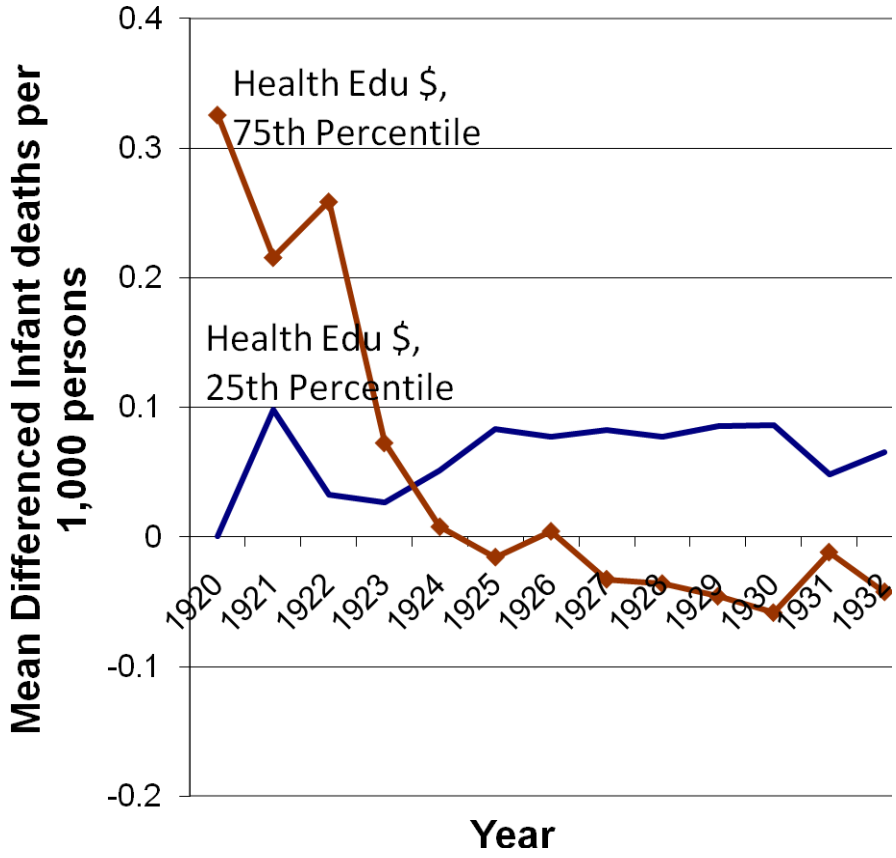

Figure 2 B - Infant Death Trends in Cities with More and Less Poverty Relief Spending

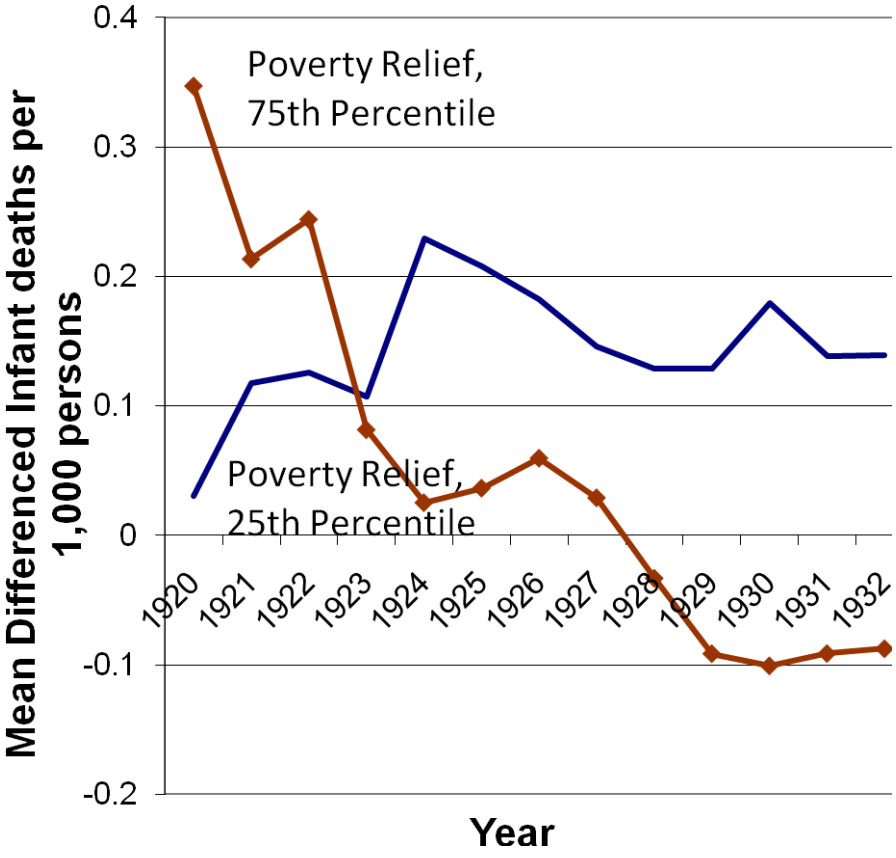

Figure 2 C - Child Death Trends in Cities with More and Less Public Health Education Spending

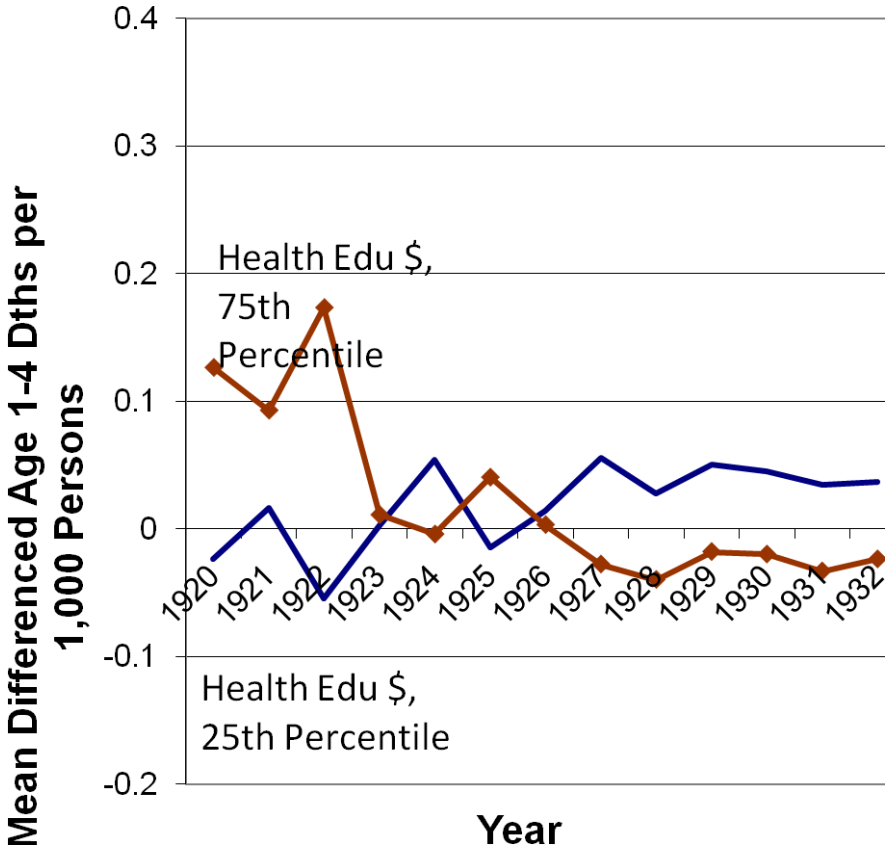

Figure 2 D - Child Death Trends in Cities with More and Less Poverty Relief Spending

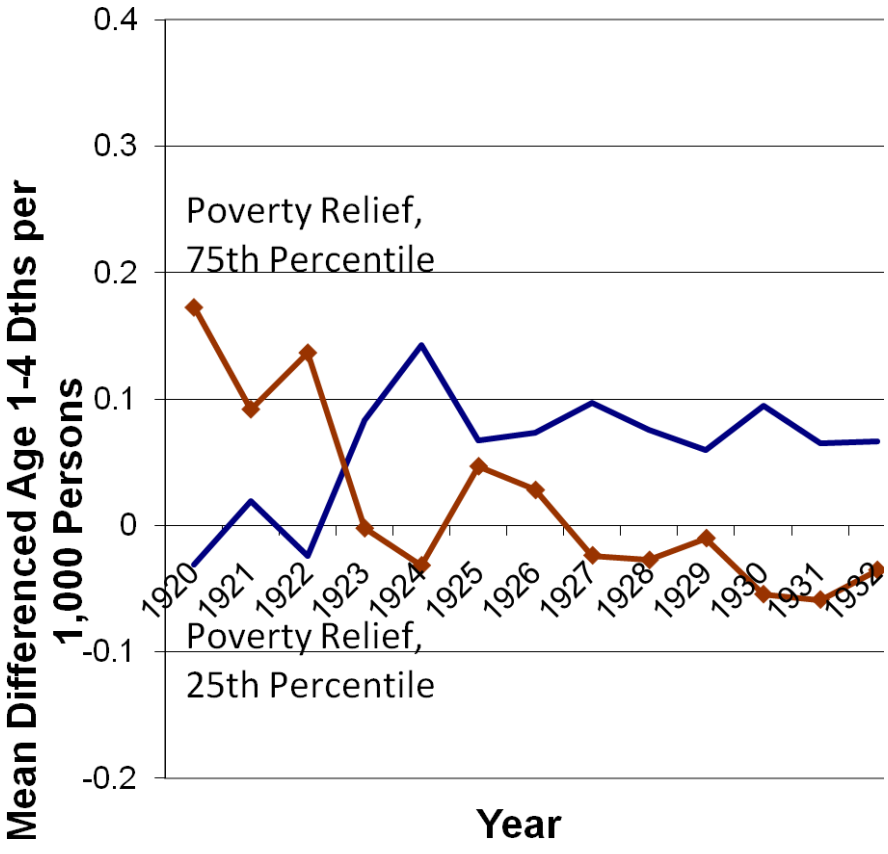

Figure 3 A – Crude Infant Death Rate Against Per Capita Public Health Education Spending

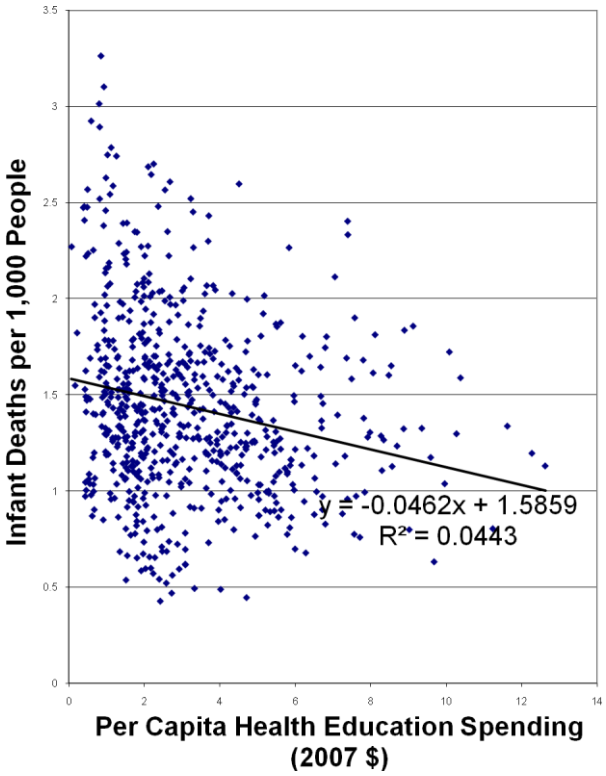

Figure 3 B - Crude Infant Death Rate Against Per Capita Poverty Relief Spending

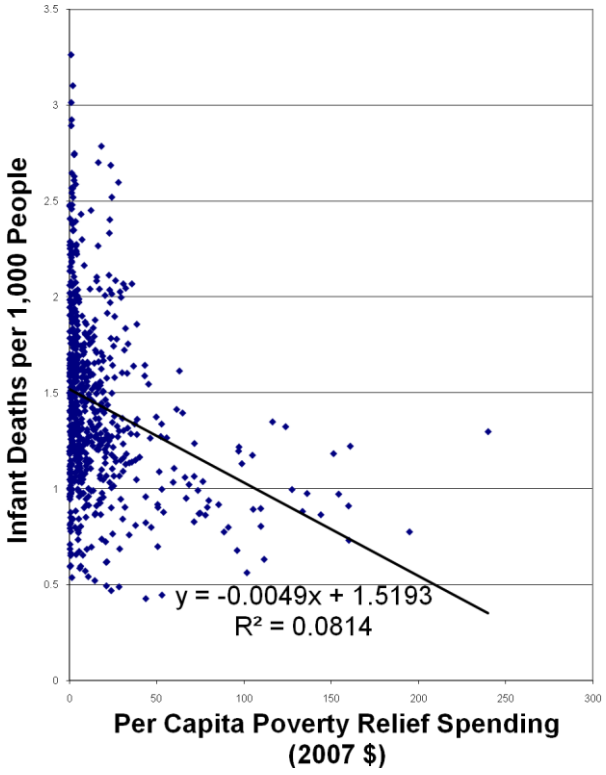

Figure 3 C – Crude Death Rate for Children Against Per Capita Public Health Education Spending

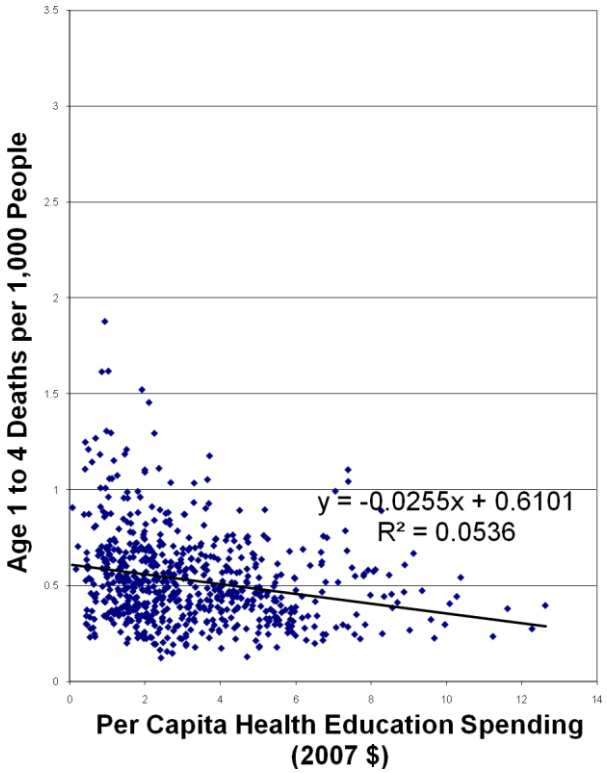

Figure 3 D - Crude Death Rate for Children Against Per Capita Poverty Relief Spending

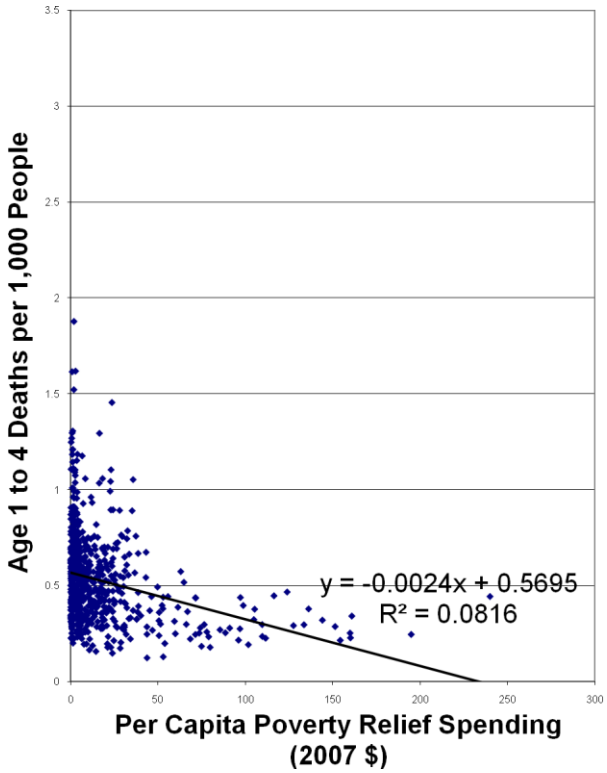

Table 1 Summary Statistics

Per Capita Spending Variables	Mean	Min	Max	Zeros
Key Spending Variables				
Health education spending	3.15	0.07	12.63	0
Child poverty relief spending	16.23	0	239.83	19
Other Spending Variables				
Other health spending	10.10	1.27	39.46	0
Sanitation spending	32.54	7.75	102.44	0
Other charitable spending	5.47	0	50.29	127
Spending on hospitals	12.66	0	106.99	92
Spending on schools and libraries	190.50	68.22	383.88	0
Income and Income Distribution Correlates	**Mean**	**Min**	**Max**	**Zeros**
Avg. annual mfg wages	15,174.34	3,403.06	28,341.15	0
Number of tax returns filed	0.07	0.01	0.22	0
Demographic Measures	**Mean**	**Min**	**Max**	**Zeros**
Percent black	0.08	0.00	0.43	0
Percent foreign born	0.19	0.00	0.46	0
Percent illiterate	0.03	0.01	0.11	0
Percent rural	0.12	0	0.39	113
Deaths	Mean	Min	Max	Zeros
Infants	624	77	8800	0
Children aged 1-4	235	26	4087	0

Table 2 Infant Age Group

Dep. Var: Infant dths/10,000 persons

	(1)	(2)	(3)	(4)
City spending variables of interest				
Lagged PHE	-0.1875	-0.0843	-0.35751**	-0.27355*
	(0.2341)	(0.075)	(0.0915)	(0.0854)
Poverty Relief	-0.03731**	-0.0056	-0.01417**	-0.0016
	(0.0097)	(0.0061)	(0.0037)	(0.0111)
(Lagged PHE)*(Poverty Relief)				-0.0021
				(0.0013)
Women's suffrage ("Before 1914" omitted)				
1915-1919			-3.7114	-3.5425
			(4.9950)	(5.0978)
1920			2.3840	2.1055
			(2.7799)	(2.9421)
Other spending variables				
Other health spending			-0.0028	-0.0038
			(0.0461)	(0.0435)
Sanitation spending			0.00563	0.00244
			(0.0182)	(0.0169)
Other charitable spending			0.05074**	0.05463**
			(0.0081)	(0.0128)
Hospital spending			0.0080	0.0142
			(0.0226)	(0.0220)
Education spending			0.03402**	0.034559**
			(0.0070)	(0.0066)
City income variables				
Manufacturing wages			0.000082	0.000077
			(0.000118)	(0.000121)
# of workers in heavy industry			-0.00050	-0.00055
			(0.00033)	(0.00033)
# of tax returns filed			17.0951	19.3408
			(17.1916)	(16.2054)
Surrounding county demographics				
Percent black			-34.5096+	-37.0301*
			(15.6544)	(15.4847)
Percent illiterate			179.793**	180.180**
			(32.8042)	(32.5958)
Percent rural			-18.8518	-20.2576
			(12.7924)	(14.2767)
Percent foreign born			-6.7599	-6.8022
			(11.5196)	(11.5294)
State weather variables				
Avg. yearly temperature			-0.0542	-0.0616
			(0.0933)	(0.0941)
Lagged Mths of extreme or severe wet			0.0749	0.0752
			(0.0520)	(0.0515)
Lagged Mths of extreme or severe drought			0.08079*	0.073696*
			(0.0275)	(0.0283)
Other variables				
Mortality rate for adults aged 20-29			0.1471	0.1245
			(0.2935)	(0.2863)
Constant	15.1877**	15.3016**	-1.0078	-1.2182
	(1.3991)	(0.216)	(4.3396)	(4.0733)
City Fixed Effects	N	Y	Y	Y
Year Fixed Effects	N	Y	Y	Y
Observations	603	603	603	603
Adjusted R-squared	0.0815	0.8757	0.8958	0.8963

Robust standard errors in parentheses

** p<0.01, * p<0.05, + p<0.1

Table 3 Children Aged 1 to 4 Age Group

Dep Var: Children 1-4 per 10k people

	(1)	(2)	(3)	(4)
City spending variables of interest				
Lagged PHE	-0.0882	-0.0644	-0.0819	-0.0406
	(0.110)	(0.039)	(0.048)	(0.046)
Poverty Relief	-0.01806**	0.0005	0.0016	0.007769+
	(0.003)	(0.003)	(0.002)	(0.004)
(Lagged PHE)*(Poverty Relief)				-0.0011
				(0.001)
Women's suffrage ("Before 1914" omitted)				
1915-1919			-4.95168+	-4.86845+
			(2.433)	(2.438)
1920			-0.7002	-0.8375
			(1.477)	(1.537)
Other spending variables				
Other health spending			-0.0064	-0.0069
			(0.033)	(0.032)
Sanitation spending			0.0089	0.0074
			(0.011)	(0.011)
Other charitable spending			-0.0049	-0.0030
			(0.014)	(0.015)
Hospital spending			-0.0119	-0.0089
			(0.008)	(0.009)
Education spending			0.00731*	0.007568*
			(0.002)	(0.003)
City income variables				
Manufacturing wages			0.0000019	-0.0000002
			(0.000023)	(0.000025)
# of workers in heavy industry			0.00010	0.00008
			(0.0002)	(0.0002)
# of tax returns filed			5.8027	6.9093
			(4.302)	(4.566)
Surrounding county demographics				
Percent black			-5.1985	-6.4405
			(13.834)	(13.785)
Percent illiterate			90.5063*	90.6969*
			(33.485)	(33.039)
Percent rural			-7.2044	-7.8971
			(4.806)	(5.201)
Percent foreign born			1.6386	1.6178
			(7.496)	(7.457)
State weather variables				
Avg. yearly temperature			-0.0583	-0.0620
			(0.062)	(0.061)
Lagged Mths of extreme or severe wet			0.0134	0.0136
			(0.019)	(0.019)
Lagged Mths of extreme or severe drought			0.0332	0.0297
			(0.019)	(0.019)
Other variables				
Mortality rate for adults aged 20-29			0.0505	0.0394
			(0.124)	(0.121)
Constant	5.61366**	5.8159**	2.7802	2.6766
	(0.617)	(0.187)	(3.683)	(3.616)
City Fixed Effects	N	Y	Y	Y
Year Fixed Effects	N	Y	Y	Y
Observations	603	603	603	603
Adjusted R-squared	0.086282976	0.783260537	0.792166769	0.792523963

Standard errors in parentheses, clustered at census region

** p<0.01, * p<0.05, + p<0.1

Table 4 Robustness Checks

Dependent variable	Inft dths/10,000 women aged 15-44		Infant Mortality Rate	
	(1)	(2)	(3)	(4)
City spending variables of interest				
Lagged PHE	-0.9525*	-0.6667+	-0.0407	0.3092
	(0.408)	(0.291)	(0.185)	(0.227)
Poverty Relief	-0.0455+	-0.0026	-0.0172	0.0349
	(0.021)	(0.046)	(0.024)	(0.044)
(Lagged PHE)*(Poverty Relief)		-0.0073		-0.0088*
		(0.0047)		(0.004)
Women's suffrage ("Before 1914" omitted)				
1915-1919	-48.3340	-47.7590	-36.7883+	-36.0533+
	(26.492)	(27.044)	(17.821)	(17.885)
1920	-12.4985	-13.4467	24.2985	29.1963
	(12.577)	(13.066)	(30.061)	(30.119)
Other spending variables				
Other health spending	-0.1309	-0.1341	0.0039	0.0006
	(0.127)	(0.120)	(0.165)	(0.155)
Sanitation spending	0.0293	0.0184	-0.0206	-0.0348
	(0.071)	(0.066)	(0.078)	(0.073)
Other charitable spending	0.1818**	0.19506**	0.19709*	0.21275+
	(0.039)	(0.049)	(0.079)	(0.095)
Hospital spending	0.0533	0.0744	-0.0628	-0.0371
	(0.088)	(0.085)	(0.083)	(0.081)
Education spending	0.07606+	0.07789+	0.0307	0.0333
	(0.036)	(0.034)	(0.026)	(0.026)
City income variables				
Manufacturing wages	0.00030	0.00029	0.00014	0.00012
	(0.0005)	(0.0005)	(0.0004)	(0.0004)
# of workers in heavy industry	-0.0018	-0.0020	-0.0020	-0.0022
	(0.0014)	(0.001)	(0.002)	(0.002)
# of tax returns filed	-4.6755	2.9690	-42.7906	-32.9114
	(66.713)	(62.371)	(40.208)	(34.811)
Surrounding county demographics				
Percent black	-60.6524	-69.2322	-65.6383	-77.1859
	(91.902)	(93.628)	(103.796)	(107.074)
Percent illiterate	402.790+	404.107+	241.2630	248.7640
	(179.220)	(183.795)	(304.914)	(309.894)
Percent rural	-138.569*	-143.354*	-139.934**	-147.030**
	(49.344)	(54.021)	(35.501)	(34.986)
Percent foreign born	55.2335	55.0898	31.6662	30.4050
	(71.224)	(71.428)	(79.794)	(79.342)
State weather variables				
Avg. yearly temperature	-0.6788	-0.7042	-0.5375	-0.5704
	(0.508)	(0.518)	(0.511)	(0.511)
Lagged Mths of extreme or severe wet	0.3536	0.3548	0.2421	0.2421
	(0.193)	(0.191)	(0.180)	(0.174)
Lagged Mths of extreme or severe drought	0.1455	0.1214	0.2284+	0.1975
	(0.130)	(0.130)	(0.109)	(0.107)
Other variables				
Mortality rate for adults aged 20-29	0.0842	0.0074	-0.1280	-0.2168
	(0.614)	(0.596)	(0.365)	(0.367)
Constant	43.8542+	43.1380+	103.264**	103.065**
	(21.539)	(20.713)	(29.192)	(28.081)
City Fixed Effects	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Observations	603	603	541	541
Adjusted R-squared	0.8849	0.8853	0.8274	0.8284

Standard errors in parentheses, clustered at census region

** p<0.01, * p<0.05, + p<0.1

Table 5 City Specific Trends

Dep. Var: Infant dths/10,000 persons	(1)	(2)	(3)
City spending variables of interest			
Lagged PHE	-0.0921	-0.0210	0.0181
	(0.0573)	(0.0475)	(0.052)
Poverty Relief	-0.0045	-0.0142+	-0.0057
	(0.0068)	(0.0069)	(0.0141)
(Lagged PHE)*(Poverty Relief)			-0.00142
			(0.00122)
Women's suffrage ("Before 1914" omitted)			
1915-1919		-4.8107	-4.6730
		(3.6325)	(3.607)
1920		9.9949**	10.476**
		(2.8612)	(2.6497)
Other spending variables			
Other health spending		0.0105	0.0100
		(0.0417)	(0.041)
Sanitation spending		-0.0050	-0.0064
		(0.0107)	(0.0104)
Other charitable spending		0.1203**	0.1226**
		(0.0353)	(0.036)
Hospital spending		-0.0186	-0.0154
		(0.0208)	(0.0206)
Education spending		0.0129+	0.01379*
		(0.0058)	(0.005)
City income variables			
Manufacturing wages		0.0003076**	0.003069**
		(0.000048)	(0.000048)
# of workers in heavy industry		0.000129	0.00014
		(0.00033)	(0.00034)
# of tax returns filed		-10.9568	-9.7145
		(18.1296)	(17.367)
State weather variables			
Avg. yearly temperature		-0.1139	-0.1177
		(0.1402)	(0.142)
Lagged Mths of extreme or severe wet		0.0713	0.0708
		(0.0575)	(0.0569)
Lagged Mths of extreme or severe drought		0.061+	0.058+
		(0.3101)	(0.031)
Constant	17.043**	18.2079+	17.7787+
	(0.3332)	(8.8783)	(8.746)
City Fixed Effects	Y	Y	Y
Year Fixed Effects	Y	Y	Y
City Specific Trends	Y	Y	Y
Observations	603	603	603
Adjusted R-squared	0.91468	0.92112	0.92114

Standard errors in parentheses, clustered at census region

** p<0.01, * p<0.05, + p<0.1

Data Appendix

Demographic data by county, published by the Bureau of the Census in 1920 and 1930, is used to control for the number of black, illiterate and foreign born in and near a city. Controlling for these variables will be important, since the foreign born and black populations generally had much higher mortality rates than the native white population and were targeted by some of the social programs aimed to reduce child mortality (Lindenmeyer 1995). There was wide variation in the demographics between counties, with the populations over 40 percent black in some counties and populations over 45 percent foreign born in other counties in some years.

To control for average income and income distributions, which the Children's Bureau initially believed were so crucial in determining child mortality rates, two measures are used. First, average annual earnings in the manufacturing sector compiled from the biannual Census of Manufactures were included to help control for the overall wealth of a city. State per capita income, estimated by Robert Martin (1939), was used to help interpolate the missing years.[16] The interpolation formula used was $MW_{i,t}=SPCI_t\left(\frac{1}{2}\frac{MW_{i,t-1}}{SPCI_{t-1}}+\frac{1}{2}\frac{MW_{i,t+1}}{SPCI_{t+1}}\right)$, where $SPCI_t$ is state per capita income in year t. Average annual earnings per worker, calculated by dividing the average annual earning in manufacturing by the average number of wage earners employed, and the percentage of workers in polluting industries is given in middle panel of Table 1. Second, the number of tax returns filed as a share of the population in a year helps control for the number of people in a city who were part of the upper tail of the income distribution. This gives the number of households in a city with incomes over $5,000 (about $60,000 in 2007 dollars), and individuals with incomes over $2,000 in a city. After controlling for a measure of average income, increases in the share of the population filing tax returns would be associated with lower shares of income for the population that was not earning enough to pay income taxes.

One potential problem with using average annual earnings to measure the average wages in the different areas is that they may be highly correlated with the amount of pollution in that area (Ruhm 2000). For this reason I look at the number of persons employed in each industry, separating polluting industries from non-polluting industries. I then count the number of workers in polluting industries such as steel, coal, automotive, leather, rubber, smelting and wood pulp, and include this number in the estimation to both control for and test the impact of the extent of industrial pollution, a severe problem in many cities in the early 1900s. For a list of those industries classified as "polluting," see Table A1 below. The 1931 and 1933 Census of Manufactures lack city by industry level data, so estimates from a linear trendline will be included in the estimation. Although this will miss the variation between years, it should still pick up the variation between cities. Because of the large drop off in manufacturing jobs between 1927 and 1929, for some cities the trendline estimated negative values. For these, I set the observation to zero.

[16] Martin (1939) does not give a good description of how he came to his estimates. Fishback and Kachanovskaya (2009) ran regressions for each state with the BEA state income data as a function of the Martin data without an intercept over the period from 1929 to 1938 when the two sets of series. The R-squareds from each of the regressions were all above 0.98. When they ran correlations of the growth rates for the overlap periods, they are all over 0.6 and most are over 0.9.

Table A1
List of Industries Classified as Polluting

Industries classified as "heavy" and "polluting"

Heavy Industry

- Brass, bronze and other nonferrous alloys, and manufactures of these alloys and of copper
- Copper, tin and sheet-iron work, including galvanized-iron work
- Forgings, iron and steel, not made in steel works or rolling mills
- Foundry and machine shop products
- Iron and steel: Blast furnaces
- Iron and steel: Cast iron
- Iron and steel: processed
- Iron and steel: Steel works and rolling mills
- Leather: Tanned, curried and finished
- Motor vehicle bodies and motor vehicle parts
- Motor vehicles, not including motorcycles
- Rubber goods, other than tires or inner tubes
- Rubber tires and inner tubes
- Smelting and refining, metals other than gold, silver or platinum

Other polluting industries

- Belting, leather
- Lumber and Timber, not elsewhere classified
- Lumber, planing-mill products
- Paper and wood pulp
- Tanning materials, natural dyestuffs, mordants and assistants