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County health outcomes linkage to county spending on social services, building infrastructure, and law and order

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ABSTRACT

Will counties that reallocate money from law enforcement to social services improve subsequent markers of population wellbeing? In this study, we measure the association between county government spending across multiple sectors and Life Expectancy at Birth (LEB) in the U.S. using data from the U.S. Census Bureau. We constructed a Structural Equation Model to determine whether social expenditure, building infrastructure, and spending on law and order were positively or negatively associated with LEB three-years after initial spending. The analysis compared data between 2002-05 and 2007-10 and was stratified for urban and rural counties. In rural counties, a one-standard-deviation increase in social spending increased subsequent LEB by 0.58 (SE 0.16) and 0.36 (SE 0.16) years in 2005 and 2010, respectively. In urban counties, a one-standard-deviation increase in building infrastructure spending increased subsequent LEB by 1.14 (SE 0.51) and 1.05 (SE 0.49) years in 2005 and 2010, respectively. In 2002, a one-standard-deviation increase in law and order spending significantly decreased subsequent life expectancy, 2.2 (SE 1.27) and 0.46 (SE 0.13) years in urban and rural counties, respectively. Similarly, investments in building infrastructure for urban counties and social services for rural counties were associated with subsequently higher life expectancy three years later after initial investments.

1. Introduction

A persistent policy problem concerns the optimal locus of action and allocation of resources to effect change in population health. Former Director of the Centers for Disease Control and Prevention Thomas Frieden argues that interventions addressing the socioeconomic determinants of health have the broadest population health impact (Frieden, 2010). Under the Frieden Health Impact Pyramid framework, the clinical interventions and individual counseling that account for most health systems spending have the least population health impact; while socioeconomic factors have the greatest capacity to increase population impact. Large 19th and early 20th century mortality declines in the U.S. and Europe predated the availability of effective antimicrobials and access to health care for the majority of populations (McKeown, 1978). Higher quality housing, more nutritious diets, cleaner air and water improved social safety nets and contributed to better health over the last 200 years. These gains were not automatic results of economic growth. Rather, improving the socioeconomic determinants of health was partly social and cultural, but also required political will and purposeful governmental resource allocations (Szreter, 1988).

Government spending on public health was estimated at $93.5 billion in 2018, accounting for less than 3% of the $3.6 trillion in total health spending in the U.S., or perhaps even less (Dieleman et al., 2016; Leider et al., 2016). Most health services research focuses on efficient economic choices about how to pay for and deliver efficient and cost-beneficial clinical interventions for individuals. While individual access to medical care is of critical importance – and great public and political interest – changing the upstream social determinants of health is the appropriate concern of governmental policy makers. Dramatic increases in spending on health care crowd out public health and other social services, but the converse does not necessarily hold (Tran, Zimmerman, & Fielding, 2017). Extending a population-focused analysis to include not only the impacts of a government's public health spending but also its spending on social services is an important and

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underexamined line of inquiry.

This paper scrutinizes Frieden's thesis that socioeconomic conditions and government spending choices impact health. Much of the literature in this area has looked at ecological correlations between socioeconomic conditions and health in states or nations without attending to spending choices by governments. Population health has been extensively shown to be linked to population level measures of education, income, unemployment, racial segregation, and income inequality (Bor, Cohen, & Galea, 2017; Brenner & Mooney, 1983; Chetty et al., 2016; Meara, Richards, & Cutler, 2008). Maps of population health in the U.S. regularly show inequities at an extremely granular level. There are large health disparities among states in the nation and among counties within a state. Thus, analysis of smaller geographic areas are likely to correctly link socioeconomic measurements and spending choices to the health of populations that are directly impacted by that spending.

Variation in mortality across the U.S. is shaped by rural-urban disparities (Spencer, Wheeler, Rotter, & Holmes, 2018). All-cause mortality in rural counties was 1.2 times higher than in urban counties in 2016 (Cosby et al., 2019), and urban residents were expected to live approximately 2 more years than rural residents in 2009 (Singh & Siahpush, 2014). In the early 20th century, mortality in the U.S. was characterized by an urban penalty, meaning that cities had higher mortality rates that the rural parts of the country. This penalty was shifted to rural areas in the last three decades by improvements in public health infrastructure, such as sanitation and clean water. Cosby et al. (2019), estimate that rural-urban mortality disparities had a 75% increase between 2004 and 2016, the most affected areas were counties with high-poverty rates. In this vein, a recent study by Chetty and colleagues aggregated to commuting zones found that low-income individuals are more likely to have a higher life expectancy at birth if they live in cities with high levels of government expenditures, highly educated populations, and high incomes (Chetty et al., 2016). Other research has found that addressing nonmedical needs, such as housing, are key contributors to advancing population health(Fraze, Lewis, Rodriguez, & Fisher, 2016; Gusmano, Rodwin, & Weisz, 2018).

Typically, research that finds a connection between socioeconomic conditions and population health is not translatable into direct actions. Policy makers make policies and budgets; they cannot directly make a county become richer, have improved health outcomes, or become suddenly more educated. Furthermore, most policy makers pursue locally determined spending priorities for political reasons that may or may not include an explicit focus on health. One way to connect research on social determinants of health to policy maker choices has been to study the direct link of budgetary spending patterns and health. National spending on public health is dominated by formulas based on population and issues of national interests (Buehler & Holtgrave, 2007). Local budgeting may be more responsive to local priorities and needs. With few exceptions, budgets need to be made every year in a county, and local and state budgets must be balanced every year, thus deficit spending is not an option. Therefore, spending decisions by counties are especially important to consider in explaining county-based variation in population health outcomes.

Although the public health community advocates that health should be a consideration in all policies, there is a dearth of evidence demonstrating that state and county government spending choices in areas other than health influence subsequent health outcomes. A recent study found that higher ratios of social to health spending are associated with improvements in non-communicable diseases in the U.S. (Bradley et al., 2016). Similar findings have been recorded in Canadian provinces improving infant mortality and life expectancy at birth through social spending (Dutton, Forest, Kneebone, & Zwicker, 2018). Moreover, high-income countries show a positive correlation between social and health spending (Papanicolas, Woskie, Orlander, Orav, & Jha, 2019). Mays and Smith showed that local public health spending was linked to lower mortality (Mays & Smith, 2011). Similarly, county non-hospital health spending was associated with reductions ranging from 6% to 12% in vaccine-preventable disease incidence (Verma, Clark, Leider, & Bishai, 2017). Research on the impact of county spending choices has been slowed by gaps in data availability and data comparability on spending at the county level. Other methodological issues include multicollinearity of spending for different health-related services, endogeneity of certain spending decisions, and difficulties in determining causal links between spending and outcomes across a community.

The impacts of local governments' funding decisions on the health and wellbeing of their constituents became an especially important topic in 2020 and remain to be in 2021 due to the COVID-19 pandemic and rising racial inequities. As many communities are facing popular pressure to re-examine spending for police and public safety, it is worth exploring the ways in which these expenditures may or may not be related to the overall health and wellbeing of communities. Limited empirical guidance is available regarding the impacts of law and order spending on population-level health outcomes (Weidner & Schultz, 2019). Examining correlates and consequences of spending for law and order versus other competing community priorities is thus especially timely and politically relevant.

This paper has the goal of measuring the association between county government spending across multiple sectors and county life expectancy at birth. Our hypothesis is that spending categories that are related to social programs such as welfare programs, public health, and education, have a positive relationship with increasing life expectancy at birth; while we expect negative correlations between law and order spending and population health. In addition, this paper aims to identify which spending categories have the greatest capacity to increase life expectancy at birth in urban and rural counties. This study is the first we know of to assess the relationship of county level government spending in non-health care sectors on life expectancy at birth.

2. Material and methods

2.1. Data

County expenditure data were drawn from the Census of Governments, which is conducted by the Census Bureau every five years collecting data on taxes, revenue, and expenditure from every county government in the U.S. (Leider et al., 2018; US Census Bureau, 2012). Data were available for 3,140 counties for years 2002 and 2007. The analysis included direct expenditure on sewerage, fire protection, solid waste management, highways, public health, elementary and secondary education, natural resources, libraries, parks and recreation, public welfare, police protection, judicial and legal, and housing and community development. Table A-1 in the Appendix provides a detailed explanation on how each spending category is defined by the Census Bureau. Expenditure data were inflation adjusted to 2013 prices using the government spending deflator of the Bureau of Economic Analysis (Bureau of Economic Analysis, 2014).

To assess the relationship between county government spending across multiple sectors and county life expectancy at birth we constructed a Structural Equation Model (SEM), for which life expectancy at birth was retrieved for years 2005 and 2010 to allow a 3-year lag for spending to influence population's health. Government spending in a given year can affect health that same year (e.g. by controlling an epidemic) or in subsequent years by improving health literacy and the environment. Life expectancy in a given year may directly affect spending that same year as we saw with the COVID-19 pandemic. Thus, using lagged health as the outcome helps to control this sort of reverse causality that could bias estimates towards zero. The analysis produced robustness checks on the lag period testing both 2- and 4-year lags that can be found in Tables A-9 – A-12 in the Appendix. County level LEB was retrieved from the Institute of Health Metrics and Evaluation (IHME) (Institute for Health Metrics and Evaluation, 2016). Economic stress was used as a control variable proxied by the percentage of the population living in poverty and the percentage of unemployed workers in the total labor force, both variables were retrieved from the Inter-university Consortium for Political and Social Research (Haines & Inter-university Consortium for Political and Social Research, 2018). Economic stress variables are highly correlated with the number of individuals qualifying for state and federal means-tested entitlement benefits like unemployment assistance, Medicaid, and food assistance.

The analysis was stratified by urban and rural areas. Counties were defined as urban or rural based on the Rural-Urban Continuum Codes developed by the United States Department of Agriculture (USDA) (USDA, 2014). The USDA provides the urban-rural definition for years 2003 and 2013. We assumed urban-rural codes did not change over a decade – decades were defined as 1994–2003, and 2004–2013; thus, the 2003 definition was used for year 2002 and 2013 definition was used for year 2007. Table A-2 in the Appendix presents counties distribution across urban and rural areas in 2003 and 2013. Out of the 1897 (2028) counties included in the 2002-05 (2007-10) analysis, 799 (873) counties were classified as urban.

2.2. The role of state and federal spending

Local county governments make spending choices that depend on context. Part of that context is available revenue from their own taxation as well as intergovernmental transfers from state and federal government. The county spending data in our study include state and federal intergovernmental transfers. As noted above, county residents' personal economic circumstances will qualify some for means-tested state and federal entitlement programs and aggregate data on county poverty and unemployment can account for that type of personal-level state and federal spending. Sometimes federal and state spending arrives in a county to pay for social determinants of health that might confound local county budget allocations. Examples include federal and state highways, state police, national guard operations, military bases, etc. Unfortunately there is no systematic tabulation at the county level of these direct expenditures by state and federal government. This spending is a source of bias. If state and federal programs are drawn towards needy areas they could crowd out county spending on social determinants of health and this would bias downward estimates of the connection between county spending and health. On the other hand, if state and federal programs are pro-actively drawn towards politically connected counties due to affluence and advocacy they could be more common in counties that spend more on local priorities and this would bias estimates upwards. The unavailability of systematic data on state and federal programs in counties is a limitation that is discussed later in the paper.

2.3. Sample

To mitigate any skewing effects of more populous counties having larger expenditures in general and vice versa with less populous counties, we constructed per capita expenditures by dividing county direct expenditures by their population each year. Per capita spending was logged to normalize the distribution. Population data were retrieved from the U.S. Census. Population data were not available for 10 counties; reducing the sample at this stage to 3,130 counties each year.

Some counties had extremely high and low total per capita expenditure and served as leverage points in the analysis. To control for this, we excluded outliers whose total per capita expenditure was above the 99% percentile or below the 1% percentile. The exclusion rule dropped 32 counties each year, leaving 3,098 counties to be analyzed. Table A-3 in the Appendix lists the counties that were excluded from the analysis. LEB was not available for Denali Borough in Alaska, reducing our sample to 3,097 counties. Additionally, some counties declared having zero expenditure on certain direct expenditure variables because these allocations were being covered by either state or federal governments instead of local governments. Since the aim of this study is to estimate the effect of local governments spending decisions on life expectancy at birth, we excluded counties with an expenditure of zero, 1,200 counties were excluded in 2002 and 1,069 in 2005. The final analytic sample consists of 1,897 counties for the 2002-05 analysis and 2,028 counties for the 2007-10 analysis. As a robustness check, we also estimated our model with the full sample that includes those counties with zero expenditure, results are in Table A-7 and A-8.

2.4. Model specification

We constructed an SEM linking expenditure categories to life expectancy at birth controlling for county economic status. The model depicts a system in which observed budget categories define four latent variables, and the latent variables are interrelated between each other and to population health. County budget allocations reflect thirteen cross-correlated budget categories, making it difficult to tease out their interplay and their independent correlation to health. The SEM solves this problem by employing four latent variables and offers a solution to the problem of multicollinearity.

One of the challenges of constructing an SEM is to determine the actual structure. As discussed below, the data on county level spending encompassed 18 different categories of annual spending that needed to be broken into a smaller number of aggregates. To develop a model of the structural pillars of public spending we turned to the literature and found prior support for aggregating a share of county spending to the category of social spending (McCullough, 2017). Subsequently, the research team initiated a series of four phone interviews with county level public finance officials to ask if there are consistent categories of public spending that receive joint consideration. Based on the results of these interviews and the literature, we expanded our categorization beyond "social spending" to include two additional categories proxying "law and order" and "infrastructure". We subsequently embarked on iteratively allocating budget line items to these categories and checking goodness of fit indicators to balance a categorization that made sense and permitted statistical convergence.

An SEM assumes full-joint-normality of all the variables in the model, this assumption can be relaxed if the observed exogenous variables are normally distributed. Figure A-1 in the appendix shows the distribution of life expectancy at birth and Figure A-2 the distribution of all exogenous variables included in the model. All were normally distributed.

Fig. 1 illustrates the path diagram of the baseline SEM and offers a conceptual framework. The model shows that proximal determinants of health include economic stresses like poverty and unemployment, infrastructure, social services and law and order. The link between poverty and health runs through both direct deprivation of safe and uncrowded housing as well as through allostatic load (Korte, Koolhaas, Wingfield, & McEwen, 2005; McEwen & Seeman, 1999). The link from social infrastructure to health is also straightforward via access to safe roads and public hygiene (Cutler & Miller, 2005). Similarly social services include inputs to health in the form of public health, schools, and parks (Winkleby, Jatulis, Frank, & Fortmann, 1992). Finally, we include law and order as a determinant of health because the experience of incarceration and policing can lead to health effects in the community (Bellin, Fletcher, & Safyer, 1993). Boxes represent variables that are observed in the data and circles represent unobserved variables that are considered latent variables. In our model, these hypotheses are the relationships between a set of expenditure categories used to measure latent variables representing public spending on social, infrastructure, and law and order. These relationships are outlined in equations 2 to 4. The rate of poverty and unemployment are used to measure economic stress. This model allows one to ask whether social expenditure, building infrastructure, or spending on law and order is associated with life expectancy and whether this association is positive or negative. Our SEM is similar to a seemingly unrelated regression model in which equations are modeled simultaneously with correlated errors and we used the maximum likelihood method to estimate the parameters. An SEM

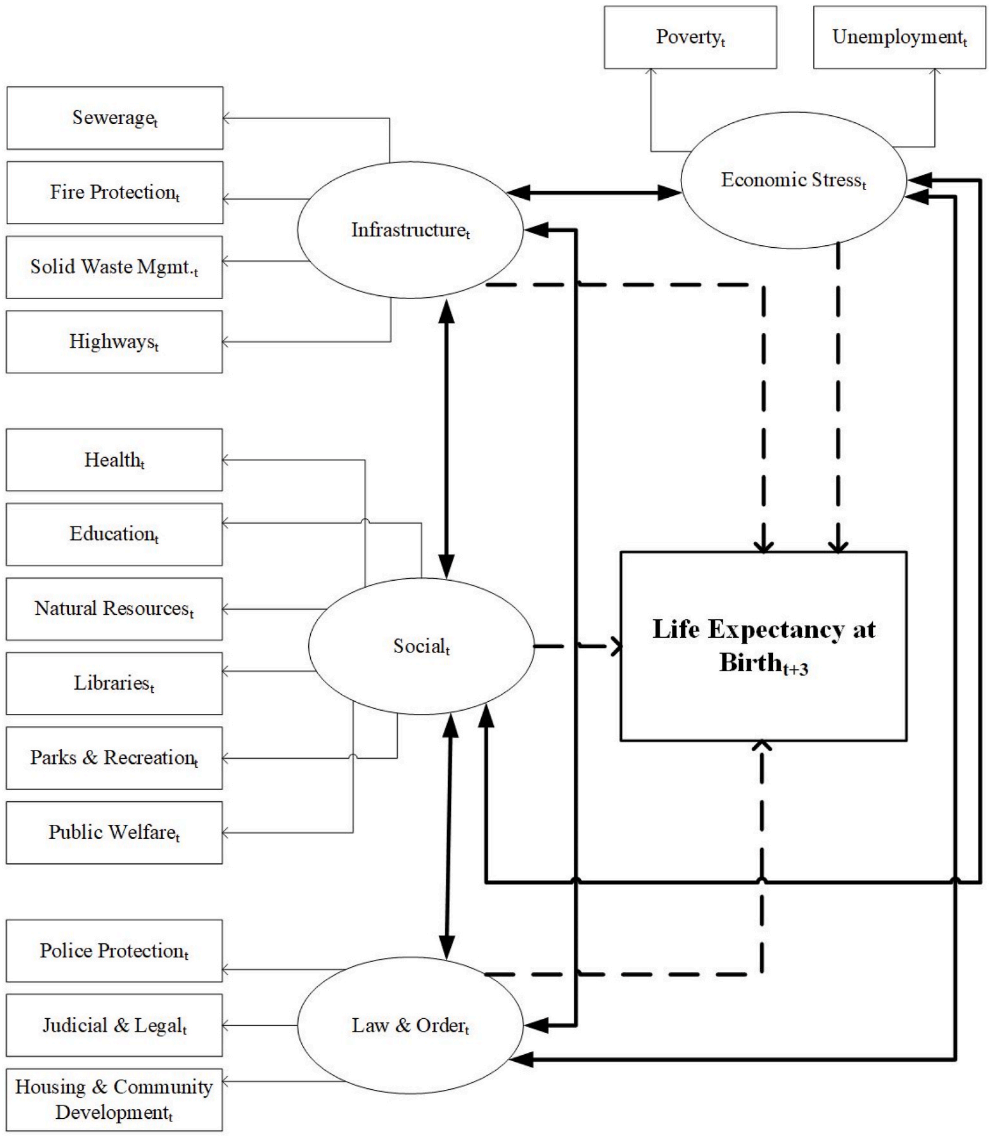

Fig. 1. Relationship model of public spending and life expectancy at birth in counties of the United States.
Note: Spending is measured in 2002 [2007] and life expectancy at birth is measured in 2005 [2010].

assumes the outcome of interest is normally distributed to produce unbiased estimates.

Life expectancy at birth and public spending were measured at time $t + 3$ and time t, respectively, to account for the endogeneity between them and to try control for reverse causation. In the 21st century the processes responsible for human demise do not instantaneously connect the social and physical environment to survival e.g. via war or famine. The analysis was conducted separately for years 2002-05 and 2007-10 and stratified for urban and rural counties. We begin by characterizing life expectancy at birth as a function of four latent variables, three accounting for public spending and one for economic stress, resulting in the following function:

$$\text{LEB}_{t+3,\ i} = \alpha_0 + \beta_1 \text{Social}_{t,\ i} + \beta_2 \text{Infrastructure}_{t,\ i} + \beta_3 \text{Law}_{t,\ i} + \beta_4 \text{Economy}_{t,\ i} + \varepsilon_{t1} \quad [1]$$

LEB represents life expectancy at birth in period $t + 3$ ($t = 2002$ and 2007) for county i ($i = 1897$ in 2002-05 and $i = 2028$ in 2007-10) as a function of three latent variables that capture per capita spending on social, infrastructure, and law and order at time t. LEB is also affected by the latent variable economic stress at time t.

A representative county chooses the amount of per capita spending on social, infrastructure, and law and order as a function of each other since resources are limited and expenditure categories are competing for budgetary share. In addition, county budget allocations are also affected by their level of poverty and unemployment. Hence the full set of equations for the structural model of resource allocation at the county level is as follows:

$$\text{Social}_{t,\ i} = \alpha_0 + \gamma_1 \text{X}_{t,\ i} + \gamma_2 \text{Infrastructure}_{t,\ i} + \gamma_3 \text{Law}_{t,\ i} + \gamma_4 \text{Economy}_{t,\ i} + \varepsilon_{t2} \quad [2]$$

$$\text{Infrastructure}_{t,\ i} = \alpha_0 + \theta_1 \text{Y}_{t,\ i} + \theta_2 \text{Law}_{t,\ i} + \theta_3 \text{Social}_{t,\ i} + \theta_4 \text{Economy}_{t,\ i} + \varepsilon_{t3} \quad [3]$$

$$\text{Law}_{t,\ i} = \alpha_0 + \eta_1 \text{Z}_{t,\ i} + \eta_2 \text{Social}_{t,\ i} + \eta_3 \text{Infrastructure}_{t,\ i} + \eta_4 \text{Economy}_{t,\ i} + \varepsilon_{t4} \quad [4]$$

$$\text{Economy}_{t,\ i} = \alpha_0 + \delta_1 \text{A}_{t,\ i} + \delta_2 \text{Social}_{t,\ i} + \delta_3 \text{Infrastructure}_{t,\ i} + \delta_4 \text{Law}_{t,\ i} + \varepsilon_{t5} \qquad [5]$$

$X_{t,\,i}$, $Y_{t,\,i}$, $Z_{t,\,i}$, and $A_{t,\,i}$ are four vectors at time t whose elements are observable expenditure categories or social indicators. The observable components are weighted by a vector of estimated statistical parameters γ_1, θ_1, η_1, and δ_1 respectively for $X_{t,\,i}$, $Y_{t,\,i}$, $Z_{t,\,i}$, and $A_{t,i}$. $X_{t,\,i}$ is composed of expenditure on public health, elementary and secondary education, natural resources, libraries, parks and recreation, and public welfare. $Y_{t,\,i}$ is composed of expenditure on sewerage, fire protection, solid waste management, and highways. And $Z_{t,\,i}$ is composed of expenditure on police protection, judicial and legal, and housing and community development. Vector $A_{t,\,i}$ is composed of the percentage of the population living in poverty and the percentage of unemployed workers in the total labor force. Finally, $\varepsilon_{t1}, \ldots, \varepsilon_{t5}$ are the structural disturbances.

As mentioned earlier, we lagged public spending on LEB to account for reverse causation. Our baseline model used a 3-year lag, but we also tested 2 and 4 years for sensitivity. We also tested if reverse causation existed by allowing LEB in *t-1* affect each expenditure category in *t*, and later affect LEB in $t+3$, and as we expected this model did not achieve convergence.

We estimated our SEM using Stata version 14. The standard errors were calculated as the square root of the diagonal elements of the observed information matrix (OIM), which are the second derivatives of the log-likelihood function (StataCorp, 2013).

To test the goodness of fit of the model, we computed statistics under population error, baseline comparison, and size of residuals (StataCorp, 2013). Once we validated the goodness of fit of our model, we ran a simulation to identify individual effects of the various spending categories on life expectancy based on the 2007-10 model. The simulation was conducted separately for urban and rural counties. We sequentially increased spending by 1 US$ per person in each spending category underlying the latent infrastructure variable for urban counties and by 1 US $ per person in the spending categories underlying the latent social variable for rural counties. Incremental person-years saved for the whole country were computed by summing across all counties the product between county population and the gains in life expectancy from a 1 US$ per person increase in spending on that budget item in the county. Recall that to estimate our SEM for 2007-10 we worked with a subsample of 2,028 counties whose spending categories were greater than zero. However, in order to expand to the entire country, we extrapolated our incremental person-years to all 3,097 counties by conducting a state fixed effect regression of incremental-person years on population size.

3. Results

Table 1 shows descriptive statistics for the analytic sample stratified for urban and rural counties of per capita spending by spending category, as well as levels of poverty, unemployment, and life expectancy at birth (similar estimates with the full national level sample are provided on Table A-4 of the Appendix). In the analytic sample, life expectancy registered a significant average increase between 2005 and 2010 of 0.8 years (95% CI: 0.7–1.1) in urban counties and 0.7 years (95% CI: 0.5–0.8) in rural counties. Individuals living in an urban county in 2010 were expected to live an average of 77.8 years, while individuals living in a rural county in 2010 were expected to live 77.1 years. As expected, rural counties had higher levels of poverty and unemployment.

Comparing the direct spending categories that make up the infrastructure latent variable between urban and rural counties, we found significant differences in spending on sewerage, fire protection, and highways, both in 2002 and 2007. Spending on sewerage and fire protection was higher in urban counties than in rural counties; while spending on highways was higher in rural counties. In 2007, urban and rural counties had an average spending per person of 136 US$ (95% CI: 130–142) and 106 US$ (95% CI: 99–113) on sewerage, respectively; while average spending per person on highways was 337 US$ (95% CI: 322–352) in rural counties and 216 US$ (95% CI: 207–226) in urban counties. Among the spending categories that make up social spending, there were no significant differences between urban and rural counties in spending on public health, elementary and secondary education, and public welfare, both in 2002 and 2007. In contrast, there were significant differences in spending on natural resources, libraries, and parks and recreation. All spending categories that make law and order were significantly different between urban and rural counties in both years ($p < 0.001$). Police protection was one of the larger spending categories in our analysis and one of the only categories that saw increases from 2002-05 to 2007-10, 188.9 (Inter Quartile Range (IQR): 131.1–228.9) and 193.5 (IQR: 132.5–232.7), respectively, and in both urban and rural counties.

Table 1
Descriptive Statistics stratified by Rural-Urban Continuum Codes.

	2002–05				2007–10			
	Urban		Rural		Urban		Rural	
Variable	Mean	IQR	Mean	IQR	Mean	IQR	Mean	IQR
Life Expectancy at Birth (years)	77.0	75.6–78.4	76.4	74.8–78.1	77.8	76.4–79.4	77.1	75.6–78.8
Population living in poverty (% of total)	11.2	8.0–13.8	14.4	10.0–17.5	12.0	8.7–14.8	14.9	10.8–17.7
Unemployment rate (%)	5.0	3.9-5.7	6.0	4.3–7.2	7.7	6.3–8.8	8.0	6.0–9.7
Infrastructure ($ per capita)								
Sewerage	129.8	69.7–165.3	100.5	45.8–122.1	135.7	71.1–175.3	105.6	48.5–126.4
Fire Protection	103.2	52.7–143.3	65.8	31.0–84.3	108.5	53.9–147.9	71.7	29.8–88.9
Solid Waste Management	70.0	32.7–98.9	71.8	34.7–98.0	67.2	30.7–89.5	70.3	31.0–90.6
Highways	218.8	129.1–276.2	333.7	165.9–451.9	216.3	125.0–269.7	337.2	163.0–447.5
Social ($ per capita)								
Health	120.9	27.7–176.7	117.6	20.5–140.7	111.4	28.9–160.1	115.0	21.5–135.4
Education - Elementary and Secondary Education	2054.4	1671.0–2320.6	2076.0	1705.6–2356.8	1981.9	1637.6–2232.4	1957.1	1621.0–2191.7
Natural Resources	25.4	3.0–22.1	40.5	6.6–46.1	31.3	3.3–28.5	58.0	6.6–53.0
Libraries	35.5	15.6–50.0	27.6	10.3–37.5	35.5	15.0–47.2	28.2	10.3–36.9
Parks and Recreation	90.3	35.8–122.4	64.4	24.2–81.1	88.8	36.0–122.9	67.3	24.6–82.1
Public Welfare	127.8	8.4–186.8	137.5	7.3–180.7	118.8	7.6–176.3	127.1	5.7–182.3
Law & Order ($ per capita)								
Police Protection	211.9	147.5–267.0	172.2	124.1–205.7	217.6	151.0–263.9	175.3	122.4–211.2
Judicial and Legal	62.5	34.9–79.7	54.6	27.5–69.0	58.8	32.3–76.2	53.5	26.5–67.5
Housing and Community Development	91.6	29.5–125.2	69.4	22.1–90.3	88.2	27.7–114.4	70.3	21.0–88.3
Observations	799		1098		873		1155	

Table 2 describes the SEM standardized coefficients of the association between public spending categories and life expectancy at birth. For observed variables underlying each latent variable, these standardized coefficients should be interpreted as correlation coefficients because the observable variables are factors in a measurement model and they are not independent of each other (StataCorp, 2013).

In rural counties, the standardized estimates show that investments in social programs, such as public health and education, have a significant positive association with life expectancy in both 2002-05 and 2007-10. A one-standard-deviation increase in the propensity to spend in social programs was associated with a subsequent increase in life expectancy of 0.57 (SE 0.16) years and 0.36 (SE 0.16) years for 2002-05 and 2007-10, respectively. Only in the 2002-05 analysis, we find that the propensity to spend in infrastructure had a significant positive relationship with subsequent life expectancy in rural counties, while the propensity to spend in law and order had a significant negative relationship with subsequent life expectancy. A one-standard-deviation increase in the propensity to spend in infrastructure was associated with an increase of 0.17 years (SE 0.06) in subsequent life expectancy, and a one-standard-deviation increase in the propensity to spend in law and order was associated with a decrease of 0.46 years (SE 0.13) in subsequent life expectancy.

For urban counties, the only latent variable with a significant association with subsequent life expectancy was infrastructure, both in 2002-05 and 2007-10. A one-standard-deviation increase in infrastructure spending was associated with a significant increase of 1.14 (SE 0.51) years and 1.05 (SE 0.49) years in the 2002-05 and 2007-10 analysis, respectively.

An SEM allows one to measure the correlation between each directly observed expenditure variable and the latent variables to understand better the mechanism through which expenditure is associated with LEB. Tables A-5 and A-6 present the disaggregated estimations by budget category of the standardized coefficients presented in Table 2. For rural counties, the 2007-10 model shows that among the expenditure categories that make up the social latent variable, parks and recreation, natural resources, and libraries are highly correlated with the social spending latent construct, 63.1, 51.6, and 41.3 respectively ($p < 0.01$). While for urban counties, fire protection and sewerage had the greatest correlation with the infrastructure latent variable in both years of analysis. In 2007-10, fire protection and sewerage had a correlation with the propensity to spend on infrastructure of 70.3 and 55.4, respectively. For the 2002-05 analysis, police protection had the highest correlation with the law and order construct, 82.8 and 73.8 in urban and rural counties, respectively ($p < 0.01$).

Table 3 presents measures of the goodness of fit of our model stratified by geographical region for the 2002-05 and 2007-10 analysis. Our model has a fair fit because all the values of CFI and TLI are close to 1, and the upper bound of all RMSEA is close to 0.10. Finally, the model fits well according to the size of the residuals because all SRMR values are below 0.08 and all CD values are close to 1.

As a robustness check, we estimated our model with the full sample of 3,097 counties at both time periods 2002-05 and 2007-10—including those with zero spending (See Table A-7 and A-8 of the Appendix.). The full sample model showed similar goodness of fit. The direction of our results holds for those statistically significant variables in the analytical sample, although the magnitude is slightly different. For example, for rural counties, a one-standard-deviation increase in social spending was associated with a significant increase of 0.22 (SE 0.10) years, while a one-standard-deviation increase in law and order spending was associated with a 0.19 (SE 0.08) decrease in the 2007-10 analysis.

In addition, we also tested different time lags, 2-years and 4-years (Results are in Table A-9 to A-12 of the Appendix.), Goodness of fit measures were best for the 3-year lag model. Different period-lags confirmed the direction of our findings for urban and rural counties.

Table 4 presents the simulation to quantify the magnitude of association of the various spending categories on life expectancy based on the 2007-10 model. For rural counties, we found that the top three spending categories with the greatest magnitude of person-years gained from increasing spending by 1 US$ per person – equivalent to US$ 46 million – are natural resources (339,999 person-years), libraries (234,755 person-years), and parks and recreation (209,633 person-years). In urban counties, an increase of US$ 243 million – equivalent to a 1 US$ increase per person – in fire protection had an effect size of 139,593 person-years saved. Increases of a similar amount of money in sewerage and highways had an effect size of 82,091and 75,934 person-years saved, respectively.

Table 2
The relationship between county spending and Life Expectancy at Birth in the United States stratified by urban-rural areas, standardized coefficients.

	LEB			
	2002–05		2007–10	
VARIABLES	Urban (1)	Rural (2)	Urban$^{\phi}$ (3)	Rural (4)
Infrastructure	1.142**	0.174***	1.048**	0.029
	[0.506]	[0.064]	[0.49]	[0.06]
Social	1.297	0.573***	0.088	0.357**
	[1.335]	[0.156]	[0.693]	[0.157]
Law & Order	−2.138*	−0.462***	−0.811	−0.158
	[1.269]	[0.132]	[0.746]	[0.148]
Economic Stress	0.121	−0.396***	−0.546**	−0.637***
	[0.509]	[0.084]	[0.258]	[0.124]
Constant	38.583***	36.183***	36.961***	36.586***
	[0.966]	[0.773]	[0.885]	[0.762]
Observations	799	1098	873	1155

Notes.
Standard errors in brackets.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
(ϕ) Housing and Community Development is not included in Law & Order for urban 2007-10.

4. Discussion

We find evidence consistent with prior literature showing that spending categories besides health are associated with improved population health; additionally, our findings re-affirm well-known associations between economic stress and worse health in subsequent years. More importantly, we found that county's fiscal spending choices can be of sufficient magnitude to offset the negative shocks of economic stress. Whereas a one-standard-deviation rise in economic stress lowered life expectancy by 0.39–0.64 years, a one-standard-deviation increment in spending on infrastructure (sewerage, fire protection, solid waste, and highways) was associated with later increases in life expectancy of 0.17–1.14 years. A one-standard-deviation rise in social spending (health, education, natural resource regulation, libraries, and parks) was associated with later increases in life expectancy of 0.36–0.57 years in rural counties.

We found no evidence that spending on law and order improved life expectancy. Coefficients were generally negative and only significant in 2002-05. Law and order spending may or may not directly be crafted with increased life expectancy as its primary objective, especially if funding decisions are made in response to an exogenous shock or stimulus. Our finding that there are no observable health gains that accrue due to law and order spending supports a level of equipoise about the acceptability of future controlled experiments to test whether modest reductions in funding for law and order would lead to measurable decreases in life expectancy.

Using a simulation to trace the magnitude of the association of county spending line items to life expectancy, we found that spending that goes into the regulation of industries which develop, utilize, or affect natural resources, as well as the regulation of agricultural

Table 3
Goodness of fit of the SEM.

	2002–05		2007–10	
FIT STATISTIC	Urban	Rural	Urban$^{\phi}$	Rural
Population error				
RMSEA	0.105*** [0.099–0.111]	0.099*** [0.093–0.104]	0.099*** [0.093–0.105]	0.097*** [0.092–0.102]
Baseline comparison				
CFI	0.784	0.752	0.806	0.759
TLI	0.727	0.687	0.748	0.695
Size of residuals				
SRMR	0.084	0.078	0.076	0.075
CD	0.991	0.971	0.973	0.962

Notes.
90% confidence intervals in brackets.
(ϕ) Housing and Community Development is not included in Law & Order for urban 2007-10.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 4
Person-years saved given a simulated 1 US$ increase in annual per capita county spending in 2007.

	Subsample (n = 2028) (population = 257,796 thousands)			All counties (n = 3097) (population = 288,729 thousands)		
VARIABLES	Incremental investment (thousands, US$) Total	Incremental person-years saved Total	Average person-years saved per county Mean (95% CI)	Incremental investment (thousands, US$) Total	Incremental person-years saved Total	Average person-years saved per county Mean (95% CI)
Infrastructure (Urban counties)						
Sewerage	224,522	70,028	80.2 (66.4–94.0)	243,063	82,091	71.1 (58.8–83.4)
Fire Protection	224,522	116,947	134.0 (121.6–146.3)	243,063	139,593	121.0 (65.8–176.1)
Solid Waste Mgmt.	224,522	68,969	79.0 (63.9–94.1)	243,062	75,934	65.8 (55.1–76.5)
Highways	224,522	28,190	32.3 (28.3–36.2)	243,063	34,724	30.1 (25.5–34.7)
Social (Rural counties)						
Health	33,275	53,485	46.3 (40.1–52.5)	45,666	77,997	40.1 (37.2–43.1)
Education	33,275	2390	2.1 (2.0–2.2)	45,666	3302	1.7 (1.6–1.8)
Natural Resources	33,274	237,003	205.2 (184.4–225.9)	45,667	339,999	175.0 (162.5–187.5)
Libraries	33,274	163,777	141.8 (124.8–158.8)	45,666	234,755	120.8 (114.1–127.6)
Parks and Recreation	33,275	137,591	119.1 (108.3–130.0)	45,666	209,633	107.9 (103.2–112.6)
Public Welfare	33,275	96,333	83.4 (73.8–93.0)	45,666	158,759	81.7 (76.7–86.7)

Notes: Baseline investments are shown on Table 1. Average baseline prediction of LEB is 77.4427 (SD = 1.7311) in 2010. Reported results: Population × Δ Investment; $\text{Incremental person-years} = \sum_{i}^{N} \Delta\text{LEB} * \text{population}$, for county i, $i = 873$ urban counties and $i = 1155$ rural counties, for the 2007-10 analysis; Average person-years saved per county and 95% CI in parenthesis.

products and establishments, have the greatest association with increased life expectancy among individuals that live in rural counties. Prior experience has shown that places with poor environmental regulation are more likely to have sick individuals, e.g., in Flint, Michigan, where the drinking water source was changed to the Flint River to cut costs (Ruckart et al., 2019).

It is important to remember that the data in the current study was observational and that the spending choices made by counties were all subject to local context. Our analysis used a comprehensive measure of local government spending, though some state or federal spending that routes directly to individuals is not included in our analyses. Omitting, state and federal spending may bias our results towards zero if spending by higher levels of government is systematically made to rescue highly vulnerable counties. Alternatively, state and federal funding may be "pulled in" to highly advantaged counties due to superior political advocacy thus biasing our results away from zero. The status-quo is for counties to make spending decisions in an evidence-free zone regarding their accountability for outcomes related to human well-being. There are select few if any studies that make any attempt to show any connection whatsoever between spending choices and population health outcomes. Evidence of non-causal association between spending and life expectancy may still help ensure that locally-managed spending choices are as evidence-driven as possible.

Even though the analysis lagged data on life expectancy to ensure all spending occurred prior to measurement of life expectancy, some county leaders could have recognized the presence of unmeasured social risk factors or social assets omitted by the model and they could have allocated funds based on this data. Since the spending choices were non-random, the associations revealed in the analysis cannot be regarded as causal. The effects uncovered could be biased upwards or downwards based on whether counties were spending more due to unobservable assets in a particular area or spending more due to unobservable deficiencies. Both mechanisms are tenable.

There are limits to over-interpreting the associations in this analysis. It may not be the case that library spending or resource regulation directly causes better health. Counties that choose to regulate industry or to build a library and maintain cultural-scientific facilities may also be more likely to be formed by more advantaged households, whose members might be more likely to be oriented to better health than members from counties that do not push for library construction. Families that can afford to choose where to live could self-select themselves on the basis of health concerns to move to counties that offer infrastructure and social services conducive to health. If this were to be the case, this could argue for the belief that governments could attract in-migration of healthier people through generous social offerings. This theory would contrast with an alternative approach to attracting the migration of corporations through the provision of generous economic or tax incentives to businesses.

Our study was also limited by including the subsample of counties whose local governments had positive spending across all thirteen spending categories. It is possible that some of the counties that were not included in the subsample have higher levels of life expectancy because they have high levels of social spending funded by state governments. However, we re-estimated our model with the full sample of 3,097 counties and found similar results in terms of the direction and significance of the parameters, but of lower magnitude. These estimates can be found in Table A-7 and A-8 in the Appendix.

Some might think that the use of county-level aggregates might be introducing an ecological fallacy. However, in our study, county-level spending and the policies that control it are inherently ecological. To commit the ecological fallacy, one needs to aggregate phenomena that are inherently individual and then attribute the findings at the ecological level to individuals. Our study is not claiming that personal social spending affects individual health. Instead, we claim that the allocation of local government resources is associated with the subsequent health of a whole population. This fact is important given that individuals are compelled to fund social services collectively through taxes, and collective benefit is the correct metric to assess impact.

The relationship between the latent variables and life expectancy should not be interpreted as the causal effect of increasing one additional US$ per person because all thirteen spending categories are highly cross-correlated between themselves. The estimated coefficients of the model represent the association between observed and unobserved variables that rely on a system that is simultaneously estimated. However, even though a structural equation model cannot address causality, it allows one to relate all latent variables as a joint system that acts over an observed outcome. This is a loose approximation to how local government officials allocate scarce resources across budget categories that are competing between them for resources.

Similarly, the simulation phase of our study assumed counties could allocate extra dollars to each spending category per constituent without accounting for where that money came for. The simulation is essentially assuming a county can print or borrow a small amount of money—$1 per capita to allocate to various line items. In reality, there would be effects from either reducing some other allocation or raising new revenue in the real world. Future research would have to explore fiscally neutral spending simulations.

5. Conclusions

How local government officials allocate resources across all different spending categories matters and it affects the health of its constituents. In this paper, we provided evidence that county-level spending beyond health care in the social sphere and infrastructure has the potential of improving life expectancy at birth by using a structural equation model specification. Moreover, we provide evidence that resource allocation is not a one size fits all solution. The needs of urban counties are not the same as the needs of rural counties. Investments in infrastructure in urban counties and investments in social services in rural counties were associated with life expectancy improvements three years later. Modest reductions in law and order spending were associated with lower subsequent life expectancy, and in rural counties lower law and order spending was associated with higher subsequent life expectancy.

CRediT authorship contribution statement

Carolina Cardona: Data curation, Formal analysis, Software, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Neha Sahai Anand:** Data curation, Investigation, Methodology, Writing – review & editing. **Y. Natalia Alfonso:** Data curation, Writing – review & editing. **Jonathon P. Leider:** Conceptualization, Funding acquisition, Investigation, Writing – review & editing. **J. Mac McCullough:** Conceptualization, Funding acquisition, Investigation, Writing – review & editing. **Beth Resnick:** Conceptualization, Funding acquisition, Investigation, Writing – review & editing. **David Bishai:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Writing – review & editing.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ssmph.2021.100930.

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