Maternal Social Factors and their Influence on Neonatal Outcomes

An Annotated Bibliography

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Executive Summary:

This annotated bibliography was collected to provide a concise source of the existing research investigating the connections between maternal social factors and subsequent neonatal outcomes. It was constructed with the goal of being comprehensive of the literature evaluating these specific exposures and outcomes in the United States (US) in order to provide guidance for future program and policy development to address upstream social disparities affecting pregnant mothers in the US. An extensive MEDLINE search was performed as outlined in the Methods section to identify the 29 articles reviewed below. A review of existing literature on this topic has not been recently performed to this extent. Though I and several of my colleagues consider it sensible that factors such as poor socioeconomic status (SES), low income, or being of a minority race would have negative impacts on neonatal outcomes, the subsequent literature demonstrates diverse and conflicting results.

The Problem:

Substantial work exists identifying prevalence of poor neonatal health outcomes including low birth weight and prematurity, as well as the impact these outcomes have on neonatal and infant mortality, development of chronic conditions into childhood and adulthood, and the costs of these outcomes on the healthcare system. Less is known about the specific causes of poor neonatal health outcomes, as these are likely multifactorial and affected by every aspect of the mother's physical and mental health.

Matthews et al. describe this public health problem, exploring Vital Statistic data that demonstrated prematurity and low birth weight accounted for 36% of infant deaths in 2013.[26] Incidence of prematurity and low birth weight have also been found to be higher in the United States than in other developed, high income countries, at 8.3% and 9.9%, respectively.[13,24,25,28] How is it that the United States is falling behind in such an important aspect of health, and what can be done to improve these outcomes and decrease infant mortality as well as chronic health problems?

A common proposal, and one that has been acted upon multiple times in the past 30 years, is to expand health insurance coverage to these women under the assumption that improving health insurance will allow these women to access care and decrease incidence of negative neonatal outcomes. However, is this assumption evidence-based? Medicaid has expanded to provide a source of insurance for many pregnant women, funding 40% of all births in the United States in 2011.[2] Despite this, the US is being outperformed by comparison countries as above, indicating there is more to be done to address known sources of neonatal/infant morbidity and mortality and poor childhood health.

There also exists evidence evaluating the costs of poor neonatal health outcomes on the US healthcare system. St John et al. demonstrate that approximately $10.2 billion are spent annually on newborn care alone, with 57% of this spent on infants born <37 weeks gestation, a population that comprises merely 9% of live births in the United States.[36] Furthermore, a Thompson–Reuters study commissioned by the March of Dimes estimated that in 2007, one premature birth generated excess maternal and infant first-year costs of $49,666 compared with full-term healthy births.[20] Further described below, Rogowski et al. found an excess cost of $216,000 spent in the

first year of life on very low birth weight infants when compared to infants born between 1250-1499g, which are still significantly low birth weights.[31] These demonstrate the substantial cost reduction that could be produced by addressing causes of low birth weight and prematurity as well as other poor neonatal health outcomes.

The following studies describe the impact of social factors on infant birth weight, prematurity, and other neonatal health outcomes, and several studies evaluate efficacy of programs and policies designed to address these social factors. The health and cost impacts of poor neonatal health outcomes cannot be overstated. The goal of this paper is to provide a collection of evidence in support of policy to improve upstream social determinants of health specifically for pregnant and reproductive-age women in order to improve neonatal health outcomes and decrease the financial burden on the US healthcare system.

Methods:

A PubMed MEDLINE search was performed with the search terms "pregnancy" and "insurance coverage" which yielded 1,139 results; this was refined to include specifically "neonatal outcomes" for this review, which resulted in 89 articles. Upon review of the most pertinent articles, the following list of MESH terms was developed to identify 20 additional articles: "Pregnancy," "Pregnant Women," "Pregnant Woman," "Prenatal Care," "Social Class," "Insurance Coverage," "United States," "Neonatal Mortality." 7 additional articles were identified via the snowball method, evaluating appropriate reference articles from the initial searched papers. The article list was then refined to include only those studies which specifically evaluated social factors as exposures (socioeconomic status, race, insurance status, income), examined neonatal outcomes (including but not limited to birth weight, gestational age at delivery, neonatal mortality), and were performed in the US. 43 articles met inclusion criteria, and these were reviewed in full, with 29 articles included in the final qualitative analysis specifically evaluating the effects of maternal social factors on neonatal health outcomes (Figure 1).

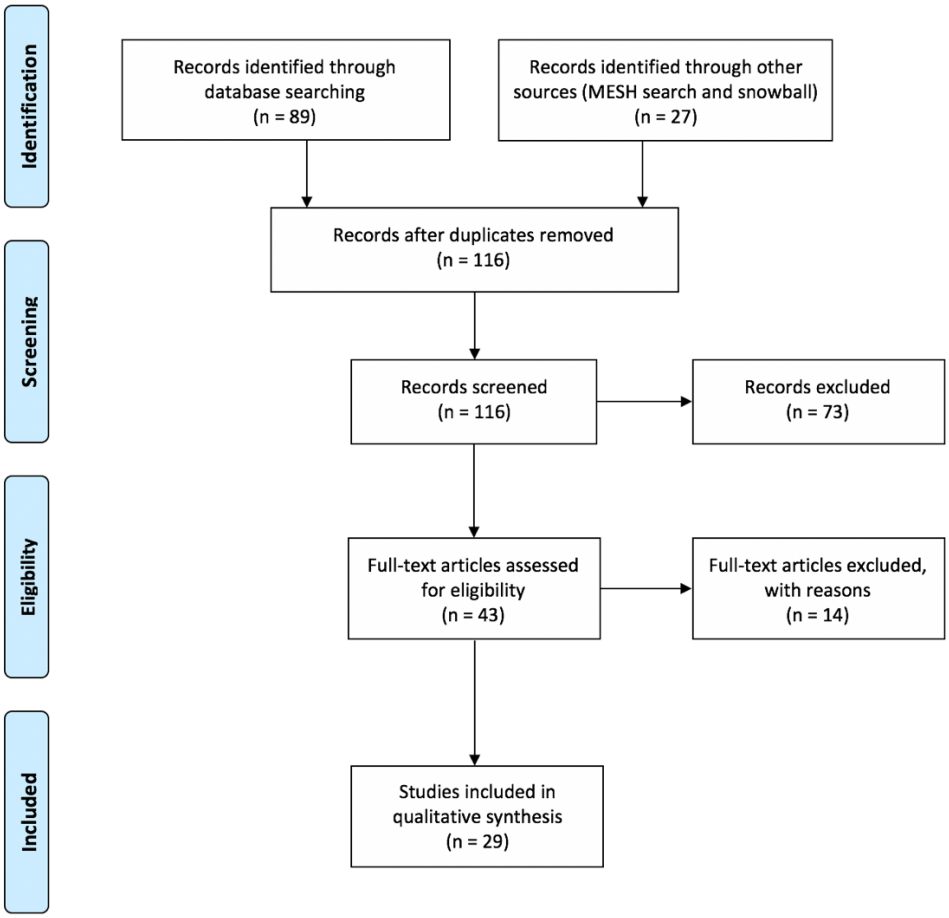

Figure 1: PRISMA Diagram depicting flow of identification and screening of research articles evaluating effects of maternal socioeconomic, racial, and insurance factors and their effects on neonatal outcomes.

Themes:

Upon review, the focus and conclusions of these articles were organized into the following six general themes:

Social Disadvantage and its Impact on Neonatal Health Outcomes:
Seven articles evaluated specifically the overall effects of maternal social disadvantage on neonatal outcomes. Social Disadvantage is scored in these articles with women scoring higher for experiencing lack of health insurance or poor health insurance, single marital status, poor neighborhood income, low socioeconomic status, Black maternal race, low education achieved, or limited access to healthcare. All of these articles draw a correlation between social disadvantage and poor neonatal health outcomes, notably low birth weight and premature birth. They identify causal pathways to explain relationships identified throughout this review and demonstrate the impact of programs established to assist with social disadvantage.

Of note is the associations identified in the Gavin et al. article, demonstrated in Figure 2. They demonstrate that social disadvantage, substance use, and maternal stressors all demonstrated associations with poor neonatal outcomes that were not statistically significant. All of these exposures were, however, statistically significantly associated with increase in maternal health conditions, which in turn demonstrated a statistically significant correlation with worse neonatal outcomes. This proposes a causal pathway for all of these exposures to impact neonatal outcomes and also implies reasoning for why later studies demonstrate no correlation with social factors on neonatal outcomes. If these studies attempted to identify direct causation, they may have found insignificant results, as demonstrated in the Gavin study, prompting them to reject the connection between social factors and neonatal outcomes. Overall the results from these studies support the idea that social disadvantage leads to negative impacts on neonatal outcomes.

Socioeconomic Factors Throughout the Lifespan and Their Impact on Neonatal Outcomes:
Three studies specifically examined lifelong effects of social factors on neonatal outcomes. Two determined that poor social influences (defined similarly to social disadvantage above) throughout the lifespan have a dose-response effect on poor neonatal outcomes. The primary potential cause is weathering, the idea that progressive and collective stress causes changes in hormonal axes in women that could lead to lower birthweights or premature deliveries.

The third article looks at insurance coverage over multiple generations and demonstrates that Medicaid expansions caused lasting improvements that extended to grandchildren when compared to uninsured women. Articles in this theme demonstrate that higher social scores in children were protective even if social environments worsened over time, and that improved social environments with age can overcome the impacts of poor childhood social environments. These results suggest that policy and programs to improve social factors in women can never be enacted too early or too late, and that development of these policies or programs would positively impact neonatal health outcomes.

Socioeconomic and Racial Influences on Neonatal Outcomes:
Eight articles either evaluated racial impacts on neonatal health outcomes, or stratified social outcomes based on race to demonstrate how race affects neonatal outcomes. Overall these articles demonstrate Black women are more likely to deliver premature and lower birth weight neonates and have higher rates of neonatal mortality. Several studies demonstrate Hispanic women to actually have better birth outcomes than White women. This is possibly due to community and family contributions to resilience, indicating the importance of social support in overcoming racial disparity and weathering as discussed below. They also demonstrate that differences in incidence of low birth weight and premature birth are larger among women of higher socioeconomic status, contributing to evidence that race/ethnicity individually impacts neonatal outcomes outside of inherent socioeconomic differences. These articles demonstrate the importance of policy and programs focused on eliminating racial disparities in access to care, education, medical management, and physician implicit biases.

Private Insurance vs Public Insurance Impacts on Neonatal Outcomes:
Two dissenting articles specifically compared neonatal outcomes in populations covered by private insurance with populations covered by public insurance. The first study concluded no difference in neonatal outcomes when comparing private and public health insurance; however,

they did not consider preterm delivery to be a negative neonatal outcome. Incidence of preterm delivery (which is considered a poor neonatal outcome in this overall review) was observed to be lesser in privately insured women in this study. Therefore, this review disagrees with authors' conclusions that neonatal outcomes are not affected. The second article demonstrates lower incidence of low birth weight, preterm births, and very preterm births in privately insured women. These studies demonstrate that some aspect of private insurance provides for better neonatal outcomes, and they support policy reforming public insurance to improve coverage for pregnant women.

Insurance Coverage Improves Neonatal Outcomes:
Two articles explored the theme that insurance coverage improves neonatal outcomes. The first article evaluated neonatal outcomes before and after Massachusetts health reform. They demonstrated that those with insurance coverage had longer hospital stays (as opposed to inappropriately early discharge), fewer diagnoses, and fewer procedures performed than uninsured neonates. The second study demonstrated 2.6-times increased odds of neonatal death in uninsured neonates when compared to insured neonates. Both of these conclude that improved access to care and improved insurance coverage in these mothers would translate to improved neonatal outcomes overall.

Insurance Coverage Provides no Change in Neonatal Outcomes:
Four studies demonstrate no effects on neonatal outcomes associated with maternal insurance coverage. The first study evaluated effects of CHIP and CHIPRA and concluded no effect on neonatal outcomes; however, they demonstrated that CHIPRA did decrease incidence of preterm birth, which is considered a poor neonatal outcome in the remainder of this article. A second article evaluated effects of presumptive eligibility and demonstrated that expansion of private insurance coverage increased smoking cessation among pregnant women. They did not find any correlation between insurance coverage and improved neonatal outcomes; although, many other studies connect smoking during pregnancy with poor neonatal outcomes, so these results could potentially expand to improve neonatal outcomes in future study. A third evaluated neonatal outcomes in Massachusetts before and after Massachusetts health reform which introduced universal coverage for pregnant women. They found no change in neonatal outcomes; however, they recognize that Massachusetts had a robust safety net for pregnant women prior to the reform, so these women already received high quality care and reform merely provided coverage they already had. The final article was a review of existing literature examining impacts of Medicaid expansion; authors attempt to conclude that the evidence for improvement in neonatal outcomes is weak. However, three of the four articles that specifically evaluate neonatal outcomes are reported to demonstrate improvements in prematurity and low birth weight in specific populations, and the fourth is inaccurately evaluated by the authors. Upon personal review, this article also demonstrates improvements in neonatal outcomes.

Although the articles fitting this theme demonstrate no effect of health insurance coverage on neonatal outcomes, they all have significant limitations or inaccurate conclusions, weakening the evidence that insurance coverage has no effect.

Overall Conclusions

In addition to the above summary and the following in depth review, the following are overall conclusions recognized by evaluating these articles as a whole.

- Of the existing literature studying maternal social factors and neonatal outcomes, the majority of results support the idea that poorer social conditions (low socioeconomic status, Black race, lower education, unemployment, etc) lead to poorer neonatal health outcomes.
- The costs of poor neonatal health outcomes are substantial and only increasing over time with increasing technology. Improvement of neonatal health outcomes provides an avenue for substantial decrease in health care expenditures.
- Programs and policies devoted to improving upstream social factors will improve neonatal health outcomes.
- Racial inequality in neonatal health outcomes exists and is larger at higher socioeconomic levels. Elucidation of this fact, understanding of caregivers' implicit biases, and specific programs and policies dedicated to improving care and access to care for racial minorities provide many opportunities to improve neonatal outcomes.
- Insurance coverage alone appears to improve neonatal outcomes, and those with private insurance demonstrate better neonatal outcomes. Focus on expanding and improving insurance coverage for pregnant women is another avenue to improve neonatal outcomes and decrease health care costs from poor neonatal outcomes

Annotated Bibliography

Description of the Problem and Possible Social Contributors:

Adams EK, Nishimura B, Merritt RK, Melvin C. Costs of poor birth outcomes among privately insured. J Health Care Finance. 2003 Spring;29(3):11-27. PMID: 12635991.

Authors evaluated costs for care in a population of >12,000 privately insured neonates in 1996, collected in MarketScan data from Medstat Systems, Inc. which included private sector claims from over 200 payers nationwide. They demonstrated that those who were born premature or who had other negative neonatal outcomes accounted for 23.4% of the population and were responsible for 82% of the total $56 million in neonatal care costs during that year – those born extremely premature (4% of population) alone contributed 45% of total costs. The incremental cost of preterm/poor neonatal outcome births compared to term healthy births was $14,600. Authors also explore cost of rehospitalization for infants due to problems resulting from poor birth outcomes; though, this is outside the scope of this review. This was, at the time, increasing in cost from previous studies. Authors note specific social interventions that would have the greatest impact on cost are smoking cessation, family planning, and preconceptual counseling, offering specific avenues for intervention to decrease risk of poor neonatal outcomes and their subsequent costs. Though no studies demonstrate the cost in recent years, this significant burden in the 90s is suggestive of persistent and possibly larger burden in health care costs today due to improvements in technology and increased ability to care for infants with negative birth outcomes.

Rogowski J. Cost-effectiveness of care for very low birth weight infants. Pediatrics. 1998 Jul;102(1 Pt 1):35-43. doi: 10.1542/peds.102.1.35. PMID: 9651411.

Authors examined all very low birth weight (VLBW) infants born in California during 1986-87 and evaluated costs of treatment in the first year of life. VLBW infants account for 1.2% of births, but 46% of infant deaths. Of the study sample, two-thirds were discharged alive from the hospital, 32% died within the first 28 days of life, and another 5% died throughout the remainder of the first year. Average first year costs for VLBW survivors with birth weight <1500g was $93,800, but when stratified there was a significant gradient: <750g = $273,900; 750-999g = $138,800; 1000-1249g = $75,100; 1250-1499g = $58,000. Authors did demonstrate an initial increase in medical expenditures with increased weight in the <750g group; though once this threshold was crossed, costs decreased as above. This study demonstrated the impact that improvement in birth weight can have on costs to the healthcare system. Though this was performed 20 years ago, costs have likely remained the same or even possibly increased due to improvements in technology and more understanding of neonatal intensive care. This demonstrates that policies that can improve neonatal outcomes such as neonatal birth weight can dramatically reduce costs.

Wallace HM, Micik S, Wise P. Community study of infant mortality in San Diego County. J Trop Pediatr. 1994 Jun;40(3):172-8. doi: 10.1093/tropej/40.3.172. PMID: 8078117.

Researchers evaluated California State Department of Health Services birth and infant death certificate data to evaluate timing and causes of infant mortality in San Diego County in 1985. They demonstrate that two-thirds of all infant deaths occurred in the neonatal period (0-27 days of life), more than half of these occurred in the first 24 hours of life, and nearly half of neonatal deaths were attributable to perinatal causes including low birth weight (<2500g), Respiratory Distress Syndrome, asphyxia, meconium aspiration, and intraventricular hemorrhage. The incidence of low birth weight in the neonatal death group was 10 times the incidence of low birth weight in the control group. On demographic evaluation, the neonatal mortality group consisted of a larger proportion of Black mothers, mothers under 20 years of age, and mothers whose care was publicly funded (MediCal or county source) compared to the control group. On multivariate analysis, researchers demonstrate that almost 85% of Black neonatal deaths were associated with low birth weight, compared to 70% of Hispanic neonatal deaths, and less than two-thirds of White neonatal deaths. In this study population, mortality for preterm infants was 7 times greater than those born at term.

This study identifies multiple maternal social risk factors for poor neonatal health outcomes and neonatal mortality that are further explored in the following articles.

Social Disadvantage and its Impact on Neonatal Health Outcomes

Gavin AR, Nurius P, Logan-Greene P. Mediators of adverse birth outcomes among socially disadvantaged women. J Womens Health (Larchmt). 2012 Jun;21(6):634-42. doi: 10.1089/jwh.2011.2766. Epub 2011 Dec 13. PMID: 22150295; PMCID: PMC3366100.

Authors performed a prospective cohort study evaluating data from a diverse group of 2168 women who received prenatal care from a single university academic medical center from 2004-2010. Women completed questionnaires regarding their health behaviors and sociodemographic characteristics including living with partner, educational attainment, and employment status. They also scored antenatal depression, antidepressant use, substance use, and maternal health conditions to evaluate potential contributing factors. Social characteristics were matched with birth outcome data, specifically infant birth weight and gestational age at birth. Results demonstrated association between social disadvantage, psychosocial stress, and antenatal substance use with poor offspring birth outcomes indirectly, via these characteristics' impacts on maternal health conditions. Figure 2 effectively outlines their findings of associations and provides a descriptive causal pathway for social factors' effects on neonatal health outcomes and also provides an explanation for other articles' findings of no association between these exposures and outcomes.

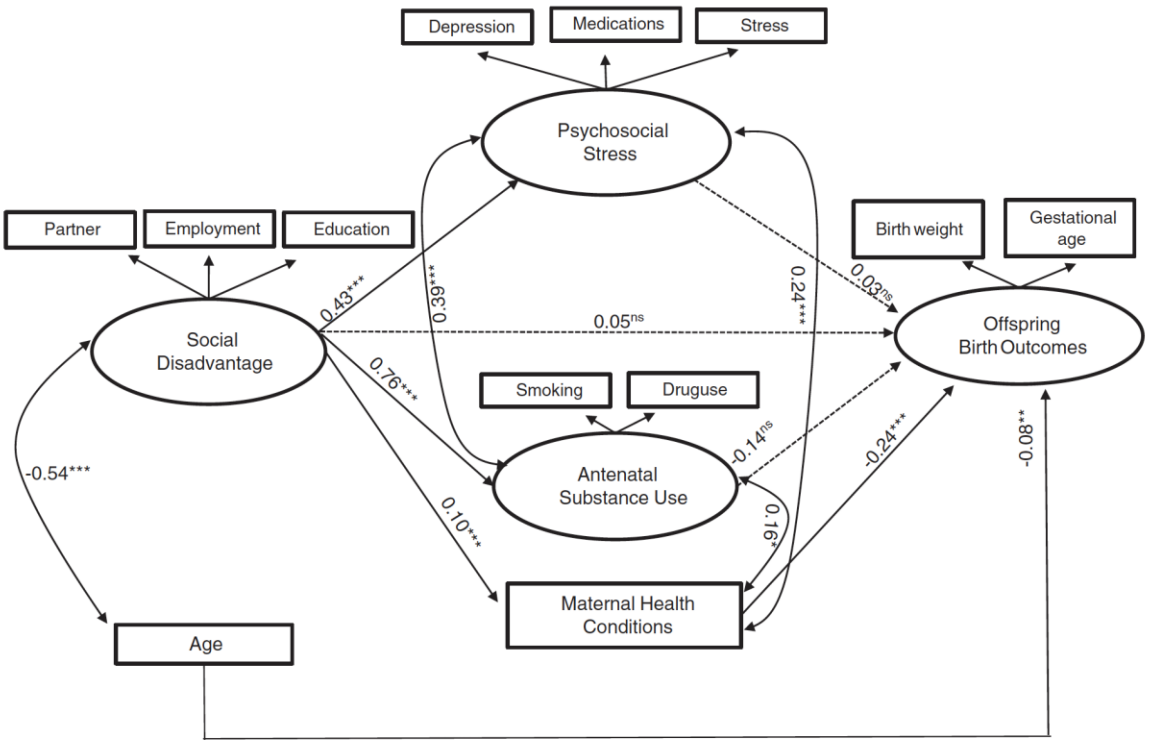

FIG. 2. The SEM and the standardized model parameter estimates. Coefficients are standardized regression estimates (β). Solid lines represent regression paths that are significant at $p < 0.05$ or greater; dotted lines are not significant. Single-headed arrows are regression paths; double-headed arrows are correlations. ns, nonsignificant; *$p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Bohanon FJ, Nunez Lopez O, Adhikari D, Mehta HB, Rojas-Khalil Y, Bowen-Jallow KA, Radhakrishnan RS. Race, Income and Insurance Status Affect Neonatal Sepsis Mortality and Healthcare Resource Utilization. Pediatr Infect Dis J. 2018 Jul;37(7):e178-e184. doi: 10.1097/INF.0000000000001846. PMID: 29189608; PMCID: PMC5953763.

Authors performed a retrospective cross-sectional analysis utilizing data from the Kid's Inpatient Database to identify >160,000 neonates diagnosed with sepsis and compared mortality with maternal characteristics such as insurance coverage, household income, and race. They demonstrated increased mortality among self-pay patients, those with low household income, and low birth weight patients when compared with privately insured, higher SES neonates, indicating increased mortality from sepsis associated with these specific socioeconomic disparities. Results demonstrated self-pay patients had 3.26 times the odds of mortality, average 2.49 days shorter length of stay, but did have decrease in average total cost by $5015.50 ± 783.15 when compared to privately insured neonates. Those with low household income had 1.19 times the odds of mortality compared to higher household incomes, and black neonates had shorter length of stay than white neonates. The authors outline provision of care to those without insurance coverage or with a lesser income to be integral to improving neonatal outcomes and reducing risk of death due to neonatal sepsis.

Singh GK, Kogan MD. Persistent socioeconomic disparities in infant, neonatal, and postneonatalmortality rates in the United States, 1969-2001. Pediatrics. 2007; 119:e928–39. [PubMed:17403832]

This study was an analysis of National Vital Statistics System data linked to county-level socioeconomic data consisting of indicators of education, occupation, wealth, income distribution, unemployment rate, poverty rate, and housing quality. The authors demonstrated significant overall improvement in infant mortality between 1969-2001; however, since 1985, relative socioeconomic disparities in neonatal and post-neonatal mortality persisted. They also demonstrated an increasingly wide gap in postneonatal and infant mortality between lower and higher socioeconomic status groups – 36% higher neonatal mortality in the most deprived group compared to least deprived in 1985-89, increasing to 43% higher neonatal mortality in the most deprived group in 1995-2000. This increase in mortality range was found to be associated with maternal education (difference increase from 22% to 41% between <12 years and >16 years education from 1986 and 2001), social conditions, smoking during pregnancy, and availability of healthcare services.

Blumenshine P, Egerter S, Barclay CJ, et al. Socioeconomic disparities in adverse birth outcomes: a systematic review. Am J Prev Med. 2010; 39:263–272. [PubMed: 20709259]

Authors performed a review of the literature regarding socioeconomic disparities and their effects on birth outcomes published from 1999-2007, specifically those associating a socioeconomic predictor and birthweight, gestational age, or intrauterine growth. They discovered that 93/106 studies meeting inclusion criteria demonstrated significant and consistent association between socioeconomic disadvantage and increased risk of adverse health behavior and adverse effects on neonatal outcomes. They call for identification of effective policy actions to ameliorate social disparities and allow for decrease in adverse birth outcomes.

Paneth N, Wallenstein S, Kiely JL, Susser M. Social class indicators and mortality in low birth weight infants. Am J Epidemiol. 1982 Aug;116(2):364-75. doi: 10.1093/oxfordjournals.aje.a113420. PMID: 7114045.

Authors evaluate mortality data for over 10,000 low birthweight infants (501-2000g) in New York City from 1976-78 to demonstrate that race, sex, and gestational age-for-weight all impact neonatal mortality even within narrow birth weight bands, but that maternal education, prenatal care, and type of service for delivery do not impact weight-specific mortality, despite these factors' influence of crude neonatal mortality. Researchers separated infants into 250g birth weight bands and analyzed mortality between categories with a chi-squared analysis, followed by linear logistic models to determine odds ratios for effects of each social variable. They demonstrate that Black neonates at lower birth weights had lower mortality rates than White neonates, opposite to the effects seen in overall neonatal mortality, but this was a weaker correlation than overall effects of race. When analyzing social factors, nonmarried status and lower education actually had decreased rate of neonatal mortality in higher birth weight groups, but these effects disappeared when adjusted for sex, race, and gestational age. Authors conclude that social factors' negative impact on overall neonatal mortality are mediated by their negative effects birth weight, as in this cohort of low birth weight infants, social factors themselves did not have statistically significant impacts on weight-specific mortality.

Shultz CJ 2nd, Shultz KA. Poverty and prenatal health care in America: trends, costs, and recommendations. J Ambul Care Mark. 1994;5(2):149-59. doi: 10.1300/j273v05n02_12. PMID: 10165478.

This article is a review of the existing literature regarding correlations between poverty, insurance status, and health outcomes in various facets. In particular authors summarize factors that lead to low birthweight and premature delivery; these include low income and minority women, women at extremes of child-bearing age, those with unplanned pregnancy, increased parity, low maternal education, poor social support, improper nutrition, substance use, and psychological stress. Authors also draw a correlation in the literature between access to prenatal care and neonatal outcomes, demonstrating multiple studies that conclude women with the above social disadvantages experience difficulties accessing prenatal care and thus, worse neonatal health outcomes. They do note that access to care alone is not sufficient to improve these outcomes, and "daily stresses and personal problems that the poor experience demand priority over preventive health behaviors and medical care." Authors call for implementation of prenatal outreach and case managed care programs. While significant advancements in Medicaid availability have been implemented since this paper was published, substantial opportunity still exists for development of outreach and care programs to enhance both access to care and social support for women of social disadvantage.

Soneji S, Beltrán-Sánchez H. Association of Special Supplemental Nutrition Program for Women, Infants, and Children With Preterm Birth and Infant Mortality. JAMA Netw Open. 2019 Dec 2;2(12):e1916722. doi: 10.1001/jamanetworkopen.2019.16722. PMID: 31800070; PMCID: PMC6902759.

This study was performed to evaluate the impacts of the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) on neonate gestational age and infant mortality from preterm birth. Authors performed a cohort study utilizing data from 2011-2017 US live birth certificates to evaluate over 11 million live-births whose insurance coverage and WIC benefits were recorded on the birth certificates. Authors demonstrate that mothers covered by Medicaid who received WIC benefits during pregnancy had 0.87 times the odds of delivering a preterm infant when compared to women covered by Medicaid who did not receive WIC benefits. This decrease in likelihood of preterm delivery with receipt of WIC benefits was consistent throughout racial stratification, with all racial/ethnic subgroups demonstrating similar decreased odds of preterm birth. They also conclude that infant mortality was lower in those who received WIC benefits, though the specifics of this are outside the scope of this review.

In this study, WIC benefits among expectant mothers was a protective factor for both preterm birth and infant mortality, demonstrating the value of social and nutritive support programs in improving neonatal health outcomes. One of the most impactful results in this study is that authors found a 6.5% (35,000 person) decrease in access to WIC benefits over the time period of the study, possibly due to logistical barriers to enrollment, social stigma around redeeming benefits, and limited selection due to retailers not carrying WIC-eligible foods and products. Thus, authors conclude that public health campaigns and policy to increase enrollment and funding of WIC programs would help improve neonatal health outcomes in low-income Medicaid-enrolled women.

Socioeconomic Factors Throughout the Lifespan and Their Impact on Neonatal Outcomes

Astone NM, Misra D, Lynch C. The effect of maternal socio-economic status throughout the lifespan on infant birthweight. Paediatr Perinat Epidemiol. 2007 Jul;21(4):310-8. doi: 10.1111/j.1365-3016.2007.00821.x. PMID: 17564587.

Investigators performed a three-generation cohort study (80% African Americans and 20% highly disadvantaged European Americans) evaluating Pathways to Adulthood Study data to compare indicators of a woman's socioeconomic status throughout childhood and at time of delivery to her respective infant's birthweight. Their analysis determined that maternal SES in childhood and in adulthood each independently impact birth weight with a positive association – the higher the mother's SES, the more normal the infant's birth weight. They demonstrate that childhood SES is the strongest factor, as women with equally low SES at time of delivery, but with a higher childhood SES experience less of an impact on infant birthweight as those with low SES throughout their life – indicating higher SES in childhood is a protective factor for these women. Conversely, however, women with low childhood SES (indicated by maternal education) who are able to themselves achieve higher levels of education and income are able to mitigate disadvantage in their child's birthweight. This study outlines persistent, intergenerational disadvantage as a source of poor neonatal health outcomes.

Love C, David RJ, Rankin KM, Collins JW Jr. Exploring weathering: effects of lifelong economic environment and maternal age on low birth weight, small for gestational age, and preterm birth in African-American and white women. Am J Epidemiol. 2010 Jul 15;172(2):127-34. doi: 10.1093/aje/kwq109. Epub 2010 Jun 24. PMID: 20576757.

This study examined singleton births among non-Hispanic Black and White women in Cook County, IL, while also evaluating maternal age, neighborhood income, and infant birthweight to evaluate the effects of different experiences of exposure to impoverished environments across generations. Interestingly, they found that age was the only factor that correlated differently between racial groups – in Black women with low SES, age had a negative association with infant birthweight (Low birthweight OR>1, increasing with age), presumably due to "weathering" or cumulative stress. White women with low SES and Black women living in higher income neighborhoods both did not experience weathering with increasing age, demonstrating the impact of an adverse economic or social environment over time, amplified by racial differences as well. They conclude that to eliminate racial inequalities in birth outcomes, interventions must change social and economic environments across the life course, if not across generations.

East C, Miller S, Page M, and Wherry L. Multi-generational Impacts of Childhood Access to the Safety Net: Early Life Exposure to Medicaid and the Next Generation's Health. National Bureau of Economic Research Working Paper No 23810. Sept 2017, revised Feb 2019. JEL No. I1,I13,I14,I18.

Authors utilized Vital Statistics natality data from 1994-2015 to evaluate health outcomes of children of mothers who were born between 1979 and 1986 to determine multi-generational effects of expanded Medicaid coverage. This timeframe is when the largest increases in prenatal Medicaid coverage occurred. The basis behind this evaluation is the idea that maternal insurance coverage as an infant communicates to lifelong health benefits than are passed onto subsequent generations. They specifically evaluate birth

weight and gestational age. Findings indicate that maternal Medicaid coverage in utero significantly correlated with an average 44g increase in birth weight and a 0.7% decrease in incidence of very low birth weight in their children compared to those outside the study population. In utero coverage also correlated with decreased incidence of delivery prior to 28-weeks gestation; although no difference was seen in incidence of small-for-gestational-age infants.

The improvement in neonatal outcomes due to distant Medicaid coverage in this study are about half of what has been demonstrated elsewhere on the immediately affected population by Medicaid expansion, indicating that insurance coverage has its strongest effects on the immediately affected neonates. This study does, however, indicate that these improved outcomes do extend to later generations and authors call for the employment of this knowledge as further evidence for the need for improved coverage for pregnant women.

Socioeconomic and Racial Influences on Neonatal Outcomes

Braveman PA, Heck K, Egerter S, et al. The role of socioeconomic factors in Black-White disparities in preterm birth. Am J Public Health. 2015; 105:694–702. [PubMed: 25211759]

In this study, authors used California Maternal and Infant Health Assessment survey and birth certificate data to evaluate rates of preterm birth in various subgroups stratified by race and socioeconomic advantage/disadvantage. They observed higher rates of preterm birth among the socioeconomically disadvantaged groups compared to those with higher socioeconomic status; moreover, the majority of Black women surveyed fell within these socioeconomically disadvantaged groups whereas only ~25% of White women matched these SES characteristics. When stratified by race, they found among the group with lower SES, rates among Black and White women did not differ greatly. However, in higher SES groups, White women experienced significant improvement in rates of preterm birth while the rates among Black women remained the same or worsened, indicating the presence of "unmeasured dimensions of disadvantage affecting Black women across socioeconomic levels."

de Jongh BE, Locke R, Paul DA, Hoffman M. The differential effects of maternal age, race/ethnicity and insurance on neonatal intensive care unit admission rates. BMC Pregnancy Childbirth. 2012 Sep 17;12:97. doi: 10.1186/1471-2393-12-97. PMID: 22985092; PMCID: PMC3495040.

Authors evaluated data from the Consortium of Safe Labor Database to relate neonatal intensive care unit admissions to multiple maternal factors, including maternal age, gestational age, race, insurance coverage, and previous cesarean section. Researchers observed increased risk of NICU admissions comparing mothers >35 years old with public insurance to those with private insurance, and suggested weathering in lower SES groups among all races as a causative factor to develop issues leading to NICU admission. Interestingly, they found Hispanic mothers to have lower odds of NICU admissions and preterm birth than the other observed racial groups, possibly due to resilience developed through a supportive community. The key observation from this study is that private insurance coverage decreases NICU admissions in infants born to Hispanic and White mothers but is not protective in Black mothers. The observed racial disparity in NICU admissions was actually more pronounced among privately insured mothers compared to publicly insured, again demonstrating racial differences not mitigated (and potentially exacerbated) by higher SES (indicated by private insurance coverage).

Rosenbach M, O'Neil S, Cook B, Trebino L, Walker DK. Characteristics, access, utilization, satisfaction, and outcomes of healthy start participants in eight sites. Matern Child Health J. 2010 Sep;14(5):666-679. doi: 10.1007/s10995-009-0474-1. Epub 2009 Jul 10. PMID: 19590941; PMCID: PMC2923711.

The Healthy Start program was developed by the Maternal and Child Health Bureau to address racial and ethnic disparities in infant mortality, providing language-specific outreach, health education, and case management. Authors examined outcomes among Healthy Start participants in eight clinical sites to evaluate efficacy of this program using computer-assisted telephone interviewing to collect data from participants with infants ages 6-12months old. Specific to this review, authors examined low birth weight and

extended hospital length of stay due to medical problems. They demonstrate a 3-fold higher incidence of low birth weight infants in Black patients (14%) compared to Hispanic and non-Hispanic White patients (5%). Proportion of infants who had medical problems lengthening hospital stay were not different between participants and control group of low-income mothers – 12% and 13% respectively (these data were not stratified by race). Authors did find decreased smoking and alcohol during pregnancy in the Healthy Start population compared to an external comparison group – two pregnancy exposures known to worsen neonatal health outcomes. This article describes the benefits of a guided care program as well as access to care in many areas of their evaluation; however, when it comes to specifically evaluating neonatal outcomes, racial differences exist that far outweigh the benefit of this program.

Tabet M, Jakhar S, Williams CA, Rawat U, Hailegiorgis YD, Flick LH, Chang JJ. Racial/Ethnic Differences in Correlates of Spontaneous and Medically-Indicated Late Preterm Births among Adolescents. J Pediatr Adolesc Gynecol. 2017 Feb;30(1):63-70. doi: 10.1016/j.jpag.2016.08.004. Epub 2016 Aug 16. PMID: 27543000.

Researchers performed a retrospective cohort study using 2012 birth certificate data to associate maternal risk factors and late-preterm-birth delivery (GA 34/0 – 36/6) among 171,573 adolescent mothers stratified according to maternal race/ethnicity to determine racial differences in standard correlates with preterm birth. Authors explain that non-Hispanic White women and Asian/Pacific Islander women have ~7% preterm birth incidence whereas Black women have >10% incidence. They demonstrate that statistically significant race-specific risk factors for spontaneous late-preterm-birth delivery include: single marital status among Asian women; no insurance coverage among Asian, White, and Hispanic women; inadequate prenatal care among all groups except American Indian; adequate plus prenatal care among all racial subgroups; prenatal smoking among White and Black women; insufficient weight gain among all groups except American Indian; prepregnancy underweight in White, Black, and Hispanic women; and obesity among White, Black, and Hispanic women. These series of findings elucidate different areas to focus prenatal care for differing racial groups.

Authors also examined medically indicated late-preterm-births, but information on cause and fetal condition were not available, so only those data naturally occurring late-preterm-births were included here.

Penfield CA, Cheng YW, Caughey AB. Obstetric outcomes in adolescent pregnancies: a racial/ethnic comparison. J Matern Fetal Neonatal Med. 2013 Sep;26(14):1430-4. doi: 10.3109/14767058.2013.784738. Epub 2013 Apr 25. PMID: 23488933.

Authors performed a retrospective cohort study of singleton births to nulliparous adolescents aged 12-19 between 1988-2008 from UCSF Medical Center data, evaluating preterm delivery, cesarean section delivery, gestational diabetes, preeclampsia, birth weight and APGAR scores. They demonstrate a statistically significant difference in rates of preterm delivery, with African American adolescents having lower odds of preterm delivery than White adolescents. Differences in low birth weight and Apgar score <7 were not statistically significant. They also performed a multivariate analysis which demonstrated improved outcomes in non-White adolescents in all observed

outcomes except low birth weight – when controlled for gestational age, African American adolescents had a statistically significant increase in incidence of low birth weight compared to White adolescents. They conclude that adolescents of African American, Asian, and Latina descent may have similar or decreased risk of these complications; however, as above, they did demonstrate increased incidence of low birth weight in African American adolescents in the multivariate analysis. Authors consider differences in gynecological maturation, prime childbearing age, and immigrant adherence to positive health behaviors as possible explanations for these findings. The population in this study was substantially skewed toward racial minority groups, especially African American, limiting external validity to the US population as a whole.

Willis E, McManus P, Magallanes N, Johnson S, Majnik A. Conquering racial disparities in perinatal outcomes. Clin Perinatol. 2014 Dec;41(4):847-75. doi: 10.1016/j.clp.2014.08.008. Epub 2014 Oct 7. PMID: 25459778.

In this review, authors discuss articles that evaluate trends, epigenetic causes, programs and policies to examine racial/ethnic disparities in birth outcomes. They focus on genetic studies that concluded racial differences alone do not account for these differences – authors of one study hypothesized that if race was the causative factor, that those women who were of the "purest African ancestry" would have the worst outcomes. This was not observed, and rates were nearly identical when the population was stratified by allelic race alone, indicating that biologic race does not contribute to the poor neonatal outcomes seen in minority populations. They conclude these poor outcomes must result from social status, intergenerational exposures, and perceived or real discriminatory practices in the US. The authors of this review do, conversely, report on studies that show racial differences in neonatal outcomes even when these social factors are accounted for and matched. Several other studies demonstrate epigenetic differences in racial minorities, and postulate that perhaps a combination of genetic and environmental influences lead to poorer neonatal outcomes, and these epigenetic changes can be passed through generations to increase risk over time as generations of women are exposed to compounding environmental stressors.

The authors also evaluate several case studies, one of which demonstrated improved neonatal outcomes with culturally appropriate and targeted case management, addressing both social and health-related stressors for at-risk populations. These authors also discuss the weathering theory, that maternal and neonatal health worsen over time with increased exposure to life stressors with a physiologic effect on maternal endocrine balance, but also touch on the theory of resilience, where social factors can become protective for these women if they find sufficient support. Authors conclude that community action plans must be inclusive of all aspects that impact the socioeconomic factors affecting neonatal outcomes and must work to eliminate institutionalized racism that permeates education, healthcare, housing, justice, and labor. Multidisciplinary, multilevel, and multilayered interventions may be able to reduce stress-associated epigenetic changes that contribute to poor neonatal health outcomes in these populations.

Zhang S, Cardarelli K, Shim R, Ye J, Booker KL, Rust G. Racial disparities in economic and clinical outcomes of pregnancy among Medicaid recipients. Matern Child Health J. 2013 Oct;17(8):1518-25. doi: 10.1007/s10995-012-1162-0. PMID: 23065298; PMCID: PMC4039287.

This cross-sectional study, published in 2012, examines adverse pregnancy outcomes and Medicaid payments in nearly 1.5 million Medicaid patients. They evaluated data from Medicaid Analytic eXtract files in 14 southern states to determine African American women were more likely to experience preterm birth (AOR 1.34), small birth size for gestational age (AOR 1.03), and fetal death/stillbirth (AOR 1.89), among other negative pregnancy outcomes, even after adjusting for multiple covariates. They demonstrate that racial disparities in adverse pregnancy and neonatal outcomes account for at least $114 – $214 million in Medicaid costs per year, and this could translate into equivalent savings based on reducing the highest adverse event rate group to the benchmark lowest race/ethnicity group. Authors call for future research into specific interventions to target the elimination of racial/ethnic disparities to improve pregnancy and neonatal outcomes as well as decrease costs in this population.

Healy AJ, Malone FD, Sullivan LM, Porter TF, Luthy DA, Comstock CH, Saade G, Berkowitz R, Klugman S, Dugoff L, Craigo SD, Timor-Tritsch I, Carr SR, Wolfe HM, Bianchi DW, D'Alton ME; FASTER Trial Research Consortium. Early access to prenatal care: implications for racial disparity in perinatal mortality. Obstet Gynecol. 2006 Mar;107(3):625-31. doi: 10.1097/01.AOG.0000201978.83607.96. PMID: 16507934.

Investigators examined data from the FASTER (First- and Second-Trimester Evaluation of Risk) trial on over 35,000 pregnancies who all had access to early prenatal care from multiple centers from 1999-2002 and evaluated fetal and neonatal demise (collectively perinatal mortality) stratified based on race. They demonstrate that all minority races experienced higher rates of intrauterine growth restriction, preterm and very preterm birth, and perinatal mortality than White mothers. Adjusted odds ratios for perinatal mortality when compared with the White population were: Black 3.5, Hispanic 1.5, and other 1.9 (American Indian/Alaskan Native, and Asian/Pacific Islander as well as other). Disparities persisted despite multiple attempts at adjustment for various other factors. These data demonstrate that racial disparities in perinatal mortality persist despite equal early access to prenatal care, suggesting further underlying racial differences in neonatal outcomes than solely access to care, and that focusing only on access to prenatal care is insufficient to improve neonatal outcomes in this population.

Private Insurance vs Public Insurance Impacts on Neonatal Outcomes

Daw JR, Sommers BD. Association of the Affordable Care Act Dependent Coverage Provision With Prenatal Care Use and Birth Outcomes. JAMA. 2018 Feb 13;319(6):579-587. doi: 10.1001/jama.2018.0030. PMID: 29450525; PMCID: PMC5838787.

The ACA Dependent Coverage Provision requires private health insurers to allow young adults to remain on a parent's insurance plan until their 26th birthday. Here, the authors performed a retrospective cohort study to evaluate differences between an exposure group (those who benefitted from the Dependent Coverage Provision) and a control group (those who fell outside the age range for the Dependent Coverage Provision) in the primary outcomes of payment source for birth, early prenatal care, and adequate prenatal care; as well as in the secondary outcomes of cesarean delivery, premature birth, low birth weight, and neonatal intensive care unit admission. They demonstrated that initiation of the Affordable Care Act Dependent Coverage Provision was associated with increased private insurance payment for birth, increased use of prenatal care, and modest reduction in preterm births, but was not associated with changes in cesarean delivery rates, low birth weight, or NICU admission. These differences were concentrated among unmarried women.

Guillory VJ, Lai SM, Suminski R, Crawford G. Low birth weight in Kansas. J Health Care Poor Underserved. 2015 May;26(2):577-602. doi: 10.1353/hpu.2015.0039. PMID: 25913351.

Authors examined data from the Office of Vital Statistics at the Kansas Department of Health and Environment, birth certificates, and Medicaid eligibility data to compare birth weight and prenatal care utilization to insurance status – separated into private insurance coverage and other (no insurance, Medicaid insurance, Medicaid eligible). They demonstrate that women with private insurance at time of delivery had half the rate of low birth weight infants as those without private insurance and had a lesser risk of preterm and very preterm births – adjusted odds for delivery of a low birth weight infant were 33% higher in the group of women without private insurance compared to those with private insurance. They also connected private insurance with an increased likelihood of establishing prenatal care earlier in pregnancy and obtaining adequate prenatal care. Although, notably those women who lacked private insurance but obtained adequate prenatal care had the highest odds of delivering a low birth weight infant. The authors support extension of Medicaid coverage to all uninsured women of child-bearing age, but note this may not be the only variable, as those women without private insurance also had three times the prevalence of tobacco use and four times the prevalence of alcohol use as those with private insurance.

Insurance Coverage Improves Neonatal Outcomes

Cseh A, Koford BC, Phelps RT. Hospital Utilization and Universal Health Insurance Coverage: Evidence from the Massachusetts Health Care Reform Act. Appl Health Econ Health Policy. 2015 Dec;13(6):627-35. doi: 10.1007/s40258-015-0178-1. PMID: 26037893.

This study was designed to evaluate evidence of a single state's universal health insurance coverage plan to attempt to predict effects of the Affordable Care Act. Researchers evaluated data from the Nationwide Inpatient Sample to determine changes in insurance status, length of stay, number of diagnoses, and procedures for discharge before, during, and after implementation of the Massachusetts Health Care Reform Act. Pertinent to this review, researchers determined that after attaining universal health coverage, neonate length of stay increased, while the number of diagnoses and procedures for neonates decreased, overall indicating an improvement in overall health of neonates after implementation of the Massachusetts health reform. The authors do not make conjecture as to the precise effect of universal health coverage; though, assuming similar trends to other articles presented here, increased health care coverage may have allowed for improved access to care leading to decrease in neonatal diagnoses and decrease in required procedures as seen here.

Morriss FH Jr. Increased risk of death among uninsured neonates. Health Serv Res. 2013 Aug;48(4):1232-55. doi: 10.1111/1475-6773.12042. Epub 2013 Feb 13. PMID: 23402526; PMCID: PMC3725523.

Authors analyzed data from the Kids' Inpatient Databases for 2003, 2006, and 2009; the Healthcare Cost and Utilization Project; and the Agency for Healthcare Research and Quality to evaluate neonatal deaths and determine association with insurance coverage. Their article focuses on specifically the evaluation of the 2006 data but note that repeating the study on the data from 2003 and 2009 yielded similar results. Of over 4 million births, there were 17,892 deaths, 9.5% of which were uninsured, with the largest risks of death being attributed to 5 health conditions (preterm/low birth weight/intrauterine growth restriction, intraventricular hemorrhage, hypoxia, necrotizing enterocolitis and congenital malformation) with adjusted odds ratios of 13.7-3.1. Lack of insurance itself had a neonatal mortality adjusted odds ratio of 2.6 when compared to insured patients – odds which were notably higher than several medical conditions evaluated here (sepsis, respiratory distress syndrome, delivery complications).

These neonates were less likely to be admitted by transfer to a medical center with a higher level of care, more likely to have been born in rural hospitals and less likely to receive ample resources in the perinatal period. To extend to other socioeconomic factors, authors noted associations between uninsured patients and low median household income as well as rural area of residence. Authors conclude that an important area of focus is "improved access to care via development of a regionalized system that optimizes births and neonatal care in the most appropriate facilities," a goal which is not accomplished in the existing voluntary system. This translates to improved access for uninsured mothers, or potentially to improved insurance coverage for these patients to allow for access to care in higher-level facilities.

Insurance Coverage Provides no Change in Neonatal Outcomes

Wherry LR, Fabi R, Schickedanz A, Saloner B. State And Federal Coverage For Pregnant Immigrants: Prenatal Care Increased, No Change Detected For Infant Health. Health Aff (Millwood). 2017 Apr 1;36(4):607-615. doi: 10.1377/hlthaff.2016.1198. Erratum in: Health Aff (Millwood). 2017 Jul 1;36(7):1349. PMID: 28373325.

Authors examined the effects of state funded programs, the CHIP unborn child option, and the CHIPRA option on immigrant women, targeting specific outcomes of receipt of prenatal care, mode of delivery, and neonatal outcomes. When examining effects in their population of immigrant women as a whole, these policies increased usage of prenatal care, and CHIPRA specifically decreased incidence of preterm births. As a whole, however, these policies did not impact neonatal outcomes. This finding was consistent when authors evaluated the subgroup of immigrant women with lower education. These results indicate that insurance coverage may not improve neonatal health outcomes in a specific population of immigrant women.

However, characterizing preterm birth as a negative neonatal health outcome as was done throughout the remainder of this review, CHIPRA did successfully decrease poor neonatal outcomes by decreasing incidence of preterm births.

Jarlenski M, Bleich SN, Bennett WL, Stuart EA, Barry CL. Medicaid enrollment policy increased smoking cessation among pregnant women but had no impact on birth outcomes. Health Aff (Millwood). 2014 Jun;33(6):997-1005. doi: 10.1377/hlthaff.2013.1167. PMID: 24889949; PMCID: PMC4248559.

Authors evaluated data from the CDC's Pregnancy Risk Assessment Monitoring System to evaluate outcomes before and after adoptions of optional Medicaid enrollment options in 19 states. They determined the adoption of presumptive eligibility, which allows women to receive prenatal care while their Medicaid application is pending, increased smoking cessation by 7.7%, but did not have any effect on adverse birth outcomes, despite known associations between tobacco use and low birth weight infants. Adoption of the unborn-child option, providing coverage for women who cannot document citizenship or residency, was not significantly associated with changes in rates of smoking cessation, preterm birth, or having an infant who was small for gestational age. Thus, the presumptive-eligibility enrollment policy is likely beneficial in reducing smoking but may not necessarily lead to improved neonatal outcomes; although, the association between early smoking cessation and improved neonatal outcomes has been shown in other studies.

Boudreaux MH, Dagher RK, Lorch SA. The Association of Health Reform and Infant Health: Evidence from Massachusetts. Health Serv Res. 2018 Aug;53(4):2406-2425. doi: 10.1111/1475-6773.12779. Epub 2017 Oct 2. PMID: 28967677; PMCID: PMC6051966.

Authors used National Center for Health Statistics data to compare linked birth-death files from 2001-2012 (information needed to be aggregated on the county level for appropriate comparison), birth weight, APGAR scores, prematurity, and small for gestational age with maternal factors including insurance status, race, and age before and after Massachusetts health reform. They compared these changes to those in surrounding states before and after their respective health reform implementation. Authors also

evaluated Current Population Survey data to determine effects of reform on unadjusted uninsured rates for child-bearing age women.

Their data demonstrate no significant association with Massachusetts health reform and neonatal outcomes. Demographically the population in Massachusetts consisted of generally older age at delivery, lower prevalence of poverty and unemployment, and less likely to be in an unmarried household than in comparison states; women evaluated in Massachusetts were, however, more likely to be Black or Hispanic; considering elsewhere that racial minority groups tend to have less insurance coverage and poorer outcomes, it is notable this population experienced no changes in birth outcomes with health reform. Authors note data used was ecological in design due to using county mortality rates and may not represent morbidity and mortality differences with insurance coverage when examined on the individual level. Authors also note that Massachusetts' pregnancy care safety net at baseline may have covered many uninsured pregnant women with high-quality and timely care so that the reform had a lesser impact than the ACA may have in other states without an established robust coverage for the uninsured.

Howell EM. The impact of the Medicaid expansions for pregnant women: a synthesis of the evidence. Med Care Res Rev. 2001 Mar;58(1):3-30. doi: 10.1177/107755870105800101. PMID: 11236231.

Published in 2001, this article was a review of existing literature regarding effects of the Medicaid expansions beginning in the late 1980s on outcomes during and after pregnancy. The expansions discussed here provided all pregnant women and newborns with family income less than 133% of the poverty level with universal Medicaid eligibility. Authors evaluated 14 studies, four of which specifically studied incidences of low birth weight and prematurity in comparison populations before and after Medicaid expansion. One concluded that Medicaid expansion was associated with decrease in incidences of low birth weight and prematurity in White women and Black teenagers, though when controlling for confounding variables, the change in incidence for White women was low (5.5% premature to 5.4% premature).[8] These authors report that Currie and Gruber also demonstrate no change in incidence of birthweight and prematurity.[10]* A third article by Dubay et al. demonstrated significant declines in low birth weight in White women without a high school education but demonstrated no change in other populations.[14] Lastly, Long and Marquis found declines in low birth weight in low-income areas after Medicaid expansion in one time period study, and lower rates of low birth weight in the Medicaid expansion group compared to an uninsured group in a second time period;[22] however, authors note this study was performed in one state over two years and does not demonstrate a dramatically large change. The remainder of the article evaluates studies with results outside the scope of this review. Authors conclude that despite improvements in insurance coverage and prenatal care utilization, the evidence that Medicaid expansion improved outcomes of low birth weight and prenatal care is present, but weak.

*Upon my own review, however, one of their key points regarding the Currie and Gruber study is incorrect – this study demonstrated a significant decrease on incidence of low

birth weight and infant mortality, bolstering the evidence of positive effects of Medicaid expansion on neonatal outcomes.

References

1. Adams EK, Nishimura B, Merritt RK, Melvin C. Costs of poor birth outcomes among privately insured. J Health Care Finance. 2003 Spring;29(3):11-27. PMID: 12635991.
2. Antos SC, Smyth M. Public benefits: statutory application delays and Medicaid. Albany, NY: Greater Upstate Law Project, Inc., 2005.
3. Astone NM, Misra D, Lynch C. The effect of maternal socio-economic status throughout the lifespan on infant birthweight. Paediatr Perinat Epidemiol. 2007 Jul;21(4):310-8. doi: 10.1111/j.1365-3016.2007.00821.x. PMID: 17564587.
4. Blumenshine P, Egerter S, Barclay CJ, et al. Socioeconomic disparities in adverse birth outcomes: a systematic review. Am J Prev Med. 2010; 39:263–272. [PubMed: 20709259].
5. Bohanon FJ, Nunez Lopez O, Adhikari D, Mehta HB, Rojas-Khalil Y, Bowen-Jallow KA, Radhakrishnan RS. Race, Income and Insurance Status Affect Neonatal Sepsis Mortality and Healthcare Resource Utilization. Pediatr Infect Dis J. 2018 Jul;37(7):e178-e184. doi: 10.1097/INF.0000000000001846. PMID: 29189608; PMCID: PMC5953763.
6. Boudreaux MH, Dagher RK, Lorch SA. The Association of Health Reform and Infant Health: Evidence from Massachusetts. Health Serv Res. 2018 Aug;53(4):2406-2425. doi: 10.1111/1475-6773.12779. Epub 2017 Oct 2. PMID: 28967677; PMCID: PMC6051966.
7. Braveman PA, Heck K, Egerter S, et al. The role of socioeconomic factors in Black-White disparities in preterm birth. Am J Public Health. 2015; 105:694–702. [PubMed: 25211759].
8. Cole, N. 1995. Increasing access to health care: The effects of Medicaid expansions for pregnant women. Cambridge, MA: Abt Associates.
9. Cseh A, Koford BC, Phelps RT. Hospital Utilization and Universal Health Insurance Coverage: Evidence from the Massachusetts Health Care Reform Act. Appl Health Econ Health Policy. 2015 Dec;13(6):627-35. doi: 10.1007/s40258-015-0178-1. PMID: 26037893.
10. Currie, J., and J. Gruber. 1996. Saving babies: The efficacy and cost of recent changes in the Medicaid eligibility of pregnant women. Journal of Political Economy 104 (6): 1263-96
11. Daw JR, Sommers BD. Association of the Affordable Care Act Dependent Coverage Provision With Prenatal Care Use and Birth Outcomes. JAMA. 2018 Feb 13;319(6):579-587. doi: 10.1001/jama.2018.0030. PMID: 29450525; PMCID: PMC5838787.
12. de Jongh BE, Locke R, Paul DA, Hoffman M. The differential effects of maternal age, race/ethnicity and insurance on neonatal intensive care unit admission rates. BMC Pregnancy Childbirth. 2012 Sep 17;12:97. doi: 10.1186/1471-2393-12-97. PMID: 22985092; PMCID: PMC3495040.
13. Delnord M, Hindori-Mohangoo AD, Smith LK, et al; Euro-Peristat Scientific Committee. Variations in very preterm birth rates in 30 high-income countries: are valid international comparisons possible using routine data? BJOG. 2017;124(5):785-794. doi:10.1111/1471-0528.14273.
14. Dubay, L., T. Joyce, R. Kaestner, and G. M. Kenney. Forthcoming. Changes in prenatal care timing and low birthweight by race and socioeconomic status: Implications for the Medicaid expansions for pregnant women. Health Services Research.
15. East C, Miller S, Page M, and Wherry L. Multi-generational Impacts of Childhood Access to the Safety Net: Early Life Exposure to Medicaid and the Next Generation's Health. National Bureau of Economic Research Working Paper No 23810. Sept 2017, revised Feb 2019. JEL No. I1,I13,I14,I18.
16. Gavin AR, Nurius P, Logan-Greene P. Mediators of adverse birth outcomes among socially disadvantaged women. J Womens Health (Larchmt). 2012 Jun;21(6):634-42. doi: 10.1089/jwh.2011.2766. Epub 2011 Dec 13. PMID: 22150295; PMCID: PMC3366100.
17. Guillory VJ, Lai SM, Suminski R, Crawford G. Low birth weight in Kansas. J Health Care Poor Underserved. 2015 May;26(2):577-602. doi: 10.1353/hpu.2015.0039. PMID: 25913351.
18. Healy AJ, Malone FD, Sullivan LM, Porter TF, Luthy DA, Comstock CH, Saade G, Berkowitz R, Klugman S, Dugoff L, Craigo SD, Timor-Tritsch I, Carr SR, Wolfe HM, Bianchi DW, D'Alton ME; FASTER Trial Research Consortium. Early access to prenatal care: implications for racial disparity in perinatal mortality. Obstet Gynecol. 2006 Mar;107(3):625-31. doi: 10.1097/01.AOG.0000201978.83607.96. PMID: 16507934.
19. Howell EM. The impact of the Medicaid expansions for pregnant women: a synthesis of the evidence. Med Care Res Rev. 2001 Mar;58(1):3-30. doi: 10.1177/107755870105800101. PMID: 11236231.
20. Howson CP (2009). March of dimes: White paper on preterm birth: The global and regional toll. March of Dimes Foundation.
21. Jarlenski M, Bleich SN, Bennett WL, Stuart EA, Barry CL. Medicaid enrollment policy increased smoking cessation among pregnant women but had no impact on birth outcomes. Health Aff (Millwood). 2014 Jun;33(6):997-1005. doi: 10.1377/hlthaff.2013.1167. PMID: 24889949; PMCID: PMC4248559.
22. Long, S. H., and M. S. Marquis. 1998. The effects of Florida's Medicaid eligibility expansion for pregnant women. American Journal of Public Health 88 (3): 371-76.
23. Love C, David RJ, Rankin KM, Collins JW Jr. Exploring weathering: effects of lifelong economic environment and maternal age on low birth weight, small for gestational age, and preterm birth in African-American and white women. Am J Epidemiol. 2010 Jul 15;172(2):127-34. doi: 10.1093/aje/kwq109. Epub 2010 Jun 24. PMID: 20576757.
24. MacDorman MF, Matthews TJ, Mohangoo AD, Zeitlin J. International comparisons of infant mortality and related factors: United States and Europe, 2010. Natl Vital Stat Rep. 2014;63(5):1-6.
25. Martin JA, Hamilton BE, Osterman MJK, Driscoll AK, Drake P. Births: final data for 2017. Natl Vital Stat Rep. 2018;67(8):1-50.
26. Matthews TJ, MacDorman MF, Thoma ME. Infant mortality statistics from the 2013 period linked birth/infant death data set. Natl Vital Stat Rep. 2015;64(9):1-30.
27. Morriss FH Jr. Increased risk of death among uninsured neonates. Health Serv Res. 2013 Aug;48(4):1232-55. doi: 10.1111/1475-6773.12042. Epub 2013 Feb 13. PMID: 23402526; PMCID: PMC3725523.
28. Murphy SL, Mathews TJ, Martin JA, Minkovitz CS, Strobino DM. Annual Summary of Vital Statistics: 2013-2014. Pediatrics. 2017;139(6): e20163239. doi:10.1542/peds.2016-3239.
29. Paneth N, Wallenstein S, Kiely JL, Susser M. Social class indicators and mortality in low birth weight infants. Am J Epidemiol. 1982 Aug;116(2):364-75. doi: 10.1093/oxfordjournals.aje.a113420. PMID: 7114045.
30. Penfield CA, Cheng YW, Caughey AB. Obstetric outcomes in adolescent pregnancies: a racial/ethnic comparison. J Matern Fetal Neonatal Med. 2013 Sep;26(14):1430-4. doi: 10.3109/14767058.2013.784738. Epub 2013 Apr 25. PMID: 23488933.

31. Rogowski J. Cost-effectiveness of care for very low birth weight infants. Pediatrics. 1998 Jul;102(1 Pt 1):35-43. doi: 10.1542/peds.102.1.35. PMID: 9651411.
32. Rosenbach M, O'Neil S, Cook B, Trebino L, Walker DK. Characteristics, access, utilization, satisfaction, and outcomes of healthy start participants in eight sites. Matern Child Health J. 2010 Sep;14(5):666-679. doi: 10.1007/s10995-009-0474-1. Epub 2009 Jul 10. PMID: 19590941; PMCID: PMC2923711.
33. Shultz CJ 2nd, Shultz KA. Poverty and prenatal health care in America: trends, costs, and recommendations. J Ambul Care Mark. 1994;5(2):149-59. doi: 10.1300/j273v05n02_12. PMID: 10165478.
34. Singh GK, Kogan MD. Persistent socioeconomic disparities in infant, neonatal, and postneonatal mortality rates in the United States, 1969-2001. Pediatrics. 2007; 119:e928–39. [PubMed: 17403832].
35. Soneji S, Beltrán-Sánchez H. Association of Special Supplemental Nutrition Program for Women, Infants, and Children With Preterm Birth and Infant Mortality. JAMA Netw Open. 2019 Dec 2;2(12):e1916722. doi: 10.1001/jamanetworkopen.2019.16722. PMID: 31800070; PMCID: PMC6902759.
36. St John EB, Nelson KG, Cliver SP, Bishnoi RR, Goldenberg RL. Cost of neonatal care according to gestational age at birth and survival status. Am J Obstet Gynecol. 2000 Jan;182(1 Pt 1):170-5. doi: 10.1016/s0002-9378(00)70509-6. PMID: 10649175.
37. Tabet M, Jakhar S, Williams CA, Rawat U, Hailegiorgis YD, Flick LH, Chang JJ. Racial/Ethnic Differences in Correlates of Spontaneous and Medically-Indicated Late Preterm Births among Adolescents. J Pediatr Adolesc Gynecol. 2017 Feb;30(1):63-70. doi: 10.1016/j.jpag.2016.08.004. Epub 2016 Aug 16. PMID: 27543000.
38. Wallace HM, Micik S, Wise P. Community study of infant mortality in San Diego County. J Trop Pediatr. 1994 Jun;40(3):172-8. doi: 10.1093/tropej/40.3.172. PMID: 8078117.
39. Wherry LR, Fabi R, Schickedanz A, Saloner B. State And Federal Coverage For Pregnant Immigrants: Prenatal Care Increased, No Change Detected For Infant Health. Health Aff (Millwood). 2017 Apr 1;36(4):607-615. doi: 10.1377/hlthaff.2016.1198. Erratum in: Health Aff (Millwood). 2017 Jul 1;36(7):1349. PMID: 28373325.
40. Willis E, McManus P, Magallanes N, Johnson S, Majnik A. Conquering racial disparities in perinatal outcomes. Clin Perinatol. 2014 Dec;41(4):847-75. doi: 10.1016/j.clp.2014.08.008. Epub 2014 Oct 7. PMID: 25459778.
41. Zhang S, Cardarelli K, Shim R, Ye J, Booker KL, Rust G. Racial disparities in economic and clinical outcomes of pregnancy among Medicaid recipients. Matern Child Health J. 2013 Oct;17(8):1518-25. doi: 10.1007/s10995-012-1162-0. PMID: 23065298; PMCID: PMC4039287.