Health Economics, Policy and Law (2023), **18**, 111–120
doi:10.1017/S1744133122000111

HEALTH ECONOMICS, POLICY and LAW

ARTICLE

Neighborhood inequalities and the decline of infant mortality in São Paulo

Michael K. Gusmano[1]* , Irina Grafova[2], Rafael Ayoub[3], Daniel Weisz[4] and Victor G. Rodwin[3]

[1]College of Health, Lehigh University, Bethlehem, PA, USA, [2]Rutgers University, Piscataway, NJ, USA, [3]New York University, New York, NY, USA and [4]Columbia University, New York, NY, USA
*Corresponding author. Email: mig321@lehigh.edu

(Received 2 August 2020; revised 19 February 2022; accepted 18 May 2022; first published online 8 July 2022)

Abstract

This paper documents changes in infant mortality (IM) rates in São Paulo, Brazil, between 2003 and 2013 and examines the association among neighborhood characteristics and IM. We investigate the extent to which increased use of health care services and improvements in economic and social conditions are associated with reductions in IM. Using data from the Brazilian Census and the São Paulo Secretaria Municipal da Saúde/SMS, we conducted a longitudinal analysis of panel data in all 96 districts of São Paulo for every year between 2003 and 2013. Our regression model includes district level measures that reflect economic, health care and social determinants of IM. We find that investments in health care have contributed to lower IM rates in the city, but the direct effect of increased spending is most evident for people living in São Paulo's middle- and high-income neighborhoods. Improvements in social conditions were more strongly associated with IM declines than increases in the use of health care among São Paulo's low-income neighborhoods. To reduce health inequalities, policies should target benefits to lower-income neighborhoods. Subsequent research should document the consequences of recent changes in Brazil's economic capacity and commitment to public health spending for population health.

Key words: Brazil; infant mortality; São Paulo; social determinants

1. Introduction

Even before the outbreak of COVID-19, the Brazilian political economy had been in crisis. In 2016, the federal government decided to cap public spending on health care and education for 20 years into the future. Before 2014, Brazil increased spending on public health and health care services and improved access to primary care for its lowest-income residents (Macinko *et al.*, 2011; Paim *et al.*, 2011; Inman, 2012; Guanais, 2015). These investments appear to have improved population health and reduced avoidable deaths (Gusmano *et al.*, 2016). Here we investigate the extent to which increased use of health care services and improvements in economic and social conditions were associated with reductions in infant mortality (IM) across diverse neighborhoods in the city of São Paulo, between 2003 and 2013.

We find an overall decline of IM rates in São Paulo of 23%, but it was far more pronounced in the high-income neighborhoods in comparison with the rest of the city. The gap between high- and low-income neighborhoods increased over the 2003–2013 period. The decline in IM rates among middle- and high-income neighborhoods is associated with use of health care services.

1.1 Infant mortality as an indicator

IM may be influenced by public health interventions designed to reduce teenage pregnancies and to improve the health of pregnant women. Access to prenatal care may encourage expectant

mothers to improve health behaviors and may reduce IM and improve outcomes (Muennig *et al.*, 2018). IM is also influenced by an array of economic and social factors, including education, income, housing, exposure to poor air and water quality and other environmental toxins and social disorganization, more generally (Ravalin and Tevis, 2017).

1.2 The Brazilian and São Paulo health and social policy context

Public health care expenditures cover 47% of health care financing in Brazil, leaving 53% from private sources. The federal, state and local governments contribute 45, 28 and 27% of the public health care spending, respectively (World Bank, 2014). However, this mix varies by state and city. Sistema Único de Saúde (SUS) offers comprehensive health coverage to all, free of charge. This public network includes health facilities run by the federal government, state and municipal governments, as well as those contracted to private and nonprofit institutions. When private health insurance plans do not cover costly procedures and medicines, patients can still rely on SUS, which undermines funding of primary care by SUS and contributes to concerns that SUS is always underfunded while private insurance expenditure and out-of-pocket payments continue to increase. In São Paulo, of the 11.5 million population, about 4.5 million rely only on SUS and an additional 4 million (those with some form of private health insurance) also take advantage of their eligibility for services under SUS when their private insurance does not provide full coverage, or when the most specialized services are only available in public hospitals (São Paulo Municipal Department of Health, https://www.prefeitura.sp.gov.br/cidade/secretarias/saude/tabnet/). For-profit hospitals treat both SUS and private insurance enrollees but SUS enrollees face longer waiting times while patients with private insurance enjoy comfortable accommodations and often better quality of care, as well.

The Family Health Strategy (FHS), which is part of SUS, was implemented, in 1994, to expand primary care to the poorest areas of the country. Composed of physicians, nurses, medical assistants and local community health workers, each FHS team serves about 3500 people in a given territory (Macinko *et al.*, 2011). The FHS is available in most municipalities, covering nearly 93 million people (Macinko *et al.*, 2011). Since there are no user fees for these services and most medications are free of charge, the program is popular and has increased health care coverage, improved access to effective primary care and reduced IM (Macinko *et al.*, 2006, 2011).

Government health care spending, per capita, increased significantly between 2000 and 2013. For the state of São Paulo, the average annual rate of increase in per capita spending during the period 2000–2010 was 21.5%. São Paulo is among the top four in per capita SUS consultations and since 2000 these consultations have increased more than six times as fast (66%) as Brazil's average growth in per capita consultations (10%).

Brazil has also developed programs designed to address poverty and improve child health. In particular, the Bolsa Família conditional cash transfer program was established in 2003, the first year in our analysis. Bolsa Família has been a key component of the government's Plano Brasil Sem Miséria (Brazil Without Poverty) strategy (Watts, 2013). It is a means-tested program whose benefit levels depend on household income and family size. To receive the cash payments, children under seven must receive required immunizations and attend growth monitoring visits twice a year. School age children (6–17) must enroll in school and maintain minimum attendance rates (75%).

SUS has increased health service use among children under the age of seven (Shei *et al.*, 2013). Between 2003 and 2013, the number of households receiving Bolsa Família payments increased from 3.6 million to 13.8 million. By 2013, the program covered nearly a quarter of Brazil's population. In the city of São Paulo, payments doubled from R$72.33 to 144.91 during the time period (Table 1).

2. Methods

Our definition of neighborhood corresponds to the 96 administrative districts of São Paulo. There are no datasets that include relevant variables at the individual level. Previous published research

https://doi.org/10.1017/S1744133122000111 Published online by Cambridge University Press

Table 1. Neighborhood-level economic, health care and social conditions in São Paulo, 2003 and 2013

	Low-income neighborhoods		Middle-income neighborhoods		High-income neighborhoods	
	2003	2013	2003	2013	2003	2013
IM	15.10	12.76**	14.36	10.44$^{\#\#}$	10.35	6.70††
Economic						
Households receiving Bolsa Família payments[a]	0.00	9.65**	0.00	5.56$^{\#\#}$	0.00	2.76††
Health care						
% Births with no prenatal care	1.95	1.35**	1.83	1.66	1.24	0.78††
% Births with 7 or more prenatal consults	55.17	73.25**	60.04	73.99$^{\#\#}$	73.50	85.29††
Health center attendance per 20,000 population	0.73	0.94**	0.92	0.83	0.57	0.49
Social conditions						
% Births to women under age 20 years	17.45	16.42*	14.25	12.05$^{\#\#}$	8.94	5.51††
% Births to women aged 40 years or older	2.04	2.83**	2.50	3.64$^{\#\#}$	3.55	5.83††
% Births to women with less than 4 years of school	6.24	1.17**	5.84	1.10$^{\#\#}$	3.92	0.62††
% Births to women with 12+ years of school	11.40	14.96**	18.69	27.77$^{\#\#}$	43.30	62.86††
% of households with no sewer	20.39	10.45**	6.34	3.77$^{\#}$	1.89	1.34
Murder rate below 2 per 10,000 population, %	3.23	77.41**	6.25	96.87$^{\#\#}$	56.25	100.00††

Data source: São Paulo Secretaria Municipal da Saúde/SMS.
Note: 2013 low-income neighborhood characteristic is statistically different from 2003 low-income neighborhood characteristics at $p < 0.05$ (*) and $p < 0.01$ (**). 2013 middle-income neighborhood characteristic is statistically different from 2003 middle-income neighborhood characteristics at $p < 0.05$ ($^{\#}$) and $p < 0.01$ ($^{\#\#}$). 2013 high-income neighborhood characteristic is statistically different from 2003 high-income neighborhood characteristics at $p < 0.01$ (††).
[a]Centro de Geoprocessamento e Estatística – CGEO.

on differences in IM rates has relied on similar ecological level data (Padilla *et al.*, 2016). Data on population and neighborhood-level median household income, births and deaths are respectively from the Brazilian Census and the São Paulo Secretaria Municipal da Saúde/SMS. Data on Bolsa Família payments are from the Centro de Geoprocessamento e Estatística – CGEO. We analyze these data for the city and each of the 96 neighborhoods.

To investigate the relationship between neighborhood characteristics and IM, we run separate regression models for high-, middle- and low-income neighborhoods. Economic, social and health care factors may affect IM and there is evidence that their impact may differ by neighborhood income level (Wang *et al.*, 2009; Luo *et al.*, 2010). We stratified our regression analysis by neighborhood income level and compared the lowest, middle and highest tertiles, an approach consistent with previous literature (Bravo *et al.*, 2015; Fernandes *et al.*, 2015). Since we have district-level average monthly income among individuals aged 10 years and older, we stratify the districts by three income groups.

Our measure of the highest tertile neighborhood income is the percentage of the population with 10 times the minimum income in 2000. Our models for each category of neighborhood include district level measures that reflect economic, social and health care determinants of IM (Table 2). The economic measure available at the district level is the percentage of households receiving Bolsa Família cash welfare payments. Our health care use measures are the percentage of births with no prenatal care visits, the percentage of births with at least seven prenatal visits and the number of people, per 20,000 population, using public health care centers.

Our measures of social conditions include the percentage of teen births, births to mothers over the age of 40, births to mothers with less than 4 years of school, births to mothers with more than

https://doi.org/10.1017/S1744133122000111 Published online by Cambridge University Press

Table 2. Regression models predicting IM rates for high-, middle- and low-income neighborhoods, São Paulo, 2003–2013

	High-income district coefficients	Middle-income district coefficients	Low-income district coefficients
Economic			
% Households receiving Bolsa Família payments[a]	−20.4293 (14.0265)	−1.5864 (10.6075)	−10.0152 (5.4022)
Health care			
% Births with no prenatal care	−35.4074 (47.3503)	29.2793 (33.4988)	−57.4730 (45.1078)
% Births with 7 or more prenatal consults	**−23.5111 (8.2623)****	−0.1881 (5.6089)	−5.5867 (4.0377)
Health Center Attendance	−2.0668 (1.3943)	**−2.9776 (1.4500)***	−0.7715 (0.8600)
Social conditions			
% Births to women under age 20 years	1.7602 (12.5529)	−13.1476 (12.9406)	6.3263 (9.0640)
% Births to women aged 40 years or older	**−66.0052 (23.1495)****	**−79.2789 (35.3723)***	−63.0534 (33.7863)
Log of % births to women with 4+ years of school	0.4369 (0.5434)	0.2980 (0.7130)	**−1.6107 (0.6258)***
Log of % births to women with 12+ years of school	1.1273 (2.8335)	0.7476 (1.9690)	−1.4393 (0.9386)
% of households with no sewer	71.0900 (47.6334)	−7.0615 (15.2703)	−0.7245 (4.3897)
Murder rate below 2 per 10,000 population	0.5013 (0.8131)	−0.3641 (0.6440)	**−0.9243 (0.4736)**[#]
Year dummies			
2004.year	1.0656 (0.9556)	−0.3895 (0.9352)	0.9449 (0.7863)
2005.year	0.5876 (1.0050)	−1.1091 (1.0319)	−0.1467 (0.8018)
2006.year	**2.5828 (1.1178)***	−1.7574 (1.1720)	1.5404 (0.9057)
2007.year	1.6805 (1.2470)	−1.2089 (1.2873)	0.5274 (0.9991)
2008.year	2.5112 (1.3838)	−1.1529 (1.4340)	−0.5512 (1.1992)
2009.year	2.0795 (1.4390)	−2.2986 (1.4263)	0.2136 (1.2375)
2010.year	1.8794 (1.5130)	−1.6388 (1.5026)	−0.9725 (1.3499)
2011.year	2.5276 (1.6084)	**−3.7359 (1.6540)***	−0.6358 (1.4238)
2012.year	2.2366 (1.6659)	−2.4087 (1.6665)	−1.7109 (1.4249)
2013.year	1.3693 (1.8728)	−3.0261 (1.9331)	−1.6227 (1.6148)
Intercept	**32.2825 (8.1788)****	**23.1520 (6.7977)****	**12.4310 (4.4573)****
N	348	352	341

Source: São Paulo Secretaria Municipal da Saúde/SMS.
Note: *p < 0.05; **p < 0.01; [#]p < 0.052.
[a]Centro de Geoprocessamento e Estatística – CGEO.

12 years of school and households without access to sewers. We include the murder rate as a proxy measure of social disorganization which also reflect poverty and overall crime rate (Table 2) (Wilkinson *et al.*, 1998).

We include the percentage of teen births (women under age 20 years) because a large literature finds that teen births are associated with a higher rate of IM (Schultz, 1997; Grafova *et al.*, 2019). We included the percentage of births to women aged 40 years or older because these are also associated with a greater likelihood of adverse health outcomes among infants and because there is a worldwide trend of women giving birth at older ages. As Ribeiro *et al.* (2014) explain, growth in the number of older women giving birth is driven by 'the changing social role of women in the labor market and within the family, the search for financial stability and the achievement of high educational levels'. At the same time, 'the social, economic and emotional maturity results in greater knowledge about the importance of adequate monitoring of pregnancy; however, they can become risk factors for late pregnancy' (Ribeiro *et al.*, 2014).

We include the percentage of births to women with 4 or more years of school and the percentage of births to women with 12 or more years of school because neighborhood-level socio-economic status has been linked to IM (Kane *et al.*, 2017; Yourkavitch *et al.*, 2018). Similarly, the percentage of households without access to sewer services is both a measure of neighborhood disadvantage and a direct measure of poor hygiene both of which are associated with high rates of IM.

Finally, crime rates are often used as a proxy measure for social disorganization, a concept developed in the 1940s based on studies of crime in neighborhoods of Chicago (Shaw and McKay, 1942). These studies concluded that crime was often related to neighborhood dynamics, not the characteristics of the people living within them. Specifically, they used the term, 'social disorganization', to mean that traditional social organizations (churches, schools, voluntary organizations, families) were weak and unable to regulate the behavior of young people living in the neighborhood. These studies were rediscovered in the 1980s by sociologists such as Bursik (1986, 1988), Sampson and Groves (1989) and Wilson (1990, 1996). This more recent research has focused on 'intervening mechanisms' between the traditional social disorganization variables and crime rates. For example, Sampson and Groves (1989) argue that social disorganization leads to a reduction of social capital and collective efficacy that increase crime and violence. Specifically, they point to the importance of friendship networks, the prevalence of unsupervised peer groups and the level of organizational participation in the neighborhood. These results have been replicated using data from different cities and countries (Sun *et al.*, 2004). In these studies the measures of collective efficacy were expanded to include measures of trust and willingness of neighbors to intervene for the common good (Sampson *et al.*, 1997: 919). Other research suggests that the effects of social disorganization on crime are more pronounced when social disorganization occurs within the context of high levels of poverty (Smith and Jarjoura, 1988; Warner and Pierce, 1993).

Since we do not have measures of these intervening factors at the neighborhood level, we use murder rate as a proxy for these factors. We draw on panel data from all 96 districts of São Paulo for every year between 2003 and 2013. In our final model we excluded the district of Marsilac because it is characterized by unusually high variation, over time, in its IM rates and its rates of socio-economic disadvantage (Wooldridge, 2012). We conducted regression analysis on both the entire sample and on the one that excluded Marsilac. We found that including Marsilac biased the regression estimation results.

To control for unobserved differences among districts we estimate the following linear fixed effects regression model: $IM_{it} = \alpha_0 + \alpha_1 Economic_{it} + \alpha_2 HealthCare_{it} + \alpha_3 Social_{it} + \alpha_4 Year_t + u_i + v_{it}$, where IM_{it} is IM in district i in year t; $Economic_{it}$ measures economic environment of district i at year t as reflected by the district percentage of households receiving Bolsa Família cash welfare payments; $HealthCare_{it}$ includes district-level health care utilization as reflected by the percentage of births with no prenatal care visits, the percentage of births with at least seven prenatal visits and

https://doi.org/10.1017/S1744133122000111 Published online by Cambridge University Press

health center attendance rates; $Social_{it}$ includes measures of district social environment, such as the percentage of teen births, births to mothers over the age of 40, births to mothers with less than 4 years of school, births to mothers with more than 12 years of school, households without access to sewers and the murder rate.

$Year_t$ accounts for unmeasured time variant characteristics, such as national and state policy changes that would affect all districts. U_i is the unobserved time invariant district-specific component and v_{it} is the idiosyncratic error. The linear fixed effects model uses within district changes, over time, to estimate the relationship among district IM and various district characteristics.

Based on the Hausman test, we rejected an alternative random effects model. Since serial correlation in linear fixed effects models can bias the standard errors and results in less efficient estimates, we applied the Wooldridge test. It showed that we cannot reject the hypothesis of no first-order autocorrelation. We also re-estimated regressions using robust standard error and found that the estimation results change only slightly. We conducted the Chow test to examine whether the estimated effects of economic, social conditions and health care factors differ across the three groups of neighborhoods. Specifically, we estimated a combined linear fixed effects model augmented by a set of variables that interacted all of the independent variables with a dummy variable for high-income neighborhoods and another dummy variable for middle-income neighborhoods. Next, we tested whether these interaction terms were significant from each other and from zero.

We accounted for a possibility that the marginal effect of district socio-economic factors may vary. We expected that a higher level of maternal educational attainment would be associated with lower IM rates. It follows that the increase in the percent of births to women holding at least a high school diploma would result in an IM reduction. However, it is likely that the size of the reduction in IM rates may be greater for the neighborhoods with lower early education rates than for those with higher early education rates. To account for this possibility, we conducted a check for nonlinear functional for by using a quadratic regression model and a linear-log regression model. Neither model resulted in significantly different results.

Finally, we take into account the non-linearity of relationships we examine in several ways. First, we take account for it through our choice of social and economic factors. Yourkavitch *et al.* (2018) and Kane *et al.* (2017) point out not only that disadvantage or absence thereof matter, but also that affluence/advantage matters. Following this approach, we introduce variables reflecting both ends of the spectrum. For instance, we include both the percentage of births with no prenatal care and the percentage births with seven or more prenatal consults. Second, by stratifying the data by neighborhood income level we allow the relationship between IM and the social, economic and health system factors, to vary by neighborhood income level. Third, by focusing on the log of the percentage of births to women with 4 or more years of school and the log of the percentage births to women with 12 or more years of school, we allow the maternal age distribution to have a non-linear association with IM.

3. Results

According to the 2000 Brazilian Census, the median percentage of the population with an income that was 10 times the minimum monthly income was 5.95 in the low-income neighborhoods of São Paulo, 19.69 in the middle-income neighborhoods and 44.57 in the high-income neighborhoods. Between 2003 and 2013, all of these neighborhoods experienced improvements in economic and social conditions and the use of health care services (Table 2). During this time period, the city's IM rate declined by approximately 23% (Figure 1). High-, middle- and low-income neighborhoods all experienced declines, but the decrease was larger (by 42%) in the city's high-income neighborhoods where it fell from 10.52 to 6.14. In contrast, in the low-income neighborhoods, IM rates fell from by only 18% (from 15.32 to 12.59). Over the 2003–2013 period district level inequality in IM increased.

https://doi.org/10.1017/S1744133122000111 Published online by Cambridge University Press

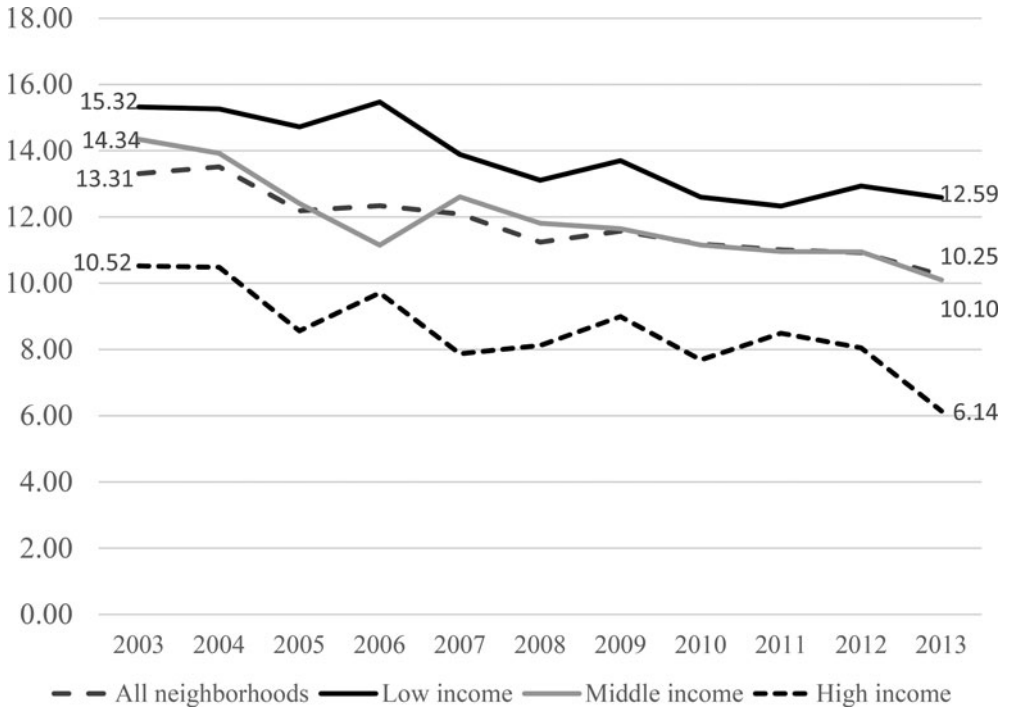

Figure 1. Median Infant Mortality Rates in São Paulo by Neighborhood Income, 2003-2013

3.1 Factors associated with IM differ by neighborhood income

Our regression model for the low-income neighborhoods of São Paulo found that the neighborhood murder rate, and the percentage of mothers with at least 4 years of education, were both negatively correlated with IM, although the change in murder rate just missed being statistically significant at the 0.05 level ($p < 0.052$) (Table 2). In the middle-income neighborhoods, we found no statistically significant correlation between IM and any of the social or economic variables. We found that the use of health centers and the percentage of births to mothers over the age of 40 were both negatively correlated. In the high-income neighborhoods, we found no correlation between social and economic variables and IM, but did find a significant negative correlation between the percentage of women with seven or more prenatal care consultations and the percentage of births to mothers over the age of 40.

We relied on the Chow test to examine whether the estimated effects of the factors described above differ across the three groups of neighborhoods. The test indicates that a higher percentage of women having seven or more prenatal visits was associated with lower IM rates in high-income neighborhoods, so we reject the hypothesis that the correlation between neighborhood prevalence of seven or more prenatal visits and IM is the same in high-, middle- and low-income neighborhoods. We find a negative correlation between the percentage of mothers with at least 4 years of education and IM in low-income neighborhoods and reject the hypothesis that the correlation between the percentage of mothers with at least 4 years of education and IM is the same in low-income neighborhoods and in middle- or high-income neighborhoods. The Chow test also indicates that for the low-income neighborhoods murder rate is negatively correlated with IM ($p < 0.052$), but it cannot reject the hypothesis that there is a correlation between murder rate and IM in middle- and high-income neighborhoods ($p < 0.136$). The Chow test indicates that there are statistically significant differences in the size of the estimated impact of several health care and social condition factors on IM across three income groups of districts. We find these

https://doi.org/10.1017/S1744133122000111 Published online by Cambridge University Press

across-district differences in the impact of (1) maternal education (as reflected by having at least 4 years of schooling), (2) prenatal care utilization (as reflected by having at least seven prenatal care visits) and (3) sewage.

4. Discussion

Increases in health care expenditures contributed to lower IM rates, but the direct effect of increased spending is most evident for people living in São Paulo's middle- and high-income neighborhoods. The Brazilian economy grew at a rapid rate between 2003 and 2013 and about 40 million Brazilians were lifted out of poverty (Reis, 2014). Even before the economy started growing at this pace, the government adopted policies to reduce IM (Alves and Belluzzo, 2004). Between 2000 and 2010, per capita spending on SUS consultations, in São Paulo, increased 66%, the highest rate of increase in Brazil.

Among São Paulo's the middle-income neighborhoods, increased use of health centers is associated with lower IM rates. In the high-income neighborhoods, the density of health centers is not correlated with IM rates. Residents of the high-income neighborhoods are more likely to have private insurance and rely on physicians in private practice. Although it is plausible that better access to private health care services may help to explain our results, we cannot be certain because we do not have individual data on insurance coverage. Among the high-income neighborhoods, however, higher use of prenatal care is significantly correlated with lower IM rates. Our finding that an increase in the percentage of births to mothers aged 40 and over in the middle- and high-income neighborhoods of the city requires further investigation. Previous studies suggest that mothers aged 40 years and over are at higher risk for complications and IM (Ribeiro *et al.*, 2014). This finding may reflect the fact that older women living in these neighborhoods received care from specialists, but we cannot test this hypothesis with our data.

In São Paulo's low-income neighborhoods, improvements in education and, to a lesser extent, declines in the murder rate, were far more important factors explaining IM declines than health care or Bolsa Família payments, but it is possible that the limited significance of Bolsa Família in our results may reflect the limited variation across districts. These findings are consistent with studies that highlight the importance of social conditions for IM. Although prenatal care and other health care services may have been important to women and children living in low-income neighborhoods, their impact on IM was minimal compared to the impact of improvements in social and economic conditions.

Allowing for non-linearity in several different ways provides some interesting insights. We find that a higher percentage of births to women with at least 4 years of school is associated with a lower IM rate in low-income neighborhoods. This is consistent with the literature highlighting the importance of maternal education for child outcomes. It is non-linear since we control for logged percentage of births to women with at least 4 years of school. This implies that having more mothers with at least 4 years of schooling decreases IM but does so at a decreasing rate. In other words, decreasing IM in low-income neighborhoods via increased prevalence of elementary school education among women can only achieve limited impact. Increasing women's educational attainment should be combined with other policies. Our results indicate that in low-income neighborhoods policies targeting social disorganization may also improve IM rates. Thus, non-linearity can provide some insights into future policies that aim to decrease IM.

Allowing for non-linearity in stratifying our sample provides policy insights; yet it also limits the analytic sample which may result in imprecise estimates. For instance, a higher percentage of births to women aged 40 years old or older is associated with a lower IM rate in all three neighborhood income groups. Moreover, the size of the estimated coefficients is similar across all three groups. However, this association is not statistically significant for the low-income neighborhoods. It is possible that this finding could be due to smaller sample sizes in the stratified analysis thereby resulting in imprecise estimates.

https://doi.org/10.1017/S1744133122000111 Published online by Cambridge University Press

A limitation of our study is the use of neighborhood- rather than individual-level data, which limits our sample size. In addition, our fixed effects model assumes strict exogeneity. This implies that explanatory variables in each time period are uncorrelated with the idiosyncratic error. This may not be a realistic assumption and we do not know how much this may influence the results.

Despite the impressive IM declines among São Paulo's high-, middle- and low-income neighborhoods, its public health system faces challenges. After the rapid economic growth over the period 2003–2013 (3.77% average annual real GDP) the Brazilian economy suffered a great recession (World Bank, 2022). It started reaching positive growth rates in 2018, but the outbreak of COVID-19 has led to a sharp economic decline. Although the overall rate of IM has continued to decline, efforts to reduce disparities among neighborhoods will be influenced by the extent to which policymakers in Brazil and São Paulo are willing to maintain substantial investments in health and social services at a time of economic hardship (Szwarcwald *et al.*, 2020).

Since 2015, the government has cut spending to reduce budget deficits. According to some critics, these policy changes have increased socio-economic inequalities in Brazil (Center for Economic and Social Rights, 2018). Improvements in geographic inequities among IM rates within São Paulo depend not only on direct investments in the health care system, but also on efforts to reduce social and economic inequities and the use of income-specific policies targeted to different neighborhoods according to their economic status. Looking to the 2022 elections and faced with declining popularity due to his hands off approach to the COVID-19 pandemic, President Bolsonaro has proposed an increase in social welfare spending (Ayres and Brito, 2021). Whether this proposal will be enacted is not yet clear, but it is important to understand that, without this sort of targeting, additional improvements in the health care system may disproportionately benefit those who live in the city's wealthiest neighborhoods.

References

Ayres M and Brito R (2021) Brazil finance minister says welfare plan may require fiscal waiver. Reuters. Available at https://www.reuters.com/world/americas/bolsonaro-says-new-welfare-program-respect-brazil-spending-cap-2021-10-20/.

Bravo MA, Son J, de Freitas CU, Gouveia, N and Bell ML (2015) Air pollution and mortality in São Paulo, Brazil: effects of multiple pollutants and analysis of susceptible populations. *Journal of Exposure Science and Environmental Epidemiology* **26**, 150.

Bursik Jr, RJ (1986) Ecological stability and the dynamics of delinquency. *Crime and Justice* **8**, 35–66.

Bursik Jr, RJ (1988) Social disorganization and theories of crime and delinquency: problems and prospects. *Criminology* **26**, 519–552.

Center for Economic and Social Rights (2018) Human Rights in Times of Austerity. Available at https://www.cesr.org/sites/default/files/Brazil%20Austerity%20Factsheet%20English%20FINAL.pdf.

Fernandes TG, Bando, DH, Alencar, AP, Benseñor, IM and Lotufo, PA (2015) Income inequalities and stroke mortality trends in Sao Paulo, Brazil, 1996–2011. *International Journal of Stroke* **10**, 34–37.

Grafova I, Gusmano M, Martirosyan K, Weisz D and Rodwin VG (2019) Infant mortality and neighborhood socioeconomic status in Moscow. *Journal of Urban Health* **96**, 813–822.

Guanais FC (2015) The combined effects of the expansion of primary health care and conditional cash transfers on infant mortality in Brazil, 1998–2010. *American Journal of Public Health* **105**, S593–SS59.

Gusmano MK, Rodwin, VG, Weisz, D and Ayoub, R (2016) Health improvements in BRIC cities: Moscow, São Paulo and Shanghai, 2000–2010. *World Medical & Health Policy* **8**, 127–138.

Inman P (2012) Brazil's economy overtakes UK to become world's sixth largest. The Guardian. 6 March. Available at https://www.theguardian.com/business/2012/mar/06/brazil-economy-worlds-sixth-largest (Accessed 25 January 2019).

Kane JB, Miles G, Yourkavitch J and King K (2017) Neighborhood context and birth outcomes: going beyond neighborhood disadvantage, incorporating affluence. *SSM – Population Health* **3**, 699–712.

Luo Z-C, Wilkins R, Heaman M, Martens P, Smylie J, Hart L, Wassimi S, Simonet F, Wu Y and Fraser W (2010) Neighborhood socioeconomic characteristics, birth outcomes and infant mortality among first nations and non-first nations in Manitoba, Canada. *The Open Women's Health Journal* **4**, 55–61.

Macinko J, Guanais, FC and De Souza MdFM (2006) Evaluation of the impact of the family health program on infant mortality in Brazil, 1990–2002. *Journal of Epidemiology & Community Health* **60**, 13–19.

Macinko J, De Oliveira VB, Turci MA, Guanais FC, Bonolo PF and Lima-Costa MF (2011) The influence of primary care and hospital supply on ambulatory care – sensitive hospitalizations among adults in Brazil, 1999–2007. *American Journal of Public Health* **101**, 1963–1970.

https://doi.org/10.1017/S1744133122000111 Published online by Cambridge University Press

Muennig P, Pabayo R and Reynolds M (2018) Why is infant mortality in the United States so comparatively bad? Some possible answers. *Journal of Health Politics, Policy and Law* **43**, 877–895.

Padilla WK-T, Vieira VM and Deguen S (2016) City-specific spatiotemporal infant and neonatal mortality clusters: links with socioeconomic and air pollution spatial patterns in France. *International Journal of Environmental Research and Public Health* **13**, 624.

Paim J, Travassos C, Almeida C, Bahia L and Macinko J (2011) The Brazilian health system: history, advances, and challenges. *The Lancet* **377**, 1778–1797.

Ravalin T and Tevis T (2017) Social disorganization theory and crime rates on California community college campuses, community college. *Journal of Research and Practice* **41**, 27–41.

Reis E (2014) Recent macroeconomic trends in emerging economies and implications for development Country Study: Brazil. United Nations. Available at https://www.un.org/en/development/desa/policy/capacity/presentations/newyork/dpad-egm-dec-2013-presentation-brazil.pdf.

Ribeiro FD, Ferrari RAP, Sant'Anna FL, Dalmas JC and Girotto E (2014) Extremes of maternal age and child mortality: analysis between 2000 and 2009. *Revista Paulista de Pediatria* **32**, 381–388.

Sampson RJ (1997) Collective regulation of adolescent misbehavior: Validation results from eighty Chicago neighborhoods. *Journal of Adolescent Research* **12**, 227–244.

Sampson RJ and Groves WB (1989) Community structure and crime: Testing social-disorganization theory. *American Journal of Sociology* **94**, 774–802.

Schultz TP (1997) Demand for children in low income countries. In Rosenzweig MR and Stark O (eds), *Handbook of Population and Family Economics*. Cambridge, MA, USA: Elsevier, pp. 349–430.

Shaw CR and McKay HD (1942) *Juvenile Delinquency and Urban Areas*. University of Chicago Press.

Shei A, Costa F, Reis MG and Ko AI (2013) The impact of Brazil's Bolsa Família conditional cash transfer program on children's health care utilization and health outcomes. *BMC International Health and Human Rights* **14**, 10.

Smith DA and Jarjoura GR (1988) Social structure and criminal victimization. *Journal of Research in Crime and Delinquency* **25**, 27–52.

Sun IY, Triplett R and Gainey RR (2004) Neighborhood characteristics and crime: a test of Sampson and Groves' model of social disorganization. *W. Criminology Rev* **5**, 1.

Szwarcwald CL, Almeida WD, Teixeira RA, França EB, de Miranda MJ and Malta DC (2020) Inequalities in infant mortality in Brazil at subnational levels in Brazil, 1990 to 2015. *Population Health Metrics* **18**, 4.

Warner BD and Pierce GL (1993) Reexamining social disorganization theory using calls to the police as a measure of crime. *Criminology* **31**, 493–517.

Wang C, Guttmann A, To T and Dick PT (2009) Neighborhood income and health outcomes in infants: how do those with Complex chronic conditions fare? *Archives of Pediatrics & Adolescent Medicine* **163**, 608–615.

Watts J (2013) Brazil's Bolsa Família scheme: political tool or social welfare success? The Guardian. 19 December. Available at https://www.theguardian.com/global-development/2013/dec/19/brazil-bolsa-Família-political-tool-social-welfare (Accessed 27 July 2020).

Wilkinson RG, Kawachi I and Kennedy BP (1998) Mortality, the social environment, crime and violence. *Sociology of Health & Illness* **20**, 578–597.

Wilson JQ (1990) Against the legalization of drugs. *Commentary* **89**, 21.

Wilson JQ (1996) What, if anything, can the federal government do about crime. *Persp. on Crime & Just* **1**, 1.

Wooldridge JM (2012) *Introductory Econometrics: A Modern Approach*, 5th Edn. Stamford, CT, USA: Cengage Learning, pp. 326–331.

World Bank (2014) Health Financing Profile – Brazil. World Bank. Available at https://documents1.worldbank.org/curated/en/638281468226148870/pdf/883440BRI0P1230l0final0January02014.pdf.

World Bank (2022) GDP Growth (Annual %). World Bank. Available at https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG.

Yourkavitch J, Kane JB and Miles G (2018) Neighborhood disadvantage and neighborhood affluence: associations with breastfeeding practices in urban areas. *Maternal and Child Health Journal* **22**, 546–555.

Cite this article: Gusmano MK, Grafova I, Ayoub R, Weisz D, Rodwin VG (2023). Neighborhood inequalities and the decline of infant mortality in São Paulo. *Health Economics, Policy and Law* **18**, 111–120. https://doi.org/10.1017/S1744133122000111