State and Local Government Expenditures and Infant Mortality in the United States
Neal D. Goldstein, PhD, MBI,a Aimee J. Palumbo, PhD, MPH,b Scarlett L. Bellamy, ScD,a Jonathan Purtle, DrPH, MSc,c Robert Locke, DO, MPHd,e

abstract

BACKGROUND AND OBJECTIVES: Evidence suggests that government expenditures on non–health care services can reduce infant mortality, but it is unclear what types of spending have the greatest impact among groups at highest risk. Thus, we sought to quantify how US state government spending on various services impacted infant mortality rates (IMRs) over time and whether spending differentially reduced mortality in some subpopulations.

METHODS: A longitudinal, repeated-measures study of US state-level infant mortality and state and local government spending for the years 2000–2016, the most recent data available. Expenditures included spending on education, social services, and environment and housing. Using generalized linear regression models, we assessed how changes in spending impacted infant mortality over time, overall and stratified by race and ethnicity and maternal age group.

RESULTS: State and local governments spend, on average, $9 per person. A $0.30 per-person increase in environmental spending was associated with a decrease of 0.03 deaths per 1000 live births, and a $0.73 per-person increase in social services spending was associated with a decrease of 0.02 deaths per 1000 live births. Infants born to mothers aged <20 years had the single greatest benefit from an increase in expenditures compared with all other groups. Increased expenditures in public health, housing, parks and recreation, and solid waste management were associated with the greatest reduction in overall IMR.

CONCLUSIONS: Investment in non–health care services was associated with lower IMRs among certain high-risk populations. Continued investments into improved social and environmental services hold promise for further reducing IMR disparities.

What’s known on this subject: Infant mortality in the United States remains high, with the greatest burden in infants who are Black. Government expenditures on non–health care services can reduce mortality, but it is unclear what types of spending have the greatest impact among groups at highest risk.

What this study adds: Increases in environmental, educational, and social service spending had a demonstrable impact on reducing infant mortality across all states. Infants born to mothers aged <20 years had the greatest benefit from an increase in expenditures compared with all other groups.


Departments of aEpidemiology and Biostatistics and cHealth Management and Policy, Dornsife School of Public Health, Drexel University, Philadelphia, Pennsylvania; bDepartment of Epidemiology and Biostatistics, College of Public Health, Temple University, Philadelphia, Pennsylvania; dDepartment of Pediatrics, ChristianaCare, Newark, Delaware; and eDepartment of Pediatrics, Sidney Kimmel Medical College, Thomas Jefferson University and Department of Neonatology, Thomas Jefferson University Hospitals, Philadelphia, Pennsylvania

Dr Goldstein conceptualized and designed the study and conducted all analyses, Drs Palumbo and Locke conceptualized and designed the study, Drs Bellamy and Purtle provided analytical guidance; and all authors drafted the initial manuscript, reviewed and revised the manuscript, approved the final manuscript as submitted, and agree to be accountable for all aspects of the work.

This work was presented in part at the annual meeting of the American College of Epidemiology, September 21–23, 2020, virtual meeting.

DOI: https://doi.org/10.1542/peds.2020-1134
Accepted for publication Aug 26, 2020
Since the 1990s, the United States has consistently had the highest rates of infant mortality compared with other developed nations. Despite a 71% decline in infant mortality in the United States between 1961 and 2010, infants in the United States had a 76% greater risk of death in the early part of the 21st century compared with 19 other developed nations.\(^1\) Within the United States, infant mortality rates (IMRs) vary, with southeastern states and rural counties experiencing IMRs 20% to 100% higher than other areas.\(^2,3\) Most areas in the United States experienced a decrease in IMRs from 2005–2007 to 2012–2014, but decreases also varied by state, with declines of \(\geq 16\)% in some states to no significant changes in other states.\(^4\)

Racial disparities in IMRs have also been well described, with infants of non-Hispanic Black mothers having more than twice the mortality rate compared with infants of non-Hispanic white mothers.\(^5\) Despite overall IMR improvements, substantial racial disparity and between-state variability persist.\(^6\) Much of the neonatal racial gap in the IMR derives from higher rates of premature births, congenital anomalies, and interrelated maternal health factors, whereas the postnatal IMR is affected by consequences of prematurity, congenital anomalies, sudden infant death syndrome, and accidental determinants.\(^7–9\) Social determinants, including income, education, employment, neighborhood conditions, racism, and related sources of stress, have been shown to be associated with multiple health outcomes,\(^10\) including preterm birth and infant mortality.\(^11,12\) For example, in a 2010 study, researchers observed that Black infants born in states with the highest racial disparity in education had 25% increased odds of mortality in their first year of life when compared with white infants, accounting for other known individual and ecological risk factors.\(^12\)

Biologically, social and economic stress and poor neighborhood and housing conditions can elevate maternal stress and have physiologic effects that can increase the risk of low birth weight and premature birth and impact the health of a newborn.\(^11,12\)

Although the United States spends more on health care than other developed nations, this has not consistently translated to better infant mortality outcomes.\(^13\) Thus, upstream economic investments have been advocated to stem IMR disparities.\(^10,14\) Failure to address factors that contribute to social well-being may limit the potential positive effects that investments into traditional perinatal health care access may have on IMRs. At a national level, a meaningful portion of the difference in the IMR between the United States and Europe has been attributed in part to the increased social expenditures by other developed countries.\(^15,16\)

Within the United States, societal investments have been found to be associated with improvements in adult health outcomes\(^17\) as well as low birth weight and IMR.\(^18\) However, in these studies, researchers have evaluated only overall IMR and have not explored the effects on specific racial and ethnic or age group IMR disparities on a state-by-state basis. There is evidence that social investments may have disproportionate positive effects on specific populations with the greatest need.\(^17\) Given that overall social spending may differentially impact IMRs, we sought to describe IMRs by state and region and explored how state governmental investment into non–health care spending might impact IMRs over time, with specific attention to disparities by race, ethnicity, and maternal age.

**METHODS**

**Study Design and Data Sources**

We assembled a longitudinal, state-level (plus Washington, DC) data set of annual infant mortality and expenditure data for the years 2000–2016. The dependent variable, IMR, was obtained for each state from the US National Center for Health Statistics and represented the number of infant deaths during the first year of life per 1000 live births, overall and stratified by race and ethnicity (Hispanic, non-Hispanic white, non-Hispanic Black, and Asian American) and maternal age group (<20, 20–29, 30–39, and >39 years).\(^19\) To minimize suppressed cell counts due to stratification, 3-year moving averages were created. For example, the IMR for the year 2016 was averaged from years 2015 to 2017, the most recent year data available by race and ethnicity. Stratified estimates by other races (eg, American Indian and Alaskan native) were not included because of extensive suppression.

The independent variable, expenditures, was obtained from the US Census Bureau’s annual survey of state and local government finances.\(^20\) This federally mandated survey is a comprehensive reporting of expenditures and captures all amounts of money paid out by any government agency within a state for spending other than for retirement of debt, investment in securities, or extension of credit or as agency transactions.\(^21\) Although we used this survey to track 10 mutually exclusive categories of expenditures (Supplemental Table 1), we focused on overall spending, along with 3 specific categories hypothesized to have the greatest impact on IMR: (1) education services, including schooling and libraries; (2) social services and “income maintenance,” including public welfare, hospitals, health, social insurance administration, and veterans’ services; and (3) environment and housing, including natural resources, parks and recreation, housing and community development, sewerage, and solid waste management. For
total spending and for each spending category, expenditures were divided by the states’ population in the spending year to create a per-capita measure, which was then independently standardized to z scores to facilitate comparisons across categories of expenditures. Expenditures for 2001 and 2003 were not available from the Census Bureau; therefore, we imputed these years by averaging the year before and after.

In addition to the 2 main variables of interest, we also examined the president’s political party (Republican or Democrat) and a number of state-level confounding factors, including the governor’s political party (Republican, Democrat, or Independent), state legislature party majority (Republican, Democrat, or split), percentage of families below the federal poverty line, and Gini index, a measure of income inequality (ranging from 0 for perfectly equal to 1 for completely unequal income distribution). The president’s party and Gini index have previously been implicated as impacting IMRs, suggesting that macroscale policy may impact individual health.15,22,23 Single measures of state-level poverty rate and Gini index were obtained from the 2010–2014 American Community Survey 5-year estimates.24 Year-to-year state legislature compositions were obtained from the National Conference of State Legislatures,25 and the governor’s party was obtained from the National Governors Association for each year in the study.26 Only poverty rate was included in the final adjusted analyses because the other covariates were not associated with IMR (governor’s party and legislature composition) or expenditure (president’s party and Gini index) in our data.

**Statistical Analysis**

In the statistical analysis, we used repeated-measures, mixed-effects linear regression models predicting IMRs by expenditure, controlling for poverty rate and year. A random intercept was specified per state. We included an expenditure-year interaction term to assess our primary research question: how does a change in expenditure influence IMRs over time? Considering the stratified IMR and expenditure measures, we ran separate models to assess the impact of expenditures on each subgroup individually, resulting in 36 distinct regression models for the primary analysis: 9 measures of IMR across 4 spending categories. Forest plots allowed visual comparison of IMRs by expenditure categories (estimates obtained from regression models), as well as for comparison of national, regional, and state IMRs (unadjusted). In the primary analysis, we used a 1-year lag between expenditures and the 3-year averaged IMR. For example, for the IMR in the year 2016, which was averaged for 2015–2017, expenditures were modeled from 2014. Our focus on a single-year lag was to allow for the most proximal effect: changes in spending could affect pregnancy outcomes the subsequent year. We also present the results of 2- and 3-year lags that required further time for changes in spending to be implemented, thus impacting pregnancy and the first year of life. Longer lags were not possible because the reduction in the number of data points rendered models unstable. The analytic data set and computational codes can be downloaded from https://doi.org/10.5281/zenodo.3972165.

**RESULTS**

From 2000 to 2016, infant deaths per 1000 live births ranged from a low of 3.5 (VT, 2016) to a high of 13.7 (Washington, DC, 2005), with an overall mean of 6.6 (SD = 1.5) (Fig 1). The IMR was more than twofold higher among Black infants (mean = 12.2) than white (mean = 5.5), Asian American (mean = 5.1), or Hispanic (mean = 6.0) infants. The IMR was highest among mothers aged <20 years (mean = 9.7) and lowest among mothers aged 30 to 39 years (mean = 5.7). Comparisons among national, regional (northeast, south, Midwest, and west), and state IMRs overall and by race, ethnicity, and maternal age group are shown in Supplemental Figs 5–13. There was wide variation in state and local government expenditures (Fig 1, Supplemental Table 2), with a mean total spending of $9.03 (SD = $2.86) per person, per state. Expenditures on education averaged the highest among our categories (mean = $2.63; SD = $0.61), followed by social services (mean = $2.03; SD = $0.73) and environmental services (mean = $0.59; SD = $0.30) per person, per state.

Results from the adjusted regression models suggest that increases in total, environmental, and social services spending over time may reduce IMRs during the studied years (Fig 2). A $0.30 (1 SD) increase in environmental spending per person was associated with a decrease of 0.03 deaths per 1000 live births (95% confidence interval [CI]: −0.04 to −0.01), and a $0.73 (1 SD) increase in social spending per person was
associated with a decrease of 0.02 deaths per 1000 live births (95% CI: −0.04 to −0.01). Although point estimates suggest that increased spending reduced the IMR among Black children and had the unintended consequences of increasing the IMR among Asian American children, the associations were not statistically significant, with all CIs crossing zero. Infants born to mothers aged <20 years had the single greatest benefit from an increase in social and environmental expenditures compared with all other age groups. In particular, a $0.30 (1 SD) increase in environmental spending per person was associated with a decrease of 0.08 deaths per 1000 live births among mothers aged <20 years (95% CI: −0.13 to −0.03), and a $0.73 (1 SD) increase in social spending per person was associated with a decrease of 0.06 deaths per 1000 live births among mothers aged <20 years (95% CI: −0.10 to −0.02). State-level poverty rate was an independent risk factor for IMR across the majority of models, after accounting for expenditures and year-to-year differences (Supplemental Fig 14).

More detailed spending categories and associations with overall IMR in the subsequent 3 years are presented in Fig 3 and reveal substantial heterogeneity, suggesting that targeted spending in certain categories was associated with a reduced IMR. Among environmental expenditures, increased spending on solid waste management, housing, and parks and recreation revealed the greatest inverse association with overall IMR (decreases of 0.06, 0.05, and 0.05 deaths per 1000 live births, respectively), whereas increased spending on natural resources was associated with a higher IMR. Among educational expenditures, only an increased spending on libraries was associated with a lower IMR over time (decrease of 0.03 deaths per 1000 live births).

Models that considered longer lags of 2 and 3 years between spending and subsequent-year IMR revealed a waning effect for spending on the environment and a strengthening effect for spending on social services (Fig 4). These longer lag times had wider CIs because of fewer data points being available for modeling.

DISCUSSION

As demonstrated in this study, US state expenditures on societal well-being are associated with states’ total and stratified IMRs. These findings suggest that targeted investment strategies for specific populations, particularly younger mothers, within communities may have differential impacts on IMRs and vary by state over time. These findings are highly relevant to current state policy debates because lawmakers are simultaneously being forced to make decisions about spending cuts because of reduced tax revenue resulting from the coronavirus disease 2019 pandemic and align state budgets with priorities to promote racial justice and health equity.

Societal benefits of government expenditures are heterogenous by age and racial disparities in IMRs: it is not simply a matter of increasing spending uniformly across the board. As we observed in our data,
some categories of expenditure (eg, spending on hospitals) had minimal impact on IMRs over time, whereas other categories of expenditure (eg, housing, public health, and public welfare) had substantial impact on IMRs over time. Indeed, we observed that overall and most of the specific expenditures were associated with a directionality for reduced infant mortality at the state level, although there was considerable variability. In addition, some types of government spending may have more immediate consequences than others, depending on whether its benefit is before, during, or after pregnancy.

Although it may be intuitive that increased spending on public health is associated with improved IMRs (given that such spending includes activities funded by the Supplemental Nutrition Program for Women, Infants, and Children and other health-promoting resources that focus on pregnant women),26 some other associations suggest the need for further investigation. For example, spending on solid waste includes the collection, removal, and disposal of garbage and recycling and other activities that keep streets and sidewalks clean. Although researchers have found an increased risk of low birth weight for women living near landfill sites, the associations are small and the evidence is limited in such studies.29 However, the presence of trash in neighborhoods has also been included in indices of neighborhood quality,30 and the presence of trash may be indirectly related to health outside of direct exposures through specific toxins. The finding that increased spending on natural resources was associated with higher IMRs may reflect land-use differences among states in that infant mortality tends to be higher in rural areas and areas with greater agricultural production perhaps because of less access to health care and more environmental pollutants.31,32

Premature birth (a major driver of infant mortality) is affected by the health status of a woman before pregnancy and during pregnancy and involves intergenerational pathways.33,34 These pathways suggest that to have the greatest impact, government expenditures must function upstream of pregnancy; in other words, they cannot be focused on only prenatal care, but they should also address factors that influence the root causes of health before pregnancy and may take more than a single generation to have the greatest impact.35,36 Although we may see some impact on IMRs in a relatively short time frame (demonstrated in our study), the greater benefits may be intergenerational and more difficult to measure.

There are many evidence-based ways in which government investment can promote maternal and child health. One area of investment is in direct spending on health care. In the 1980s, when Medicaid expanded services to cover pregnancies, there was a significant reduction in low birth weight infants.37 However, in a review of studies on state-level impacts of Medicaid expansion, researchers found that some states did not observe reduced IMRs after expansion.38 This may be due to social, economic, and community resource limitations mitigating expanded insurance opportunities. More recently within the Patient Protection and Affordable Care Act, Medicaid expansion was associated with decreased IMRs.39 In contrast, non–Medicaid-expansion states experienced declines in the IMR at a slower rate between 2010 and 2014 and slight increases between 2014 and 2016.39 Aside from direct spending on health care, targeted, select programs (such as nurse-family partnerships, efforts to improve

![FIGURE 3](https://www.aappublications.org/news) Categories of state and local government expenditures and their association (controlling for poverty rate and year) with overall infant mortality in the United States in the subsequent year, 2000–2016. An estimate of 0 indicates no change in IMR, an estimate <0 (left of the vertical line) indicates a decrease in IMR, and an estimate >0 (right of the vertical line) indicates an increase in IMR. Estimates correspond to the interaction term between expenditure and time and can be interpreted as how each SD change in expenditure influences subsequent 3-year averaged IMR over time.
breastfeeding rates, sudden infant death syndrome reduction campaigns, and antipoverty programs) have the potential for meaningful improvement and reducing the racial IMR gaps.40 Researchers in Florida noted that a 10% increase in targeted public health spending was correlated with a 2% reduction in the statewide IMR between 2001 and 2014.41 Yet progress may be unfulfilled without comprehensive strategies at the national, state, and local levels, combined with governmental and community commitment.40,42 The persistent lack of progress suggests that different strategies may be needed, and we should explore how investing in programs that can impact maternal health before pregnancy might influence IMRs.

In a recent study, researchers explored the associations between social spending and health outcomes, in which social spending included services related to education, income supports, transportation, environment, public safety, and housing. The authors found that a higher ratio of social spending to health spending (spending on Medicare and Medicaid) was associated with reduced mortality, including postnatal infant mortality.18 Specifically, for each increase in this ratio (ie, greater social spending), the IMR declined by 4.15 per 100 000 live births. This estimate is consistent with our aggregated finding of social expenditures. Although their analysis, like our analysis, is ecological and cannot infer causation, the evidence suggests the most effective strategy for reducing IMR is not to continue to increase spending in health care without first addressing factors that impact social well-being more broadly. More specifically, investments into traditional perinatal health care access without addressing investments into maternal and family well-being may limit the positive effects on IMRs.

Social investment as a singular strategy to reduce IMR disparities, however, faces several challenges. For example, policy makers often focus on short-term outcomes that are measurable while they are in office.43 Thus, any efforts that would not be measurable for years, if not decades, into the future will be more difficult to move through the legislative process compared to legislation that focuses on short-term solutions. Nevertheless, in our analysis, we observed a short-term (between 1 and 3 years) reduction in IMRs that can help motivate policy makers focusing on short-term outcomes. In addition, social investment would have other nonhealth benefits, such as providing education for children, pensions for the elderly, and housing for the poor, and is widely supported by the public.44 With the coronavirus disease 2019 pandemic, city, state, and federal budgets are likely to be strained for the foreseeable future. This may divert money away from social spending that has been useful for providing such services that historically have indirectly lowered IMRs.

This study has notable strengths as well as important limitations. The advantages include evaluating state-level data over a sustained time period. We were able to stratify by maternal age, race, and ethnicity, and thus identify specific populations who may benefit the most from such spending and among whom the benefits of programs may be focused. By breaking out categories of government expenditures, we are also...
able to identify areas of spending that may be more efficient loci of investment.

Limitations include the ecologic approach, limiting our ability to control for individual factors or draw causal inference. This includes our inability to simultaneously control for multiple factors that may influence the relationship between spending and infant mortality. For example, the implication that Asian American infants did not benefit from governmental spending may have been obscured by the age, education, and foreign-born status of their mothers, which all tend to be higher among Asian American women but which could not be taken into account. We also recognize that there is a nonlinear structure of investments across various populations, and inefficiencies in current expenditures mean that those most in need of services may not necessarily receive them, mitigating their general effectiveness. Third, our longest lag of 3 years may not have provided sufficient time for the maximum impact of government spending. In previous work, researchers noted the greatest benefit from social spending occurred beyond 7 years; however, we were unable to examine such a long lag in our data. Finally, use of geopolitically broad state boundaries may not be optimal for revealing more subtle variations in populations or the impact of spending on their social environment. For example, racial inequities in school funding may limit the effect of education on IMR when comparing at the state level that further community-level analysis may have revealed.

CONCLUSIONS
IMR is reflective of, and amenable to, broad social, economic, and health care delivery contexts within a society. State and local governments, via increased social and environmental expenditures, have the potential to reduce, albeit not eliminate, IMR disparities.

ABBREVIATIONS
CI: confidence interval
IMR: infant mortality rate

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Pediatrics 2020;146;
DOI: 10.1542/peds.2020-1134 originally published online October 19, 2020;

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DOI: 10.1542/peds.2020-1134 originally published online October 19, 2020;

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