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Reproductive justice & preventable deaths: State funding, family planning, abortion, and infant mortality, US 1980–2010

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1. Introduction

The infant mortality rate is well-recognized as a fundamental measure of societal well-being (Report of the Secretary’s Advisory Committee on Infant Mortality (SACIM), 2016; David & Collins, 2014). Acutely sensitive to economic, racial/ethnic, and gender inequality and to abridgment of reproductive rights (SACIM, 2016; David & Collins, 2014), infant mortality is both associated with unintended pregnancy (SACIM, 2016; Finer & Zolna, 2014; Tsui, McDonald-Mosley & Burke, 2010), and serves as a gauge for infant morbidity and maternal mortality (SACIM, 2016). In 2008, an estimated 41% of births globally (Singh, Sedgh & Hussain, 2010) and 49% of US births (Finer & Zolna, 2014) were unintended pregnancies, with risk highest among impoverished women (Finer & Zolna, 2014; Tsui et al., 2010; Singh et al., 2010).

Contributing to risk of unintended pregnancies and their sequelae are inadequate reproductive health policies and resources (Gruskin, 2013; Frost, Sonfield, Zolna & Fine, 2015). These include lack of awareness of and access to such goods and services as appropriate contraceptives, family planning services, and abortion procedures (SACIM, 2016; David & Collins, 2014; Finer &
For each of the six years for which the Guttmacher data were available (1980, 1987, 1994, 2001, 2006, and 2010) (Sonfield & Gold, 2012), we computed, for both types of services: (1) the fraction of total state expenditures they comprised, and (2) per capita state spending (per woman, age 15–44), with amounts expressed in 2010 constant dollars (US Department of Labor, 2016; US Census Bureau, 2016a). We used both measures because research on the political sociology of the welfare state demonstrates both matter: the fraction of state spending aligns with the “welfare effort” conceptualization of the welfare state, and the per capita approach captures the level of public resources that are available to the average person in a state (Clayton & Pontusson, 1998).

So that we could meaningfully compare parameter estimates for these two variables, we modeled each measure as an ordinal categorical variable, ranging from 0 to 4. For the abortion expenditure data, we created a 5-category variable, whereby the lowest category included states which reported $0 funding (ranging from 8 in 1980 to 20 in 2006; mean (standard deviation [SD]) = 14.0 (3.6)) plus the small number with unreported funding (ranging from 4 in 1987 and 2006 to 9 in 2001; mean (SD) = 5.6 (1.7)), and categories 1 to 4 were quartiles based on distribution of funding > $0. We used the same 5 categories for state family planning expenditures, noting however that these expenditures exceeded $0 in all states in all years.

2.2. Outcome data: infant death rates

Using data from the publicly available National Center for Health Statistics (NCHS) US compressed mortality file (CMF) (National Center for Health Statistics, 2016a), we computed the infant death rate, defined as: \[ \text{[deaths < age 1]} \frac{\text{[population < age 1]}}{\text{[population < age 1]}} \] in the same calendar year (National Center for Health Statistics, 2016a). We used this metric instead of the infant mortality rate (\([\text{[deaths < age 1]} \text{[births]}, \text{in the same calendar year}\]) to enable results to be compared to other long-term analyses of US infant death rates (including in relation to reproductive policies) (Krieger et al., 2008, 2015a, 2015b; Krieger, Chen, Coull, Waterman & Beckfield, 2013) that extend back to 1960, a period that precedes public availability (starting in 1968) of US data on live births (US Center for Disease Control and Prevention (CDC, 2016; MacDorman, Hoyert & Mathews, 2013). Robust evidence demonstrates the infant death rate and infant mortality rate are very highly correlated \((r > 0.95)\) (National Center for Health Statistics, 2016a; MacDorman et al., 2013), and both provide an acceptable proxy for the gold-standard infant mortality rate computed using linked data on births and deaths, which are not publicly available until after 1980 (National Center for Health Statistics, 2016b).

The individual-level mortality records and census denominator data, stratified by age, gender, and race/ethnicity, were available aggregated to the county level; counties are the primary legal division of most states and most are functioning governmental units (US Census Bureau, 2016b). We report on the infant death rate lagged by one year after the exposure (state expenditure data), to reflect time elapsed since conception, and note that results were substantively identical to analyses with no lag, as would be expected given relatively little year-to-year variability in our dependent and independent variables.

2.3. Covariates

We included data on nine key state- and county-level sociodemographic and health service covariates identified in the literature as being associated with risk of infant mortality (SACIM, 2016; David & Collins, 2014; Finer & Zolna, 2014; Tsui et al., 2010; Singh et al., 2010; Gruskin, 2013; Frost et al., 2015; Grossman & Jacobowitz, 1981; Corman & Grossman, 1985; Joyce, 1987a, 1987b; Meier and McFarlane, 1994; McFarlane & Meier, 1998; McFarlane & Meier, 2001), is provided by a handful of studies, initially conducted in the 1980s (Grossman & Jacobowitz, 1981; Corman & Grossman, 1985; Joyce, 1987a, 1987b), and followed by a few that extended the data through 1998 (Meier & McFarlane, 1994; McFarlane & Meier, 1998; McFarlane & Meier, 2001). No studies to our knowledge have reported on these associations since 1998.

Suggesting it would be worthwhile to extend the time frame of analyses are several salient temporal changes: (a) declines in the infant mortality rate and changes in its recognized determinants (e.g., socially patterned declines in smoking during pregnancy and increases in gestational diabetes) (SACIM, 2016; Singh & Kogan, 2007); (b) declines in state funding for both reproductive health services (Sonfield & Gold, 2012; Schreiber & Traxler, 2015) and other social services influencing risk of infant mortality (Clayton & Pontusson, 1998; Rabarison, 2013); and (c) shifts in rates of contraceptive use (by type), unintended pregnancies, and use of abortion services (SACIM, 2016; Finer & Zolna, 2014; Rabarison, 2013; Jones, Mosher & Daniels, 2012; Frost, Henshaw & Sonfield, 2010; Kost, 2015; Jones and Kavanaugh, 2011; Jacobs & Stanfors, 2015). Thus, at this time of sharp debate over growing restrictions affecting provision of family planning and abortion services (Gruskin, 2013; Schreiber & Traxler, 2015; Gee, 2014; Devi, 2015), it is important to test the hypothesis that inverse associations continue to exist between provisions of these services and infant mortality rates.

We obtained data to analyze, for 1980–2010, associations between infant mortality and US state-only funding for family planning and abortion services, using data for the six years for which high quality publicly available data exist for these state expenditures (1980, 1987, 1994, 2001, 2006, and 2010) (Sonfield & Gold, 2012).

2. Material and methods

2.1. Exposure data: state expenditures on family planning and abortion services

Numerous theoretical frameworks for analyzing societal determinants of health and health inequities, as employed in social epidemiology, political sociology, and health policy, emphasize the joint importance of resources, rights, and governance, including for reproductive health and reproductive justice (Krieger, 2011; Cottingham et al., 2010; Silliman, Fried, Ross & Gutierrez, 2004). We accordingly focused on state-only expenditures for family planning and abortion services as the exposure of interest. These measures provide quantifiable evidence of state support for these services (Corman & Grossman, 1985; Joyce, 1987a, 1987b; Meier & McFarlane, 1994; McFarlane & Meier, 1998, 2001) and avoid well-known difficulties in assessing implementation and enforcement of enacted legislation (Winter, 2012; Cole & Fielding, 2007). We obtained these high quality state-only funding data from a unique series of periodic reports issued by the Guttmacher Institute, which were designed to be compared validly over time (Sonfield & Gold, 2012). State family planning services, as defined in these reports, comprise “the package of direct patient care services provided through family planning programs to clients receiving reversible contraceptives” (Sonfield & Gold, 2012, p. 5).
2. Additional covariates

produced many empty cells. Due to model non-convergence caused by joint distributions that

categories available in the CMF were populations of color. We were unable to control for individual-

Finer & Zolna, 2014). For 1980 level data on the percent of counties with no abortion providers

values. We additionally included, as a potential mediator, state-

speciﬁc Minnesota Population Center, 2016 ), and we estimated year-

across socioeconomic levels (SACIM, 2016; David & Collins, 2014; Finer & Zolna, 2014). For 1980–1988, the lack of county data for Alaska required the state’s data to be analyzed as one county (Krieger et al., 2008).

2.4. County income data

The CMF contains no socioeconomic data. We therefore linked the mortality data to county median family income obtained from US census decennial 1980–2010 data (missingness < 1%), which we adjusted for inﬂation and regional cost of living (US Department of Labor, 2016; Krieger et al., 2008). We used linear interpolation for intercensal years and then assigned counties to income quintiles, weighted by county population size, given its enormous variation (Krieger et al., 2008). For 1980–1988, the lack of county data for Alaska required the state’s data to be analyzed as one county (Krieger et al., 2008).

2.5. Racial/ethnic data

We included data on racial/ethnic composition as a covariate, at the county level, with race/ethnicity conceptualized as a social category arising out of and reinforcing inequitable race relations (Krieger, 2011; Winant, 2000). Warranting its inclusion are well-known racial/ethnic inequities in infant mortality, both within and across socioeconomic levels (SACIM, 2016; David & Collins, 2014; Finer & Zolna, 2014). For 1980–2010, the only racial/ethnic categories available in the CMF were “white,” “black,” and “other” populations of color. We were unable to control for individual-level race/ethnicity or to run models stratified by race/ethnicity due to model non-convergence caused by joint distributions that produced many empty cells.

2.6. Additional covariates

At the state-level, to address different funding streams affecting access to reproductive and other health services, we included year-specific data on Title X funding per capita (Sonfield & Gold, 2012) and Medicaid funding per capita (Sonfield & Gold, 2012), and as a marker for need for reproductive health services, we included year-specific data on state fertility rates (National Center for Health Statistics, 2016c). At the county-level, additional census-derived covariates were: percent of adults age 25 and older with less than a high school education; percent urban; and percent female labor force participation (US Census Bureau, 2016c, 2016d; Minnesota Population Center, 2016), and we estimated year-specific data by logistic interpolation between decennial census values. We additionally included, as a potential mediator, state-level data on the percent of counties with no abortion providers (Henshaw & Kost, 2008), and estimated year-specific values by interpolating and extrapolating based on the 1974–2004 data available (Henshaw & Kost, 2008).

2.7. Human subjects protection

Because our analyses solely used publicly available de-identified pre-existing coded data aggregated to the US county level along with county and state-level economic data, our study was exempted from Institutional Review Board review (HSC Protocol #20630–102).

2.8. Statistical analyses

To provide robust tests of our hypotheses, we triangulated (UNAIDS, 2010; Reiss, 2009; Baggaley & Fraser, 2010; Richmond, Al-Amin A, Davy Smith & Relton, 2014) complementary and appropriate multilevel statistical analyses, each employing Poisson log-linear models (Goldstein, 2011), albeit with different assumptions. Triangulation encompasses using both diverse sources of data and diverse modeling techniques, ideally with uncorrelated biases and errors, with robust results more likely to be unbiased (UNAIDS, 2010; Reiss, 2009; Baggaley & Fraser, 2010; Richmond et al., 2014).

For the first approach, we employed year-speciﬁc multilevel Poisson log-linear mixed models with random state and county effects (Goldstein, 2011). These analyses address the question: in any given year, is state funding associated with state infant death rates, controlling for covariates? All models included random state effects ($u_i$) and a randomly-distributed county-level error term ($v_j$), along with the specified covariates. The basic model is as follows:

$$y_{ij} \sim \text{Poisson}(\lambda_{ij})$$

$$\log(\lambda_{ij}) = \log(n_{ij}) + (\beta_0 + u_i + v_j)$$

and where $y_{ij}$ and $n_{ij}$ represent the number of infant deaths and population size, respectively, observed in county $j$ in state $i$; additional models added the relevant covariates. For the second approach, we employed a multilevel panel analysis (Goldstein, 2011), using overdispersed Poisson log-linear models with fixed state effects and a dummy variable for year. We also included interactions between year and covariates to allow for temporal changes in covariate effects. This latter approach asks the question: within states, what is the association between changes in state funding and changes in infant death rates, controlling for covariates?

We opted to use both modeling approaches because although panel data treating states as a unit of analysis are often used to analyze policy impacts, including via a difference-in-difference modeling approach, the strong assumption of fixed state effects over time may not necessarily hold (Goldstein, 2011). In our case, preliminary inspection of model results for approach #2 indicated that although some states were fairly consistent in their random effects over time, others were much more variable, thereby rendering problematic an assumption of fixed state effects over time (data available upon request). By using both the random-effects and fixed-effects approaches to unmeasured between-state heterogeneity, however, our analyses effectively control for all unmeasured covariates that do not change over time within states, but nevertheless make states different.

For each approach, we analyzed five models. Model 1 included, as fixed effects, county income quintile and county racial/ethnic composition (percent of population under age 1 categorized as “black”). Building on Model 1, Models 2 through 5 respectively employed our two different approaches to modeling the state expenditure data: per capita (the “a” models) and as fraction of total state expenditures (the “b” models). Model 2 added the state-level expenditure data on family planning and abortion services. Model 3 next added the state-level data on Title X funding per capita, Medicaid funding per capita, and fertility rate. Model 4 then added the county-level data on education,
urbanicity, and female labor force participation. Finally, Model 5 added the state-level data on percent of counties with no abortion provider. We fit models in R (R core team, 2014), and assessed model fit using the AIC and BIC diagnostic tests, as implemented by the lme4 package for mixed-effects models (Bates, Maechler, Bolker & Walker S, 2014).

3. Results

During the study period, the mean US county infant death rate declined by half (1980: 13.2 per 1000 (SD 9.0); 2010: 6.6 (SD 7.5)).

### Table 1

| Variable                                      | Year       | 1980       | 1987       | 1994       | 2001       | 2006       | 2010       |
|-----------------------------------------------|------------|------------|------------|------------|------------|------------|------------|
| **Outcome: Infant death rate**                |            |            |            |            |            |            |            |
| US County infant death rate (deaths < 1 yr)   |            | 13.2 (9.0) | 9.4 (7.5)  | 8.4 (10.1) | 7.2 (8.0)  | 7.0 (7.4)  | 6.6 (7.5)  |
| **N of infant deaths (in 1000 s)**            |            | 45.5       | 38.4       | 31.7       | 27.6       | 28.5       | 24.6       |
| Person-years at risk (N, in 1000 s)           |            | 3269.7     | 3610.5     | 3837.1     | 4012.7     | 4041.7     | 3944.2     |
| **Exposures: State-only expenditures**        |            |            |            |            |            |            |            |
| $ per capita (women age 15–44): mean (SD)     |            | (0.0039; 0.0025; 0.0025; 0.0025; 0.0025; 0.0025) | (0.0039; 0.0025; 0.0025; 0.0025; 0.0025; 0.0025) | (0.0039; 0.0025; 0.0025; 0.0025; 0.0025; 0.0025) | (0.0039; 0.0025; 0.0025; 0.0025; 0.0025; 0.0025) | (0.0039; 0.0025; 0.0025; 0.0025; 0.0025; 0.0025) | (0.0039; 0.0025; 0.0025; 0.0025; 0.0025; 0.0025) |
| % of state expenditures: mean (SD)            |            | 0.12 (0.05) | 0.09 (0.04) | 0.08 (0.04) | 0.09 (0.05) | 0.11 (0.07) | 0.10 (0.05) |
| **Covariates**                                |            |            |            |            |            |            |            |
| State Title X funding per capita: mean (SD)   |            | 16.0 (5.8) | 13.2 (5.0) | 16.2 (6.9) | 22.2 (11.3) | 30.0 (19.7) | 33.1 (13.7) |
| Medicaid funding per capita: mean (SD)        |            | 16.0 (5.8) | 13.2 (5.0) | 16.2 (6.9) | 22.2 (11.3) | 30.0 (19.7) | 33.1 (13.7) |
| State fertility rate per 1000                  |            | 71.72 (12.44) | 65.98 (7.28) | 63.89 (6.10) | 63.70 (7.10) | 68.41 (8.05) | 69.52 (8.34) |
| State percent of counties with no access to   |            | 766.3 (30.0) | 706.8 (29.4) | 73.4 (27.6) | 76.0 (27.3) | 76.3 (26.6) | 76.3 (26.6) |
| abortion providers                            |            |            |            |            |            |            |            |
| County median family income ($)*: mean (SD)   |            | 39,171 (8,546) | 39,268 (9,402) | 41,480 (9,973) | 43,880 (10,223) | 43,523 (10,238) | 43,231 (10,677) |
| % of county population < age 1              |            | 10.5 (17.3) | 10.3 (17.0) | 10.7 (17.7) | 10.7 (16.7) | 10.9 (16.5) | 11.5 (16.9) |
| Percent adults age 25 and older with less than |            | 40.7 (12.3) | 33.4 (10.9) | 27.1 (9.6) | 21.9 (8.5) | 18.3 (7.61) | 15.9 (7.0) |
| a high school education: mean (SD)           |            | (0.97; 0.70) | (0.3; 0.70) | (0.4; 0.70) | (0.4; 0.70) | (0.4; 0.70) | (0.4; 0.70) |
| Percent female labor force participation:     |            | 57.4 (7.9) | 65.6 (7.5) | 69.4 (7.2) | 69.5 (7.2) | 65.7 (7.8) | 62.5 (9.0) |

Note: Sources of expenditure data (Sonfield and Gold, 2012): (1) R.B. Gold, Publicly funded abortions in FY 1980 and FY 1981, Fam Plan Perspec. 14 (1982) 204–207; (2) R. Nestor, Public funding of contraceptive services, 1980–1982, Fam Plan Perspec. 14 (1983) 198–203; (3) R.B. Gold, S. Guardado, Public funding of family planning, sterilization and abortion services, 1987, Fam Plan Perspec. 20 (1988) 228–233; (4) T. Sollom, R.B. Gold, R. Saul, Public funding for contraception, sterilization and abortion services, 1994, Fam Plan Perspec. 28 (1996) 166–173; (5) A. Sonfield, R.B. Gold, Public Funding for Contraceptive, Sterilization and Abortion Services, FY 1980–2001, Guttmacher Institute, New York, 2005; (6) A. Sonfield, C. Alrich, R.B. Gold, Public Funding for Family Planning, Sterilization and Abortion Services, FY 1980–2006, Occasional Report, No. 38, Guttmacher Institute, New York, 2008; (7) A. Sonfield, R.B. Gold, Public Funding for Family Planning, Sterilization and Abortion Services, FY 1980–2010, Guttmacher Institute, New York, 2012

* all dollars expressed in 2010 constant dollars.

* defined as: “the package of direct patient care services provided through family planning programs to clients receiving reversible contraceptives,” comprising “client counseling and education, contraceptive drugs and devices, related diagnostic tests (e.g., those for pregnancy, Pap, HIV and other STIs) and treatment after diagnosis (e.g., for urinary tract infections and STIs other than HIV)” (16, p. 5).
Additionally, regarding the covariates (Table 1), between 1980 and 2010, the mean of county median family income (in 2010 constant dollars) rose by 10% (1980: $39,171 (SD 8,545); 2010: $43,231 (SD 10,677)) and, in any given year, widely varied across counties – for example, in 2010, it ranged from $16,290 to $116,546. By contrast, the mean percent of county population...
Tables 2 and 3 present the multivariate results, respectively, for the repeat cross-sectional and the panel analyses. Since 2000, in all models, an inverse association existed between state funding for abortion services and the infant death rates, with virtually identical results observed for 2001, 2006, and 2010, regardless of analytic approach or method of modeling the expenditure data. Thus, for abortion funding, in models including all covariates (i.e., Tables 2 and 3, Models 5a and 5b), the rate ratio for infant death per one-unit change in funding quartile for abortion services ranged between 0.94 to 0.98 (95% confidence intervals excluding 1, except for the 2001 cross-sectional analysis, whose upper bound equaled 1), yielding an average 15% reduction in risk (i.e., 0.86* (range: 8 to 22%), comparing the top-funding versus no funding categories. For state-only funding for family planning services, an inverse association with infant death rates, robust to analytic approach, was observed only in 1994 for per capita funding, and the reduction of risk of infant death, per a one-unit change in funding quartile, was similarly lower (Table 2, Model 5a: RR 0.95 (95% CI 0.93, 0.96); Table 3 Model 5a: RR 0.96, 95% CI 0.94, 0.98).

Two additional findings robust to analytic approach pertained to increased risk associated with county lower income and higher proportion of black infants. For county income, the inverse association increased over time, e.g., the RR comparing the lowest to highest county income quintile in 1980 equaled 1.12 (95% CI 1.07, 1.18) in the year-specific analysis (Table 2, Model 1) and 1.09 (95% CI 1.05, 1.13) in the panel analysis (Table 3, Model 1); in 2010, these RR’s equaled, respectively, 1.45 (95% CI 1.36, 1.54) and 1.36 (95% CI 1.29,1.43). For race/ethnicity, the excess risk associated with a 10% increase in the county percent of black infants rose from 1980 to 1987 and then modestly declined, with values for 2010 on par with those for 1980. Thus, in the repeat cross-sectional analysis (Table 2, Model 1), the RR rose from 2.70 in 1980 (95% CI 2.46, 2.95) to 3.86 in 1987 (95% CI 3.60, 4.16) and declined to 2.19 in 2010 (95% CI 1.94, 2.47); the analogous RR for the panel analysis (Table 3, Model 1) were 2.82 (95% CI 2.63, 3.01), 3.78 (95% CI 3.52, 4.05), and 2.50 (95% CI 2.28, 2.75).

4. Discussion

Our analysis of US county infant death rates during the 1980–2010 period provides robust new evidence that, since 2000, state-only expenditures on abortion services have become inversely associated with risk of infant death. Additionally, between 1980 and 2010, the socioeconomic gradient for infant death steepened and the excess risk observed in counties with a high proportion of black infants persisted in all years. Inverse associations between state-only funding for family planning and risk of infant death, however, were observed only in 1994.

Before interpreting these results, it is important to consider study limitations. An ideal data set would have: (a) employed 1960–2010 US national annual individual-level data on infant deaths linked to live births, in records containing socioeconomic data and other relevant covariates (e.g., maternal age, intended vs. unintended pregnancy, gestational length, maternal residence in the year prior to and including the birth and death of the infant, and access to both public and private health insurance); (b) nested these records within counties (and hence states), and (c) linked them to detailed annual high-quality data on (i) federal, state, county, and private charitable expenditures on family planning and abortion services and other maternal and child health services, including those focused on reducing perinatal mortality, as utilized by state residents and non-residents, and (ii) state-level data on abortion rates and unintended pregnancy rates. No such linked data sets exist (Finer & Zolna, 2014; Singh & Kogan, 2007; Sonfield & Gold, 2012; National Center for Health Statistics, 2016a, 2016b; Guttmacher Institute, 2016; Pazol, Creanga, Burley, Hayes & Jamieson, 2013; Mosher, Jones & Abma, 2012).

Our alternative approach thus entailed using the best measured exposure data (Sonfield & Gold, 2012), in conjunction with the corresponding national mortality data (National Center for Health Statistics, 2016a), additionally linked to relevant state- and county-level covariates (Krieger et al., 2008; National Center for Health Statistics, 2016b; US Census Bureau, 2016c, 2016d; Minnesota Population Center, 2016; Henshaw & Kost, 2008). Suggesting our approach is reasonable, the infant death rate, as noted above, is highly correlated with the infant mortality rate (National Center for Health Statistics, 2016a; MacDorman et al., 2013). Socioeconomic gradients in infant mortality rates and their trends detected using county-level economic data (Krieger et al., 2008; Blumenshine, Egerton, Barclay, Cubbin & Brauman, 2010) are similar to those observed using individual- and household-level economic data (Blumenshine et al., 2010). Our approach also takes into account documented high correlations between the social indicator of county racial/ethnic composition (% black, for persons < age 1) and geographic variation in US infant mortality rates (SACIM, 2016; David & Collins, 2014; Singh & Kogan, 2007; Christopher & Simpson, 2014), and also documented high correlations in rates of abortion in relation to women’s state of residence and the state in which the abortion occurred (Guttmacher Institute, 2016; Pazol et al., 2013). Additional potential data limitations, moreover, would likely lead to conservative, not inflated, effect estimates, including: (1) measurement error regarding funding levels (especially since no evidence indicates any systematic bias in relation to state, time, or funding source (Sonfield & Gold, 2012)); (2) women’s travel to other states to have abortions; (3) including the handful of states not reporting funding with the two-fold larger number of states reporting $0 funding; and (4) lack of data on alternative sources of abortion funding (e.g., charitable donations).

Drawing on methods employed from political sociology (Clayton & Pontyssen, 1998), our study innovatively modeled the state-only family planning and abortion service expenditures both in per capita terms (per woman, age 15–44) and as fraction of total state spending. An additional strength is that our exposure variable (actual state funding) avoids reliance on defining exposures in relation to laws that may or may not be implemented or enforced (Winter, 2012; Cole & Fielding, 2007) and, given the time period examined, also avoids complications of comparisons before and after passage of the Affordable Care Act (SACIM, 2016).

Furthermore, in contrast to the handful of prior analyses of US state reproductive health funding and birth outcomes (Grossman & Jacobwitz, 1981; Corman & Grossman, 1985; Joyce, 1987a, 1987b;
Table 2
Rate ratios for state spending on family planning and abortion services on US infant death rates, net of specified county-level sociodemographic and socioeconomic covariates: 1980, 1987, 1994, 2001, 2006, and 2010.

| Year | Parameter | Rate ratio (95% confidence interval) |
|------|-----------|--------------------------------------|
|      |           | Model 1                               |
|      |           | 10.27 (9.40, 11.22)                   |
|      |           | 10.64 (8.62, 13.13)                   |
|      |           | 10.70 (8.67, 13.20)                   |
|      |           | 9.97 (7.72, 12.87)                    |
|      |           | 9.99 (7.73, 12.92)                    |
|      |           | 10.04 (7.76, 13.00)                   |
|      |           | Model 2a                              |
|      |           | 10.28 (9.41, 11.22)                   |
|      |           | 10.64 (8.62, 13.13)                   |
|      |           | 10.70 (8.67, 13.20)                   |
|      |           | 9.97 (7.72, 12.87)                    |
|      |           | 9.99 (7.73, 12.92)                    |
|      |           | 10.04 (7.76, 13.00)                   |
|      |           | Model 2b                              |
|      |           | 10.28 (9.41, 11.22)                   |
|      |           | 10.64 (8.62, 13.13)                   |
|      |           | 10.70 (8.67, 13.20)                   |
|      |           | 9.97 (7.72, 12.87)                    |
|      |           | 9.99 (7.73, 12.92)                    |
|      |           | 10.04 (7.76, 13.00)                   |
|      |           | Model 3a                              |
|      |           | 10.64 (8.62, 13.13)                   |
|      |           | 10.70 (8.67, 13.20)                   |
|      |           | 9.97 (7.72, 12.87)                    |
|      |           | 9.99 (7.73, 12.92)                    |
|      |           | 10.04 (7.76, 13.00)                   |
|      |           | Model 3b                              |
|      |           | 10.70 (8.67, 13.20)                   |
|      |           | 9.97 (7.72, 12.87)                    |
|      |           | 9.99 (7.73, 12.92)                    |
|      |           | 10.04 (7.76, 13.00)                   |
|      |           | Model 4a                              |
|      |           | 9.97 (7.72, 12.87)                    |
|      |           | 9.99 (7.73, 12.92)                    |
|      |           | 10.04 (7.76, 13.00)                   |
|      |           | Model 4b                              |
|      |           | 9.97 (7.72, 12.87)                    |
|      |           | 9.99 (7.73, 12.92)                    |
|      |           | 10.04 (7.76, 13.00)                   |
|      |           | Model 5a                              |
|      |           | 9.97 (7.72, 12.87)                    |
|      |           | 9.99 (7.73, 12.92)                    |
|      |           | 10.04 (7.76, 13.00)                   |
|      |           | Model 5b                              |
|      |           | 9.97 (7.72, 12.87)                    |
|      |           | 9.99 (7.73, 12.92)                    |
|      |           | 10.04 (7.76, 13.00)                   |
| Year | Parameter | Model 1 | Model 2a | Model 2b | Model 3a | Model 3b | Model 4a | Model 4b | Model 5a | Model 5b |
|------|-----------|---------|----------|----------|----------|----------|----------|----------|----------|----------|
| 1987 | (intercept: infant deaths per 1000 persons < age 1) | 7.37 (7.08, 7.68) | 7.49 (6.91, 8.11) | 7.78 (7.16, 8.46) | 6.79 (2.74, 16.81) | 7.15 (2.83, 18.05) | 7.28 (2.52, 20.51) | 7.19 (2.52, 20.51) | 8.00 (2.70, 23.67) | 7.78 (2.63, 23.04) |
|      | County income quintile |                     |          |          |          |          |          |          |          |          |
|      | 1 (lowest) | 1.16 (1.12, 1.21) | 1.16 (1.11, 1.20) | 1.16 (1.11, 1.21) | 1.17 (1.12, 1.22) | 1.17 (1.09, 1.25) | 1.17 (1.09, 1.25) | 1.17 (1.09, 1.25) | 1.17 (1.09, 1.25) | 1.17 (1.09, 1.25) |
|      | 2         | 1.18 (1.14, 1.23) | 1.19 (1.14, 1.23) | 1.19 (1.14, 1.23) | 1.20 (1.15, 1.24) | 1.16 (1.10, 1.22) | 1.16 (1.10, 1.22) | 1.16 (1.10, 1.22) | 1.16 (1.10, 1.22) | 1.16 (1.10, 1.22) |
|      | 3         | 1.20 (1.16, 1.25) | 1.21 (1.16, 1.25) | 1.21 (1.16, 1.25) | 1.21 (1.17, 1.26) | 1.18 (1.13, 1.23) | 1.18 (1.13, 1.23) | 1.18 (1.13, 1.23) | 1.18 (1.13, 1.24) | 1.18 (1.13, 1.24) |
|      | 4         | 1.14 (1.10, 1.18) | 1.14 (1.10, 1.19) | 1.14 (1.10, 1.19) | 1.15 (1.11, 1.19) | 1.14 (1.10, 1.19) | 1.14 (1.10, 1.19) | 1.14 (1.10, 1.19) | 1.14 (1.10, 1.19) | 1.14 (1.10, 1.19) |
|      | 5 (highest; referent group) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
|      | County: % persons < age 1 = “black” (per 10% increase) | 3.87 (3.60, 4.16) | 3.86 (3.59, 4.16) | 3.88 (3.59, 4.19) | 3.88 (3.59, 4.19) | 2.53 (2.27, 2.81) | 2.53 (2.27, 2.81) | 2.53 (2.27, 2.81) | 2.53 (2.27, 2.81) | 2.53 (2.27, 2.81) |
|      | State expenditures on family planning: per capita (women age 15–44) (categories: 0–4) | 0.98 (0.95, 1.01) | 0.99 (0.90, 1.08) | 1.00 (0.92, 1.10) | 1.01 (0.92, 1.10) |          |          |          |          |
|      |          | 0.97 (0.94, 0.99) | 0.97 (0.89, 1.05) | 1.00 (0.92, 1.09) | 1.01 (0.92, 1.10) |          |          |          |          |
|      | State expenditures on abortion services: per capita (women age 15–44) (categories: 0–4) | 1.02 (1.00, 1.05) | 1.03 (0.97, 1.10) | 1.00 (0.93, 1.07) | 0.98 (0.89, 1.07) |          |          |          |          |
|      |          | 1.02 (1.00, 1.04) | 1.02 (0.96, 1.09) | 1.00 (0.94, 1.07) | 0.99 (0.90, 1.08) |          |          |          |          |
|      | State Title X funding per capita (women age 15–44) (categories: 0–4) | 1.00 (0.91, 1.11) | 1.01 (0.92, 1.11) | 1.01 (0.91, 1.12) | 1.02 (0.92, 1.13) | 1.01 (0.92, 1.12) |          |          |          |
|      | State Medicaid funding per capita (women age 15–44) (categories: 0–4) | 0.98 (0.89, 1.08) | 0.99 (0.89, 1.09) | 0.98 (0.89, 1.08) | 0.98 (0.89, 1.08) | 0.98 (0.89, 1.09) | 0.98 (0.89, 1.09) |          |          |
|      | State fertility rate: live births per 1000 women age 15–44 (per change in rate of 10 per 1000) | 1.01 (0.96, 1.06) | 1.01 (0.95, 1.06) | 1.00 (0.94, 1.06) | 1.00 (0.94, 1.06) | 1.00 (0.94, 1.06) | 1.00 (0.94, 1.06) |          |          |
|      | County: % urban (per 10% increase) | 1.23 (1.17, 1.29) | 1.23 (1.17, 1.29) | 1.23 (1.17, 1.29) | 1.23 (1.17, 1.29) |          |          |          |          |
|      | County: % less than high school education (per 10% increase) | 1.66 (1.33, 2.07) | 1.66 (1.33, 2.07) | 1.65 (1.33, 2.07) | 1.66 (1.33, 2.07) |          |          |          |          |
|      | County: % female labor force participation | 0.86 (0.63, 1.18) | 0.86 (0.63, 1.18) | 0.86 (0.63, 1.18) | 0.86 (0.63, 1.18) |          |          |          |          |
|      | State: % of counties with no abortion provider | 0.87 (0.58, 1.32) | 0.87 (0.58, 1.32) | 0.87 (0.58, 1.32) | 0.87 (0.58, 1.32) |          |          |          |          |
|      | State random effect (SD) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) |
|      | County random effect (SD) | 0.010 (0.098) | 0.008 (0.087) | 0.007 (0.084) | 0.008 (0.08) | 0.080 (0.283) | 0.080 (0.283) | 0.080 (0.283) | 0.080 (0.283) | 0.080 (0.283) |
|      | AIC | 13006.29 | 12056.05 | 12052.05 | 12114.63 | 12114.14 | 11645.80 | 11645.80 | 11647.38 | 11647.50 |
|      | BIC | 13054.64 | 12115.80 | 12111.79 | 12192.29 | 12191.80 | 11741.07 | 11741.08 | 11748.61 | 11748.73 |
| Year | Infant Deaths per 1000 Persons < Age 1 | County Income Quintile | State Expenditures on Family Planning | State Expenditures on Abortion Services | State Title X Funding per Capita | State Medicaid Funding per Capita | State Fertility Rate | County: % Urban | County: % Less Than High School Education | County: % Female Labor Force Participation | State: % of Counties with No Abortion Provider | State Random Effect (SD) | County Random Effect (SD) | AIC | BIC |
|------|--------------------------------------|-----------------------|-------------------------------------|--------------------------------------|--------------------------------|--------------------------------|---------------------|----------------|-------------------------------|--------------------------------|---------------------------------|-----------------|-----------------|-----|-----|
| 1994 | 5.40 (5.14, 5.68) 5.88 (5.51, 6.27) 5.80 (5.43, 6.20) 7.98 (6.57, 9.69) 8.00 (6.59, 9.83) 8.66 (2.98, 26.32) 6.50 (4.10, 9.08) 7.72 (2.38, 25.05) | County Income Quintile | | | | | | | | | | | | | | |
| 2001 | 4.65 (4.43, 4.88) 4.99 (4.63, 5.39) 5.06 (4.67, 5.48) 6.24 (4.92, 7.89) 6.54 (5.23, 8.17) 6.04 (3.57, 10.24) 6.38 (3.84, 10.61) 5.54 (3.27, 9.41) 5.98 (3.59, 9.96) | | | | | | | | | | | | | | | |
Table 2 (continued)

| Year | Parameter | Rate ratio (95% confidence interval) |
|------|-----------|-------------------------------------|
|      |           | Model 1    | Model 2a   | Model 2b   | Model 3a   | Model 3b   | Model 4a   | Model 4b   | Model 5a   | Model 5b   |
| 3    |           | 1.34 (1.25, 1.43) | 1.30 (1.22, 1.39) | 1.30 (1.21, 1.39) | 1.31 (1.22, 1.40) | 1.31 (1.22, 1.40) | 1.33 (1.24, 1.43) | 1.33 (1.24, 1.43) | 1.32 (1.23, 1.41) | 1.32 (1.23, 1.41) |
| 4    |           | 1.27 (1.19, 1.35) | 1.23 (1.15, 1.32) | 1.23 (1.15, 1.32) | 1.24 (1.16, 1.32) | 1.24 (1.16, 1.32) | 1.24 (1.16, 1.32) | 1.24 (1.16, 1.32) | 1.23 (1.15, 1.31) | 1.23 (1.15, 1.31) |
| 5 (highest; referent group) |           | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| County: % persons < age 1 = "black" (per 10% increase) |           | 2.79 (2.52, 3.08) | 2.63 (2.36, 2.91) | 2.63 (2.37, 2.92) | 2.53 (2.27, 2.82) | 2.64 (2.34, 2.97) | 2.64 (2.34, 2.98) | 2.58 (2.29, 2.91) | 2.59 (2.30, 2.93) |
| State expenditures on family planning: | per capita (women age 15–44) (categories: 0–4) | 1.01 (0.99, 1.03) | 1.01 (0.99, 1.04) | 1.01 (0.98, 1.03) | 1.00 (0.98, 1.03) | 1.00 (0.98, 1.03) | 1.00 (0.98, 1.03) | 1.00 (0.98, 1.03) |
| State expenditures on abortion services: | per capita (women age 15–44) (categories: 0–4) | 0.97 (0.95, 0.98) | 0.96 (0.95, 0.97) | 0.97 (0.95, 0.98) | 0.97 (0.95, 0.98) | 0.97 (0.95, 0.98) | 0.97 (0.95, 0.98) | 0.97 (0.95, 0.98) |
| State Title X funding per capita (women age 15–44) (categories: 0–4) | 1.03 (1.00, 1.07) | 1.03 (1.00, 1.06) | 1.03 (1.00, 1.06) | 1.03 (1.00, 1.06) | 1.04 (1.01, 1.07) | 1.03 (1.00, 1.07) |
| State Medicaid funding per capita (women age 15–44) (categories: 0–4) | 0.98 (0.95, 1.01) | 0.98 (0.95, 1.01) | 0.99 (0.96, 1.02) | 0.99 (0.96, 1.02) | 0.99 (0.96, 1.02) | 0.99 (0.96, 1.02) |
| State fertility rate: live births per 1000 women age 15–44 (per change in rate of 10 per 1000) | 0.98 (0.97, 1.00) | 0.98 (0.97, 0.99) | 0.98 (0.96, 0.99) | 0.98 (0.96, 0.99) | 0.97 (0.96, 0.99) | 0.97 (0.96, 0.99) |
| County: % urban (per 10% increase) | 1.03 (0.94, 1.12) | 1.03 (0.95, 1.12) | 1.05 (0.96, 1.14) | 1.05 (0.96, 1.14) |
| County: % less than high school education (per 10% increase) | 0.97 (0.65, 1.43) | 0.97 (0.65, 1.44) | 0.97 (0.65, 1.43) | 0.96 (0.65, 1.43) |
| County: % female labor force participation | 1.06 (0.65, 1.71) | 1.04 (0.64, 1.67) | 0.96 (0.59, 1.55) | 0.94 (0.58, 1.53) |
| State: % of counties with no abortion provider | 1.21 (1.07, 1.37) | 1.19 (1.05, 1.35) |
| State random effect (SD) | 0.031 (0.176) | 0.028 (0.168) | 0.028 (0.167) | 0.027 (0.164) | 0.027 (0.163) | 0.023 (0.151) | 0.023 (0.150) | 0.023 (0.150) |
| County random effect (SD) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) |
| AIC | 12006.38 | 10184.33 | 10182.90 | 10181.45 | 10179.21 | 9973.99 | 9972.15 | 9966.80 | 9966.77 |
| BIC | 12054.79 | 10243.03 | 10241.60 | 10257.76 | 10255.52 | 10067.69 | 10065.86 | 10066.36 | 10066.33 |
| 2006 (intercept: infant deaths per 1000 persons < age 1) | 4.90 (4.64, 5.18) | 5.07 (4.67, 5.51) | 4.92 (4.53, 5.35) | 5.28 (4.72, 7.50) | 5.60 (4.47, 7.01) | 4.54 (2.86, 7.20) | 4.74 (3.04, 7.37) | 4.52 (2.85, 7.18) | 4.76 (3.06, 7.41) |
| County income quintile | 1 (lowest) | 1.37 (1.29, 1.45) | 1.36 (1.28, 1.44) | 1.35 (1.27, 1.43) | 1.35 (1.28, 1.44) | 1.34 (1.27, 1.42) | 1.33 (1.23, 1.44) | 1.33 (1.23, 1.44) | 1.32 (1.22, 1.43) | 1.32 (1.22, 1.43) |
| 2 | 1.28 (1.21, 1.36) | 1.27 (1.19, 1.35) | 1.27 (1.19, 1.35) | 1.26 (1.19, 1.34) | 1.26 (1.18, 1.35) | 1.26 (1.18, 1.35) | 1.26 (1.18, 1.35) | 1.26 (1.18, 1.35) |
| 3 | 1.25 (1.17, 1.33) | 1.24 (1.16, 1.32) | 1.24 (1.16, 1.32) | 1.23 (1.15, 1.31) | 1.21 (1.14, 1.30) | 1.22 (1.14, 1.30) | 1.21 (1.13, 1.29) | 1.22 (1.14, 1.30) |
| 4 | 1.18 (1.11, 1.26) | 1.17 (1.10, 1.24) | 1.17 (1.10, 1.24) | 1.16 (1.09, 1.23) | 1.16 (1.09, 1.24) | 1.17 (1.09, 1.24) | 1.16 (1.09, 1.23) | 1.16 (1.09, 1.24) |
| State expenditures on family planning: | per capita (women age 15–44) (categories: 0–4) | 1.01 (0.99, 1.03) | 1.01 (0.98, 1.05) | 1.02 (1.00, 1.04) | 1.02 (1.00, 1.04) |
|--------------------------------------|-----------------------------------------------|-------------------|-------------------|-------------------|-------------------|
| State expenditures on abortion services: | per capita (women age 15–44) (categories: 0–4) | 0.97 (0.95, 0.98) | 0.97 (0.95, 0.98) | 0.97 (0.96, 0.98) | 0.97 (0.96, 0.98) |
| State Title X funding per capita (women age 15–44) (categories: 0–4) | | 0.99 (0.96, 1.03) | 1.00 (0.98, 1.03) | 1.00 (0.97, 1.02) | 1.00 (0.97, 1.02) |
| State Medicaid funding per capita (women age 15–44) (categories: 0–4) | | 0.99 (0.95, 1.04) | 0.97 (0.94, 0.99) | 0.98 (0.96, 1.01) | 0.97 (0.94, 0.99) |
| State fertility rate: live births per 1000 women age 15–44 (per change in rate of 10 per 1000) | | 1.00 (0.98, 1.02) | 0.99 (0.98, 1.01) | 0.99 (0.98, 1.01) | 0.99 (0.97, 1.00) |
| County: % urban (per 10% increase) | | 1.04 (0.96, 1.12) | 1.05 (0.97, 1.13) | 1.05 (0.97, 1.13) | 1.05 (0.97, 1.14) |
| County: % less than high school education (per 10% increase) | | 1.64 (1.11, 2.43) | 1.60 (1.08, 2.37) | 1.65 (1.11, 2.44) | 1.61 (1.09, 2.38) |
| County: % female labor force participation | | 1.27 (0.84, 1.92) | 1.27 (0.84, 1.91) | 1.22 (0.80, 1.87) | 1.22 (0.80, 1.86) |
| State: % of counties with no abortion provider | | 1.06 (0.93, 1.19) | 1.05 (0.93, 1.19) | | |
| State random effect (SD) | 0.024 (0.156) | 0.024 (0.155) | 0.024 (0.155) | 0.027 (0.165) | 0.024 (0.156) | 0.024 (0.155) | 0.024 (0.155) | 0.024 (0.155) |
| County random effect (SD) | 0.007 (0.084) | 0.004 (0.065) | 0.004 (0.061) | 0.004 (0.065) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) |
| AIC | 12206.57 | 12088.69 | 12086.52 | 12094.02 | 12101.03 | 11883.03 | 11876.43 | 11884.31 | 11877.82 |
| BIC | 12254.98 | 12149.12 | 12146.95 | 12179.59 | 11979.53 | 11972.93 | 11986.85 | 11980.35 | |

2010 (intercept: infant deaths per 1000 persons < age 1) | 4.33 (4.08, 4.59) | 4.93 (4.57, 5.31) | 5.02 (4.65, 5.41) | 7.50 (5.70, 9.90) | 7.51 (5.70, 9.90) | 10.36 (6.64, 16.17) | 10.24 (6.62, 15.86) | 10.39 (6.64, 16.24) | 10.31 (6.66, 15.98) |

County income quintile | 1 (lowest) | 1.45 (1.36, 1.54) | 1.43 (1.34, 1.53) | 1.42 (1.33, 1.52) | 1.44 (1.35, 1.54) | 1.43 (1.34, 1.53) | 1.37 (1.26, 1.50) | 1.36 (1.24, 1.48) | 1.37 (1.26, 1.51) | 1.36 (1.25, 1.49) |
| 2 | 1.32 (1.24, 1.41) | 1.29 (1.21, 1.38) | 1.28 (1.20, 1.37) | 1.30 (1.22, 1.40) | 1.29 (1.21, 1.38) | 1.27 (1.18, 1.36) | 1.25 (1.16, 1.35) | 1.27 (1.17, 1.37) | 1.25 (1.16, 1.35) | 1.26 (1.17, 1.36) |
| 3 | 1.29 (1.21, 1.39) | 1.28 (1.19, 1.38) | 1.26 (1.18, 1.36) | 1.27 (1.19, 1.37) | 1.27 (1.18, 1.36) | 1.26 (1.17, 1.36) | 1.25 (1.16, 1.34) | 1.26 (1.17, 1.36) | 1.25 (1.16, 1.35) | 1.25 (1.16, 1.35) |
| 4 | 1.16 (1.08, 1.24) | 1.14 (1.06, 1.22) | 1.14 (1.06, 1.22) | 1.15 (1.07, 1.23) | 1.15 (1.07, 1.23) | 1.14 (1.06, 1.22) | 1.13 (1.06, 1.21) | 1.14 (1.06, 1.22) | 1.13 (1.06, 1.21) | 1.13 (1.06, 1.21) |
| 5 (highest; referent group) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |

County: % persons < age 1 = “black” (per 10% increase) | 2.19 (1.94, 2.47) | 2.27 (2.03, 2.54) | 2.30 (2.06, 2.56) | 2.22 (1.99, 2.49) | 2.26 (2.02, 2.52) | 2.35 (2.09, 2.65) | 2.37 (2.11, 2.67) | 2.36 (2.08, 2.66) | 2.39 (2.12, 2.70) | 2.39 (2.12, 2.70) |
| Year Parameter | Rate ratio (95% confidence interval) |
|----------------|-------------------------------------|
|                | Model 1 | Model 2a | Model 2b | Model 3a | Model 3b | Model 4a | Model 4b | Model 5a | Model 5b |
| State expenditures on family planning: per capita (women age 15–44) (categories: 0-4) | 0.97 (0.96, 0.99) | 0.99 (0.97, 1.01) | 0.98 (0.96, 1.00) | 0.98 (0.96, 1.00) |
| State expenditures on abortion services: per capita (women age 15–44) (categories: 0-4) | 0.96 (0.95, 0.98) | 0.96 (0.94, 0.97) | 0.96 (0.95, 0.98) | 0.96 (0.94, 0.98) |
| State Title X funding per capita (women age 15–44) (categories: 0-4) | 1.02 (0.98, 1.05) | 1.01 (0.98, 1.04) | 1.01 (0.98, 1.05) | 1.01 (0.97, 1.04) |
| State Medicaid funding per capita (women age 15–44) (categories: 0-4) | 0.96 (0.93, 0.99) | 0.97 (0.93, 1.00) | 0.97 (0.94, 1.00) | 0.98 (0.94, 1.01) |
| State fertility rate: live births per 1000 women age 15–44 (per change in rate of 10 per 1000) | 0.98 (0.96, 0.99) | 0.98 (0.96, 0.99) | 0.98 (0.96, 0.99) | 0.98 (0.96, 0.99) |
| County: % urban (per 10% increase) | 0.92 (0.84, 1.00) | 0.92 (0.84, 1.00) | 0.92 (0.84, 1.00) | 0.91 (0.84, 1.00) |
| County: % less than high school education (per 10% increase) | 0.89 (0.58, 1.38) | 0.92 (0.59, 1.42) | 0.89 (0.57, 1.39) | 0.90 (0.58, 1.41) |
| County: % female labor force participation | 0.71 (0.47, 1.08) | 0.71 (0.47, 1.07) | 0.72 (0.47, 1.08) | 0.72 (0.48, 1.09) |
| State: % of counties with no abortion provider | 0.99 (0.86, 1.14) | 0.97 (0.85, 1.11) | 0.97 (0.85, 1.11) | 0.97 (0.85, 1.11) |
| State random effect (SD) | 0.030 (0.172) | 0.033 (0.182) | 0.032 (0.179) | 0.033 (0.181) |
| County random effect (SD) | 0.007 (0.081) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) |
| AIC | 11402.75 | 10341.75 | 10323.14 | 10333.45 |
| BIC | 11451.15 | 10401.12 | 10382.51 | 10410.64 |

* Based on year-specific Poisson loglinear mixed models with state and county random effects. All infant death rates are lagged by one year.

* All dollars expressed in 2010 constant dollars.

* Categories: 0 = either $0 or funding not reported; 1 to 4 = quartiles based on distribution of funding > $0
| Year | Intercept: infant deaths per 1000 persons < age 1 | Rate ratio (95% confidence interval) |
|------|-----------------------------------------------|----------------------------------|
|      | Model 1 | Model 2 | Model 2a | Model 3 | Model 3a | Model 4 | Model 4a | Model 5 | Model 5a | Model 5b |
| 1980 | 12.33 (11.13, 13.66) | 11.61 (10.91, 12.34) | 11.54 (10.12, 13.14) | 7.98 (6.29, 10.14) | 9.21 (7.26, 11.95) | 8.36 (6.01, 11.63) |
|      | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| 1980 | 0.77 (0.74, 0.81) | 0.76 (0.70, 0.82) | 0.76 (0.70, 0.82) | 0.90 (0.72, 1.12) | 0.87 (0.70, 1.08) | 0.84 (0.56, 1.26) | 0.74 (0.50, 1.11) | 0.83 (0.55, 1.26) | 0.74 (0.49, 1.11) |
| 1987 | 0.54 (0.52, 0.56) | 0.59 (0.55, 0.64) | 0.58 (0.53, 0.63) | 0.78 (0.63, 0.96) | 0.74 (0.60, 0.92) | 0.73 (0.45, 1.20) | 0.71 (0.43, 1.16) | 0.69 (0.41, 1.14) | 0.63 (0.38, 1.05) |
| 1994 | 0.56 (0.44, 0.69) | 0.51 (0.47, 0.55) | 0.51 (0.46, 0.56) | 0.68 (0.53, 0.86) | 0.74 (0.59, 0.93) | 0.71 (0.41, 1.22) | 0.73 (0.43, 1.24) | 0.69 (0.40, 1.10) | 0.71 (0.42, 1.22) |
| 2001 | 0.48 (0.46, 0.50) | 0.52 (0.48, 0.57) | 0.50 (0.46, 0.54) | 0.55 (0.43, 0.70) | 0.60 (0.47, 0.76) | 0.55 (0.34, 0.89) | 0.60 (0.38, 0.96) | 0.55 (0.34, 0.89) | 0.59 (0.37, 0.94) |
| 2006 | 0.42 (0.40, 0.44) | 0.49 (0.45, 0.54) | 0.49 (0.45, 0.54) | 0.71 (0.54, 0.93) | 0.75 (0.56, 0.98) | 1.16 (0.72, 1.86) | 1.14 (0.71, 1.81) | 1.14 (0.71, 1.84) | 1.11 (0.69, 1.77) |
| 2010 | 0.34 (0.32, 0.37) | 0.48 (0.45, 0.51) | 0.48 (0.45, 0.51) | 0.55 (0.43, 0.70) | 0.60 (0.47, 0.76) | 0.55 (0.34, 0.89) | 0.60 (0.38, 0.96) | 0.55 (0.34, 0.89) | 0.59 (0.37, 0.94) |

**Table 3**

Panel analysis: state family planning and abortion services expenditures and US infant death rates (1980–2010).
| Year | Model 1 | Model 2a | Model 2b | Model 3a | Model 3b | Model 4a | Model 4b | Model 5a | Model 5b |
|------|--------|---------|---------|---------|---------|---------|---------|---------|---------|
| 1980 | 1.01 (1.00, 1.03) | 1.01 (1.00, 1.03) | 1.02 (1.00, 1.04) | 1.02 (1.00, 1.03) | 1.01 (1.00, 1.03) | 1.01 (1.00, 1.03) | 1.01 (1.00, 1.03) | 1.01 (1.00, 1.03) | 1.01 (1.00, 1.03) |
| 1987 | 0.98 (0.97, 0.99) | 0.99 (0.97, 1.00) | 0.99 (0.97, 1.00) | 0.99 (0.97, 1.00) | 0.99 (0.97, 1.00) | 0.99 (0.97, 1.00) | 0.99 (0.97, 1.00) | 0.99 (0.97, 1.00) | 0.99 (0.97, 1.00) |
| 1994 | 0.97 (0.96, 0.99) | 0.98 (0.96, 1.00) | 0.98 (0.96, 1.00) | 0.96 (0.94, 0.98) | 0.96 (0.94, 0.98) | 0.96 (0.94, 0.98) | 0.96 (0.94, 0.98) | 0.96 (0.94, 0.98) | 0.96 (0.94, 0.98) |
| 2001 | 1.01 (0.99, 1.03) | 1.04 (1.02, 1.06) | 1.02 (1.00, 1.04) | 1.02 (1.00, 1.04) | 1.02 (1.00, 1.04) | 1.02 (1.00, 1.04) | 1.02 (1.00, 1.04) | 1.02 (1.00, 1.04) | 1.02 (1.00, 1.04) |
| 2004 | 1.03 (1.01, 1.05) | 1.06 (1.04, 1.09) | 1.05 (1.02, 1.07) | 1.04 (1.02, 1.06) | 1.04 (1.02, 1.06) | 1.04 (1.02, 1.06) | 1.04 (1.02, 1.06) | 1.04 (1.02, 1.06) | 1.04 (1.02, 1.06) |
| 2010 | 0.99 (0.98, 1.01) | 1.01 (1.00, 1.02) | 0.99 (0.97, 1.02) | 0.97 (0.96, 1.01) | 0.99 (0.97, 1.02) | 0.99 (0.97, 1.02) | 0.99 (0.97, 1.02) | 0.99 (0.97, 1.02) | 0.99 (0.97, 1.02) |

State-only expenditures on family planning: fraction of total state expenditures (categories 0–4b)
### County Percent Less Than High School Education (per 10% change)

| Year | 1980 | 1987 | 1994 | 2001 |
|------|------|------|------|------|
| 2001 | 0.85 (0.59, 1.22) | 0.85 (0.59, 1.22) | 0.85 (0.59, 1.23) | 0.84 (0.58, 1.21) |
| 2006 | 1.57 (1.10, 2.24) | 1.58 (1.11, 2.24) | 1.57 (1.10, 2.23) | 1.57 (1.10, 2.24) |
| 2010 | 1.06 (0.71, 1.57) | 1.12 (0.75, 1.66) | 1.01 (0.68, 1.51) | 1.05 (0.70, 1.56) |

### County Percent Female Labor Force Participation (per 10% change)

| Year | 1980 | 1987 | 1994 | 2001 |
|------|------|------|------|------|
| 1980 | 0.86 (0.67, 1.09) | 0.83 (0.65, 1.06) | 0.87 (0.68, 1.11) | 0.85 (0.66, 1.09) |
| 1987 | 1.12 (0.82, 1.52) | 1.15 (0.85, 1.56) | 1.14 (0.84, 1.55) | 1.16 (0.86, 1.58) |
| 1994 | 1.11 (0.73, 1.67) | 1.10 (0.73, 1.67) | 1.13 (0.75, 1.71) | 1.14 (0.75, 1.72) |
| 2001 | 1.15 (0.72, 1.83) | 1.10 (0.72, 1.83) | 1.08 (0.68, 1.74) | 1.08 (0.67, 1.75) |
| 2006 | 1.24 (0.83, 1.86) | 1.20 (0.80, 1.78) | 1.23 (0.82, 1.85) | 1.19 (0.79, 1.79) |
| 2010 | 0.75 (0.50, 1.11) | 0.73 (0.49, 1.08) | 0.77 (0.51, 1.15) | 0.77 (0.52, 1.15) |

### State Percent of Counties with No Abortion

| Year | 1980 | 1987 | 1994 | 2001 |
|------|------|------|------|------|
| 1980 | 1.08 (0.94, 1.23) | 1.10 (0.96, 1.27) | 1.12 (0.93, 1.31) | 1.15 (0.97, 1.36) |
| 1987 | 1.09 (0.93, 1.27) | 1.12 (0.95, 1.31) | 1.21 (1.02, 1.44) | 1.15 (0.97, 1.36) |
| 1994 | 1.15 (0.97, 1.36) | 1.21 (1.02, 1.44) | 1.21 (1.02, 1.44) | 1.21 (1.02, 1.44) |
| 2001 | 1.19 (1.00, 1.43) | 1.21 (1.02, 1.44) | 1.21 (1.02, 1.44) | 1.21 (1.02, 1.44) |
| 2006 | 1.10 (0.92, 1.32) | 1.11 (0.93, 1.32) | 1.11 (0.93, 1.32) | 1.11 (0.93, 1.32) |
| 2010 | 1.02 (0.86, 1.22) | 1.00 (0.84, 1.18) | 1.00 (0.84, 1.18) | 1.00 (0.84, 1.18) |

Overdispersion parameter: 1.304377, 1.277615, 1.276587, 1.270277, 1.267798, 1.232980, 1.231788, 1.232987, 1.231408

Residual deviance: 24662.73, 22400.67, 22381.32, 22277.61, 22248.42, 21345.10, 21328.71, 21337.89, 21316.47

We employed two complementary multilevel statistical approaches (Goldstein, 2011), each premised on different statistical assumptions, which allowed us to examine (controlling for the same covariates) both: (a) the year-specific exposure-outcome associations across states (with random state effects), and (b) the associations within states (with state fixed effects) over time. By triangulating (UNAIDS, 2010; Reiss, 2009; Baggaley & Fraser, 2010; Richmond et al., 2014) these different analytic approaches and different methods of modeling the exposure variable, each with their different assumptions, we were able to identify associations robust to analytic and modeling approach. The similarity of our findings to those of the earlier studies (Grossman & Jacobowitz, 1981; Corman & Grossman, 1985; Joyce, 1987a; 1987b; McFarlane & McFarlane, 1994; McFarlane & Meier, 1998, 2001) is especially noteworthy because the time periods analyzed by these earlier studies (i.e., 1970–1972 (Grossman & Jacobowitz, 1981), 1969–1978 (Corman & Grossman, 1985), 1976–1978 (Joyce, 1987a), and 1982–1998 (McFarlane & McFarlane, 1994; McFarlane & Meier, 1998, 2001)) differed with respect to available contraceptive technologies and laws regulating access to both contraception and abortion (Frost et al., 2015; Schreiber & Traxler, 2015).
if and when want to have children – and, if they do have children, to be able to bear healthy infants who can survive and thrive (Cottingham et al., 2010; Silliman et al., 2004; Luna & Luker, 2013).

In conclusion, extending results of prior analyses (Grossman & Jacobowitz, 1981; Corman & Grossman, 1985; Joyce, 1987a, 1987b; Meier & McFarlane, 1994; McFarlane & Meier, 1998, 2001), our study provides contemporary evidence that state-only expenditures for reproductive services matter for infant death rates, and that currently reduced public funding for abortion in the US is associated with increased risk of infant death, even after taking into account county median family income (with its increasing inverse association) and the percent of infants who are black (with its persistent positive association). The implication is that increasing restrictions on access to and public funding for abortions (Gruskin, 2013; Gee, 2014; Devi, 2015), along with low income (SACIM, 2016; David & Collins, 2014; Singh & Kogan, 2007; Krieger et al., 2008; Blumenshine et al., 2010; Christopher & Simpson, 2014), can be expected to adversely affect US infant death rates, especially for low-income infants of color. Insofar as reducing infant mortality is a government priority (SACIM, 2016; Cottingham et al., 2010; Christopher & Simpson, 2014), our data underscore, despite the highly charged political context, the need for adequate public funding for abortion services and for redressing socioeconomic and racial/ethnic inequities in risk of infant death.

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Conflict of interest
None.

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