

BMJ Open Impact of federal transfers upon US infant mortality rates: a secondary analysis using a fixed effects regression approach

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ABSTRACT

Objectives In order to improve health outcomes, the federal government allocates hundreds of billions of annual dollars to individual states in order to further the well-being of its citizens. This study examines the impact of such federal intergovernmental transfers on reducing state-level infant mortality rates.

Setting Annual data are collected from all 50 US states between 2004 and 2013.

Participants Entire US population under the age of 1 year between 2004 and 2013.

Primary and secondary outcome measures State-level infant mortality rate, neonatal mortality rate and postneonatal mortality rate.

Results Using a fixed effects regression model to control for unmeasurable differences between states, the impact of federal transfers on state-level infant mortality rates is estimated. After controlling for differences across states, increases in per capita federal transfers are significantly associated with lower infant, neonatal and postneonatal mortality rates. Holding all other variables constant, a \$200 increase in the amount of federal transfers per capita would save one child's life for every 10 000 live births.

Conclusions Considerable debate exists regarding the role of federal transfers in improving the well-being of children and families. These findings indicate that increases in federal transfers are strongly associated with reductions in infant mortality rates. Such benefits should be carefully considered when state officials are deciding whether to accept or reject federal funds.

INTRODUCTION

Despite having the largest economy in the world, the USA has an infant mortality rate that ranks 26th among the Organization for Economic Co-operation and Development countries.¹ In 2010, the US infant mortality rate of 6.1 per 1000 live births was considerably higher than that of virtually every country in Europe.^{1–3} In addition, there is considerable variation in infant mortality across the US states. For example, infants born in Mississippi (infant mortality rate of 9.7 in 2013) were more than twice as likely to die before reaching the age of 1 year than

Strengths and limitations of this study

- A fixed effects regression model is used to estimate the impact of federal transfers on state-level infant mortality rates during the years of 2004–2013.
- After controlling for differences across states, increases in federal transfers are significantly associated with lower infant, neonatal and postneonatal mortality rates.
- Generalisations are limited to the time period of 2004–2013.

infants born in Iowa (infant mortality rate of 4.1).⁴ One important factor behind such wide differences in infant mortality are the socio-economic differences across states.^{5,6}

The federal government allocates hundreds of billions of dollars annually to state and local governments to help fund programmes intended to improve the well-being of the overall population and specifically the health and well-being of low-income infants and pregnant women. Improving the health of pregnant women is important because prematurity and low birth weight are among the strongest predictors of infant mortality,⁷ and lower socioeconomic status (particularly poverty) is strongly linked to these conditions.^{1,8} Federal resources allow low-income infants and pregnant women to receive benefits from several programmes, including Medicaid, the Children's Health Insurance Program (CHIP), the Supplemental Nutritional Assistance Program (SNAP), Temporary Assistance for Needy Families, the Healthy Start Program and the Special Supplemental Nutrition Program for Women, Infants and Children (WIC).⁹

Such programmes are funded by a combination of federal and state funds. This occurs through a system of fiscal federalism, whereby the federal government collects revenue at the national level and then redistributes these

funds back to the states. The states then use this money (matching it with some of their own) to administer the programmes. A strength of this system is that it allows the federal government to partially address fiscal inequities across state lines. Since not all states have the same tax base from which to draw resources for funding public health or other well-being initiatives, the federal government provides intergovernmental transfers to maintain the viability of the programmes. Fiscal federalism thus attempts to ensure that residents of all states are provided with a minimum standard of living.¹⁰

Yet what evidence exists to show that this fiscal federalism is actually effective? In particular, does it reduce one of the most important overall indicators of a population's health—infant mortality? While prior research has examined the effects of specific programmes on infant mortality,¹¹ this study is the first to analyse whether the aggregate amount of federal transfers (per capita) is associated with reductions in state-level infant mortality rates. A strong argument can be made that these resources should be examined in total because their overall effect may be much greater than that of any individual programme.¹² If such transfers are positively related to the quality of care and well-being that infants and pregnant women receive, then increases in the amount of federal transfers a state receives on a per-capita basis should predict reductions in the state's infant mortality rate. However, it is possible that increases in federal transfers might actually increase infant mortality if the transfers undermine local decision making, create unhealthy competition among service providers or lead to an inefficient allocation of resources.¹³

METHODS

Data sources

Our empirical analysis relies on annual data for all 50 US states between the 10-year period of 2004 and 2013. This period was chosen because information was available on each of our variables during these years. Consequently, every state has a series of 10 observations per variable; one for each year from 2004 to 2013, resulting in a total of 500 observations (50 states times 10 observations per state).

Our dataset is constructed from a variety of sources. Infant, neonatal and postneonatal mortality data were obtained from the National Vital Statistics Reports published by the US Department of Health and Human Services.¹⁴ Federal per capita transfers received was obtained from the Urban Institute/Brookings Institution Tax Policy Center.¹⁵ Data regarding a state's proportion of African-American and Hispanic residents, as well as rates of poverty, were obtained from the US Census Bureau.^{16–18} Gross domestic product (GDP) data were obtained from the US Department of Commerce Bureau of Economic Analysis,¹⁹ while state-level Gini coefficients (an overall measure of income inequality) were extracted from a database maintained by Mark Frank, a professor of economics at Sam Houston State University.²⁰ State and

local direct expenditures were obtained from the Tax Policy Center.¹⁵ The average freshman graduation rate data were obtained from the National Center for Education Statistics. The quality of these data sources is high, and coverage was complete for the years of 2004–2013. All data sets are public data.

Patients and public involvement

Patients and public were not involved.

Dependent and independent variables

We use state-level infant, neonatal and postneonatal mortality rates as our dependent variables. The infant mortality rate is defined as the number of children per one thousand live births who die before reaching the age of 1 year. The neonatal mortality rate is the number of children per one thousand live births who die between the age of 0 and 27 days. The postneonatal mortality rate is the number of children per one thousand live births who die between the age of 28 days and 364 days. Each dependent variable was inspected for skewness and kurtosis; they each approximated the normal distribution and did not require special estimation procedures.

Neonatal mortality accounts for two-thirds of infant mortality.²¹ Neonatal deaths are frequently related to prematurity and low birth weight, while postneonatal deaths are more likely to result from postbirth events such as accidents and disease that are related to hospital access, as well as the regionalisation of care.^{22–24} For this reason, our analysis examines the effect of federal transfers on the infant mortality rate, the neonatal mortality rate and the postneonatal mortality rate using three separate regressions.

The main independent variable of interest is the dollar amount of federal transfers received per capita. Each year the federal government transfers money to state and local governments to fund programmes such as Medicaid, SNAP and WIC. The size of these federal transfers has grown considerably over time. In 1929, federal transfers comprised approximately 1% of state and local revenue.²⁵ By 2009, this figure had climbed to 28%, with the federal government distributing roughly \$600 billion in aid to state and local governments annually.¹⁵ We examine whether changes in the amount of per capita federal transfers received by a state over time are associated with changes in the state's infant mortality rate, neonatal mortality rate and postneonatal mortality rate.

To accomplish this, it is important to control for confounding variables that might affect the infant mortality rate. These variables include race and ethnicity,²¹ economic conditions (poverty rate, income inequality as measured by the Gini coefficient and state-level GDP),²⁶ education (the average freshman graduation rate) and the overall amount of state expenditures. Each of these variables is included in our models to isolate the effect that federal transfers may have on state-level infant, neonatal and postneonatal mortality rates. In addition, we reran all of our models using the percentage of high

school graduates, as well as college graduates, with identical results to using the average freshman graduation rate.

Statistical analyses

We rely on a fixed effects regression to estimate the main models. Because each of the 50 states differs in ways that are difficult to measure, performing an ordinary least squares (OLS) regression on the pooled data would result in biased coefficient estimates.²⁷ For state-level panel data, the fixed effects method is preferred.²⁸ The fixed effects model addresses the problem of unobserved heterogeneity by examining variation that occurs within a state over time; this allows a limited form of endogeneity.²⁹ Thus, the fixed effects model is examining each state individually (ignoring variation between the states, as this may occur for unobservable reasons) and estimating how changes in the independent variable (the amount of federal transfers to the state) predict changes in the dependent variable (the infant, neonatal or postneonatal mortality rate for that state). The fixed effects approach is widely used in economic analysis of panel data and nested groups,^{27–29} and it assumes a linear relationship between the independent variable of interest and the dependent variable. Although it is possible that a non-linear relationship exists, our approach assumes linearity.

This study also controls for year effects to rule out the possibility that the results are driven by broader trends in infant mortality rates, federal transfers or economic period effects. For example, although the Great Recession of 2008 and 2009 occurred during our study period, our model controls for year effects, and therefore, the results are not being driven by the effects of economic changes such as the Great Recession. Data analysis was conducted in 2017 and 2018. Finally, the results of a variance inflation factor test and Cook’s distance did not reveal issues with multicollinearity or influential observations.

RESULTS

Descriptive statistics for the sample are presented in table 1. On average, 10.6% of state residents are African-American, while 10.2% are Hispanic during the sample period. The average state-level poverty rate is 13.0% and ranges from a low of 5.4% to a high of 25.8%. State and local direct expenditures, GDP and federal transfers were converted to 2013 dollar values using the inflation calculator provided by the Bureau of Labor Statistics (<https://data.bls.gov/cgi-bin/cpicalc.pl>). The average state-level GDP per capita is \$50 636 and varies from \$33 281 to \$86 195. The average amount of federal transfers per capita is \$2033.

In table 2, we examine the effect that changes in federal transfers have on changes in infant, neonatal and postneonatal mortality rates. Table 2 indicates that controlling for each state’s unique makeup and economic/demographic composition, increases in federal transfers are negatively associated with infant, neonatal and postneonatal mortality rates. These relationships are statistically significant and suggest that increases in per capita federal transfers are associated with decreases in state-level infant, neonatal and postneonatal mortality rates. This effect is particularly pronounced when examining the impact of federal transfers on a state’s overall infant mortality rate.

As noted earlier, it is important to keep in mind that our model coefficients are predicting the effects of changes in the independent variables on changes in the dependent variables, while holding state-specific characteristics constant.²⁷ This approach is superior to a pooled OLS regression when using state-level panel data, because it allows us to observe how changes in the amount of federal transfers received by a state predicts changes in that state’s infant mortality rate, while controlling for any state-level differences that may also affect infant mortality rates.²⁶

The practical significance of these findings is substantial. Holding all other variables constant, a \$200 increase in the amount of federal transfers per capita would save one child’s life for every 10 000 live births. This figure is

Table 1 Descriptive statistics state-level observations, 2004–2013

	N	Mean	SD	Min	Max
Infant mortality rate	500	6.5	1.3	3.8	11.4
Neonatal mortality rate	497	4.3	0.9	1.9	6.7
Postneonatal mortality rate	497	2.3	0.7	1.0	4.7
Proportion of black residents	500	10.6	9.5	0.4	37.4
Proportion of Hispanic residents	500	10.2	9.8	0.9	47.3
Poverty rate	500	13.0	3.4	5.4	25.8
Gini coefficient	500	0.6	0.0	0.5	0.7
Gross domestic product (per capita)	500	50 636	9800	33 281	86 195
State and local direct expenditures (per capita)	500	4897	3556	934	18 104
Average freshman graduation rate	500	77.7	7.6	51.3	93.3
Federal transfers received (per capita)	500	2033	659	919	4932

Table 2 Fixed effects regressions of the infant, neonatal and postneonatal mortality rates dependent variable: infant mortality rate, neonatal mortality rate and postneonatal mortality rate

	Infant mortality rate	Neonatal mortality rate	Postneonatal mortality rate
Intercept	4.3	4.6	-0.17
Proportion of black residents	0.25*	0.15	0.097
Proportion of Hispanic residents	-0.12	-0.038	-0.010*
Poverty rate	-0.019	0.0025	-0.022*
Gini coefficient	0.59	-1.62	2.2*
Gross domestic product (per capita)	0.00000097	0.00000029	0.00000063
State and local direct spending (per capita)	0.000057	-0.00000058	0.000058**
Average freshman graduation rate	-0.019	-0.019*	-0.00045
Federal transfers received (per capita)	-0.00049***	-0.00027*	-0.00019*

Source	N	F-statistic	P values	R ²	Adj. R ²
Infant mortality rate	500	51.7	0.00	0.89	0.87
Neonatal mortality rate	497	28.4	0.00	0.81	0.78
Postneonatal mortality rate	497	33.3	0.00	0.84	0.81

*P≤0.05, **p≤0.01, ***p≤0.001 (two-tailed test).

obtained by multiplying the coefficient estimate for the federal transfer variable (in the fixed effects model with infant mortality as the dependent variable) by 200. This yields the figure -0.098, which is 0.1 fewer deaths per 1000 live births (ie, 1 fewer death per 10000 live births). Given that the value of a lost life is several million dollars (and untold emotional cost),³⁰ federal transfers appear to play a valuable role in reducing overall infant mortality.

Finally, in a further analysis, we looked at white and black infant mortality rates separately. Our results indicated that federal transfers were associated with a lower neonatal mortality rate for both groups but that these results were particularly robust for black infants. The overall findings in this paper would therefore appear to be of heightened importance for black children in the USA.

DISCUSSION

Understanding the extent to which federal transfers are associated with infant mortality is critical for several reasons. First, the USA has among the highest infant mortality rates within the group of Western industrialised countries. Understanding the role that federal initiatives might play in helping to bring down this rate is essential to improving paediatric health.

Second, transfers are a large part of federal expenditures and represent a substantial source of revenue for state and local governments.³¹ Thus, it is important to determine whether such transfers are achieving their intended effect by equalising fiscal inequities in health outcomes across the states.

Third, federally funded programmes provide valuable assistance to millions of American families. For example, prior research suggests that government policies that increase wages can, in turn, reduce infant mortality.³²

This study provides additional evidence by showing whether per capita increases in overall federal funding can also reduce infant mortality rates. This knowledge is important for federal officials who must decide on the amount of funding to disburse as well as state officials who must decide on whether to accept these funds.

Finally, the infant mortality rate is a particularly useful gauge of a population's overall health status. Along with life expectancy, it serves as an important proxy for the quality of population health.³³ Consequently, higher rates of infant mortality are associated with poorer outcomes on a range of health indicators.³⁴ As a result, we would argue that federal transfers are helping to reduce a state's infant mortality rate, and they may also be helping to improve other measures of health as well.

Our results strongly suggest that increases in federal transfers are associated with reductions in infant mortality rates. This supports the argument that federal aid helps to ensure a minimum standard of care.³⁵ Without federal funds, states that have difficulty generating tax revenue might be forced to implement budget cuts. These cuts could strain social service providers and have an adverse impact on children's health. By collecting money at the national level and distributing it to under-resourced states, the federal government helps to promote equality of opportunity for children regardless of the state in which they happen to be born. In so doing, federal transfers can increase the welfare of American society as a whole, irrespective of state boundaries or regional differences.

Furthermore, as the American Public Health Association³⁶ notes, 'Higher spending on safety net programs is associated with improved health outcomes, and this association has been demonstrated in comparisons of the United States with other developed countries and U.S. states with each other' (2017: 1). We would argue

that such improved health outcomes result in a reduction of largely preventable health conditions and illnesses, including infant mortality, and as noted earlier, the infant mortality rate can be viewed as a useful indicator of population well-being and health.

Our analysis extends previous research in that prior studies have focused solely on the effectiveness of specific programmes in reducing infant mortality. The results from these studies have been mixed.³⁷ It has been pointed out that one of the problems plaguing such studies is that women are often eligible and 'enrolled in, more than one program, making it difficult to evaluate the effectiveness of a single program' (2012: 27).³⁷ As we argue, there are substantive reasons for considering the array of federal programmes as an overall package in their impact on rates of infant mortality.

We should also point out that federal spending could lower the infant mortality rate in at least one of two ways. The first is that it may directly reduce the number of infant deaths. This has been the mechanism that we have argued throughout. Specifically, federal spending could help reduce low birthweight babies, illness/infection, sudden death syndrome/sudden unexpected death syndrome and so on.^{38–40} These, in turn, would have the effect of reducing the overall infant mortality rate.

However, an alternative mechanism is possible; in states receiving more federal dollars, contraception may be more readily available for individuals, particularly for women at high risk of infant death. As a result, higher risk women may be less likely to become pregnant in such states. Therefore, greater numbers of infant deaths were prevented because such high-risk children were never born.

Regardless of the mechanism, we would argue that governors who have turned down federal funds should carefully reconsider the benefits offered by federal aid. Even though transfers can lead to increased spending and taxes, the benefits of reduced infant mortality may outweigh these costs. This is not to trivialise the importance of local autonomy, decision making or taxation; certainly these are valid considerations. However, these costs must be weighed against the benefits of federal transfers, which may save a substantial number of children's lives

When viewing the US infant mortality rate in the context of other developed nations, it is clear that the USA has significant room for improvement. Increased reliance on a system of federal transfers may provide an important key to achieving an infant mortality rate that is on par with other modern industrialised countries. These transfers could increase the welfare of thousands of children and families by sparing them the loss of a child. In addition, they could increase the welfare of American society as a whole by reducing the amount of productivity and innovation that is lost when infant children unnecessarily die. Finally, as argued earlier, federal transfers may also be exerting a positive effect on other indicators of health and well-being.

Strengths and limitations

This study has several strengths as well as limitations. With respect to strengths, the entire US population under the age of 1 year has been analysed between the 10-year period of 2004–2013. Using high-quality data sources, the impact of federal transfers on infant mortality has been examined. This represents the first study to analyse the overall effect of federal transfers on state-level infant mortality rates.

Second, we have used a particularly rigorous statistical approach to analyse the relationship between federal transfers and state-level infant mortality rates. By using a fixed effects regression model, the vexing problem of unobserved heterogeneity across states has been addressed.

Third, we believe our study has important policy implications. Rather than using model simulations typically found in economic policy analysis, we have used high quality federal and state data to model and statistically estimate the relationship between federal transfers and infant mortality. As such, our findings have 'real world implications' within the context of the USA.

With respect to limitations, our analysis examines federal transfers in the aggregate. Thus, it does not parse out the effects of changes in the CHIP, the SNAP, or other individual programmes. However, while it is important to evaluate the effects of individual programmes, we have argued that it is likely these programmes work in concert. The goal of this study has been not to evaluate a specific programme but to determine whether federal transfers, generally speaking, are linked to infant mortality rates. This is important because it goes to the heart of the debate regarding federal transfers and whether they have a role in promoting public health. Evaluations of individual programmes are critical to understanding the effectiveness of those programmes, but it is also valuable to inquire whether the social safety net as a whole is working. Based on the results of this study, it appears that overall federal transfers to states have saved children's lives.

Nevertheless, it is true that some federal transfers might not have a direct effect on infant mortality. In particular, Medicaid constitutes about half of federal transfers, and nearly two-thirds of Medicaid dollars are spent on the elderly or disabled.^{41 42} In addition, there is little reason to believe that federal transfers for highway spending would affect infant mortality. Therefore, to test the robustness of our findings, we re-estimated each of our models with a federal transfer variable that subtracted the amount of federal Medicaid dollars and federal highway funds that individual states received. The federal transfer variable for each model remained statistically significant and retained the same sign as in table 2. This robustness check confirms a strong relationship between federal transfers and infant mortality rates.

However, it also represents a second benefit. The coefficient for the federal transfer variable is 50% larger when we remove highway and Medicaid spending. Thus, by focusing on more targeted spending, the benefit of \$200

in federal transfers produces an increase from saving 1 life per 10 000 live births to saving 1.5 lives per 10 000 live births. This suggests that examining federal transfers in the aggregate may underestimate the impact of transfers on infant mortality, as non-targeted spending may make federal transfers appear less cost-effective than they in fact are. For this reason, our results should be viewed as a conservative test regarding the impact of federal transfers on reducing infant mortality. We leave it to further researchers to fine tune the array of federal programmes having the largest impact on reducing infant mortality.

A second limitation of our study is that we have focused on the 10-year time period from 2004 to 2013. While we controlled for year effects in the model to take into account general trends in federal transfers and infant mortality rates, future researchers could improve on our work by examining additional time periods as data become available. In addition, because of data limitations, we were not able to take into account a broad array of maternal population-level characteristics that are known to be associated with infant mortality.

Third, this study may be partially limited in its ability to show causality. While the fixed effects regression allows the component of the residual term that pertains to state-level fixed effects to be correlated with the independent variables, this does not address potential correlation between the independent variables and the component of the residual term that does not pertain to state-level fixed effects. Assuming the residual term is composed of two components, $\upsilon + \lambda$, where υ represents state-level fixed effects and λ is the component of the residual that does not pertain to state-level fixed effects, correlation of λ with the independent variables would bias the coefficient estimates.²⁷ Future researchers could remedy this by using instrumental variables estimation or making use of a natural experiment.

Finally, we have not performed a cost–benefit analysis to determine whether an increase in federal transfers would be politically feasible. The purpose of this study is simply to show that changes in federal transfers predict changes in infant mortality rates over time and that the effects on infant children are not trivial. Future researchers should perform a cost–benefit analysis to determine if the cost of increased federal transfers justifies the potential health savings. However, researchers would be wise to recognise that reducing infant mortality rates is just one potential benefit of transfers and that all transfer benefits (eg, increases in mothers' health) should be considered in the aggregate when determining whether an increase in federal transfer benefits outweighs the costs.

CONCLUSIONS

The system of intergovernmental transfers that has evolved over the past 100 years in the USA is a source of significant contention. Public health agencies laud federal transfers for providing a minimum level of health for children, while governors turn down programmes

that are almost exclusively federally funded. Our research indicates that federal transfers were indeed successful in reducing infant mortality rates during the 10-year period from 2004 to 2013. In short, it would appear that federal transfers can prevent the unnecessary deaths of thousands of children, and these benefits should be carefully considered when state officials are deciding whether to accept or reject federal funds.

Contributors MM and MRR designed and conducted analysis of the study, along with drafting the manuscript.

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