Examining Interventions to Address Infant Mortality in Allegheny County, Pennsylvania

DANA SCHULTZ, SUSAN L. LOVEJOY, EVAN D. PEET

Sponsored by the Richard King Mellon Foundation
Preface

Poor birth and infant outcomes and pronounced racial disparities persist in Allegheny County, Pennsylvania, despite robust maternal and child health and social service systems. In this report, we use predictive models of which interventions women are likely to participate in, develop a causal inference framework to estimate the effectiveness of those interventions, and reveal how that effectiveness varies for women with different risk and other factors.

This research was sponsored by the Richard King Mellon Foundation. This report should be of interest to health care and community-based social service providers and policymakers in Allegheny County, as well as others who share the goal of preventing and reducing infant mortality.

Social and Behavioral Policy Program

RAND Social and Economic Well-Being is a division of the RAND Corporation that seeks to actively improve the health and social and economic well-being of populations and communities throughout the world. This research was conducted in the Social and Behavioral Policy Program within RAND Social and Economic Well-Being. The program focuses on such topics as risk factors and prevention programs, social safety net programs and other social supports, poverty, aging, disability, child and youth health and well-being, and quality of life, as well as other policy concerns that are influenced by social and behavioral actions and systems that affect well-being. For more information, email sbp@rand.org.
Contents

Preface ............................................................................................................................................ iii
Figures ............................................................................................................................................ vi
Tables ............................................................................................................................................. ix
Summary ........................................................................................................................................ xi
Abbreviations ............................................................................................................................ xxvii
1. Introduction ............................................................................................................................... 1
   Allegheny County Landscape ........................................................................................................ 2
   Infant Mortality Causes ................................................................................................................ 5
   This Project ................................................................................................................................... 8
   Organization of This Report ......................................................................................................... 10
2. Methods ................................................................................................................................... 11
   Literature Review ....................................................................................................................... 11
   Environmental Scan .................................................................................................................... 12
   Causal Inference Framework .................................................................................................... 13
3. Intervention Types and the Evidence Base ............................................................................. 23
   Medical-Setting Interventions ................................................................................................. 24
   Health Promotion and Education ............................................................................................ 31
   Support and Referrals ............................................................................................................... 35
   Policy Interventions .................................................................................................................. 42
   Summary of Interventions ........................................................................................................ 45
   Timing of Intervention ............................................................................................................... 47
   Potential Barriers to Engagement ............................................................................................ 48
   Summary ................................................................................................................................... 50
4. National, State, and Local Infant Mortality Prevention Efforts ........................................... 51
   National Efforts ....................................................................................................................... 51
   State Efforts ............................................................................................................................. 53
   Local Efforts ............................................................................................................................. 54
   Key Features of Infant Mortality Prevention Efforts .................................................................. 57
5. Inventory of Allegheny County Programs, Services, and Supports Related to Preventing
   Infant Mortality ......................................................................................................................... 59
   Medical-Setting Interventions ................................................................................................. 59
   Health Promotion and Education ............................................................................................ 61
   Support and Referrals ............................................................................................................... 64
   Summary of Available Programs, Services, and Supports ...................................................... 70
6. Allegheny County Birth Outcomes, Risk and Contextual Factors, and Intervention
   Participation ................................................................................................................................. 73
Figures

Figure S.1. Summary of Programs, Services, and Supports (as of 2018) ....................................... xvii
Figure 1. Trends in Infant Mortality ............................................................................................. 2
Figure 2. Trends in the Disparity Between Black and White Infant Mortality Rates, 2003 to 2016 ................................................................................................................................................. 3
Figure 3. Leading Causes and Underlying Factors Related to Infant Mortality in Allegheny County .......................................................................................................................................................... 6
Figure 4. Keyword Categories ................................................................................................... 12
Figure 5. Structure of Data Types and Time Periods ..................................................................... 19
Figure 6. Interventions Targeting Underlying Causes of Infant Mortality ..................................... 23
Figure 7. Categories of Programs, Services, and Supports by Intervention Timing ....................... 48
Figure 8. Summary of Programs, Services, and Supports (as of 2018) ....................................... 71
Figure 9. Timing of Infant Deaths in the Infant Mortality Prediction System with Intervention Management Database ......................................................................................................................... 74
Figure 10. Causes of Infant Mortality in the Infant Mortality Prediction System with Intervention Management Database ......................................................................................................................... 75
Figure 11. Trends in Birth Outcomes in the Infant Mortality Prediction System with Intervention Management database ........................................................................................................................................ 76
Figure 12. Prevalence of Maternal Health Risk Factors by Birth Outcome in the Infant Mortality Prediction System with Intervention Management Database ................................................................. 77
Figure 13. Maternal Health Risk Factors in the Infant Mortality Prediction System with Intervention Management Database ................................................................. 78
Figure 14. Maternal Behavior Risk Factors in the Infant Mortality Prediction System with Intervention Management Database ................................................................. 79
Figure 15. Factors Related to the Maternal and Infant Context in the Infant Mortality Prediction System with Intervention Management Database ................................................................................................. 80
Figure 16. Correlation of Intervention Participation ........................................................................ 83
Figure 17. Preconception Care in the Infant Mortality Prediction System with Intervention Management Database ......................................................................................................................... 85
Figure 18. Prenatal Care in the Infant Mortality Prediction System with Intervention Management Database ......................................................................................................................... 86
Figure 19. Birth Doulas in the Infant Mortality Prediction System with Intervention Management Database ......................................................................................................................... 87
Figure 20. Home Visiting in the Infant Mortality Prediction System with Intervention Management Database ......................................................................................................................... 88
Figure 21. Family Support Centers and the Women, Infants, and Children Program in the Infant Mortality Prediction System with Intervention Management Database ................................................. 89
Figure 22. Behavioral Health Services in the Infant Mortality Prediction System with Intervention Management Database ......................................................................................................................... 90
Figure 23. Relative Importance of Predictors of Participation in Any Preconception or Interconception Care .......................................................................................................................................................... 95
Figure 24. Relative Importance of Predictors of Participation in Any Prenatal Care .................. 96
Figure 25. Relative Importance of Predictors of Participation in Doula Support ....................... 97
Figure 26. Relative Importance of Predictors of Participation in Any Home Visiting ................. 98
Figure 27. Relative Importance of Predictors of Participation in Pregnancy and Postpartum Support Services Through Family Support Centers ................................................................. 99
Figure 28. Relative Importance of Predictors of Participation in Breastfeeding and Nutrition Support Services Through the Women, Infants, and Children Program ................................................................. 99
Figure 29. Relative Importance of Predictors of Participation in Behavioral Health Services .. 100
Figure 30. Accuracy of Intervention Participation Models ................................................................. 101
Figure 31. Distribution of Births in the Infant Mortality Prediction System with Intervention Management Database .......................................................................................................................... 105
Figure 32. Causal Effects of Preconception/Interconception Care on Infant Mortality .................. 107
Figure 33. Causal Effects of Specific Types of Preconception/Interconception Care on Infant Mortality .......................................................................................................................................................................................... 108
Figure 34. Causal Effects of Prenatal Care on Infant Mortality ......................................................... 109
Figure 35. Causal Effects of Specific Types of Prenatal Care on Infant Mortality ............................. 110
Figure 36. Causal Effects of Doula Support on Infant Mortality ....................................................... 111
Figure 37. Causal Effects of Home Visiting on Infant Mortality ....................................................... 112
Figure 38. Causal Effects of Home Visiting by Intervention Timing on Infant Mortality .......... 113
Figure 39. Causal Effects of Specific Types of Home Visiting on Infant Mortality .............................. 114
Figure 40. Causal Effects of Family Support Centers on Infant Mortality ................................... 115
Figure 41. Causal Effects of Family Support Centers by Duration of Participation .................. 116
Figure 42. Causal Effects of the Women, Infants, and Children Program on Infant Mortality .. 118
Figure 43. Causal Effects of Behavioral Health Services on Infant Mortality ................................. 119
Figure 44. Causal Effects of Behavioral Health Services by Intervention Timing ......................... 120
Figure 45. Causal Effects of Specific Types of Behavioral Health Services ................................. 121
Figure 46. Intervention Effects by Risk Factor: Any Preconception/Interconception Care ...... 129
Figure 47. Intervention Effects by Risk Factor: Any Prenatal Care .................................................. 129
Figure 48. Intervention Effects by Risk Factor: Doula Support ....................................................... 130
Figure 49. Intervention Effects by Risk Factor: Any Home Visiting ................................................. 132
Figure 50. Combined Intervention Effects: Any Home Visiting ..................................................... 132
Figure 51. Intervention Effects by Risk Factor: Family Support Centers ........................................ 133
Figure 52. Combined Intervention Effects: Family Support Center .............................................. 134
Figure 53. Intervention Effects by Risk Factor: Women, Infants, and Children Program ........ 135
Figure 54. Combined Intervention Effects: Women, Infants, and Children Program ............ 135
Figure 55. Intervention Effects by Risk Factor: Any Behavioral Health Services .................. 136
Figure 56. Combined Intervention Effects: Any Behavioral Health Services ....................... 137
Tables

Table 1. Linkage Between Underlying Factors and Leading Causes of Infant Mortality .......... 8
Table 2. Summary of Data Sources in the Infant Mortality Prediction System with Intervention Management Database ........................................................................................................ 15
Table 3. Evidence for Medical-Setting Interventions .......................................................... 31
Table 4. Evidence for Health Promotion and Education Interventions ............................... 35
Table 5. Evidence for Support and Referral Interventions .................................................. 42
Table 6. Summary of Evidence for Policy Interventions ..................................................... 45
Table 7. Interventions Available by Implementation Method ............................................. 46
Table 9. Allegheny County Medical-Setting Interventions ............................................... 61
Table 10. Allegheny County Health Promotion and Education Interventions ............... 63
Table 11. Allegheny County Support and Referral Interventions ..................................... 67
Table 12. Timing of Infant Mortality by Race ................................................................. 74
Table 13. Causes of Infant Mortality by Race ................................................................. 75
Table 14. Maternal Health Risk Factors by Race in the Infant Mortality Prediction System with Intervention Management Database ...................................................... 78
Table 15. Maternal Behavior Risk Factors by Race in the Infant Mortality Prediction System with Intervention Management Database ..................................................... 79
Table 16. Maternal and Infant Context by Race in the Infant Mortality Prediction System with Intervention Management Database ......................................................... 81
Table 17. Description of Intervention Data Available in the Infant Mortality Prediction System with Intervention Management Database ....................................................... 81
Table 18. Intervention Participation by Race in the Infant Mortality Prediction System with Intervention Management Database ............................................................... 84
Table 19. Example Predictors by Data Type .................................................................. 93
Table 20. Summary of Intervention Effectiveness ......................................................... 122
Table 21. Summary of Intervention Effectiveness by Risk Factor and by Other Interventions 137
Table 22. Summary of Recommendations Based on Research Findings ..................... 142
Throughout the world, localities use comparisons of the rate at which infants die within a year of birth—infant mortality—as a measure of success for maternal and child health improvement efforts, health care quality and access, environmental quality, socioeconomic conditions, and public health practices. In 2016, the infant mortality rate in Pennsylvania was 6.15 per 1,000, which was slightly higher than the national average of 5.87 per 1,000 (Centers for Disease Control and Prevention [CDC], n.d.b.); within Pennsylvania, the Allegheny County rate was about even with the national rate, at 5.85 (CDC, n.d.b.). In addition, racial disparities in infant mortality rates are commonly observed at both state and national levels and are pronounced in Allegheny County. In 2016, the rate of infant mortality in Allegheny County was 3.78 for white infants compared with 13.29 for black infants (CDC, n.d.b.).

Despite the widespread availability of services and programs to support healthy pregnancies and deliveries in the county, substantial rates of infant mortality persist. Locally based supports and services offer prenatal care to pregnant women in a medical setting, in the community, or at home. The Allegheny County Health Department also offers or partners with a number of different programs or services outside the health care system that focus on pregnant women or new mothers, including several options for in-home support, a breastfeeding helpline, safe sleep initiatives, and smoking cessation support. While many other community-based organizations provide services and supports to pregnant and postpartum women, there has been a lack of data available regarding the capacity or reach of these programs, services, and supports or how women access or engage with these efforts.

Aggregate data on infant deaths are available, and these data provide general information on the causes of infant mortality and factors that contribute to it. Nationally, the top five leading causes of infant mortality account for 57 percent of all infant deaths: birth defects (20.8 percent), preterm birth and low birth weight combined (17.0 percent), sudden infant death syndrome (6.5 percent), maternal pregnancy complications (6.1 percent), and accidents (5.3 percent) (Kochanek et al., 2017). The leading causes of infant mortality in Allegheny County are generally the same, as are their percentages (Kokenda, 2015). Underlying each of the leading causes are multiple and varied maternal factors that increase the risk of poor birth outcomes and infant death. These factors fall into five broad, interrelated categories of risk: maternal health, mental health, stress, risky behaviors, and the context in which the mother lives. Many women, particularly those with low socioeconomic status, face multiple and concurrent risk factors within and across these categories of underlying causes.

However, aggregate data on the rates and causes of mortality provide little actionable information, other than identifying localities that may need to pay special attention to enhancing efforts to help make pregnancies, deliveries, and infancy safer. Based in Allegheny County, the
Richard King Mellon Foundation took note of the region’s infant mortality rates, driven by stark racial disparities, and established a vision to prevent infant mortality in the region. To realize this vision, the foundation funded a multifaceted effort, called Prediction and Reduction of Infant Mortality in Allegheny County, to develop an approach to predict the risk of infant mortality, understand the effectiveness of available interventions, and optimize intervention referrals based on risk profiles. The project combined the efforts of researchers from RAND, the University of Pittsburgh, and the Magee Women’s Research Institute, in collaboration with a broad coalition of community-based stakeholders focused on maternal and child health. With this effort, the foundation sought to address the apparent disconnect between the region’s robust maternal and child health care system and relatively poor birth and infant outcomes and racial disparities.

Approach

This project had two key components designed to improve the understanding of both individual risk for infant mortality and the capacity and effectiveness of existing interventions to address the risk factors. The University of Pittsburgh team led the first component, which first involved integrating data from a variety of sources into the Infant Mortality Prediction System with the Intervention Management (IMPReSIt) database, an aggregation of data built specifically for this research effort. With the database, researchers linked each individual’s data across sources, which provided a unique opportunity to observe, for each birth in the cohort, important maternal factors such as comorbid conditions, prior pregnancy outcomes, and—crucially—interventions that the woman may have received before, during, or after pregnancy. The foundation of the IMPReSIt database consists of the vital statistics data from the Allegheny County Health Department, which includes the universe of child births and deaths in Allegheny County during the ten-year study period, from 2003 to 2013. From this foundation, the IMPReSIt database links each mother-infant dyad to data on health and clinical services received from the University of Pittsburgh Medical Center; data describing the mother’s utilization of publicly funded social services such as Women, Infants, and Children (WIC); housing assistance; Family Support Centers; substance use disorder services; and mental health services from the Allegheny County Department of Human Services Data Warehouse, as well as data from individual programs such as Healthy Start. The University of Pittsburgh team then used the IMPReSIt database to develop a real-time adaptive predictive risk assessment model that would enable health providers and community-based social service providers to identify those most at risk for poor birth outcomes.

For the second component of the project, RAND led the effort to (1) identify effective interventions and efforts to prevent infant mortality, (2) inventory the programs, services, and supports available in Allegheny County, and (3) build a framework that leverages the unique size and breadth of the IMPReSIt database and the infant mortality predictive results to enable causal inference analysis of each intervention’s effects on the risk of infant mortality.
To accomplish these objectives, we used the following methods:

- A literature review to gather information on the state of the evidence base for interventions that address the underlying causes of infant mortality and to document national, state, and local efforts to address infant mortality.
- An environmental scan to inventory the programs, services, and supports available in Allegheny County that might address the underlying factors that contribute to infant mortality and ultimately prevent or reduce infant deaths and other poor birth outcomes.
- A causal inference framework to identify the causal effects to the risk of infant mortality of each intervention we observed in the IMPreS1v database. This framework involved four steps:
  - **Step 1** leveraged the predictive models of infant mortality developed by the University of Pittsburgh team and developed additional, similar models with refined purposes to feed into steps 3 and 4.
  - **Step 2** developed predictive models of participation in each of the interventions in order to understand what drives participation, identify which factors are important to the interventions’ causal effects, and control for selective participation in interventions.
  - **Step 3** combined the infant mortality and intervention participation predictions to estimate the causal effects of the interventions.
  - **Step 4** investigated the degree to which interventions were effective among women with particular risk factors (e.g., smoking or prior pregnancy history) or in combination with other interventions.

Overall, the four steps of RAND’s causal inference framework enabled RAND to predict which women are likely to participate in which interventions, estimate the effectiveness of the interventions, and understand how effectiveness varied for women with different risk and contextual factors. Together, the results of the two components of the project provide information that can help health care and community-based social service providers and policymakers identify those pregnant women most at risk for infant mortality, decipher the appropriate mix of interventions for each risk profile, and guide decisions about additional investments in interventions so that women and infants receive the best, most appropriate care based on their needs.

**The Evidence Base**

Many interventions aim to address the factors underlying infant mortality, and they have varying levels of evidence supporting their effectiveness. The possible timing of interventions spans the period before pregnancy (preconception period for first pregnancy or interconception period for time between pregnancies), the pregnancy itself (prenatal), the period from birth to 28 days (neonatal) and the period from 28 days to one year (postneonatal). Most programs, services, and supports offer intervention in the prenatal and postnatal periods, with relatively few available for the preconception period.
Generally, interventions fall into one of four categories: medical-setting interventions, health promotion and education, support and referrals, and policy interventions, though some elements of the various interventions may straddle these categories (e.g., safe sleep education may be provided in medical settings). With the exception of a few of the interventions provided within a medical environment, most interventions can be delivered in multiple settings.

- **Medical-setting interventions** include preconception/interconception care, prenatal care, enhanced prenatal care, doulas (birth support), and early elective delivery reduction. Within this category, only group prenatal care has emerging evidence of effectiveness on birth outcomes (Hill et al., 2016).

- **Health promotion and education strategies** include a wide range of efforts, such as home visiting programs, safe sleep education, accident prevention, and childbirth education. Research on the effectiveness of most of the health promotion and education efforts is scarce, though there is some limited evidence of positive effects on certain maternal risk behaviors known to lead to poor outcomes (Olds, 2002). Home visiting is one approach that has been widely studied, with some evidence that programs using nurse visitors have positive effects on birth outcomes (Donovan et al., 2007).

- **Support and referrals** include efforts such as care coordination, pregnancy and postpartum support, breastfeeding and nutrition support, behavioral health services, and family support. While some of the support and referral efforts have been shown to have positive effects on behavior or knowledge, only care coordination has emerging evidence of effectiveness in improving birth and infant outcomes (Van Dijk, Anderko, and Stetzer, 2011).

- **Policy interventions** include legislative or regulatory changes that address social determinants of health or funding decisions for programs such as the Title V Maternal and Child Health Services Block Grant program. Others include efforts such as perinatal regionalization, insurance expansion, and income supplements for pregnant women. The evidence is scarce or mixed for these policy interventions.

Although there is limited evidence of direct, positive effects on birth and infant outcomes for interventions aimed at reducing the underlying causes of infant mortality, these interventions may still provide benefits that have not yet been measured.

**National, State, and Local Infant Mortality Efforts**

At the national, state, and local levels, efforts to prevent and reduce infant mortality include a broad range of efforts across the policy, program, and practice landscape. Many of the specific intervention types just described are key components of these efforts. Overall, the efforts to address infant mortality share some key features: they are data driven and work across systems, are community focused, and are client centered. The wide range of underlying factors involved in infant mortality necessitates the involvement of multiple systems and organizations that span physical health, behavioral health, and early childhood education, among others.
National efforts. Nationally, the Health Resources Service Administration, an agency of the U.S. Department of Health and Human Services (HHS), plays a large role in infant mortality prevention efforts, including funding the following:

- the Infant Mortality Collaborative Improvement and Innovation Network, which aims to bring states together to develop plans to reduce infant mortality, build the evidence base around reducing infant mortality, and disseminate best practices
- the Title V Maternal and Child Health Services Block Grant program, which provides grants to 59 states and jurisdictions for health care services for low-income families
- 100 Healthy Start programs in 38 states and jurisdictions
- the Maternal, Infant, and Early Childhood Home Visiting Program, which provides grants to all 50 states, the District of Columbia, and five U.S. territories to implement evidence-based home visiting models
- the Safe Infant Sleep Systems Integration Program, which focuses on integration of safe sleep practices into systems that serve families.

The CDC tracks national data on infant mortality; it also supports the work of state-level perinatal quality collaboratives operating in 38 states and under development in 8 states; coordinates a sudden unexpected infant death monitoring program operating in 18 states and jurisdictions; and collects state-level data on maternal attitudes and experiences.

State efforts. Some state-level efforts to prevent and reduce infant mortality predate national efforts, whereas others emerged from the Infant Mortality Collaborative Improvement and Innovation Network or state-level task forces.

- The Georgia Department of Health used a data-driven approach that focused on consensus building among stakeholders, a public awareness campaign about safe sleep, and efforts to improve postnatal care.
- The Ohio Collaborative to Prevent Infant Mortality organized efforts within the state and developed a strategic plan for reducing infant mortality over the 2015 to 2020 period, with strategic focus on areas such as preventing preterm births and reducing smoking before, during, and after pregnancy.

While Pennsylvania does not have a statewide strategic plan, the state’s Bureau of Family Health has outlined priorities that relate to infant mortality prevention, including breastfeeding and safe sleep. The Pennsylvania Perinatal Partnership facilitates efforts of the Healthy Start projects in the state, the maternal and child health programs organized by the Department of Health’s Bureau of Family Health, and the Office of Child Development and Early Learning’s home visiting programs.

Local efforts. In some localities particularly hit by high infant mortality rates, cities and counties have developed community-wide initiatives to address the issue. Efforts such as Baltimore’s B’more for Healthy Babies (n.d.) typically involve a broad array of collaborative partners coming together to devise community-specific strategies to address the leading causes of infant mortality. These initiatives are primarily population based or focused on specific subpopulations within defined geographic areas or neighborhoods. All include data-driven decisionmaking, evidence-based models and approaches, as well as strong involvement and
engagement by community-based partners—and some have made great strides in reducing infant mortality. Since Baltimore’s initiative launched in 2009, there has been a 35-percent decrease in infant mortality, a 64-percent decrease in racial disparities, and a 71-percent decrease in sleep-related infant deaths.

Inventory of Allegheny County Programs, Services, and Supports

While Allegheny County has a wealth of existing services and programs that can potentially support at-risk women during pregnancy or postpartum, there is not a centralized resource that provides referral guidance or client-tailored information on the breadth of services and supports available. Furthermore, health care and community-based social service providers who come into contact with at-risk mothers are often not familiar with other services and supports available through their own or different systems of care. The inventory compiled through this project identifies the types and capacity of interventions currently being offered to women, in what combinations, and over what period of time. These details can help stakeholders develop a holistic view of the existing infrastructure and the need for expanding or improving access and engagement with existing interventions, or for introducing new interventions.

Overall, Allegheny County has programs, services, and supports that span medical-setting interventions, health promotion and education, and support and referral efforts, which can be used at different pre- and postnatal stages of care (Figure S.1). Health care and community-based social service providers within the county offer the three interventions with the strongest direct evidence for improving birth outcomes: group prenatal care, home visiting, and care coordination. Further, many of the options available to pregnant and postpartum women in the county align with approaches that address some of the behavioral risk factors for poor birth outcomes.
### Figure S.1. Summary of Programs, Services, and Supports (as of 2018)

#### Medical Setting

<table>
<thead>
<tr>
<th>Preconception/interconception care</th>
<th>One Key Question</th>
<th>IMPLICIT ICC One Key Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy Beginnings Plus FQHCs</td>
<td>PATH</td>
<td></td>
</tr>
<tr>
<td>Centering Pregnancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Midwife Center</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Prenatal care/enhanced prenatal care</th>
<th>Healthy Start Early Head Start Nurse-Family Partnership Public Health Nurse Home Visiting Program Allegheny Link</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healthy Start Early Head Start Nurse-Family Partnership Public Health Nurse Home Visiting Program Allegheny Link</td>
</tr>
<tr>
<td></td>
<td>Healthy Start Early Head Start Nurse-Family Partnership Public Health Nurse Home Visiting Program Allegheny Link</td>
</tr>
</tbody>
</table>

#### Health Promotion and Education

**Home visiting programs**

- Healthy Start
- Early Head Start
- Nurse-Family Partnership
- Public Health Nurse Home Visiting Program
- Allegheny Link

**Education programs**

- *Education programs are integrated into many other programs, services, or supports*
- Cribs for Kids

**Accident prevention**

- *Accident prevention is integrated into many other programs, services, or supports*
- The Safety Center

*Education programs are integrated into many other programs, services, or supports*

*Accident prevention is integrated into many other programs, services, or supports*
## Support and Referrals

### Care coordination

<table>
<thead>
<tr>
<th>Preconception</th>
<th>Prenatal</th>
<th>Neonatal</th>
<th>Postneonatal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UPMC Health Plan Maternity Program</strong></td>
<td><strong>UPMC Health Plan Maternity Program</strong></td>
<td><strong>UPMC Health Plan Maternity Program</strong></td>
<td><strong>UPMC Health Plan Maternity Program</strong></td>
</tr>
<tr>
<td><strong>Gateway Health Plan MOM Matters Program</strong></td>
<td><strong>Gateway Health Plan MOM Matters Program</strong></td>
<td><strong>Gateway Health Plan MOM Matters Program</strong></td>
<td><strong>Gateway Health Plan MOM Matters Program</strong></td>
</tr>
</tbody>
</table>

### Pregnancy/postpartum support

<table>
<thead>
<tr>
<th>Preconception</th>
<th>Prenatal</th>
<th>Neonatal</th>
<th>Postneonatal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Birth Circle</strong></td>
<td><strong>Birth Circle</strong></td>
<td><strong>Birth Circle</strong></td>
<td><strong>Birth Circle</strong></td>
</tr>
<tr>
<td><strong>Every Child</strong></td>
<td><strong>Every Child</strong></td>
<td><strong>Every Child</strong></td>
<td><strong>Every Child</strong></td>
</tr>
<tr>
<td><strong>AHN Immigrant Health Program</strong></td>
<td><strong>AHN Immigrant Health Program</strong></td>
<td><strong>AHN Immigrant Health Program</strong></td>
<td><strong>AHN Immigrant Health Program</strong></td>
</tr>
<tr>
<td><strong>Family Support Centers</strong></td>
<td><strong>Family Support Centers</strong></td>
<td><strong>Family Support Centers</strong></td>
<td><strong>Family Support Centers</strong></td>
</tr>
<tr>
<td><strong>Genesis House</strong></td>
<td><strong>Genesis House</strong></td>
<td><strong>Genesis House</strong></td>
<td><strong>Genesis House</strong></td>
</tr>
<tr>
<td><strong>Genesis Centers</strong></td>
<td><strong>Genesis Centers</strong></td>
<td><strong>Genesis Centers</strong></td>
<td><strong>Genesis Centers</strong></td>
</tr>
<tr>
<td><strong>Baby Promise</strong></td>
<td><strong>Baby Promise</strong></td>
<td><strong>Baby Promise</strong></td>
<td><strong>Baby Promise</strong></td>
</tr>
<tr>
<td><strong>Text4baby</strong></td>
<td><strong>Text4baby</strong></td>
<td><strong>Text4baby</strong></td>
<td><strong>Text4baby</strong></td>
</tr>
<tr>
<td><strong>NurturePA</strong></td>
<td><strong>NurturePA</strong></td>
<td><strong>NurturePA</strong></td>
<td><strong>NurturePA</strong></td>
</tr>
</tbody>
</table>

### Breastfeeding support

<table>
<thead>
<tr>
<th>Preconception</th>
<th>Prenatal</th>
<th>Neonatal</th>
<th>Postneonatal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WIC</strong></td>
<td><strong>WIC</strong></td>
<td><strong>WIC</strong></td>
<td><strong>WIC</strong></td>
</tr>
<tr>
<td><strong>Mid-Atlantic Mother’s Milk Bank</strong></td>
<td><strong>Mid-Atlantic Mother’s Milk Bank</strong></td>
<td><strong>Mid-Atlantic Mother’s Milk Bank</strong></td>
<td><strong>Mid-Atlantic Mother’s Milk Bank</strong></td>
</tr>
<tr>
<td><strong>Allegheny County Breastfeeding Coalition</strong></td>
<td><strong>Allegheny County Breastfeeding Coalition</strong></td>
<td><strong>Allegheny County Breastfeeding Coalition</strong></td>
<td><strong>Allegheny County Breastfeeding Coalition</strong></td>
</tr>
</tbody>
</table>

### Behavioral health services

<table>
<thead>
<tr>
<th>Preconception</th>
<th>Prenatal</th>
<th>Neonatal</th>
<th>Postneonatal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sojourner House POWER</strong></td>
<td><strong>Sojourner House POWER</strong></td>
<td><strong>Sojourner House POWER</strong></td>
<td><strong>Sojourner House POWER</strong></td>
</tr>
<tr>
<td><strong>Familylink’s Family Treatment Centers</strong></td>
<td><strong>Familylink’s Family Treatment Centers</strong></td>
<td><strong>Familylink’s Family Treatment Centers</strong></td>
<td><strong>Familylink’s Family Treatment Centers</strong></td>
</tr>
<tr>
<td><strong>The Alexis Joy D’Achille Center</strong></td>
<td><strong>The Alexis Joy D’Achille Center</strong></td>
<td><strong>The Alexis Joy D’Achille Center</strong></td>
<td><strong>The Alexis Joy D’Achille Center</strong></td>
</tr>
<tr>
<td><strong>Magee Women’s Behavioral Health Services</strong></td>
<td><strong>Magee Women’s Behavioral Health Services</strong></td>
<td><strong>Magee Women’s Behavioral Health Services</strong></td>
<td><strong>Magee Women’s Behavioral Health Services</strong></td>
</tr>
<tr>
<td><strong>Perinatal Hope</strong></td>
<td><strong>Perinatal Hope</strong></td>
<td><strong>Perinatal Hope</strong></td>
<td><strong>Perinatal Hope</strong></td>
</tr>
<tr>
<td><strong>Pregnancy Recovery Center</strong></td>
<td><strong>Pregnancy Recovery Center</strong></td>
<td><strong>Pregnancy Recovery Center</strong></td>
<td><strong>Pregnancy Recovery Center</strong></td>
</tr>
<tr>
<td><strong>NAS Program</strong></td>
<td><strong>NAS Program</strong></td>
<td><strong>NAS Program</strong></td>
<td><strong>NAS Program</strong></td>
</tr>
</tbody>
</table>

### Family support

<table>
<thead>
<tr>
<th>Preconception</th>
<th>Prenatal</th>
<th>Neonatal</th>
<th>Postneonatal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Healthy Start</strong></td>
<td><strong>Healthy Start</strong></td>
<td><strong>Healthy Start</strong></td>
<td><strong>Healthy Start</strong></td>
</tr>
<tr>
<td><strong>Fatherhood Program</strong></td>
<td><strong>Fatherhood Program</strong></td>
<td><strong>Fatherhood Program</strong></td>
<td><strong>Fatherhood Program</strong></td>
</tr>
<tr>
<td><strong>AIU Responsible</strong></td>
<td><strong>AIU Responsible</strong></td>
<td><strong>AIU Responsible</strong></td>
<td><strong>AIU Responsible</strong></td>
</tr>
<tr>
<td><strong>Fatherhood Program</strong></td>
<td><strong>Fatherhood Program</strong></td>
<td><strong>Fatherhood Program</strong></td>
<td><strong>Fatherhood Program</strong></td>
</tr>
<tr>
<td><strong>Healthy Start Life Skills Classes</strong></td>
<td><strong>Healthy Start Life Skills Classes</strong></td>
<td><strong>Healthy Start Life Skills Classes</strong></td>
<td><strong>Healthy Start Life Skills Classes</strong></td>
</tr>
</tbody>
</table>
Birth Outcomes, Risk and Contextual Factors, and Intervention Participation

We used the IMPreS1v database to determine the effectiveness of some of the programs, services, and supports available in Allegheny County. The ten-year span of data (2003–2013) and the breadth of intervention data included in IMPreS1v allowed us to report more reliable and granular information on birth outcomes within Allegheny County than has been previously reported. The database also allowed us to summarize the various risk and contextual factors associated with the range of birth outcomes and describe participation in a set of interventions provided in medical and community settings. Select findings follow.

Birth Outcomes

- During the study period, 0.65 percent of deliveries in Allegheny County ended in an infant mortality, 11.0 percent involved a preterm birth, and 8.7 percent were low birth weight births.
- The major underlying causes of infant mortalities were prenatal or preconception factors, such as prematurity and fetal growth and congenital disorders.
- Prematurity and fetal growth problems accounted for the largest percentage of infant deaths (27 percent).

Risk and Contextual Factors

- Among all births, pregnant women with hypertension had far higher rates of low birth weight (208 per 1,000) and preterm births (250 per 1,000) than the other maternal health risk factors evaluated (gestational diabetes, prepregnancy obesity, anemia, and infections).
- Substance abuse was documented for about 4 percent of deliveries, and smoking during pregnancy for about 6 percent of deliveries. The infant mortality rate among women with any substance abuse during pregnancy was 17.7 per 1,000 births; the rate among women who smoked during pregnancy was 9.3 per 1,000.
- Among births to teen mothers, the infant mortality rate was 10.3 per 1,000; it was 13.8 per 1,000 births when the previous birth occurred less than 1.5 years before.

Intervention Participation

- Seventy-five percent of women received one or more prenatal care visits; among these, 78 percent received at least one prenatal care visit during the first trimester.
- For 7 percent of the deliveries, families received home visiting through Healthy Start, Nurse-Family Partnership, or Early Head Start.
• For 5 percent of all deliveries, families received some support from a Family Support Center, and 30 percent received WIC.

• For 15 percent of the deliveries, families had received drug, alcohol, or mental health services funded through the Allegheny County Department of Human Services at any point before delivery or during the postpartum period.

Understanding Participation in Select Allegheny County Programs, Services, and Supports

The IMPreS1v database was used to explore a wide array of possible predictors of participation in different programs, services, and supports for pregnant and postpartum women, including parental characteristics, maternal health and behavioral risk factors, pregnancy, delivery and postdelivery observations and diagnostics, and socioenvironmental risk factors. While there was some variation across interventions in which predictors emerged as the most important, the strongest associations were with demographic or socioeconomic characteristics such as maternal marital status or education level. Given that most of the programs, services, and supports examined target women and families at higher risk of infant mortality, these results suggest that the interventions are successfully engaging with the women and families they are primarily designed to reach.

We also tested the accuracy of the predictions of intervention participation. Predictions that are accurate are more likely to have reduced bias in their estimates of interventions’ effects and more likely to be useful to and community-based social service providers for understanding which women might use a given intervention. Overall, testing showed that the models produced very accurate predictions of the utilization of prenatal care, home visiting, Family Support Centers, WIC, and behavioral health services. However, our predictive model of preconception/interconception care was the least accurate, meaning that estimates of the effects of preconception/interconception care are the most likely to be biased by selective intervention participation.

Examining the Effectiveness of Select Allegheny County Programs, Services, and Supports

We found variation in the estimated effectiveness of different interventions across predicted risk levels, by time period, and by specific programs, services, or supports within an intervention category. In this section we summarize highlights of the results, expressed in terms of the size of the effect and the degree of accuracy.
**Intervention Category**

Medical interventions were estimated to have the largest impact. From the causal inference models, the estimated effects of prenatal care were found to be large and the predictions were accurate. The effects of both preconception/interconception care and doula support were similarly large, but the accuracy of our predictive models for these interventions was lower. While smaller effects were observed, home visiting and the three support and referral interventions still significantly reduced infant mortality, particularly for women with the highest levels of predicted risk.

**Risk Level**

Generally, the effectiveness of the interventions increased as the predicted risk of infant mortality increased. For the medical-setting interventions, the significant positive effects ranged from about 4 to 30 percent, depending on the specific intervention (preconception/interconception care, prenatal care, or doula support). The effects of home visiting, WIC, and behavioral health services were null at lower risk levels, but reduced risk by 5 to 7 percent for women with the highest risk levels. The effects of Family Support Centers were smaller but still significant if duration of participation in the intervention was considered.

**Time Period**

The duration and timing of participation can greatly affect effectiveness. Home visiting programs, for example, significantly reduced the risk of infant mortality, but only during the prenatal period (not after delivery). These effects were magnified as the maternal risk level increased, suggesting that earlier involvement in home visiting programs reduces infant mortality, particularly for those most at risk of poor birth outcomes. This was true of the few interventions where it was appropriate to examine effects by time period. Behavioral health services also had a significant positive effect on infant mortality risk during the preconception period, but only at the highest risk level.

**Specific Interventions**

Among intervention categories, the magnitude of the effects of specific interventions varied. Three of the four types of preconception/interconception care examined significantly reduced infant mortality and at similar rates. Whereas for prenatal care, receiving one or more exams per month during the prenatal period had a large significant effect, receiving a first-trimester exam did not affect infant mortality risk. This pattern suggests that consistent prenatal care is more important than early prenatal care, which is largely consistent with the evidence base.

Both of the home visiting programs significantly reduced the risk of infant mortality. While the magnitude of the effect varied between the programs, these differences could reflect
differences in program intensity (e.g., weekly vs. monthly home visits), the breadth of program offerings (e.g., services include prenatal care), or the approach used (e.g., program based on evidence-informed model).

Among behavioral health services, the effects of substance abuse services were large and significant, particularly at higher levels of risk, while the effects of mental health services were only significant at the lowest risk level. It is important to note that the estimates for behavioral health services likely represent lower bounds, and these programs are likely to generate significant gains to other outcomes such as maternal health and child development.

Examining Variation in Effectiveness for Select Allegheny County Programs, Services, and Supports

For the final part of the study, we examined which women are likely to receive the greatest benefits from the interventions, as well as how certain interventions and benefits might work in tandem to reduce the risk of infant mortality even further than when used alone.

Risk Factors and Characteristics

Many women, particularly those with low socioeconomic status, face multiple and concurrent risk factors. The increased effectiveness of many interventions among women with these characteristics suggests that the programs, services, and supports are reaching high-risk populations and having an impact.

Preconception/interconception care and WIC were found to be particularly effective among teens, young adult women (ages 20–24), and black women. Similarly, prenatal care significantly decreased infant mortality risk for young adult women and black women, and home visiting significantly reduced the risk for teens and black women. This pattern is consistent with the evidence base, which shows that younger women, particularly teens, are at increased risk for preterm births or low birth weight.

All of the interventions except home visiting significantly reduced infant mortality risk for women with a first pregnancy, suggesting that there are opportunities to focus recruitment and engagement activities on first-time mothers across many different programs, services, and supports and that this increased focus could foster additional gains in improved birth outcomes. The lack of an effect for home visiting may be related to timing, since home visiting was most effective in the prenatal period.

A few of the interventions worked well for women who had ever smoked, including preconception/interconception care, which may provide an opportunity to address the well-established negative effects of smoking before the pregnancy on birth outcomes, and WIC, a program whose focus on nutrition and referrals to other health and social services may have had spillover effects on smoking behavior.
Intervention effects for women with opioid use disorder worked in opposite directions for different interventions. Preconception/interconception care led to an apparent increased risk of infant mortality for women with opioid use disorder, which may reflect more about women struggling with substance abuse issues than it does about the interventions. Both WIC and behavioral health services, on the other hand, did reduce the risk of infant mortality for women with an opioid use disorder. As with smoking, for WIC the effect may be related to the intervention’s general focus on nutrition and other factors that contribute to healthy development. The positive effect was expected for behavioral health, since substance abuse services aim to help women with opioid and other substance abuse disorders.

**Compound Effects**

For many of the interventions, reductions in infant mortality were magnified when combined with other interventions. The effects of home visiting were enhanced by also having received WIC, which in turn was even more effective when combined with any of the other interventions. To some degree, these compound effects are expected, since many programs include referrals to other services and supports as part of their offerings. Nonetheless, the results show the importance of ensuring that women receive a range of programs, services, and supports to address their multiple needs.

Most interventions yielded statistically significant effects when combined with income and medical benefit programs. For home visiting and WIC, risk among women who also received income, medical, or other benefits (such as housing assistance) was significantly lower than among women who did not receive the benefits. Benefits likely ease the financial, access, and other hurdles faced by women at high risk of infant mortality. Similarly, the effects of behavioral health services were magnified when combined with other benefits, such as assisted housing, which may help alleviate stressors and increase engagement.

**Recommendations**

Through this research, we have demonstrated that predictive models of infant mortality and intervention participation are possible, and the results are informative. Risk assessment can focus the attention of both health care and community-based social service providers on the women and children who are at greatest risk of infant mortality—even before conception. Using knowledge of the risk factors that are most predictive of infant mortality, our causal inference framework describes the degree to which interventions are effective for women with different risk profiles.

Based on findings from the three stages of our study, we have developed ten recommendations to improve the quality of maternal and child health and reduce infant mortality in Allegheny County (with more details on each provided in Chapter 10 of the report):

xxiii
• **Assess infant mortality risk early using information available at all points of assessment.** Infant mortality risk can be accurately predicted, effectiveness increases at higher levels of predicted risk, and early intervention can play a key role in whether an intervention is successful.

• **Educate health care and community-based social service providers about available and effective interventions.** Successful referral to interventions often depends on health care and community-based social service providers’ knowledge of programs, services, and supports in each other’s domains.

• **Tailor referrals based on risk and intervention effects for specific risk profiles.** Referrals should be individualized based on the predicted level or infant mortality risk and risk profile, and combined to maximize effectiveness.

• **Select referrals based on the likelihood of participation.** Intervention participation can be accurately predicted, and there is variation across interventions in which factors predict participation.

• **Support outreach and engagement activities to increase participation for women at risk of poor birth outcomes.** Implementing strategies to ease barriers to participation, particularly among high-risk women, may greatly influence interventions’ effectiveness.

• **Coordinate efforts across programs, services, and supports and leverage existing contacts to facilitate referrals.** Care coordination of both medical and nonmedical care is critical to meeting the wide-ranging needs of women, particularly those at high risk for infant mortality.

• **Increase participation in early and consistent preconception, interconception, and prenatal care.** The most effective interventions we examined targeted women before pregnancy, early in their pregnancies, or between pregnancies.

• **Leverage opportunities to connect with women during first pregnancies.** Interventions were more likely to be effective with a first pregnancy, perhaps because of their focus or as a result of better engagement among first-time mothers.

• **Support the introduction or expansion of interventions that have demonstrated effectiveness in other settings and evaluate their effects in Allegheny County.** Doula support and enhanced prenatal care (e.g., CenteringPregnancy) may be particularly effective at bridging medical care and community-based social services.

• **Focus maternal education and outreach efforts on the link between risk behaviors and poor outcomes.** Some interventions managed certain risk factors (e.g., smoking and substance abuse) particularly well, suggesting that education and outreach can play a major role among women with these behavioral issues.

**Next Steps**

Our recommendations represent a nuanced response for efforts to prevent and reduce infant mortality in Allegheny County. As in other communities, most infant deaths in Allegheny County are due to prenatal and preconception factors related to maternal health. Maternal health is dependent on acute behaviors and stressors, as well as life course factors such as poverty, stress, and race. Consequently, each of our recommendations aims to improve maternal health through coordinated, consistent, and targeted efforts that are initiated as early as possible.
earlier health care and community-based service providers can engage with women, particularly those at high risk of poor birth outcomes, the better able they will be to manage the impact of chronic conditions such as hypertension, eliminate or manage risk behaviors such as substance abuse, and connect women with a range of programs, services, and supports to address needs and mitigate other stressors. Further, consistent interactions will better enable health care and community-based social service providers to respond to acute issues that arise and may increase the risk of infant mortality.

While there is no simple solution to infant mortality, the findings from this research produce great value for health care and community-based social service providers. Our findings will enable these providers to tailor recommendations to specific programs, services, and supports based on the results of a risk assessment. Understanding how intervention effectiveness varies for women with different levels of predicted risks and specific risk profiles will further contribute to the ability to tailor recommendations depending on each woman’s unique circumstances. Our findings also identified increased effectiveness for certain combinations of interventions and the potential to expand some interventions to reach more women at risk of poor birth outcomes. Together our results highlight the need to coordinate care across systems and develop new, perhaps technology-driven, approaches to increase engagement in programs, services, and supports.

Moving forward, it will be important to implement the recommendations and then assess their impact—how they are being implemented, their progress in improving birth and infant outcomes, and their sustainability—and the opportunities to build on successes. The integration of a risk assessment or referral tool into systems and practice in different health care and community service systems, support for care coordination between and among health care and community-based social service providers, and efforts to increase the knowledge and engagement of women at risk for poor birth outcomes will be key drivers of impact in the community.

To assess the overall impact of these recommendations, it will be important to include a robust and ongoing evaluation of the implementation of the risk assessment or referral tool, the care coordination efforts, and the client engagement grant program to better understand what is working well and what needs adjustment. It will also be important to assess the impact of these efforts on preventing and reducing infant mortality by examining their impact on birth outcomes. The outcomes evaluation could also be expanded to address the causes that are further upstream, such as maternal health. Further, the current evidence is somewhat limited for some of the approaches recommended for expansion (e.g., enhanced prenatal care and doula support) or introduction (e.g., mobile applications). When these are implemented, it will be important to examine their effectiveness and update the models of risk and intervention effects with additional administrative data on intervention participation and the patient-centric and socioenvironmental data collected through mobile applications. Ultimately, if data show that the approaches
recommended here prevent or reduce poor birth and infant outcomes in Allegheny County, then these approaches can and should be implemented in other communities where the problem of infant mortality persists.

None of this work would have been possible without the support of local stakeholders. Throughout this phase of the project, we have benefited from the support and engagement of a broad range of stakeholders. The Richard King Mellon Foundation has been instrumental as a convener of various agencies, organizations, and community-based providers, bringing to the table several local health care systems with an interest in integrating the tools and insights from our work into their systems of care. As we move forward to the next phase of work, we will continue to rely on the support that we have received from all of the stakeholders who share the foundation’s vision of preventing and reducing infant mortality in Allegheny County.
**Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAP</td>
<td>American Academy of Pediatrics</td>
</tr>
<tr>
<td>ACDHS</td>
<td>Allegheny County Department of Human Services</td>
</tr>
<tr>
<td>ACHD</td>
<td>Allegheny County Health Department</td>
</tr>
<tr>
<td>ACOG</td>
<td>American College of Obstetricians and Gynecologists</td>
</tr>
<tr>
<td>AHN</td>
<td>Allegheny Health Network</td>
</tr>
<tr>
<td>AIU</td>
<td>Allegheny Intermediate Unit</td>
</tr>
<tr>
<td>AMCHP</td>
<td>Association of Maternal and Child Health Programs</td>
</tr>
<tr>
<td>AUC</td>
<td>area under the curve</td>
</tr>
<tr>
<td>BBZ</td>
<td>Best Babies Zone</td>
</tr>
<tr>
<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
</tr>
<tr>
<td>CMMI</td>
<td>Center for Medicare and Medicaid Innovation</td>
</tr>
<tr>
<td>CoIIN</td>
<td>Collaborative Improvement and Innovation Networks</td>
</tr>
<tr>
<td>DML</td>
<td>double machine learning</td>
</tr>
<tr>
<td>DW</td>
<td>Allegheny County Data Warehouse</td>
</tr>
<tr>
<td>FQHC</td>
<td>Federally Qualified Health Center</td>
</tr>
<tr>
<td>HHS</td>
<td>U.S. Department of Health and Human Services</td>
</tr>
<tr>
<td>HRSA</td>
<td>Health Resources and Services Administration</td>
</tr>
<tr>
<td>ICC</td>
<td>interconception care</td>
</tr>
<tr>
<td>IMPLICIT</td>
<td>Interventions to Minimize Preterm and Low Birth Weight Infants Using Continuous Quality Improvement Techniques</td>
</tr>
<tr>
<td>IMPreSiv</td>
<td>Infant Mortality Prediction System with Intervention Management</td>
</tr>
<tr>
<td>MARS</td>
<td>Medical Archival Retrieval System</td>
</tr>
<tr>
<td>MCH</td>
<td>Allegheny County Maternal and Child Health Program</td>
</tr>
<tr>
<td>MeSH</td>
<td>Medical Subject Headings</td>
</tr>
<tr>
<td>MOMI</td>
<td>Magee Obstetric Maternal and Infant</td>
</tr>
<tr>
<td>NAS</td>
<td>neonatal abstinence syndrome</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>NICU</td>
<td>neonatal intensive care unit</td>
</tr>
<tr>
<td>PATH</td>
<td>pregnancy attitudes, timing, and how important is pregnancy prevention</td>
</tr>
<tr>
<td>POWER</td>
<td>Pennsylvania Organization for Women in Early Recovery</td>
</tr>
<tr>
<td>PQC</td>
<td>perinatal quality collaborative</td>
</tr>
<tr>
<td>SAMHSA</td>
<td>Substance Abuse and Mental Health Services Administration</td>
</tr>
<tr>
<td>SIDS</td>
<td>sudden infant death syndrome</td>
</tr>
<tr>
<td>UPMC</td>
<td>University of Pittsburgh Medical Center</td>
</tr>
<tr>
<td>WIC</td>
<td>Women, Infants, and Children</td>
</tr>
</tbody>
</table>
1. Introduction

The rate of infant mortality, calculated as the number of deaths before age one among 1,000 live births, is widely used as a measure of maternal and child health, health care quality and access, environmental quality, socioeconomic conditions, and public health practices. Countries with high or middle incomes, on a per capita basis, tend to have low infant mortality rates. But the rate of infant mortality in the United States—5.87 infants per 1,000 live births in 2016 (Centers for Disease Control and Prevention [CDC], n.d.a.)—exceeds that of its economic peers and is more than double the rate for countries with the lowest infant mortality rate (MacDorman et al., 2014). Some states and counties have even higher rates of infant mortality. In Pennsylvania, the infant mortality rate was slightly higher in 2016 than the national average at 6.15 per 1,000 (CDC, n.d.a.); within Pennsylvania, the Allegheny County rate was on par with the national rate at 5.85, with a total of 77 infant deaths in that year (CDC, n.d.a.).

The rate of infant mortality also fluctuates over time. Throughout the United States, infant mortality trended downward from 2003 to 2016 (Figure 1), decreasing from 6.84 to 5.87 during this 13-year period. In Pennsylvania, the rate decreased from 7.34 to 6.15, and in Allegheny County it dropped from 8.75 to 5.85, with more year-to-year instability than seen in rates nationally and among states, largely because of the smaller number of infant deaths at the county level. Within Pennsylvania, Allegheny County’s infant mortality rate has consistently been well below the state average; Philadelphia County, which has the most births per year, has the state’s highest infant mortality rate at 8.32 per 1,000.

Aggregate rates of mortality alone, though, provide little actionable information other than identifying localities that may need to pay special attention to enhancing efforts to help make pregnancies and deliveries safer. The Richard King Mellon Foundation, which is based in Allegheny County, established a vision to prevent infant mortality in the region. To realize this vision, the foundation funded a multifaceted effort, called Prediction and Reduction of Infant Mortality in Allegheny County, to develop a way to predict individual infant mortality risk and use individualized risk assessment to optimize referrals to promising or proven interventions based on the individual risk profile.
Figure 1. Trends in Infant Mortality

![Graph showing trends in infant mortality from 2003 to 2016 for National, Pennsylvania, and Allegheny County.](image)

SOURCE: Centers for Disease Control and Prevention (CDC), n.d.b.

Allegheny County Landscape

Situated in the southwest part of Pennsylvania, with Pittsburgh as its regional hub, Allegheny County has a population of about 1.22 million, with an average age of just over 40; 80 percent of the population is white and 13 percent is black. The median household income is just over $56,000 and the poverty rate is 11.2 percent, as measured by the number of households below the federal poverty level (U.S. Census Bureau, 2019), or “poverty line.”

At approximately 303,000, the population of the city of Pittsburgh represents about one-quarter of the total population in Allegheny County. Pittsburgh is also younger than the county as a whole, with an average age of 33.5, and more racially diverse, with 66 percent of the population white and 23 percent black (U.S. Census Bureau, 2019). According to a recent report on equity in the city, there are large racial disparities in both median annual income ($54,366 for white households vs. $26,853 for black households) and poverty, with 29 percent of black Pittsburghers living below the poverty line compared with 15.1 percent of white Pittsburghers (May et al., 2019).

Racial Disparities in Infant Mortality

Against this backdrop of socioeconomic inequities, substantial racial disparities exist in infant mortality rates in the county. These disparities have been observed at the state and national levels but are further pronounced in Allegheny County. In 2016, for example, the national rate of infant mortality among white infants was 4.93; in contrast, the national rate of infant mortality
among black infants was more than two times higher at 10.77 (CDC, n.d.a.). The racial disparity in Allegheny County is even larger. In 2016, the rate of infant mortality in Allegheny County was 3.78 for white infants and 13.29 for black infants (CDC, n.d.a.). Although the black population in Allegheny Country represents only about 13 percent of the total population and approximately 21 percent of the births, more than 40 percent of the infants who died in 2016 were black (CDC, n.d.a.).

Though Allegheny County’s rate of black infant mortality decreased between 2003 and 2016, the disparity between the mortality rate for white and black infants did not (Figure 2). Black infant mortality was more than two times greater than white infant mortality in both Pennsylvania and the nation, but the disparity was stable. In contrast, in Allegheny County, black infant mortality was three times higher than white infant mortality in 2016, with substantial fluctuations in disparity from 2003 to 2016 largely due to the small number of infant deaths for each group. The elevated and persistent racial disparities in infant mortality over time in Allegheny County were a key motivation for this research.

**Figure 2. Trends in the Disparity Between Black and White Infant Mortality Rates, 2003 to 2016**

![Trends in the Disparity Between Black and White Infant Mortality Rates, 2003 to 2016](source: CDC, n.d.b.)

**Access to Perinatal Care**

The relatively high rate of infant mortality in the county and the substantial racial disparity persist despite the widespread availability of services and programs to support healthy pregnancies and deliveries. A robust network of supports provides maternal and child health care in Allegheny County. Pregnant women may receive support and services related to their pregnancy through prenatal care in a medical setting, through home visits, and through an array of social services in the community or at home. Most pregnant women in Allegheny County (97
percent) begin receiving prenatal care during the first two trimesters of pregnancy (Balke, 2015). However, for 19 percent of the infant deaths from 2008 to 2012, the mother received no prenatal care or prenatal care beginning only in the third trimester (Balke, 2015).

The Allegheny County Health Department (ACHD) offers or partners with a number of different programs or services outside the health care system for pregnant women or new mothers, including several options for in-home support, a breastfeeding helpline, safe sleep initiatives, and smoking cessation support. While other community-based organizations provide services and supports to pregnant and postpartum women, there is little information about the capacity or reach of these efforts or how women access or engage with them.

**Policy Efforts to Address Disparities in Infant Mortality**

Since 2012, ACHD has convened the Infant Mortality Collaborative, which specifically focuses on organizing efforts to address disparities in the infant mortality rate by race and neighborhood. The collaborative includes a multidisciplinary group of stakeholders who meet quarterly. In 2015, ACHD released its *Plan for a Healthier Allegheny*, identifying maternal and child health among its five priority areas. Within each priority area, the plan specified a goal and then detailed objectives, outcomes, expected impact, and strategies aligned with that goal. For maternal and child health, the goal was defined as “reduce morbidity and mortality, by improving the health and quality of life of women, infants, children, caretakers, and their families, especially in vulnerable communities” (ACHD, 2017, p. 11). Two of the objectives directly addressed infant mortality:

- Reduce the overall infant mortality rate by 5 percent and the disparity in rates between white and black populations by 10 percent.
- Reduce the proportion of preterm births by 10 percent, low birth weight births by 10 percent, and extremely low birth weight births by 25 percent.

To put these objectives in context, a 5-percent reduction in infant mortality relative to the 2015 rate would equate to a rate of 5.93 per 1,000. Only in two years (2014 and 2016) in the span between 2003 and 2016 was Allegheny County’s infant mortality rate below 6.00 (Figure 1). A 10-percent reduction in the disparity between black and white infant mortality would drop black infant mortality from 3.05 times the rate of white infant mortality to 2.75 times that rate. While this would represent a meaningful reduction in the infant mortality disparity in Allegheny County, the disparity would still be significantly larger than those of both the state and the nation.

The *Plan for a Healthier Allegheny* also outlined specific strategies for each objective, including efforts such as home visiting, preconception or interconception care, smoking cessation programs, and community-based behavioral health care. Many of these strategies align with the evidence base on effective and promising programs for improving birth outcomes by addressing the causes of infant mortality and the risk factors that underlie them.
Infant Mortality Causes

Data on infant deaths provide general information on the causes of infant mortality and factors that contribute to it (see box for brief descriptions of the leading causes). Nationally, the top five leading causes of infant mortality account for 55.7 percent of all infant deaths: birth defects (20.8 percent), preterm birth and low birth weight combined (17 percent), sudden infant death syndrome (SIDS) (6.5 percent), maternal pregnancy complications (6.1 percent), accidents (5.3 percent), and complications placenta, cord, and membranes (3.6 percent) (Kochanek et al., 2017). The Allegheny County leading causes are the same, though the order of the top five are slightly different, as are their proportions (Kokenda, 2015).

Leading Causes of Infant Mortality

**Birth defects.** Congenital malformation of the nervous system; eye, ear, face, and neck; circulatory system; respiratory system; cleft lip or cleft palate; digestive system; genital organs; urinary system; or musculoskeletal system.

**Low birth weight.** Extremely low birth weight (999 grams or less) or low birth weight (1,000 to 2,499 grams). (For reference, 2,499 grams is just over 5.5 pounds.)

**Preterm birth.** Extreme immaturity (birth at less than 28 completed weeks of gestation) and other preterm infants (birth at 28 or more completed weeks but less than 37 completed weeks of gestation).

**Sudden infant death syndrome.** Sudden, unexplained death.

**Maternal complications of pregnancy.** Incompetent cervix, premature rupture of membranes, oligohydramnios, polyhydramnios, ectopic pregnancy, multiple pregnancy, maternal death, or malpresentation before labor.

**Accidents.** Unintentional injuries (e.g., suffocation or drowning).

**Complications of placenta, cord, and membranes.** Placenta praevia, other forms of placental separation and hemorrhage, other and unspecified morphological and functional abnormalities of placenta, placental transfusion syndromes, prolapsed cord, other compression or unspecified conditions of umbilical cord, chorioamnionitis, or other abnormalities of membranes.

For comprehensive definitions of each term, please refer to the *International Classification of Diseases* (Centers for Medicare and Medicaid Services, 2017).

Underlying each of the leading causes are multiple and varied maternal factors that increase risk for poor birth outcomes and infant death (CDC, 2019) (Figure 3). These factors fall into five broad, interrelated categories of risk: maternal health, mental health, stress, risk behaviors, and the context in which the mother lives. Each of these underlying factors is linked to one or more of the leading causes of infant mortality (Table 1). Many women, particularly those with low socioeconomic status, face multiple and concurrent risk factors within and across these categories of underlying causes.
**Maternal health.** There is evidence that hypertension, obesity, and diabetes, as well as poor nutrition during pregnancy, are linked to increased risk for birth defects (Balsells et al., 2009; Wolff et al., 2009; Marchi et al., 2015; Ramakrishnan et al., 2015; Zhao et al., 2015; Sinclair et al., 2016). Underlying risk factors for preterm birth or low birth weight include anemia, hypertension, obesity, and infections (Haider et al., 2013; Koren, 2013; Huang et al., 2014; Huang et al., 2015; Marchi et al., 2015; Faucher et al., 2016; Sinclair et al., 2016). Infections and diabetes are both linked to complications of the placenta, cord, and membranes (Tita and Andrews, 2010; Hamza et al., 2013). Pregnant women with diabetes, hypertension, or obesity are also at elevated risk for maternal complications of pregnancy (Koren, 2013; Bramham et al., 2014; Marchi et al., 2015; Carolan-Olah, 2016).

**Maternal mental health.** Mental health issues during pregnancy, including mood disorders, anxiety disorders, and serious mental illness, increase risk for preterm birth or low birth weight and maternal complications of pregnancy. Several systematic reviews found evidence that
untreated maternal depression increases the odds of preterm birth and low birth weight (Grigoriadis et al., 2013; Szegda et al., 2014; Jarde et al., 2016). Anxiety and depression are also both risk factors for maternal complications of pregnancy, such as preeclampsia (Chunfang et al., 2009). Serious mental illnesses, such as bipolar disorder and schizophrenia, have also been linked to both preterm birth and low birth weight (Prince et al., 2007; H. C. Lee and Lin, 2010).

**Maternal stress.** Pregnancy can be a time of increased stress for women, and the factors related to stress can result in preterm birth or low birth weight. Environmental and psychosocial stress during pregnancy has been associated with increased risk for preterm birth or low birth weight (Beydoun and Saftlas, 2008; Shapiro et al., 2013; Witt et al., 2014). Elevated levels of cortisol, the stress hormone, in the mother have been found to directly affect the likelihood of preterm birth (Giurgescu, 2009). The cumulative burden of stress over time is referred to as allostatic load, which has been found to be elevated with age, for African Americans, and for those with lower socioeconomic status (Geronimus et al., 2006; Hux, Catov, and Roberts, 2014). Further, there is evidence that some of the sources of chronic stress, including racial discrimination and intimate partner violence, are related to preterm birth and low birth weight (Giurgescu et al., 2011; Allhusen et al., 2015).

**Maternal risk behaviors.** Alcohol use during pregnancy is the leading cause of environment-related birth defects, and it increases the risk of preterm birth and low birth weight, as well as SIDS (Warren and Foudin, 2001; Parazzini et al., 2003; Paintner, Williams, and Burd, 2012; Truong et al., 2013). Substance use is a growing concern for pregnant women, particularly of opioids. Between 1999 and 2014, the national rate of opioid use disorder identified at hospital deliveries increased 333 percent from 1.5 cases per 1,000 discharges after hospital delivery to 6.5 per 1,000 (CDC, 2018b). Opioid use during pregnancy increases risk for low birth weight, maternal complications such as toxemia, and neonatal abstinence syndrome in the newborn (Behnke et al., 2013; Minozzi et al., 2013). Other drugs, including cocaine and methamphetamines, are also associated with poor birth and infant outcomes, including birth defects, low birth weight, and complications such as placental abruption (Forrester and Merz, 2006; Behnke et al., 2013; Viteri et al., 2015). Tobacco exposure remains prevalent among pregnant women with the negative effects on preterm birth, fetal growth, birth defects, placenta complications, and SIDS well established (Behnke et al., 2013; U.S. Department of Health and Human Services [HHS], 2014; Cui et al., 2016; Friedmann et al., 2017; Perry, Mulcahy, and DeFranco, 2017).

**Maternal and infant context.** Higher maternal age (34 and older) may increase risk for birth defects and maternal complications of pregnancy (Huang et al., 2008; Bayrampour and Heaman, 2010; de Queiroz Herkrath et al., 2012), whereas lower maternal age (younger than 18 years) may increase risk for preterm births or low birth weight (Gibb et al., 2012; Kozuki et al., 2013a). Shorter intervals between pregnancies are associated with adverse pregnancy outcomes, including preterm birth and low birth weight (Conde-Agudelo, Rosas-Berm, and Kafury-Goeta, 2006; Kozuki et al., 2013b; Bigelow and Bryant, 2015), as are unintended pregnancies (Logan et
al., 2007; Gipson, Koenig, and Hindin, 2008). Infant sleep positioning, bed sharing, and bedding type are all associated with risk for SIDS (Hauck et al., 2002; American Academy of Pediatrics [AAP], 2011). Poor air quality may be associated with increased risk for birth defects and preterm birth or low birth weight (Stieb et al., 2012; Chen et al., 2014; Zhu et al., 2015).

Table 1. Linkage Between Underlying Factors and Leading Causes of Infant Mortality

<table>
<thead>
<tr>
<th>Maternal health</th>
<th>Preterm Birth or Low Birth Weight</th>
<th>Birth Defects</th>
<th>SIDS</th>
<th>Complications of Placenta, Cord, and Membranes</th>
<th>Maternal Complications of Pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes</td>
<td>✅</td>
<td>✅</td>
<td>✅</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>Anemia</td>
<td>✅</td>
<td></td>
<td>✅</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>✅</td>
<td>✅</td>
<td>✅</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obesity</td>
<td>✅</td>
<td></td>
<td>✅</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infections</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutrition</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal mental health</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal stress</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal risk behaviors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol use</td>
<td>✅</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drug use</td>
<td>✅</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoking/smoke exposure</td>
<td>✅</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal/infant context</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal age</td>
<td>✅</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pregnancy interval</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed/sleep arrangements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental toxins</td>
<td>✅</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This Project

Starting in July 2016 and with support from the Richard King Mellon Foundation, a group of research partners in the Pittsburgh area undertook the Prediction and Reduction of Infant Mortality in Allegheny County project to address infant mortality in the region. The foundation sought to better understand and address the disconnect between the region’s robust maternal and child health care system and the relatively poor birth and infant outcomes that appear to be
driven by stark racial disparities in infant mortality. The multifaceted project combined the efforts of researchers from RAND, the University of Pittsburgh, and the Magee Women’s Research Institute, in collaboration with a broad-based community coalition of stakeholders in the maternal and child health care arena. The project had two key components designed to improve the understanding of individual risk for infant mortality and the capacity and effectiveness of existing interventions to address the risk factors.

**Component 1: University of Pittsburgh**

For the first component, the University of Pittsburgh and RAND teams worked together to obtain rights to use data from a variety of sources and integrate them into the Infant Mortality Prediction System with Intervention Management (IMPreSIV) database. The database includes vital statistics records of all births and infant deaths from ACHD, the social services database from the Allegheny County Department of Human Services (ACDHS), the Magee Obstetric Maternal and Infant (MOMI) database, and individual-level data from programs such as Healthy Start and the Nurse-Family Partnership. The goal of this component was to create a unique database that would enable researchers to extract novel insights regarding infant mortality in Allegheny County. Once the database was constructed, the University of Pittsburgh team used it to develop a real-time adaptive predictive risk assessment model that would enable health providers and community-based social service providers to identify those most at risk for poor birth outcomes.

**Component 2: RAND**

For the second component of the project—and the subject of this report—RAND led the effort to identify effective interventions and efforts to prevent infant mortality; inventory the programs, services, and supports available in Allegheny County; and build a framework that leverages the unique size and breadth of the IMPreSIV database and the infant mortality predictive results to produce causal inference models of each intervention’s effects on the risk of infant mortality. To this end, we used the following methods:

- **Literature review.** Gather information on the state of the evidence base for interventions that address the underlying causes of infant mortality and document national, state, and local efforts to address infant mortality
- **Environmental scan.** Inventory the array of programs, services, and supports available in Allegheny County that address the underlying factors that contribute to infant mortality.
- **Causal inference framework.** Employ statistical methods in a series of steps to determine the effectiveness of interventions in Allegheny County.

Together, the predictive risk assessment model; the inventory of programs, services, and supports; and the causal inference framework results on intervention effectiveness lay the
groundwork for the development of a tool to help identify those most at risk of poor birth outcomes, provide information on the appropriate mix of interventions for each risk profile, and guide decisions about additional investments so that women and infants receive the best, most appropriate care based on their needs.

Organization of This Report

This report summarizes RAND’s efforts to review the evidence on interventions to address infant mortality; catalog available programs, services, and supports both inside and outside Allegheny County; and determine the effectiveness of existing interventions.

- Chapter 2 describes in detail the methods for the literature review that summarizes the evidence on interventions; the environmental scan to develop an inventory of available programs, services, and supports addressing the underlying causes of infant mortality; and the causal inference framework to examine intervention effectiveness.
- Chapter 3 summarizes the evidence base for interventions that address the underlying causes of infant mortality and describes the settings, timing, and issues related to participant engagement in these interventions.
- Chapter 4 describes the policy, program, and practice landscape at the national, state, and local levels for preventing and reducing infant mortality.
- Chapter 5 provides an inventory of Allegheny County programs, services, and supports that may address some of the underlying causes of infant mortality.
- Chapter 6 offers findings from the IMPreSlv database regarding birth outcomes and intervention participation, as well as information on risk and contextual factors.
- Chapter 7 presents the results of our predictive modeling of participation in select interventions available in Allegheny County.
- Chapter 8 examines the effectiveness of select interventions in Allegheny County in reducing the risk of infant mortality.
- Chapter 9 describes variation in the effectiveness of select Allegheny County interventions in reducing the risk of infant mortality for those with specific risk factors or who receive different combinations of interventions.
- Chapter 10 offers recommendations, limitations of the database and analysis, and next steps related to interventions to prevent or reduce infant mortality in Allegheny County.
2. Methods

This chapter first summarizes the methods used to conduct the literature review on the evidence base on interventions (Chapter 3) and gather an inventory of national, state, and local efforts to prevent infant mortality (Chapter 4). Then, we describe the methods for the environmental scan to assess the local availability and capacity of different programs, services, and supports to prevent and reduce infant mortality (Chapter 5). We also summarize the methods for our analyses that describe birth outcomes within Allegheny County during the study period, the various risk and contextual factors associated with the range of birth outcomes, and the prevalence of the interventions within the IMPReSIV database (Chapter 6). The chapter also describes the causal inference framework used to develop the series of models to determine the effectiveness of existing interventions (Chapters 7 through 9).

Literature Review

Our literature review examined the current evidence base for existing interventions that may address the underlying causes of infant mortality and documented national, state, and local efforts to address infant mortality.

We performed a series of keyword searches to document the link between birth outcomes and interventions (Figure 4). Within the PubMed, PsycInfo, CINAHL, and ERIC databases, we searched each outcome separately with the intervention-related keywords for the period 2006–2016. The results from each search were combined into one master EndNote library with results from each underlying cause grouped into individual folders within the library. All duplicates between database and outcome searches were removed. English-language systematic reviews, meta-analyses, practice guidelines, and literature reviews were included in the results. In addition to duplicates, some animal studies and previous versions of large systematic reviews were removed.
This initial search, covering from 2006, when the literature review started, to 2016, yielded a total of 227 articles. We supplemented the literature search with searches of the gray literature and targeted web searches for examples of specific interventions currently in use (e.g., the National Institute for Children’s Health Quality website, Kaiser Health News, the Commonwealth Fund, and others), which yielded an additional 20 reports or articles. We also conducted additional searches for other birth outcomes such as SIDS and accidents when the initial search did not yield these results. For all relevant articles, we reviewed the titles and abstracts to identify key articles and then extracted key data from those articles. The results of this work are presented in Chapters 3 and 4.

Environmental Scan

The environmental scan was designed to inventory the programs, services, and supports available in Allegheny County that might address the underlying factors that contribute to infant mortality and ultimately prevent or reduce infant deaths (see Chapter 5). We began our scan by assembling a list of programs, services, and supports in Allegheny County that were known to the project team members from previous work on maternal and child health and well-being. We
supplemented the list with input from local participants in a project working group for this project who were aware of other programs, services, or supports; a search of the ACDHS’ database of programs and services; and a search of the U.S. Substance Abuse and Mental Health Services Administration’s (SAMHSA’s) database of substance use programs in the area.

We documented the following key attributes, to the extent possible based on the contents of public documents obtained primarily from online sources, for each program, service, or support:

- general description
- eligibility criteria
- areas served
- year started
- referral sources
- annual referrals
- recruitment methods
- annual number served
- capacity
- number and type of staff
- program or service components
- intervention model, measures, or tools
- participant incentives
- rate of participant completion
- average number of contacts per person
- average duration of participation
- other results.

We also supplemented the publicly available information with discussions and email exchanges with local community-based social service providers who agreed to share information with us. We contacted approximately 20 organizations and requested some or all of the elements just listed, depending on what we were able to find through web searches. We were not able to obtain information on all domains for each program. In some cases, programs did not collect the information we requested; in other cases, we did not receive a response to our outreach.

The results of this work are presented in Chapter 5. Additional details on the programs, services, and supports currently available in Allegheny County are included in Appendix A.

Causal Inference Framework

Our framework for causal inference is designed to build off the predictive risk assessment model formulated by the University of Pittsburgh team and identify the causal effects on the risk of infant mortality of each intervention we observe in the IMPresIv database. Our framework and the models developed for each step are designed to address common methodological
challenges, as well as challenges that are unique to the issue of infant mortality and to the IMPreSiV database, including selection bias, model misspecification, and overfitting. Appendix B provides more detail about how this approach addresses those challenges.

A common challenge when using observational (or nonexperimental) data is selection bias. If the intervention is not randomly assigned, then the people who participate in the intervention may be selectively different from those who do not. For example, mothers who invite nurses to visit them at home and discuss pregnancy and parenting may be more likely than nonparticipants to do things to improve the outcome of their pregnancy that we cannot observe through the data, such as eating a healthy diet. If there are things, like diet, that we cannot observe but that are correlated with participating in the intervention and with the outcome (infant mortality), then our estimates of the effects of the intervention will pick up part of the effects of things we do not observe. In other words, our estimates will be biased and will not describe the actual, causal effects of the intervention. Even though the IMPreSiV database contains thousands of variables for each mother and child, it is still incomplete, and therefore selection bias remains a concern. However, if we can accurately predict intervention participation with the data we observe, then we can mitigate the bias caused by selection. So, just as the University of Pittsburgh team built models to predict infant mortality, as the first step in the causal inference framework we built models to predict participation in each intervention.

Because IMPreSiV contains thousands of variables ranging from medical diagnoses to socioenvironmental risk factors for 155,218 births between 2003 and 2013 in Allegheny County, we needed to address two important methodological issues: model misspecification and overfitting. Model misspecification means that the model is an inaccurate representation of reality. If we, as researchers, were to select among the thousands of variables in the IMPreSiV database to include in the models, we would do so idiosyncratically based on our training, the past research we have read and conducted, and our personal experiences and preferences. This means that some variables would be excluded, but if any excluded variables are correlated with the intervention and the outcome, then our estimates will be biased, just as with selection. On the other hand, if we include every variable, we run the risk of overfitting. Overfitting is overcomplicating the model, and if the models are overfit, the results become unreliable when moving to a new context. In other words, overfit estimates could indicate that a particular intervention is effective, but the same estimates might not hold over time or in different places.

To address selection bias and sidestep these two methodological issues, we used cutting-edge machine learning and econometric methods to estimate the causal effects of each intervention we observed in the IMPreSiV database. With machine learning, we identified important predictors of infant mortality and important predictors of intervention participation. In essence, the machine learning algorithms allowed the data to tell us which variables to include in the model and which to exclude, and thus avoid model misspecification. Additionally, we used cross-validation—repeated splitting of the data into training and testing samples—to avoid overfitting. Using econometrics, we can account for selection bias by leveraging the predictions of intervention
participation to compare the risk of infant mortality among those predicted to participate in the intervention at similar rates.

In the remainder of this section, we will briefly describe the IMPreSlv database. Chapter 6 presents some descriptive statistics on birth outcomes within Allegheny County during the study period, summarize the various risk and contextual factors associated with the range of birth outcomes, and describe the prevalence of the interventions within the IMPreSlv database. We then describe the four steps of our causal inference framework, with the results presented in Chapters 7 through 9. Additional details on the causal inference framework and steps in the model development process are provided in Appendix B.

**Infant Mortality Prediction System with Intervention Management Database**

Our causal inference framework is built on and responsive to the IMPreSlv database that was constructed as part of the first component of the overall project. The University of Pittsburgh and RAND teams worked together to obtain the rights to use data from a variety of sources across the community and integrate the data (Table 2). This combination of data contains records of all births between 2003 and 2013, as well as a wide variety of outcomes, risk factors, and interventions.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Data Subject</th>
<th>Types of Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vital statistics</td>
<td>ACHD</td>
<td>Infant</td>
</tr>
<tr>
<td>Medical Archival Retrieval System (MARS)</td>
<td>University of Pittsburgh Medical Center (UPMC)</td>
<td>Infant, mother</td>
</tr>
<tr>
<td>MOMI</td>
<td>Magee Women’s Research Institute</td>
<td>Infant, mother</td>
</tr>
<tr>
<td>Allegheny County Data Warehouse (DW)</td>
<td>ACDHS</td>
<td>Mother</td>
</tr>
<tr>
<td>Allegheny County Maternal and Child Health Program (MCH)</td>
<td>ACHD</td>
<td>Mother</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>-------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Healthy Start</td>
<td>Healthy Start</td>
<td>Mother</td>
</tr>
<tr>
<td>American Community Survey</td>
<td>American Community Survey</td>
<td>Three-digit zip code of mother’s residence</td>
</tr>
<tr>
<td>Other socioenvironmental data</td>
<td>Multiple</td>
<td>Three-digit zip code of mother’s residence</td>
</tr>
</tbody>
</table>

The foundation of the IMPreSv database is the vital statistics data from ACHD, which includes the universe of child births and deaths in Allegheny County during the study period. On this foundation, the IMPreSv database links each mother-infant dyad to data on health and social services received during pregnancy from multiple administrative data sources. Additionally, socioenvironmental risk factors are linked to the mother-infant dyad based on the mother’s residential information.

The vital statistics data from ACHD provides a wealth of information regarding social, economic, and demographic characteristics of the mother and, in some cases, the father. These include parental education and insurance status. Major maternal and child health risk factors, such as gestational diabetes and congenital abnormalities, are also described in the vital statistics data.

The largest health care system in Allegheny County, the UPMC, covers over 60 percent of births in the county and contributed two administrative data sets to the effort:

- The MARS data describe the utilization of health services, as well as claims data and unstructured health care provider notes.
- The MOMI database provides detailed clinical data, including diagnoses, labor and delivery information, laboratory results, ultrasound results, and other procedure data.

The mother’s participation in publicly funded social services such as assisted housing, Family Support Centers, substance abuse services, and mental health services is described in the DW. The timing and duration (start and end dates) of the mother’s participation in these social services is available for each pregnancy. Similarly, data from Healthy Start and MCH describe the timing and duration of the utilization of other programs for pregnant or postpartum women. Together, these were the only interventions for which we had participation information from any of the data sources that fed into the IMPreSv database.
The primary source of data describing social, economic, demographic, and environmental factors came from the American Community Survey and was linked to the three-digit zip code of the mother’s residence. Additional social, economic, and environmental data describing air quality, toxic chemical releases, wage growth, local occupational distribution, crime rates, weather, housing information, the presence of local care facilities, and other factors came from publicly available sources, including the Western Pennsylvania Regional Data Center, the Environmental Protection Agency, the National Centers for Environmental Information, and Zillow.

The linking of each individual’s data across each data source in the IMPreSIv database was performed by a certified honest broker with identifying information removed to produce a Health Insurance Portability and Accountability Act Safe Harbor data set. As described by the Tsui Laboratory (2017), data quality assessments according to standard practices were performed to examine the completeness, validity, consistency, and currency of the data. The maternal-infant linkage provided a unique opportunity to observe, for each birth in the cohort, important maternal factors such as comorbid conditions, prior pregnancy outcomes, and—crucially—interventions that the woman may have received before, during, or after pregnancy.

In order to make the model results from our causal inference framework as relevant as possible for a range of health care and community-based social service providers, we divided the data by type and time period. If the models within the framework rely too heavily on information available only to health care providers, such as blood tests and ultrasound measurements, then the results will not be useful for community-based social service providers who cannot obtain that information. Similarly, although gestational length and birth weight are important early indicators of infant mortality risk, if the models that make up the causal inference framework rely too heavily on information that comes later in pregnancy or after birth, health care and community-based social service providers will not be able to identify high risk women early and make referrals in a timely manner.

We categorized the data into three types:

- **Reportable data** include information that women could self-report to a health care or community-based social service provider. In the IMPreSIv database, most of these data originate from birth certificate records, which are currently reported or captured at delivery. The remainder consists of information on intervention participation (from additional data sources, including the DW, the MCH, and Healthy Start) and socioenvironmental risk factors associated with the mother’s place of residence (from the American Community Survey and other socioenvironmental data sources).

- **Potentially reportable data** include major maternal diagnoses and current medications that women could possibly self-report to a health care or community-based social service provider. This includes the reportable data and additional diagnoses (e.g., autoimmune disorders) and medications (e.g., antibiotics).
• **Health care data** include information that is available and could potentially inform health care provider decisions. This includes the reportable and potentially reportable data, as well as additional information only available to health care providers. This additional information includes fetal ultrasounds, blood test results, and toxicology reports that exist within electronic medical records.

We also divided the data into three time periods:

• **Preconception data** include only information that health care or community-based social service providers could obtain within one year before conception, including parental characteristics such as age, education, and race; parental behaviors such as smoking and substance abuse; and socioenvironmental risk factors associated with the mother’s residential location.

• **Pregnancy data** include information about the mother and the fetus that could only be obtained during pregnancy, such as weight gain, complications, and ultrasound measurements.

• **Postdelivery data** include information about the mother and the child that could be obtained after delivery, such as gestational age, birth weight, delivery method, and Apgar scores.

Figure 5 describes the overall data structure by type and time period. Reportable data during the preconception period represent the smallest portion of the overall database, and health care data in the postdelivery period include all of the available data. Different shades of the same color describe the data available in different time periods. Recall that, moving from one time period to the next, new data become available and add to what was previously available. So there are some reportable data available in the preconception period (lightest shade of red), during pregnancy more reportable data become available (middle shade of red), and during the postdelivery period additional reportable data become available (darkest shade of red). Ultimately, the database builds by both time period (from preconception to pregnancy to postdelivery) and data type (from reporting to potentially reportable to health care data). The health care data available during the postdelivery period encompasses the entire IMPreS1v database.
In the following sections, we briefly describe each of the four steps of the causal inference framework. In each of these steps, we developed models for each data type (reportable, potentially reportable, and health care) at each point in time (preconception, pregnancy, and postdelivery). In other words, ultimately, we estimated the effects of each intervention in each time period and for each type of information available. Throughout our causal inference framework, we predict the risk of mortality for each infant and the likelihood of a mother’s intervention participation relative to the birth of each child, and estimate the intervention effects for each infant. The results of our causal inference framework can be used to develop a tool to refer a woman to the optimal intervention whether she is interacting with a community social
service provider before conception, a health care provider during pregnancy, or their pediatrician after delivery.

**Step 1: Infant Mortality Prediction**

In this step, we leveraged the work conducted by the University of Pittsburgh team to predict the risk of infant mortality. These predictions were based on thousands of variables in the IMPreSlv database describing parental characteristics (e.g., maternal or paternal race, age, and education), maternal health risk factors and behaviors (e.g., smoking or substance abuse), pregnancy and delivery observations and diagnostics (e.g., gestational age, complications, and ultrasound measurements), postdelivery observations and diagnostics (e.g., Apgar scores and birth weight), socioenvironmental risk factors (e.g., local air quality), and intervention participation records. We leveraged the predictive models of the University of Pittsburgh team by examining their results and ensuring that the risk factors that they identified as important were also included in our models. We then extended this work by developing our own models to predict infant mortality using each type of data at each point in time. We used machine learning algorithms that iteratively improve until the model’s accuracy is maximized. We also evaluated the accuracy of the models using area under the receiver operating characteristic curve (AUC) scores, a standard metric that describes both the rate of true positives and the rate of false positives. We used cross-validation, repeatedly dividing the data into training and testing samples, to avoid overfitting, and we oversampled to balance the data (because infant mortality is a relatively rare outcome). The results of this step are risk scores predicting infant mortality for each delivery in Allegheny County between 2003 and 2013. Additionally, this step reveals which variables are important predictors of infant mortality. Further details on the modeling approach are described in Appendix B, with the results of this step presented in Appendix C.

**Step 2: Intervention Participation Prediction**

Our second step was to develop predictive models of participation for each of the interventions included in IMPreSlv database. We used the same set of thousands of variables in the IMPreSlv database to predict whether each woman who gave birth between 2003 and 2013 in Allegheny County participated in the interventions with data in the IMPreSlv database.

Our prediction of intervention participation serves three purposes. First, understanding the drivers of intervention participation is critical to developing appropriate recommendations so that individuals are referred to interventions in which they are more likely to participate. Second, combining the predictions of intervention participation with the predictions of infant mortality reveals which of the thousands of variables in the IMPreSlv database are important in modeling the interventions’ causal effects on infant mortality. Third, we can use the predictions of intervention participation to control for selection, thereby comparing the risk of infant mortality between mothers or children who are similar in terms of their likelihood of participating in the
interventions. As before, we used cross-validation, oversampled the imbalanced outcomes, and evaluated accuracy using AUC scores.

As noted, we sought to understand the factors correlated with participation at any point in time, as well as in the three distinct time periods described. Further, because different information becomes available at different times, we used different sets of information to predict intervention participation during these time periods. For instance, information about the child’s birth or any pregnancy complications is not available preconception, so that information is not included in the model of preconception intervention participation. Additionally, in order to make the results as relevant as possible for a range of health care and community-based social service providers, we modeled intervention participation using the three data types described. The main results of this step are presented in Chapter 7, with additional details on the modeling approach in Appendix B and additional results in Appendix C.

**Step 3: Causal Effect Estimation**

Our third step in the causal inference framework combined the infant mortality and intervention participation predictions and then used econometrics to estimate the causal effect of the interventions. This cutting-edge method is called double machine learning (DML), which was introduced by Chernozhukov et al. (2018). The predictions of infant mortality and of intervention participation show which variables are important, allowing us to avoid model misspecification. And the predictions of intervention participation enable us to compare the effects of the intervention on mothers with similar predictions of participation, thus accounting for selective participation. DML takes the variation in infant mortality that cannot be explained by the risk factors and determines how much can be attributed to the interventions. In other words, if the risk factors can predict infant mortality with 90-percent accuracy, 10 percent of infant mortality is left unexplained. DML estimates how much of that unexplained portion can be explained by the interventions. Our predictive models also use cross-validation in order to avoid overfitting. Additionally, we employ repeated sample splitting with cross-fitting in order to eliminate asymptotic bias and enable the stratification of the results by the predicted risk of infant mortality (Abadie, Chingos, and West, 2018). Using the risk scores estimated in step 1, we show how effective each intervention is for mothers with an infant mortality risk predicted to be above 90, 80, 70, 60, or 50 percent. The main results of this step are presented in Chapter 8, with additional details on the modeling approach in Appendix B and additional results in Appendix C.

**Step 4: Effect Heterogeneity Estimation**

The fourth and final step in our causal inference framework examined variation in the effects of the interventions by investigating the degree to which interventions are effective for women with particular risk factors (e.g., smoking or prior pregnancy history), as well as how the effectiveness of the interventions changed when they were combined with other interventions. Additionally, we examined how the effectiveness of the interventions changed when they were
combined with benefits programs that aim to mitigate constraints to intervention participation that many women face. The results of this step enabled more precise recommendations based on an individual’s risk profile.

Overall, the four steps of our causal inference model enable us to predict who will participate in the interventions, describe the effectiveness of the interventions for different risk factors, and suggest individualized referrals based on the overall risk profile. The main results of this step are presented in Chapter 9, with additional results presented in Appendix C.
3. Intervention Types and the Evidence Base

Interventions to address the underlying factors involved in infant mortality are numerous and have varying levels of supporting evidence. We have grouped the interventions into four categories: medical-setting interventions, health promotion and education, support and referrals, and policy interventions (Figure 6). Some elements of the various interventions straddle these four categories. For example, preconception care may include screening and referral as well as patient education. Some community-wide initiatives or strategies involve activities across the categories.

Figure 6. Interventions Targeting Underlying Causes of Infant Mortality

<table>
<thead>
<tr>
<th>Interventions</th>
<th>Underlying Factors</th>
<th>Leading Causes for Allegheny County</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical-setting interventions</td>
<td>• Preconception/Interconception care</td>
<td>Preterm birth and low birth weight</td>
</tr>
<tr>
<td>• Prenatal care</td>
<td>• Maternal health</td>
<td>Birth defects</td>
</tr>
<tr>
<td>• Enhanced prenatal care</td>
<td>• Diabetes</td>
<td>Sudden infant death syndrome</td>
</tr>
<tr>
<td>• Group prenatal care</td>
<td>• Anemia</td>
<td>Maternal complications of pregnancy</td>
</tr>
<tr>
<td>• Maternity care homes</td>
<td>• Hypertension</td>
<td>Accidents</td>
</tr>
<tr>
<td>• Birth centers</td>
<td>• Obesity</td>
<td>Complications of placenta, cord, and membranes</td>
</tr>
<tr>
<td>• Doula (birth)</td>
<td>• Medications</td>
<td></td>
</tr>
<tr>
<td>• Reduce early elective deliveries</td>
<td>• Nutrition (insufficient folic acid)</td>
<td></td>
</tr>
<tr>
<td>• Risk-appropriate care</td>
<td>• Maternal mental health</td>
<td></td>
</tr>
<tr>
<td>Health promotion and education</td>
<td>• Depression</td>
<td></td>
</tr>
<tr>
<td>• Home visiting programs</td>
<td>• Anxiety</td>
<td></td>
</tr>
<tr>
<td>• Safe sleep education*</td>
<td>• Maternal stress</td>
<td></td>
</tr>
<tr>
<td>• Smoke exposure education</td>
<td>• Racial discrimination</td>
<td></td>
</tr>
<tr>
<td>• Accident prevention*</td>
<td>• Poverty</td>
<td></td>
</tr>
<tr>
<td>• Childbirth education</td>
<td>• Housing/homelessness</td>
<td></td>
</tr>
<tr>
<td>Support and referrals</td>
<td>• Domestic violence</td>
<td></td>
</tr>
<tr>
<td>• Care coordination*</td>
<td>• Maternal risk behaviors</td>
<td></td>
</tr>
<tr>
<td>• Pregnancy/postpartum support*</td>
<td>• Alcohol use</td>
<td></td>
</tr>
<tr>
<td>• Breastfeeding and nutrition support*</td>
<td>• Drug use</td>
<td></td>
</tr>
<tr>
<td>• Behavioral health services*</td>
<td>• Smoking / smoke exposure</td>
<td></td>
</tr>
<tr>
<td>• Family support</td>
<td>• Maternal / infant context</td>
<td></td>
</tr>
<tr>
<td>Policy interventions</td>
<td>• Maternal age</td>
<td></td>
</tr>
<tr>
<td>• Perinatal regionalization</td>
<td>• Pregnancy interval</td>
<td></td>
</tr>
<tr>
<td>• Expanded insurance coverage</td>
<td>• Bed / sleep arrangements</td>
<td></td>
</tr>
<tr>
<td>• may also be delivered in a medical setting</td>
<td>• Environmental toxins</td>
<td></td>
</tr>
</tbody>
</table>
In the remainder of this chapter, we describe the interventions in each category and briefly summarize the evidence base. At the end of the chapter, we also discuss the approximate timing for these interventions, as well as potential barriers to their implementation and use.

Medical-Setting Interventions

By definition, all of the medical-setting interventions are delivered by health care providers, though some types of preconception/interconception care may be provided by community-based organizations, such as Healthy Start.

Preconception Care

Preconception care consists of a group of preventive screenings and services designed to reduce modifiable risk factors before a first pregnancy to improve pregnancy outcomes, as well as maternal and child health in general (Connor et al., 2014). Preconception care is particularly important given the prevalence in the United States of unplanned pregnancies (50 percent), chronic conditions, and unhealthy behaviors such as smoking (Connor et al., 2014). In addition, risk behaviors and exposure can affect the development of the fetus before a woman knows she is pregnant or starts prenatal care. In the first weeks of pregnancy, a lack of folic acid or use of alcohol, tobacco, or other drugs can have an adverse effect on the mother and fetus. One study found that only one of six obstetrician-gynecologists or family physicians had provided preconception care to most women to whom they later provided prenatal care (Johnson et al., 2006).

The American College of Obstetricians and Gynecologists (ACOG), the National Academy of Medicine, and the CDC recommend preconception care for all women of reproductive age. ACOG and the AAP also recommend that all health visits during a woman’s reproductive years include counseling on appropriate medical care and behaviors to optimize birth outcomes. These groups have put forth four categories of intervention: physical assessment, risk screening, vaccinations, and counseling (Johnson et al., 2006). The eight areas of recommended risk screening include

- reproductive awareness and planning
- environmental hazards and toxins
- nutrition, folic acid intake, and weight management
- genetic conditions and family history
- substance use (including tobacco, alcohol, and illicit drugs)

1 In the discussion of preconception care, we include interconception care, the preconception care that is provided to women between pregnancies.

2 Formerly the Institute of Medicine.
• medical conditions and medications
• infectious diseases and vaccinations
• psychosocial concerns (e.g., depression, violence, or housing).

There is an evidence base for many of the individual components of preconception care, but evidence is limited on the effectiveness of combinations of interventions for birth or infant outcomes. Individual interventions shown to be effective at improving birth or infant outcomes include folic acid supplementation (through vitamin supplements); management of hyperglycemia; vaccination for rubella, influenza, and hepatitis; provision of antiretroviral medications to prevent transmission of HIV to the baby; dental interventions to reduce the transmission of infection; a low phenylalanine diet for women with phenylketonuria; management of diabetes; changes in antiepileptic and oral anticoagulant medications when indicated; treatment of sexually transmitted disease; weight loss for obese women; and smoking and alcohol use cessation. While interventions for smoking and alcohol use have been shown to be effective among some populations, they have not been as effective for injection drug users and polysubstance users (Johnson et al., 2006). A 2014 systematic review assessed the impact of preconception care specifically for preventing congenital disorders and birth defects. It found that the most effective interventions were folic acid fortification or supplementation, diabetic control, smoking and alcohol interventions, HIV management, screening for the risk of blood clots, obesity prevention, and epilepsy management (Shannon et al., 2014).

There is limited evidence about effective ways to deliver preconception care to improve preconception health. Two studies sought to determine whether identifying preconception risk factors through screening increases health promotion intervention rates, such as medical treatment or counseling, for medical and nonmedical risk factors (Johnson et al., 2006). In one study, an average of nine risk factors were identified for women seeking a pregnancy test in a primary care clinic. In the other study of nonpregnant women seeking care at an inner-city gynecological clinic, there was a significant increase in risk screening for medical risk factors, medications, domestic violence, and nutrition after medical staff training. However, neither study observed an increase in health care provider intervention rates after identifying the risks (Johnson et al., 2006).

**Interconception Care**

Interconception care consists of services provided to women between pregnancies. This care is particularly important for women who have had an adverse event in a previous pregnancy, as this is a strong predictor of risk for future pregnancies (Johnson et al., 2006). Postpartum visits and well-child visits offer an opportunity for screening and interventions for medical conditions, psychosocial risks, and family planning. A pilot program at an Atlanta, Georgia, hospital studied the impact of interconception care on subsequent pregnancies for women who had delivered a low birth weight baby. The program successfully identified and treated medical conditions for 7
of 21 participants; all participants initiated a contraceptive plan and had at least a nine-month pregnancy interval (Biermann et al., 2006).³

Interconception care may also be facilitated by community organizations. Healthy Start⁴ grantees have been required to include an interconception care component since 2005, and most employ care coordination and case management to provide education, identify risks, and help women seek interventions (Badura et al., 2008). In 2007, the Healthy Start grantees reported that 90 percent of their clients had a regular source of primary care (Badura et al., 2008).

One component of interconception care, reproductive life planning, is a vehicle to provide counseling about modifiable preconception health risks at every health care visit and to potentially discuss the prevention of unintended pregnancies. Several approaches to initiating discussions of reproductive goals, such as One Key Question,⁵ are in use, but robust evidence on their effectiveness is lacking. For women who do not wish to become pregnant again or who wish to delay pregnancy, discussions of family planning and contraception are an important component of interconception care, as evidence suggests that shorter pregnancy intervals and unintended pregnancies are associated with poor infant outcomes. The reduction of unintended pregnancies is a focus of the CDC’s 6/18 Initiative, which is targeting six common and costly conditions and recommending evidence-based interventions for each (CDC, 2018a). Recommendations include several specific interventions for health care payers to increase access to contraceptives for women who wish to avoid pregnancy. Several state Medicaid programs have adopted one or more of the interventions (CDC, 2018a).

An innovative initiative in the Washington, D.C., area funds midwife-delivered preconception, interconception, and prenatal care and reproductive counseling to teens at two high school clinics. A grant from CareFirst BlueCross BlueShield pays for the services and any contraceptives provided. While the program has not been formally evaluated, in the three years the midwives have delivered services at one of the schools, none of the students participating had a subsequent pregnancy, and 85 percent of the students who chose a long-acting reversible contraceptive, such as an intrauterine device or hormonal implant, were still using it one year later (Simmons-Duffin, 2018).

Prenatal Care

Prenatal care consists of a series of assessments and interventions delivered by a physician or midwife during pregnancy. It has been established as a key public health intervention to prevent low birth weight since the release of the Institute of Medicine’s 1985 report Preventing Low Birth Weight,³⁸ results from the full 24-month study have not been published.

³ Healthy Start is a Health Resources and Services Administration (HRSA) program that works in communities with high infant mortality rates. It provided grants to 100 projects in 37 states in 2019.

⁴ One Key Question was developed by the Oregon Foundation for Reproductive Health. The question, “Would you like to become pregnant within the next year?” is suggested for use in primary care for all women age 18–50.
Birthweight (Institute of Medicine, 1985). The report concluded that “although a few studies have not been able to demonstrate a positive effect of prenatal care, the overwhelming weight of the evidence indicates that prenatal care reduces low birth weight and that the effect is greatest among high-risk women” (p. 8) After the report’s release, national legislation expanded Medicaid eligibility to low-income pregnant women and children, and many states further expanded eligibility and eased the enrollment process for pregnant women. Attention then turned to the content of prenatal care, and the U.S. Public Health Service appointed a panel to study the issue. The panel’s report specified the three components of care as early and continuing risk assessment, health promotion, and psychosocial interventions and follow-up (Expert Panel on the Content of Prenatal Care, 1989).

Since the release of the Institute of Medicine report and the resulting increase in the use of early and adequate prenatal care, there has been no reduction in the incidence of low birth weight babies. Two large reviews of the evidence in 1995 questioned the effectiveness of prenatal care in preventing low birth weight (Lu et al., 2003). A 2003 review funded by the Agency for Healthcare Research and Quality and conducted by Lu and colleagues examined the impact on preventing low birth weight, preterm birth, and intrauterine growth restrictions for each of 35 individual components of care in the expert panel’s three categories of care. It found “small”6 net benefits for smoking cessation interventions, cerclage, progesterone supplementation, antibiotic treatment for asymptomatic bacteriuria and bacterial vaginosis, and Doppler assessment; “moderate” benefits for tocolytic therapy with concomitant corticosteroids and Women, Infants, and Children (WIC) program evaluations; and “substantial” benefits for corticosteroid administration. The remaining 26 interventions had “undetermined” or “zero/negative” benefit. The quality of the evidence was rated “fair”7 (30 interventions) or “poor” (5 interventions). The authors concluded that “neither preterm delivery nor intrauterine growth restriction can be effectively prevented with existing tools for risk assessment, health promotion, and medical and psychosocial interventions, and that the enrollment of all pregnant women in prenatal care, in its present form, is unlikely to result in a dramatic reduction in low birth weight” (Lu et al., 2003, p. 371).

The expert panel of 1989 recommended stratifying women based on their risk for adverse maternal and fetal outcomes, such that the frequency, timing, and content of prenatal care could be tailored appropriately. However, the evidence indicates that the frequency and content of prenatal care have not been risk stratified; frequency increased among women of all levels of risk between 1985 and 2004 (Krans and Davis, 2012). There is consensus among ACOG, the World Health Organization, and the Institute for Clinical Systems Improvement that women should

---

6 The study used a four-point scale adopted by the U.S. Preventive Services Task Force: “substantial,” “moderate,” “small,” and “zero/negative.”

7 The study used the classification adopted by the U.S. Preventive Services Task Force to rate the quality of evidence as “good,” “fair,” or “poor.”
receive a comprehensive risk assessment at their first prenatal visit, and that the frequency of visits thereafter should be determined by her needs and her medical and psychosocial risks (Krans and Davis, 2012). Based on rigorous evaluations, these organizations have endorsed reduced-frequency schedules for low-risk women. For high-risk women, the expert panel recommended more frequent and intensive prenatal visits coupled with psychosocial services, such as home visiting, care coordination or management, and group prenatal care.

Enhanced Prenatal Care

Several approaches to augment standard prenatal care are being used to attempt to improve maternal and infant outcomes, though current evidence is very limited. Three of these approaches, group prenatal care, maternity care homes, and freestanding birth centers, are being tested and evaluated as part of the Center for Medicare and Medicaid Innovation’s (CMMI’s) Strong Start for Mothers and Newborns Initiative in order to increase the evidence base.

- **Group prenatal care**, through programs such as the well-known CenteringPregnancy, typically groups 8 to 12 pregnant women to deliver prenatal care through ten meetings, which also include group discussions about health, nutrition, childbirth preparation, stress reduction, parenting, personal relationships, and other topics. Meetings may last 90 minutes to two hours. Evaluators of the Strong Start initiative, which implemented and evaluated the CenteringPregnancy approach, identified 11 studies that report on its impact on birth weight or gestational age (Hill et al., 2016). Four studies found a statistically significant reduction in the rate of preterm birth, and three showed a positive impact on birth weight; the other studies did not observe an impact on birth outcomes.

- **Maternity care homes**, based on the patient-centered medical home model, aim to provide high-quality, patient-centered, and coordinated prenatal and postpartum care. The model is relatively new and has not been implemented consistently, so there are few studies of the effectiveness of this approach on birth or infant outcomes (Hill et al., 2016).

- **Freestanding birth centers**, typically directed by midwives, provide comprehensive prenatal, delivery, and postpartum care (Hill et al., 2016). Generally, women are provided with substantial education and psychosocial support through longer visits, peer counseling, or dedicated educational sessions with a midwife. Although there is limited research on the impact of birth centers, substantial research does exist on midwife-provided care across settings. A 2016 systematic review of 15 studies on midwife-led models of care found that women receiving this care had lower rates of preterm birth (8 studies) and of loss of the baby from 24 weeks of pregnancy to 7 days after birth (13 studies). Women also had higher rates of spontaneous vaginal birth (12 studies). There were no differences in the rate of cesarean births between the intervention and control groups (Sandall et al., 2016). These studies of midwife-provided care were not limited to
women enrolled in Medicaid, thus the Strong Start evaluation may contribute to the evidence base for this population.

*Continuous Birth Support and Birth Doulas*

A 2012 Cochrane review of 22 trials in 16 countries (19 U.S. studies) found that women who received one-on-one continuous emotional support during labor were more likely to have a spontaneous vaginal delivery and less likely to have a cesarean or instrumental vaginal birth, epidural analgesia, or a baby with a low Apgar score at five minutes. Further, the continuous support was most effective when the support provider was part of neither the hospital staff nor the woman’s social network—for example, a doula (Hodnett et al., 2012). Stronger effects were observed for women who were low income or socially disadvantaged or who faced cultural or language barriers to care (Hodnett et al., 2012). There was no impact detected on neonatal complications (Hodnett et al., 2012).

*Early Elective Delivery Reduction*

ACOG recommends the restriction of elective term delivery to women with a confirmed gestational age of at least 39 weeks unless it is justified by a medical or obstetric complication (ACOG, 2009). Clark, Miller, and colleagues (2009) found that most early elective deliveries are for convenience and result in significant short-term neonatal morbidity with neonatal intensive care unit (NICU) admission rates of 13 to 21 percent. Babies born between 37 and 39 completed weeks are at increased risk of early death and feeding and breathing problems (Tita et al., 2009; Reddy et al., 2011).

While early elective deliveries take place in medical settings, interventions to reduce their incidence have been implemented at the national, state, local, and health system levels. In 2008, the Joint Commission introduced, and the National Quality Forum endorsed, a hospital quality measure for which hospitals must report their rate of early elective deliveries (Joint Commission, 2019). A 2010 study from Clark, Frye, and colleagues examined the success of three hospital-based approaches to reducing early elective deliveries:

- a “hard stop” approach that prohibited early elective inductions and primary and repeat cesarean deliveries at less than 39 weeks of gestation that was enforced by hospital staff members
- a “soft stop” approach in which compliance was left up to individual physicians
- an “education only” approach that involved the provision of available literature to attending physicians and both internal and professional association recommendations against the practice.

Across all approaches, there was a reduction in the rate of elective deliveries between 37 and 39 weeks from 9.6 to 4.3 percent of all deliveries. The “hard stop” approach led to the largest decrease in elective early term delivery.
In South Carolina, the Birth Outcomes Initiative\textsuperscript{8} reduced the rate of early elective deliveries by 50 percent between 2011 and 2013 through a multifaceted effort. It launched a public education campaign in which health care leaders and providers received a toolkit and attended a series of educational workshops. Additionally, all 43 birthing hospitals in the state signed a pledge to stop early elective deliveries. In the next phase, both Medicaid and Blue Cross Blue Shield (which together paid for 85 percent of births in the state) instituted a policy of nonpayment for early elective deliveries for both physicians and hospitals (Perelman, Delbanco, and Johnson, 2013). It is not possible to isolate the effects of education and payment changes in this multipronged effort to reduce early elective deliveries.

The Ohio Perinatal Quality Collaborative identified early elective delivery as a target for a quality improvement initiative to decrease infant mortality in 2008. A study of 20 hospitals participating in the initiative showed that early elective deliveries without a documented medical indication decreased from more than 15 percent in 2008 to less than 5 percent in 2010 (Kaplan et al., 2015). Interventions used by the hospitals included promotion of early ultrasound; adherence to ACOG criteria for the indication and timing of scheduled births; an educational campaign for pregnant women, nurses, and physicians of the risks and benefits of births between 36 and 38 weeks; improved communication between obstetricians and pediatricians; and inclusion of avoidance of early scheduled births as part of an overall culture of safety.

Table 3 summarizes the current evidence on interventions to reduce infant mortality in medical settings.

\textsuperscript{8} The leadership of the Birth Outcomes Initiative included the South Carolina Hospital Association, the provider community, Blue Cross Blue Shield of South Carolina, the March of Dimes, the South Carolina Department of Health and Environmental Control, and academic institutions.
Table 3. Evidence for Medical-Setting Interventions

<table>
<thead>
<tr>
<th>Medical-Setting Interventions</th>
<th>Summary of Evidence</th>
</tr>
</thead>
</table>
| Preconception/interconception care                     | • Strong evidence for improved birth outcomes for many of the individual components of preconception care (e.g., folic acid supplementation, vaccination, and diabetes management), but limited evidence on the effectiveness of preconception care as a package of screenings and services on birth or infant outcomes  
  • No evidence on the effectiveness of reproductive life planning on birth or infant outcomes                                                            |
| Prenatal care                                          | • Varying levels of evidence of the impact of individual components of prenatal care on low birth weight and preterm birth, including “small” net benefits for smoking cessation interventions, cerclage, progesterone supplementation, antibiotic treatment for asymptomatic bacteriuria and bacterial vaginosis, and Doppler assessment; “moderate” benefits for tocolytic therapy with concomitant corticosteroids and WIC evaluations; and “substantial” benefits for corticosteroid administration  
  • In terms of dosage, evidence for more frequent and intensive visits coupled with psychosocial supports for high-risk women and less frequent visits for low-risk women |
| Enhanced prenatal care                                 | • Group prenatal care: Emerging evidence of the effectiveness of group prenatal care using the CenteringPregnancy approach on low birth weight and preterm births  
  • Maternity care homes: Few studies on the effectiveness of maternal care homes on birth or infant outcomes since this model is new and has not been implemented consistently  
  • Birth centers: Few studies on the impact of birth centers on birth outcomes and some evidence on the effect of prenatal care provided by midwives on preterm births                                                                                                                  |
| Continuous birth support and birth doulas              | • Strong evidence that continuous support during labor results in lower risk of cesarean and lower Apgar scores, particularly when support provided by a doula  
  • No evidence on impact on infant mortality                                                                                                                   |
| Early elective delivery reduction                      | • Some evidence of successful strategies to reduce early elective deliveries such as strict hospital enforcement of the policy                                                                                                                                                                                                                   |

Health Promotion and Education

Health promotion and education strategies to reduce the underlying causes of infant mortality aim to change the knowledge, attitudes, and behaviors related to reproductive health. Activities
to support these strategies may take place in group or one-on-one arrangements and may occur in a variety of settings, including community-based organizations and medical settings.

*Home Visiting Programs*

Home visiting programs typically include services for families such as direct education, screening and assessments, and referrals to resources. They may be focused on young children, children with special health care needs, parents of young children, or the relationship between children and parents. Prenatal home visiting programs may address tobacco, alcohol, or illegal drug use, as well as behavioral issues that affect the risk of preterm or low birth weight infants, such as nutrition, sufficient use of prenatal care, and recognition of potential complications of pregnancy (Olds, 2002).

Prenatal home care programs differ in the services provided and in the types of providers making the visits and their expertise; studies of these programs have reported mixed results. Although studies of nurse prenatal home visiting programs have shown positive impacts in some areas, including the use of prenatal care (Issel, 2011) and a reduction in pregnancy-induced hypertension, few studies have demonstrated a positive effect on pregnancy outcomes (Gomby, Culross, and Behrman, 1999; Ciliska et al., 2001; Olds, 2002; Issel, 2011). In a study from Olds and colleagues (1986), prenatal nurse visitation had a positive effect on birth weight and gestation length for women under 17 and those who are smokers. In a more recent study of high-risk women having their first child, participation in a home visiting program was associated with a 60-percent decline in infant deaths; the largest association was seen among black infants (Donovan et al., 2007).

In a 2001 randomized trial, advanced practice nurses provided half of the prenatal visits at the homes of 173 high-risk black women (Brooten et al., 2001). In addition to addressing health behaviors and providing education, the nurses conducted assessments of vital signs and fetal heart rate, electronic monitoring of uterine and fetal activity, and nonstress testing to check the baby’s movement, heartbeat, and contractions. Providing care in the home removed barriers to obtaining prenatal care such as transportation, childcare, and missed work associated with time spent getting to appointments. The study observed a significant difference in fetal and infant mortality between the intervention and control groups (2 percent versus 9 percent), and the intervention group had 11 fewer preterm infants and 6 fewer infants born at less than 29 weeks’ gestation compared with the control group, though the difference was not statistically significant (Brooten et al., 2001).

Several more recent studies have found positive effects on birth outcomes. A peer-reviewed 2017 study of birth outcomes among women participating in the Nurse-Family Partnership9

---

9 The Nurse-Family Partnership model utilizes trained nurses to visit first-time mothers starting from early in the pregnancy through the child’s second birthday.
model found a significantly lower incidence of preterm births for Nurse-Family Partnership clients compared with matched controls (8.7 percent versus 12.3 percent, respectively; \( p < .0001 \)) (Thorland and Currie, 2017). An evaluation of a population-based enhanced prenatal care program that offered home visiting to all Michigan Medicaid-eligible pregnant women and infants until age one observed significant reductions in infant mortality for participating women compared with similar nonparticipants. The effects of the Michigan program were larger among black women (Meghea et al., 2015).

An independent large-scale study that is currently under way intends to update previous research and provide more reliable results through rigorous study design. The Mother and Infant Home Visiting Program Evaluation—Strong Start is evaluating the effectiveness of the Nurse-Family Partnership and Healthy Families America for improving prenatal and birth outcomes for families enrolled in Medicaid or the Children’s Health Insurance Program. The 2012 to 2017 evaluation is part of the CMMI’s Strong Start for Mothers and Newborns Initiative.

**Safe Sleep Education**

Safe sleep education to prevent SIDS and other sleep-related deaths typically consists of information guiding caregivers to place the baby on a firm surface on his or her back for sleeping; avoid soft bedding; avoid cosleeping; have infants share a bedroom with parents for the first six months to one year; avoid exposing the baby to smoke, alcohol, and other illicit drugs; breastfeed; provide immunizations; and provide a pacifier (Task Force on Sudden Infant Death Syndrome, 2016). This instruction may be provided one on one by hospital staff, pediatricians, home visitors, doulas, or first responders; as part of the curriculum of group prenatal care or prenatal classes; or through public service campaigns.

Utilizing the media and other avenues to conduct outreach and education is an effective means of providing messaging about safe sleep guidelines (Task Force on Sudden Infant Death Syndrome, 2016). Safe sleep educational campaigns have been implemented nationally, statewide, and locally. Back to Sleep, a national SIDS-reduction education campaign initiated in 1994 by a coalition led by the National Institute of Child Health and Human Development, promoted safe sleep environments and positions for infants. It provided education for both families and pediatricians about placing babies on their backs when putting them to sleep. Messaging was adjusted over time in response to new research and guidelines from the AAP, and new media were deployed. In the five years after the initiation of the Back to Sleep campaign, the overall SIDS rate in the United States dropped over 50 percent and infant back sleeping more than doubled, but the SIDS rate plateaued after 2009 (National Institute of Child Health and Human Development, n.d.). The campaign was expanded and renamed Safe to Sleep in 2012 and continues today with a focus on higher-risk populations.

Promoting safe sleep is one of the core focus areas for Collaborative Improvement and Innovation Network (CoIIN); the network’s goal was to decrease unsafe infant sleeping practices by 5 percent. To reach this goal, CoIIN focused on improving infant caregiver knowledge,
attitudes, beliefs, and practices. In addition, it formed strategic alliances and standardized safe sleep education training within provider systems (Ghandour, 2013). For example, CoIIN affiliates also encourage modeling safe sleep practices in hospitals, especially NICUs. Parents are counseled, and NICUs reinforce the counseling through cards placed on cribs that describe the babies’ sleep positioning to encourage new parents to use the same techniques at home (National Institute for Children’s Health Quality, 2015). Research has shown that most parents will model the behavior of the hospital staff with their babies at home (National Institute for Children’s Health Quality, 2015).

Another intervention that is increasingly being promoted to prevent SIDS is pairing safe sleep education with the distribution of baby boxes or portable cribs, usually through hospitals. Baby boxes are kits for infants that typically include a box, mattress, bedding, and diapers. Different states and localities operate the program differently, with some offering the boxes to all families and others offering them to low-income families only (National Institute for Children’s Health Quality, 2016). Along with the box, distributors provide standardized educational materials about safe sleep techniques. In Finland, baby boxes were introduced in 1938 and initially were offered only to low-income women. Starting in 1949, every pregnant mother who had a prenatal visit by the fourth month of pregnancy was given a baby box filled with baby products and instructions on how the box can be used as a bed (H. Lee, 2013). Infant mortality rates fell from 65 deaths per 1,000 live births in 1938 to 2.52 per 1,000 in 2015 (National Institute for Children’s Health Quality, 2016), and some have attributed this decline in part to the boxes. However, it is important to note that other factors, such as an increase in prenatal care, home visiting, and the introduction of national insurance, likely contributed to the reduction as well.

A recent study measured the impact of a mobile health intervention and a nursing-quality intervention on adherence to infant safe sleep practices. The nursing intervention consisted of education and role modeling at the hospital before discharge. The mobile health intervention provided email or text messages and educational videos that were delivered at times when issues with safe sleep typically arise. The study found the mobile health intervention improved adherence to four safe sleep practices compared with a control intervention, but the nursing intervention did not (Moon et al., 2017).

**Accident Prevention**

Suffocation accounts for the majority (84 percent) of accidents among infants (CDC, n.d.a.), and prevention is typically addressed as part of safe sleep education. Other types of injuries, such as motor vehicle accidents in which the infant is a passenger (6.8 percent), drowning (3.3 percent), burns (1.3 percent), falls (1.0 percent), and poisoning (0.7 percent), may be addressed by pediatricians during well-child visits, as part of parenting education delivered by home visitors in the prenatal or postpartum period, or through other parenting programs.
There is limited evidence on the efficacy of home visiting for accident prevention. In a systematic review of eight randomized controlled studies examining the impact of home visiting on childhood injury, six showed a lower rate of injury in the group that had home visitors (Roberts, Kramer, and Suissa, 1996). In a subsequent review that included studies of the impact of home visiting and pediatrician-based education on accident prevention, families receiving the interventions had a lower risk of injuries (Kendrick et al., 2008). Most of the studies were evaluating multifaceted interventions for families considered to be at risk for adverse child outcomes.

**Childbirth Education**

Childbirth classes are typically intended to prepare expectant women and their partners for labor and delivery and to ease anxiety about the birth process. They vary in their specific aims, content, length, and delivery mode, and evidence on a best method is lacking (Gagnon and Sandall, 2007). Two systematic reviews found that the existing studies of childbirth education are so different and methodologically flawed that no conclusions can be drawn about its effect on a range of outcomes measured (Koehn, 2002; Gagnon and Sandall, 2007).

Table 4 summarizes the evidence base for health promotion and education interventions discussed in this section.

**Table 4. Evidence for Health Promotion and Education Interventions**

<table>
<thead>
<tr>
<th>Health Promotion and Education</th>
<th>Summary of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home visiting programs</td>
<td>Mixed evidence of the effectiveness of home visiting programs, with some evidence of positive effects on birth weight, preterm births, and infant deaths for nurse home visitation programs</td>
</tr>
<tr>
<td>Safe sleep education</td>
<td>No studies that isolate the effectiveness of a particular intervention on infant outcomes, but some evidence of positive effects on safe sleep knowledge and practices and some evidence of the effectiveness of public education campaigns to increase back sleeping and change smoking behavior</td>
</tr>
<tr>
<td>Accident prevention</td>
<td>No studies that isolate the effectiveness of a particular intervention on infant outcomes, but some evidence of the effectiveness of parent education delivered during home visits on reducing accidental injuries</td>
</tr>
<tr>
<td>Childbirth education</td>
<td>Inconclusive evidence on the effectiveness for easing anxiety or pain or for improving breastfeeding, infant, or birth outcomes</td>
</tr>
</tbody>
</table>
Support and Referrals

Most interventions that use support and referrals can be offered by community-based organizations; others can be provided within a medical-care setting.

Care Coordination

Maternity care coordinators typically help pregnant women access services that address medical, nutritional, psychosocial, and resource needs. They often provide social and emotional support, which may reduce stress and encourage healthy behaviors. Care coordination may be provided by health plans, social workers embedded in clinics, or other supportive service providers such as doulas.

Several studies have demonstrated the positive effects of maternity care coordination programs on birth outcomes for low-income women (Buescher et al., 1991; Van Dijk, Anderko, and Stetzer, 2011; Hillemeier et al., 2015). Results include reductions in low birth weight, preterm delivery, infants transferred to the NICU, infant mortality, and medical costs. Two studies examined the effect of the amount of coordination service delivered. In one study, women who received maternity care coordination for three or more months had better outcomes than those receiving it for less than three months (Buescher et al., 1991). In the other study, women who received six or more hours of service were less likely to deliver infants with poor birth outcomes (Van Dijk, Anderko, and Stetzer, 2011).

The Pathways Community Hub, an innovative program launched in several counties in Ohio, offers centralized referral and coordination for health and social services to pregnant black women living in communities with poor birth outcomes. The Hub is a network of all the participating county care coordination agencies. It assigns one community health worker to reach out to each participant; assesses the woman’s health, social, and financial risk factors; and connects her to resources through “pathways.” Outcomes of the pathways are tracked, and funding is tied to the pathway outcomes, as well as specific health and social service outcomes (Hostetter, Klein, and McCarthy, 2017). A small study of the program implemented in Richmond County, Ohio, found that pregnant women who participated had a significantly lower probability of delivering a low birth weight infant (Redding et al., 2015).

Pregnancy and Postpartum Support

Doulas (Prenatal and Postnatal)

As noted earlier, doulas are trained in childbirth and may provide emotional, physical, and educational support to women before, during, and after childbirth (Kozhimannil et al., 2016). In the prenatal period, doulas typically work with the pregnant mother to develop a birth plan and address questions and concerns. A postpartum doula may provide information and support for things such as infant feeding, emotional and physical recovery from birth, mother-baby bonding, infant soothing, and basic newborn care.
Evidence regarding the value of a doula is primarily associated with the labor and delivery phase (see the earlier Continuous Birth Support and Birth Doulas section); however, some evidence regarding a broader role for doulas is also emerging. A 2016 study of doula-supported births among Medicaid beneficiaries in Minnesota found that, compared with a large multistate cohort of Medicaid births, women who had doula support in the prenatal period had 22-percent lower odds of preterm birth and a cost savings of almost $1,000 per birth as a result of lower preterm birth rates and fewer cesarean sections (Kozhimannil et al., 2016). The extent to which birth or infant outcomes might be related to the relationship building and planning for birth that occurs before labor and to a resulting reduction in maternal stress is not known.

Several cities, including Baltimore and New York, have adopted doula programs to address disparities in infant mortality rates (Ollove, 2017). In Baltimore’s program, doulas are also trained to connect women to housing, transportation, nutrition, and employment services. The New York program, started in 2010 in Brooklyn, has trained 68 doulas who have attended 580 births. While the cities typically pay the cost of the training, New York and Baltimore do not pay the cost of hiring the doulas, which can range from $100 to $5,000. Insurance coverage for doula services is uncommon, though a small number of doula agencies have contracted with individual Medicaid managed care organizations and other health plans to cover doula services (Strauss, Sakala, and Corry, 2016).

Mobile Health and Digital Platforms

Technology-based support programs may include automated texts or access to specialized applications that provide information about pregnancy and resources. For example, Text4baby, started in 2010, is a free service that sends three texts per week, timed to the pregnant woman’s due date or baby’s birth date, through the baby’s first birthday. The application had reached over 685,000 mothers from its launch through 2016 by partnering with over 1,400 national, state, and local organizations; health plans; health care providers; and Medicaid navigators (Text4baby, n.d.).

In an evaluation of Text4baby funded by HRSA, low enrollment in the study made it challenging to assess the effectiveness of the program, particularly its effect on health behaviors and outcomes (HHS, HRSA, 2015). However, the study did find that program participants were significantly more likely to report receiving information on high-priority health topics during pregnancy than women who had never heard of Text4baby. In addition, Text4baby participants demonstrated a significantly higher level of knowledge about safe sleep, infant feeding, and the best time to deliver in a healthy pregnancy than the two other groups of prenatal care users (i.e., women who had never heard of Text4baby, and women who had heard of Text4baby but did not sign up) (HHS, HRSA, 2015). Other studies have found that use of Text4baby changed beliefs about the importance of prenatal care and prenatal vitamins, as well as the risk of alcohol abuse (Evans et al., 2014). Studies have also observed some behavior changes among Text4baby users.
versus controls, including lower postpartum alcohol consumption (Evans et al., 2014) and improved rates of influenza vaccination (Jordan et al., 2015).

**Breastfeeding and Nutrition Support**

Breastfeeding and the provision of expressed breast milk are associated with a reduced risk of SIDS, and the protective effect increases when a mother breastfeeds exclusively (Task Force on Sudden Infant Death Syndrome, 2016). Support for breastfeeding can be provided through various programs and policies, such as local breastfeeding coalitions, WIC programs, hospital staff interactions with mothers, home visitors, and workplace facilitation (Association of Maternal and Child Health Programs [AMCHP], 2012).

The CDC has designated “workplace support” as one successful evidence-based breastfeeding intervention. Support may take the form of employee benefits and services such as providing designated space for breastfeeding or expressing milk, allowing flexible scheduling for expressing milk during work hours, providing high-quality breast pumps, and allowing women to telework (CDC, 2013). With the passage of the Patient Protection and Affordable Care Act, employers are required to provide space for breastfeeding (U.S. Department of Labor, 2018). Laws supporting breastfeeding in workplaces have also been passed in some states. For example, the North Carolina Office of State Personnel established a policy that provides state employees with paid break time for hourly workers, physical space for breastfeeding, and designated space for mothers for breastfeeding at childcare centers (AMCHP, 2012).

Consulting and peer support resources in communities may also play an important role in providing breastfeeding support (AMCHP, 2012). Breastfeeding coalitions are a major source of community support and can be found across the country. For example, the California Breastfeeding Coalition, an umbrella organization for regional coalitions in California that promote and support breastfeeding, provides information on promoting breastfeeding on its website, consults with hospitals, and organizes volunteers who disseminate breastfeeding promotion messages and advocate for legislation. Connecticut has a similar coalition with a similar mission; it also provides employer awards for breastfeeding-friendly businesses. Oklahoma operates the Oklahoma Breastfeeding Hotline, which is aimed at providing 24/7 support to mothers and health care providers by answering questions and directing people to resources (AMCHP, 2012). In Pennsylvania, the Keystone 10 Initiative, developed by the Pennsylvania Department of Health, helps the state’s hospitals and birth centers to improve the initiation, duration, and exclusivity rates of breastfeeding (Pennsylvania Department of Health, n.d.).

Programs that focus on healthy babies, such as CenteringPregnancy, also encourage breastfeeding; at least one session in the group prenatal care program is dedicated completely to breastfeeding education (Hill et al., 2016). Evaluations of the CenteringPregnancy program have found an increase in the rate of breastfeeding at hospital discharge (AMCHP, 2012). Women
who are enrolled in group prenatal care at birth centers are more likely to attempt breastfeeding and are more successful in following through with breastfeeding (Hill et al., 2016).

Strategies have been implemented in a variety of settings to support breastfeeding, with mixed evidence.

- **Peer counseling programs** have been shown to increase the rate and duration of breastfeeding among low-income women with term and preterm infants (Merewood et al., 2006).
- **Frequent home visiting** may increase the likelihood that mothers will breastfeeding, but this association is eliminated for women with alcohol and drug problems, regardless of the frequency of the visits or whether the visits were conducted by nurses (Turnbull and Osborn, 2012; Yonemoto et al., 2013).
- **Telephone interventions** focused on encouraging breastfeeding have inconclusive evidence for the impact on exclusive breastfeeding or breastfeeding duration (Lavender et al., 2013).
- **Providing breast pumps** through WIC and other programs to low-income women may support breastfeeding (AMCHP, 2012), but there is insufficient evidence of the effectiveness of this kind of effort.

Last, milk banks increase access to breast milk for infants whose mothers are unable to provide all or a portion of the breast milk their babies need. Banked donor milk is distributed by prescription or hospital order only and is typically provided to preterm or medically fragile infants. The Human Milk Banking Association of North America, established in 2005, accredits nonprofit milk banks and provides guidelines for screening, processing, and distribution. There are 22 association-affiliated milk banks in the United States, including one in Pittsburgh. Studies have shown that the use of banked donor milk is associated with lower rates of both infections and necrotizing enterocolitis in the NICU compared with formula (Quigley et al. 2007; Kantorowska et al., 2016) and with higher rates of exclusive maternal breastfeeding at discharge (Arslanoglu et al., 2013; Kantorowska et al., 2016; Parker et al., 2016).

**Behavioral Health Services**

Behavioral health services for pregnant women may include psychosocial services or medication to address depression, anxiety, bipolar disorder, schizophrenia, and substance use, including of tobacco, alcohol, and illegal drugs.

**Mental health.** Psychosocial treatments, including cognitive behavioral therapy and interpersonal therapy, have been shown to be effective in treating depression in pregnant women (Yonkers et al., 2009). The treatment of pregnant women with psychotropic medication involves weighing the relative risks of exposing the neonate to the medication and the risks associated with a relapse of maternal mental illness if treatment is discontinued during pregnancy. Reviews of the literature examining the risk of depression during pregnancy point to a lack of studies
assessing birth outcomes for mothers medicated for depression during pregnancy compared with those with unmedicated depression (Davalos, Yadon, and Tregellas, 2012).

**Tobacco.** A 2017 systematic review produced moderate- to high-quality evidence on the effectiveness of psychosocial interventions on smoking cessation in pregnancy (Chamberlain et al., 2017). It found that the interventions decreased the number of women smoking late in pregnancy by 35 percent, increased mean infant birth weight by 56 grams, reduced the number of low birth weight babies by 17 percent, and reduced the number of NICU admissions immediately following birth by 22 percent. Of the interventions studied, counseling had the largest effect, while the effects of health education and social support were less clear. One such intervention, the Smoking Cessation and Reduction in Pregnancy Treatment Program, is an evidence-based method meant to be integrated into routine prenatal care (Society of Public Health Educators, n.d.). It is being utilized by CoIIN teams in Alaska and Florida for women in rural or low-income households.

**Alcohol and illegal drug use.** Behavioral health treatment programs that address drug and alcohol addiction among pregnant women vary in setting (inpatient versus outpatient), intensity, and treatment components, and the findings on the effectiveness of various types of programs are mixed. We briefly review evidence on several types of interventions.

- **Brief behavioral interventions**, which include motivational interviewing, contingency management, and cognitive behavioral therapy, may take place in an outpatient setting but may also be incorporated into inpatient treatment programs. Motivational interviewing has been shown to be effective in decreasing alcohol use and smoking among pregnant women and in improving pregnancy outcomes (SAMHSA, 2017). Contingency management uses incentives to reward the completion of tasks related to treatment. Several randomized control trials have found this approach to be effective for smoking cessation. Contingency management has also demonstrated the most success among motivational interviewing and psychosocial interventions in prenatal cocaine cessation (SAMHSA, 2017). While cognitive behavioral therapy has been shown to be effective with individuals who use substances, there is little research evaluating its use as a treatment for pregnant women.

- **Medication-assisted interventions** are recommended for pregnant women with opioid use disorder, including women who misuse or abuse heroin and prescription opioids. Methadone and buprenorphine have been found to be equally effective for pregnant and postpartum women, in terms of treatment retention and illicit opioid use reduction, and both are more effective than placebos (SAMHSA, 2017). Additionally, current research does not show an increased risk of birth defects associated with pregnant women receiving buprenorphine or methadone (SAMHSA, 2018). As of this writing, there are no evidence-based medication-assisted treatments for cocaine use disorder available.
• **Psychosocial interventions** may be needed in addition to brief behavioral interventions and medication and may be coupled with case management and assistance with housing, transportation, childcare, and employment services.

• **Intensive outpatient treatment** provides women 9 to 30 contact hours per week with medical services, health promotion, psychoeducation, mental health services, and other services. A 2015 review of studies of psychosocial interventions delivered to pregnant women in outpatient drug treatment programs found that few studies captured neonatal outcomes. Among those that did, they did not observe a difference in preterm births or birth weight versus controls (Terplan et al., 2015).

• **Residential and inpatient treatment** may provide care in halfway houses, inpatient settings, and recovery homes with specialized care for pregnant women that may include prenatal care, nutrition services, transportation to appointments, childbirth education, mental health services, and education about alcohol and drug use during pregnancy (SAMHSA, 2017). A 2004 nationwide review of residential programs found treatment success (posttreatment abstinence from further drug or alcohol use, measured through in-person follow-up interviews conducted 6 to 12 months after each client’s discharge) of 68 to 71 percent for women who stayed in treatment 6 months or longer. There were strong associations between length of stay in treatment and posttreatment rates of abstinence from further drug or alcohol use in each of the studies reviewed (SAMHSA, 2017).

**Family Support**

A review of eight studies of social support during pregnancy suggests that support from partners benefits expectant mothers in terms of enabling better psychological and physical well-being and may be related to increased gestational age (one study) and birth weight (one study); two studies showed no association with birth outcomes (Feldman et al., 2000). There is also some evidence that support for pregnant black women from their mothers may increase gestational age at delivery and reduce maternal complications from delivery (Feldman et al., 2000).

Programs encouraging father or spouse support during pregnancy typically use peer-based strategies, such as having males as home visitors or community health providers to engage at-risk fathers or create opportunities for men to discuss lessons learned and give advice to others (Ohio Collaborative to Prevent Infant Mortality, 2015). A program called Family Foundations uses another approach to providing support during pregnancy and improving birth outcomes by reducing maternal stress and depression. It is a transition-to-parenthood program for first-time expectant couples that consists of a series of classes, half of which take place before birth (Feinberg et al., 2015).

Table 5 summarizes the evidence base for interventions that offer support and referral services.
Table 5. Evidence for Support and Referral Interventions

<table>
<thead>
<tr>
<th>Support and Referrals</th>
<th>Summary of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Care coordination</td>
<td>Emerging evidence of the effectiveness of maternity care coordination on birth weight, preterm births, NICU stays, and infant mortality</td>
</tr>
</tbody>
</table>
| Pregnancy and postpartum support | Limited evidence on the effectiveness of prenatal or postnatal doula support on birth or infant outcomes  
                                      | No studies on the effectiveness of pregnancy or postpartum support provided through mobile health or digital platforms on birth or infant outcomes; some limited evidence of positive effects on risk behaviors such as alcohol use, vaccination, and unsafe sleep practices |
| Breastfeeding and nutrition support | Breastfeeding support: No studies on the effectiveness of breastfeeding support strategies or programs on infant outcomes; some limited evidence of positive effects of breastfeeding support strategies or programs  
                                      | Donor milk banks: Some evidence of lower rates of infection and necrotizing enterocolitis and higher rates of breastfeeding |
| Behavioral health services | Brief behavioral interventions: No studies on the effectiveness of brief behavioral interventions on birth or infant outcomes; some evidence of positive effects on alcohol and drug use  
                                      | Medication-assisted interventions: Strong evidence of the effectiveness of medication-assisted interventions on birth weight and preterm births; also strong evidence of positive effects on retention in treatment and reducing opioid use  
                                      | Psychosocial interventions: Few studies and no evidence of the effectiveness of psychosocial interventions on birth or infant outcomes, but some evidence of positive effects on abstinence and depression |
| Family support             | Mixed evidence of the effectiveness of family support on birth or infant outcomes  
                                      | Emerging evidence that support from husbands or fathers has a positive effect on maternal stress and depression |

Policy Interventions

Many policy interventions may affect the underlying factors that contribute to infant mortality. At the national and state levels, for example, legislative or regulatory changes such as contraceptive coverage mandates or required paid maternity leave can address socioeconomic determinants of health, as can funding decisions for programs such as the Title V Maternal and Child Health Services Block Grant program. State or local laws such as bans on indoor smoking could also have an impact. In this section we describe three other types of specific policy interventions.
Perinatal Regionalization

Perinatal regionalization is a strategy to improve maternal and perinatal outcomes by establishing systems of state health departments, hospital networks, and nonprofit groups that designate where infants should be born or transferred to be born, based on the level of care mothers and infants need at birth (Association of State and Territorial Health Officials, 2014). Levels of maternal care have also been proposed by the ACOG and the Society for Maternal-Fetal Medicine. Regionalized systems assign risk-appropriate levels (I through III) to hospitals to ensure that facilities have the appropriate technology and specialized health care providers.

- Level I hospitals provide basic, uncomplicated neonatal care.
- Level II hospitals care for moderately ill infants.
- Level III hospitals are equipped to handle serious neonatal illnesses and abnormalities, including very low birth weight.

A 2010 meta-analysis found that, for very low birth weight (<1,500 g) and very preterm (28 to 32 weeks) infants, birth outside a Level III hospital is significantly associated with increased likelihood of neonatal or predischarge death (Lasswell et al., 2010). The Maternal and Child Health Bureau set a national goal for at least 90 percent of very low birth weight infants to be born in a facility for high-risk neonatal care (Lasswell et al., 2010).

Regionalization has been pursued since the 1970s, with varying levels of success. The CDC recently conducted a study of perinatal critical care to determine where there are gaps in access to appropriate care for mothers and infants (Brantley et al., 2017). While most women had access to Level III care, there was significant variation in access by state and region because most Level III facilities are in urban areas. Also, for about 10 percent of women, the closest access to critical care is in a neighboring state. The study found that access to obstetric critical care lags behind access for neonatal critical care at a time when the increase in chronic health conditions among childbearing-age women is increasing the demand for these services.

Several evaluations of the impact of perinatal regionalization were conducted in the 1980s, including an evaluation of an eight-site, five-year demonstration program. While the study found that the speed of regionalization was closely correlated with the rate of decline in infant mortality, comparable regionalization in the control areas prevented the detection of an effect (McCormick and Richardson, 1995). Another program, focused on improving care in ten rural sites by improving communication with tertiary centers, resulted in improved neonatal outcomes (McCormick and Richardson, 1995).

Enhancing perinatal regionalization is one of the priorities of CoIIN, and the collaborative has been supporting states in this work. As part of Missouri’s participation in CoIIN, the state is moving away from hospitals self-designating their level of care and is establishing a formal designation process through a regional system (National Institute for Children’s Health Quality, 2016). In Illinois, researchers found that, in 2014, only 81 percent of very preterm infants were delivered in Level III hospitals, and that only 56 percent of the 476 very preterm infants born
outside Level III hospitals were transferred within 24 hours of delivery. The Illinois network is focused on educating health care providers and raising patient awareness of nearby hospitals and their designation. For states with large rural populations, telemedicine and formal agreements with higher-level facilities in neighboring states may be alternatives to help increase access (Brantley et al., 2017).

**Expanded Insurance Coverage**

Expanded insurance coverage involves increasing the number of individuals eligible for coverage or expanding the benefits provided to already-covered individuals. Expansion of Medicaid coverage to additional low-income pregnant women to improve access to health care services is one approach that has been taken in an attempt to improve birth outcomes. Substantial literature shows increased access to care and use of perinatal care by women covered by Medicaid compared with uninsured individuals. However, the evidence about the impact on birth outcomes has been mixed (Howell, 2001; Marquis and Long, 2002).

Before the passage of the Patient Protection and Affordable Care Act in 2010, states were required to provide Medicaid coverage to pregnant women with incomes up to 133 percent of the federal poverty level and cover them up to 60 days postpartum (Gifford et al., 2017). The implementation of the act offered a unique opportunity to evaluate the impact of expanding Medicaid eligibility and benefits on birth outcomes on a large scale. The law gave states the ability to expand Medicaid eligibility by offering continuous coverage to individuals with a family income at or below 138 percent of the federal poverty level and it required Medicaid to cover “essential health benefits,” including pregnancy, maternity, pediatric care, chronic disease management, breastfeeding support, contraception, mental health and substance abuse screening and treatment, and other behavioral health services. States that expanded Medicaid were therefore able to provide coverage and services beyond the postpartum period, when women typically lost coverage.

A 2018 study comparing infant mortality trends in Washington, D.C., and the 31 states that adopted the expansion with trends in the 19 states that did not expand Medicaid found that the rate of infant mortality declined from 5.9 to 5.6 per 1,000 live births in Medicaid expansion states and rose from 6.4 to 6.5 in the nonexpansion states from 2014 to 2016. Further, the infant mortality declines in Medicaid expansion states were greater for black infants (Bhatt and Beck-Sagué, 2018). The study could not identify which features of Medicaid expansion accounted for the decrease in infant mortality. The study authors speculate that one feature may be access to prescription contraception, leading to a decline in unplanned pregnancies that are associated with increased infant mortality risk (Bhatt and Beck-Sagué, 2018).

**Income Supplements for Pregnant Women**

Low-income women are at high risk for stress, poor nutrition, and smoking or drinking during pregnancy, and they are more likely to have preterm births or low birth weight babies
(Blumenshine et al., 2010). Providing free supports, such as WIC, and free health insurance, such as Medicaid, to low-income pregnant women are policy approaches utilized in the United States. Another potential policy to improve birth outcomes is to increase the income of pregnant women living in poverty. The province of Manitoba, Canada, implemented such a policy in 2001. The Healthy Baby Prenatal Benefit provides to very low-income women an unconditional payment of up to Can$81/US$64 per month during the second and third trimesters of pregnancy, representing a nearly 10-percent increase in income for participating women (Brownell, Chartier, et al., 2016). A quasi-experimental retrospective cohort study comparing the outcomes of those who received the Healthy Baby Prenatal Benefit and those that did not among 16,557 women receiving welfare found that the benefit was associated with reductions in low birth weight births, preterm births, and small-for-gestational-age births; shorter hospital stays for infants born vaginally; and increased breastfeeding initiation (Brownell, Chartier, et al., 2016). All women who received welfare benefits during pregnancy were eligible for the benefit, but not all women applied, which could affect the comparability between the two groups. An additional study found that the Healthy Baby Prenatal Benefit was associated with a reduced disparity in birth outcomes between low-income and higher-income women (those with annual incomes higher than the threshold of Can$32,000/US$25,340) (Brownell, Nickel, et al., 2018).

Table 6 summarizes the evidence for the policy interventions discussed here.

<table>
<thead>
<tr>
<th>Policy Interventions</th>
<th>Summary of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perinatal regionalization</td>
<td>Few studies on the impact of perinatal regionalization on birth and infant outcomes; in one large study, comparable regionalization in the control group prevented the detection of an effect</td>
</tr>
<tr>
<td>Insurance expansion</td>
<td>Significant evidence of the impact of insurance expansion on increased access to and utilization of care; mixed evidence of the impact on birth outcomes</td>
</tr>
<tr>
<td>Income supplements for pregnant women</td>
<td>Payment of unconditional income supplements to low-income pregnant women in Canada associated with positive birth outcomes</td>
</tr>
</tbody>
</table>

Summary of Interventions

Overall, there is limited evidence of direct, positive effects on birth and infant outcomes for interventions aimed at reducing the underlying causes of infant mortality. Among medical interventions, only group prenatal care has emerging evidence of effectiveness on birth outcomes. Research on the effectiveness of most of the health promotion and education efforts is
scarce, although there is some limited evidence of positive effects on certain risk behaviors known to lead to poor outcomes. Home visiting has been widely studied, with some evidence that programs using nurse visitors have positive effects on birth outcomes, but there is little evidence of the effectiveness of other types of home visiting programs. While some of the support and referral efforts have positive effects on behavior or knowledge, only care coordination has emerging evidence of effectiveness in improving birth and infant outcomes. The evidence is scarce or mixed for the policy interventions examined.

With the exception of a few of the interventions provided within a medical environment, most interventions can be delivered in multiple settings (Table 7). In addition to medical-setting interventions, health care providers can provide health education, support, and referrals for a wide range of issues. Private and public health plans can play a role across all intervention categories by reimbursing for different types of supports and services in various settings or by providing maternity-care managers. Community-based organizations can offer a wide range of programs, services, and supports across all intervention categories. Mobile technology can deliver pregnancy and postpartum support through digital platforms and applications. Within each intervention category, public awareness campaigns can deliver education messages to the community.

### Table 7. Interventions Available by Implementation Method

<table>
<thead>
<tr>
<th>Interventions</th>
<th>Health Care Provider</th>
<th>Health Plan</th>
<th>Community-Based Organization</th>
<th>Mobile Technology</th>
<th>Public Awareness Campaign</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medical-Setting Interventions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preconception/interconception care</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Prenatal care</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enhanced prenatal care</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doulas (birth)</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reduced early elective deliveries</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Health Promotion and Education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home visiting programs</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
### Interventions

<table>
<thead>
<tr>
<th>Interventions</th>
<th>Health Care Provider</th>
<th>Health Plan</th>
<th>Community-Based Organization</th>
<th>Mobile Technology</th>
<th>Public Awareness Campaign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe sleep education</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Smoke exposure education</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Accident prevention</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Childbirth education</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

#### Support and Referrals

<table>
<thead>
<tr>
<th>Support and Referrals</th>
<th>Health Care Provider</th>
<th>Health Plan</th>
<th>Community-Based Organization</th>
<th>Mobile Technology</th>
<th>Public Awareness Campaign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Care coordination</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pregnancy and postpartum support</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Breastfeeding and nutrition support</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral health services</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family support</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Timing of Intervention

With a wide array of underlying causes of infant mortality, the possible timing of intervention spans the period before pregnancy (preconceptual or interconceptual), the pregnancy itself (prenatal), the period from birth to 28 days (neonatal), and the period from 28 days to one year (postneonatal). The intervention timing for programs, services, and supports clusters in the prenatal and postnatal periods, with relatively few appropriate for delivery in the preconceptual period (Figure 7).
Potential Barriers to Engagement

For agencies and organizations serving at-risk populations, engagement can often be a challenge. Ideally, pregnant women would receive all of the planned contacts and sessions associated with a given program, but in many cases, establishing and maintaining engagement among those being served is a struggle. The difficulty of establishing and maintaining engagement has been frequently cited by local intervention leaders and community-based social service providers as a major concern and impediment to the effectiveness of the programs, services, and support being offered.

Issues around engagement in social services involve three main components: recruitment, retention, and participation. Each presents its own challenges. Recruitment, or the initial enrollment in the intervention, can be problematic because often the individuals most at risk of poor outcomes are also the least likely to seek care from health care providers or others who could refer or initiate contact with needed services. For example, many women—particularly
those at high risk of poor birth outcomes—are often unaware of the need for preconception or prenatal care (Mazza and Chapman, 2010). Retention, or maintaining contact and a minimum level of involvement in the intervention, can be challenging for a variety of reasons, such as a lack of friendship with other participants or program staff, outside influences that minimize the priority of the program for the participant, and potential mismatches between the needs of the individuals being served and the objectives of the program. These factors also influence participation, or the level of engagement in the program. Even if the programs make efforts to enhance accessibility for the individuals being served (e.g., conducting visits in the home rather than the office or meeting via telephone or video conference), competing priorities can lead to missed appointments (Asheer et al., 2014).

Recent research has begun to identify the characteristics of individuals who may struggle with engagement and changes that can improve engagement in the programs. Evidence suggests that families headed by a single mother are less likely to be retained in programs (Roggman et al., 2008) and that ethnicity or minority status is also related to attrition, with some groups more likely to engage with services while others are less likely (Brand and Jungmann, 2014).

Predicting who may not engage in programs, services, and supports is easier than improving engagement. Effective engagement strategies are often costly and involve close integration with a broader network of supports. The unique long-term needs of participants often cannot be addressed by a single program, so program staff must consider how best to link participants to necessary additional supports (Asheer et al., 2014). Studies of home visiting programs have found that about two-thirds of the women who dropped out might have been retained through program modifications aimed at increasing partner participation (Brand and Jungmann, 2014). Other factors that are important for engagement include early enrollment (Roggman et al., 2008), the relationship between program participants and staff (Girvin, DePanfilis, and Daining, 2007), low staff turnover (Hicks et al., 2008), and family interaction and integration (Perrino et al., 2001). In addition, devoting more of the program time to parenting and child development contributes to participant retention (O’Brien et al., 2012). Despite this emerging evidence, strategies and approaches to engagement in social services are understudied (Sonalkar, Mody, and Gaffield, 2014).

Recent work has begun to explore “nudges,” or engagement strategies based on behavioral economics, that may alter “people’s behavior in a predictable way without forbidding any options or significantly changing their economic incentives” (Matjasko et al., 2016). These strategies are meant to leverage an individual’s use of heuristics, social interactions, and other common behavioral responses (Thaler and Sunstein, 2009). For example, research shows that people make decisions based on what they believe to be true, hinging on their own experiences, reference points, or estimates rather than what is objectively or measurably true (Gawande, 2011). With regard to infant mortality, women may insufficiently value obstetric health care services because they, or people they know, did not use these services and had positive pregnancy outcomes. Alternatively, because cognition is a limited resource, pregnant women
may choose the simpler solution of not participating in an intervention because opting out requires the least mental energy. Or pregnant women may sign up but then be put off by the time and effort required to participate, perceiving the future cost of not participating to be lower.

Research on engagement strategies suggests that some of the existing strategies used by programs, services, and supports could be reformulated to improve engagement with existing interventions at all stages—recruitment, retention, and participation. For instance, there is potential to incorporate principles like default opt-in for appointment scheduling (Chapman et al., 2010), gains-framed messaging about behavioral changes or treatments (Toll et al., 2007), and group socialization (DellaVigna, 2009). The effectiveness of these strategies in other contexts suggests that they may be solutions to the impediment to effectiveness frequently cited by local intervention leaders. However, it is important to note that there is limited research about the application or effectiveness of these strategies for public health generally, and for maternal and child health specifically (Sonalkar, Mody, and Gaffield, 2014; Matjasko et al., 2016).

Summary

In this chapter, we reviewed the evidence on interventions aimed at addressing the underlying causes of infant mortality, how the interventions are typically delivered, and the timing of their delivery. We also identified some barriers to engagement in these interventions and strategies that have been used in other contexts that may have potential to increase engagement. In Chapter 4, we examine how some of these interventions are currently being deployed in some national, state, and local efforts to address infant mortality.
4. National, State, and Local Infant Mortality Prevention Efforts

At the national, state, and local levels, efforts to prevent and reduce infant mortality include a broad range of efforts across the policy, program, and practice landscape. Many of the specific intervention types described in Chapter 3 are key components of these efforts.

National Efforts

Federal efforts to prevent and reduce infant mortality were coordinated in the Prematurity Research Expansion and Education for Mothers Who Deliver Infants Early Act, which first passed in 2006 (P.L. 109-450) and was renewed in 2013 (P.L. 113-55). Reauthorization has passed the Senate and was pending in the House as of October 2018. As its name suggests, the act supports research, planning, and implementation activities across several government agencies, as described in this section. Other federal legislation also addresses prevention and reduction of some of the leading and underlying causes of infant mortality, such as the Child Abuse Prevention and Treatment Act adopted in 1974 (P.L. 93-247) and most recently amended in 2018 (P.L. 115-271). This act requires child welfare agencies to develop plans for caring for infants born with substance abuse or withdrawal symptoms.

HRSA, an agency of the U.S. Department of Health and Human Services, plays a large role in infant mortality prevention efforts. It convenes the Secretary’s Advisory Committee on Infant Mortality, which in 2012 announced a national strategy to address infant mortality (Lu and Johnson, 2014). The core elements of that strategy include

- providing health coverage and access to prevention and intervention services
- ensuring access to high-quality, patient-centered care
- investing in prevention and public health at the community level
- fostering health equity by eliminating disparities and unequal treatment
- developing data systems to monitor performance related to access, quality, and outcomes
- collaborating across systems, agencies, and payers.

Following the release of the national strategy, HRSA initiated its Infant Mortality CoIIN to bring states together to develop plans to reduce infant mortality, build the evidence base around reducing infant mortality, and disseminate best practices. Led by the National Institute for Children’s Health Quality, the national Infant Mortality CoIIN operated from 2014 to 2017, included 51 state and jurisdiction teams, and resulted in the Infant Mortality CoIIN Prevention Toolkit, which outlines specific targeted activities for infant mortality prevention that were tested by participating states. Some of the targeted activities included education for at-risk populations
on safe sleep practices, evidence-based smoking cessation programs, and access to contraceptives for preconception and interconception care.

HRSA also funds the following programs:

- the Title V Maternal and Child Health Services Block Grant program, which provides grants to 59 states and jurisdictions for health care services for low-income families
- 100 Healthy Start programs in 38 states and jurisdictions (Maternal and Child Health Bureau, 2018b)
- the Maternal, Infant, and Early Childhood Home Visiting Program, which provides grants to all 50 states, the District of Columbia, and five U.S. territories to implement evidence-based home visiting models (Maternal and Child Health Bureau, 2018a)
- the Safe Infant Sleep Systems Integration Program, which focuses on integration of safe sleep practices into family-serving systems (Maternal and Child Health Bureau, 2018c).

The Prematurity Research Expansion and Education for Mothers Who Deliver Infants Early Act also functions as a funder, enabling the CDC to track national data on infant mortality and conduct research. The CDC’s Division of Reproductive Health

- supports the work of state-level perinatal quality collaboratives (PQCs), which are funded by CDC and operate in 38 states and under development in 8 states\(^\text{10}\)
- coordinates a sudden unexpected infant death\(^\text{11}\) monitoring program operating in 18 states and jurisdictions
- collects state-level data on maternal attitudes and experiences through the Pregnancy Risk Assessment Monitoring System.

Other federal efforts to prevent and reduce infant mortality include the CMMI Strong Start for Mothers and Newborns Initiative, which is testing different models of enhanced prenatal care to increase the evidence base for infant mortality prevention and reduction (Centers for Medicare and Medicaid Services, 2019).

Outside the federal government, other national efforts to prevent and reduce infant mortality include the March of Dimes’ Prematurity Campaign, which focuses on reducing prematurity, the leading cause of infant mortality (March of Dimes, 2015). Campaign activities include research, care innovation and community engagement, advocacy, education, and family-centered NICUs. The March of Dimes also produces the Premature Birth Report Card to track national, state, and

\(^{10}\) Only four states, including Pennsylvania, do not currently have a PQC. The Pittsburgh Regional Health Initiative (PRHI) received funding in November 2018 to establish a PQC focused on bringing together stakeholders to address maternal mortality (WHAMGlobal, 2018).

\(^{11}\) The CDC defines sudden unexpected infant death broadly to include all infant deaths, including those caused by SIDS, accidental deaths, natural deaths, and homicides.
county trends in prematurity, infant mortality, and other relevant outcomes and assign grades based on progress toward goals (March of Dimes, n.d.).

**State Efforts**

Some state-level efforts to prevent and reduce infant mortality predated national efforts, whereas others emerged from the Infant Mortality CoIIN or state-level task forces.

For example, Florida has a long history of efforts to prevent and reduce infant mortality, starting with the launch of Healthy Start in 1991 to screen all pregnant women for risk factors related to poor infant outcomes (Jones and Louis, 2017). Currently, 33 coalitions that cover all of Florida support a range of prenatal care, postnatal care, and interconception care efforts. Each coalition has autonomy to develop efforts tailored to the specific community. For example, REACHUP (Respond, Educate, Advocate, and Collaborate for Health in Underserved Populations), which started in 2006 near Tampa, focuses on several risk-reduction strategies, such as in-person assessments and care coordination. In 2007, the state legislature created the Black Infant Health Practice Initiative, which provided grants to each Healthy Start coalition to develop specific programs aimed at reducing the disparity in infant mortality.

In Georgia, the Department of Health used a data-driven approach that focused on consensus building among stakeholders, a public awareness campaign around safe sleep, and improving postnatal care (Jones and Louis, 2017). The consensus-building activities kicked off with the 2011 formation of the statewide Infant Mortality Task Force; the state also began participating in CoIIN and the PQC at that time. In 2012, the safe sleep campaign launched, focusing on educating hospitals and health care providers on safe sleep policies and guidelines and educating parents on safe sleep practices. Georgia’s postnatal care activities focused on interconception care, specifically to increase birth intervals. In 2014, the state received a Medicaid waiver that covered long-acting reversible contraception for women on Medicaid.

In 2009, Ohio’s Infant Mortality Task Force issued a report with a series of recommendations that included the formation of a statewide organization to implement the recommendations. Since then, the Ohio Collaborative to Prevent Infant Mortality has organized efforts within the state and developed the *Ohio Infant Mortality Reduction Plan 2015–2020* (Ohio Collaborative to Prevent Infant Mortality, 2015). The plan outlines strategic focus areas, such as preventing preterm births and reducing smoking before, during, and after pregnancy, and provides a work plan that lays out strategies, activities, and outcomes for each focus area.

While Pennsylvania does not have a statewide strategic plan like Ohio and other states, the Pennsylvania Bureau of Family Health laid out three priorities related to perinatal and infant health in its Title V Maternal and Child Health Services Block Grant 2016 annual report and 2018 application to HRSA. Its three priorities are to (1) equip families with the education and resources they need to initiate and continue breastfeeding their infants; (2) consistently implement safe sleep practices for all infants; and (3) make available to all women of
childbearing age the appropriate health and health-related services, screenings, and information. Along with these priority areas, the bureau’s 2016 annual report also specifies evidence-based or evidence-informed strategies and performance measures for the priority areas.

Some of Pennsylvania’s infant mortality prevention and reduction efforts are organized through the Pennsylvania Perinatal Partnership, which facilitates efforts of the Healthy Start projects in the state, the maternal and child health programs of the Department of Health’s Bureau of Family Health, and the home visiting programs of the Office of Child Development and Early Learning. The partnership focuses on education, advocacy, and collaboration across these maternal and child health programs. As noted earlier, a PQC focused on maternal mortality has now been funded to create the Maternal Coalition and Action Network.

Local Efforts

Given high infant mortality rates, a number of cities and counties have developed community-wide initiatives aimed at reducing infant mortality (Table 8). These efforts have typically involved a broad array of collaborative partners coming together to devise specific strategies that address the leading causes of infant mortality in the community. These initiatives are primarily population based or focused on specific subpopulations within defined geographic areas or neighborhoods. All include data-driven decisionmaking, evidence-based models and approaches, and strong involvement and engagement of community-based partners.


<table>
<thead>
<tr>
<th>Location</th>
<th>Initiative Launched</th>
<th>Primary Focus</th>
<th>2009</th>
<th>2012</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Black</td>
<td>White</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Black</td>
<td>White</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Black</td>
<td>White</td>
<td>All</td>
</tr>
<tr>
<td>Baltimore (city)</td>
<td>2009</td>
<td>Safe sleep</td>
<td>17.8</td>
<td>5.0</td>
<td>13.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12.2</td>
<td>4.4</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10.2</td>
<td>4.8</td>
<td>9.3</td>
</tr>
<tr>
<td>Milwaukee (city)</td>
<td>2010</td>
<td>Prematurity</td>
<td>14.2</td>
<td>6.2</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14.0</td>
<td>4.7</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>13.3</td>
<td>5.2</td>
<td>8.4</td>
</tr>
<tr>
<td>Cincinnati (Hamilton County)</td>
<td>2013</td>
<td>Pregnancy interval, smoking, safe sleep</td>
<td>15.9</td>
<td>6.0</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>13.8</td>
<td>5.6</td>
<td>8.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15.2</td>
<td>6.7</td>
<td>9.4</td>
</tr>
<tr>
<td>Columbus (Franklin County)</td>
<td>2014</td>
<td>Preterm birth and low birth weight, smoking, sleep-related deaths</td>
<td>13.4</td>
<td>6.5</td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12.4</td>
<td>6.1</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11.3</td>
<td>5.7</td>
<td>7.5</td>
</tr>
<tr>
<td>Cleveland (Cuyahoga County)</td>
<td>2017</td>
<td>Extreme prematurity, sleep-related deaths</td>
<td>14.4</td>
<td>5.7</td>
<td>9.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>13.6</td>
<td>5.5</td>
<td>8.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18.2</td>
<td>5.8</td>
<td>10.5</td>
</tr>
</tbody>
</table>

SOURCE: CDC, n.d.b.
Baltimore, Maryland

The B’more for Healthy Babies initiative started in 2009 with the goal of reducing infant mortality (B’more for Healthy Babies, n.d.). The initiative has four components:

- policy support that includes standardized safe sleep education, coordination with providers, home visiting programs, and community-based programs for pregnant women, and adoption of evidence-based models for all home visiting programs
- service improvements that include materials and training for providers on safe sleep
- community engagement and supportive programs to reach pregnant women in high-risk neighborhoods
- outreach for families and individuals that includes a safe sleep media campaign and dissemination of safe sleep materials.

When the initiative launched in 2009, the infant mortality rate was 13.3 per 1,000 live births. The rate declined to 9.3 in 2012 and stood at 8.3 per 1,000 in 2015. A recently released report from the Annie E. Casey Foundation summarized progress from 2009 to 2016, noting a 35-percent decrease in infant mortality, a 64-percent decrease in racial disparity, and a 71-percent decrease in sleep-related infant deaths over this time period (Anne E. Casey Foundation, 2018).

Cincinnati (Hamilton County), Ohio

The Cradle Cincinnati initiative was launched in 2013 to combat Cincinnati’s high infant mortality rate (Cradle Cincinnati, n.d.). After using data to determine that the primary drivers of Hamilton County’s infant deaths were short pregnancy intervals, smoking during pregnancy, and lack of safe sleep practices, the initiative focused on three strategies to address them:

- communication strategies, including public awareness media and web-based campaigns
- medical strategies, including a learning collaborative to work on quality-improvement initiatives within the provider community and an effort to renovate community health centers to make them more welcoming
- community strategies aimed at increasing engagement of those at highest risk.

In 2009, the infant mortality rate in Hamilton County was 9.4 per 1,000. When Cradle Cincinnati launched, the infant mortality rate stood at 8.4 per 1,000. While the infant mortality rate returned to 9.4 per 1,000 in 2015, it is still too soon to examine the possible impact of the strategies just outlined.

StartStrong was a parallel effort to address high rates of preterm births in the Avondale neighborhood of Cincinnati (bi3, 2017). The three-year effort brought together hospital leaders from the two hospitals where 70 percent of Avondale infants were delivered, the children’s hospital where all preterm infants are provided care, and a community-based home visiting program for first-time mothers. The StartStrong program focused on
• place-based prenatal and community-based care
• parent, family, and community engagement
• timely social services to address needs.

Over time, the infant mortality rate in Avondale decreased from 21.0 per 1,000 live births (2007–2011) to 8.6 per 1,000 live births (2012–2016). The rate of extreme preterm births (i.e., less than 28 weeks) decreased from 1.8 percent to none in the second and third years of the program.

**Cleveland (Cuyahoga County), Ohio**

Cleveland launched its First Year Cleveland initiative in 2017 to address racial disparities in the infant mortality rate, extreme preterm birth rate, and sleep-related infant deaths. The initiative identified five areas of measurable actions:

• Establish shared measurement practices.
• Support coordinated activities.
• Build public will.
• Advance public policy.
• Secure funding.

The initiative’s two-year planning and startup phase began in the summer of 2017. Before the initiative was launched in 2017, the infant mortality rate in Cuyahoga County had declined from 9.1 per 1,000 live births in 2009 to 8.7 per 1,000 in 2012 before climbing again to 10.5 per 1,000 in 2015.

**Columbus (Franklin County), Ohio**

In Columbus, the CelebrateOne initiative was launched in 2014 after the Greater Columbus Infant Mortality Task Force released a set of recommendations to reduce the infant mortality rate by 40 percent and the racial disparity by 50 percent by 2020 (City of Columbus, n.d.). The community identified preterm birth and low birth weight, smoking during pregnancy, and sleep-related deaths as the primary drivers of the high infant mortality rate. The eight recommendations include improving

• social and economic conditions in high-risk neighborhoods
• women’s health before pregnancy
• reproductive health planning
• prenatal care and supports
• quality of prenatal care
• maternal and household smoking rates
• safe sleep practices
For each recommendation, CelebrateOne identified specific strategies, and implementation began in 2016. In 2009, the infant mortality rate in Franklin County was 8.5 per 1,000 live births. The rate declined to 8.0 per 1,000 in 2012 and 7.5 per 1,000 in 2015.

**Milwaukee, Wisconsin**

Wisconsin’s Lifecourse Initiative for Healthy Families was launched in 2009 to reduce disparities in birth outcomes between black and white infants (Lifecourse Initiative for Healthy Families, n.d.). In Milwaukee, the initiative’s Community Action Plan, completed in 2012, aims to eliminate birth disparities in the city by focusing on prematurity, the leading cause of infant deaths in the city. The efforts include three priority areas:

- public awareness about unintended pregnancies and birth intervals
- support for preconception and prenatal care to address chronic health conditions
- improvements in social and economic conditions that lead to stress.

When the initiative launched in 2009, the infant mortality rate was 9.3 per 1,000 live births. The rate declined to 8.0 in 2012 and currently stands at 8.4 (2015). From 2009 to 2014, the disparity between rates of infant mortality for white and black babies decreased by 25 percent.

**Best Babies Zone**

In 2012, the W. K. Kellogg Foundation launched its Best Babies Zone (BBZ) initiative focused on reducing racial disparities in infant mortality and birth outcomes through a place-based approach that brings together multiple systems within a community (BBZ, n.d.). There are currently nine BBZs nationally, with three funded in 2012, 2017, and 2018; in Ohio, there are BBZs in the Price Hill neighborhood of Cincinnati and the Hough area of Cleveland. Each BBZ organizes its work by activating zone residents and community partners, listening to neighborhood priorities, and fostering cross-sector community actions through a multiphase process. As a result, the specific activities in a particular BBZ are tailored to the needs and priorities of that community. An evaluation of BBZ is under way that focuses on both the local and the national impact of the initiative on short-, mid-, and long-term outcomes that are ultimately expected to lead to reduced infant mortality.

**Key Features of Infant Mortality Prevention Efforts**

Many of the national, state, and particularly local efforts to address infant mortality described in this chapter share some key features that are relevant to the ongoing work in Allegheny County to address infant mortality: they are community-focused, client-centered, and data-driven efforts that work across systems. Several of these initiatives have drilled down into the data for their community to identify trends over time, the underlying factors driving poor birth outcomes,
and specific geographic areas with the highest need. The wide range of underlying factors involved in infant mortality necessitates the involvement of multiple systems and organizations that span physical health, behavioral health, and early childhood education, among other areas. Most of the initiatives focus on specific neighborhoods and work to meaningfully involve the community in identifying priorities, designing strategies, and implementing specific activities. Last, client-centeredness is at the core of many of the initiatives, such that the strategies and activities are designed and carried out to maximize engagement.
Our environmental scan was designed to first develop an inventory of existing programs, services, and supports targeting the prevailing risk factors for infant mortality in Allegheny County and then assess the availability and capacity of these programs, services, and supports to assist at-risk mothers. While Allegheny County has a wealth of existing services and programs that can potentially support at-risk women during pregnancy or postpartum, there is not a centralized resource that provides referral guidance or client-tailored information on the breadth of services and supports available. Furthermore, health care providers who come into contact with at-risk mothers are often not familiar with the services and supports available through their own or other systems of care.

This inventory identifies the types and capacity of interventions currently being offered to women, in what combinations, and over what period of time, which will help stakeholders develop a better understanding of the existing infrastructure and needed investments. With this information, interested parties may decide to expand existing interventions, improve access and engagement with existing interventions, or introduce new interventions.

Along with this inventory of programs, services, and supports currently available in Allegheny County, we summarize how the available options align with the evidence base. We provide tables that summarize the available programs, services, and supports within each of the intervention categories described in Chapter 3. We list each program’s components and data we have gathered on program reach and capacity. In addition, Appendix A provides a summary of each program, service, or support, with a description of the intervention, its setting and timing, the target population and any eligibility criteria, its reach, and any reported outcomes.

Medical-Setting Interventions

Within Allegheny County, the available medical-setting interventions fall into several categories of efforts that span the preconception and prenatal period, as well as the birth itself. As described in Chapter 3, there is a need for more studies to demonstrate the direct, positive effects of medical-setting interventions on birth and infant outcomes. Only group prenatal care programs, such as CenteringPregnancy, have emerging evidence of effectiveness on improved birth outcomes.

Preconception/Interconception Care

Several approaches to offering preconception/interconception care are being used in Allegheny County to initiate discussions about reproductive goals. Six family medicine practices
affiliated with UPMC participate in the IMPLICIT (Interventions to Minimize Preterm and Low Birth Weight Infants Using Continuous Quality Improvement Techniques) interconception care project, which involves maternal screening for four risk factors, intervention, and referral for mothers with young children during well-child visits. A two-year study of the feasibility of implementing the model found that mothers were screened at more than 50 percent of well-child visits, women screened positive for one or more of the four risk factors at 65 percent of well-child visits, and rates of documentation of interventions ranged from 58 percent for multivitamin use to 98 percent for depression treatment (Srinivasan et al., 2018). One Key Question is being used by some individual health care providers, but there are not any protocols guiding its usage or means of determining the extent of its use. PATH (pregnancy attitudes, timing, and how important is pregnancy prevention) is a question-based tool developed with a local collaborator on the basis of research, clinical judgment, and experience with patients with a range of pregnancy intentions and goals. While there are not specific guidelines about using the PATH questions, or evidence to support them, the PATH questions are intended for use by a variety of health care providers and focused on a patient-centered approach to reproductive goal setting (Callegari et al., 2017). Together, these efforts have the potential to help build the evidence about whether reproductive life planning improves birth outcomes in Allegheny County and how resources should be devoted to studying their impact.

**Prenatal Care**

Routine prenatal care is widely available to underserved pregnant women in Allegheny County. According to ACHD, the vast majority of pregnant women in Allegheny County receive prenatal care during the first two trimesters of pregnancy (Balke, 2015). For women on Medical Assistance (Pennsylvania’s Medicaid program), the Pennsylvania Department of Human Services offers Healthy Beginnings Plus at nine hospitals and family health centers throughout the county (Pennsylvania Department of Human Services, n.d.). Allegheny County also has 23 Federally Qualified Health Centers (FQHCs), 10 of which specifically provide prenatal care (Pennsylvania Association of Community Health Centers, n.d.).

Enhanced prenatal care in the form of CenteringPregnancy is offered at Magee-Womens Hospital and through the Allegheny Health Network, although it is not clear how many pregnant women participate in a CenteringPregnancy program across both health systems. Allegheny County also has one birth center, the Midwife Center for Birth and Women’s Health, that supports over 400 deliveries, 1,600 gynecological visits, and 500 behavioral health visits annually. The Midwife Center participated in the CMMI Strong Start initiative that tested the effectiveness of the birth center model, and it continues to offer a suite of pregnancy and childbirth supports to its mothers.

The Birth Circle, part of the UPMC Department of Family Medicine, is a doula program that provides a full range of pregnancy and postpartum support, including continuous support during birth, to about 245 women annually, according to 2016 records. There are also other fee-based
doula services available, and one of the Medicaid managed care organizations operating in Allegheny County pays for doulas for its members.

Table 9 summarizes details of Allegheny County intervention offerings in medical settings, including information on program components, capacity, and reach.

**Table 9. Allegheny County Medical-Setting Interventions**

<table>
<thead>
<tr>
<th>Program Components</th>
<th>Capacity and Reach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preconception/Interconception Care</strong></td>
<td></td>
</tr>
<tr>
<td>IMPLICIT Interconception Care Project</td>
<td>Maternal screening at well-child visits; interventions and referrals for positive screens</td>
</tr>
<tr>
<td>One Key Question</td>
<td>Reproductive goals counseling during primary care visits for women ages 18–50</td>
</tr>
<tr>
<td>PATH</td>
<td>Reproductive goals counseling during visits to Magee and Veterans Health Administration health care providers</td>
</tr>
<tr>
<td><strong>Enhanced Prenatal Care</strong></td>
<td></td>
</tr>
<tr>
<td>CenteringPregnancy</td>
<td>10 group prenatal visits with facilitated group discussions</td>
</tr>
<tr>
<td>Midwife Center for Birth and Women’s Health</td>
<td>Wraparound prenatal care with behavioral health services, prenatal classes, breastfeeding support, and postnatal home visits</td>
</tr>
<tr>
<td>Birth Circle</td>
<td>Doula support during birth</td>
</tr>
</tbody>
</table>

**Health Promotion and Education**

In Allegheny County, health promotion and education approaches cover the prenatal, postnatal, and neonatal periods and may also provide a mix of activities that include health promotion and education, as well as support and referrals. As noted in Chapter 3, with the exception of home visiting, the evidence on the effectiveness of most of the health promotion and education efforts to prevent or reduce infant mortality has not been established, although there is some evidence of positive effects on certain risk behaviors known to increase risk for poor outcomes.
Home Visiting

Allegheny County has a range of home visiting programs available to pregnant and postpartum women, including evidence-based nurse home visiting programs and other types of home visiting programs where promising or evidence-informed practices are being used. In 2017, the ACDHS established Allegheny Link to serve as centralized intake and referral hotline for home visiting programs. Pregnant and postpartum women can also access these programs directly or through referrals from other programs or services.

ACHD supports three nurse home visiting programs. The Nurse-Family Partnership program follows the evidence-based national model, serving about 220 families annually. The Public Health Nurse Home Visiting Program, serving up to 300 families annually, uses an evidence-informed model to provide monthly home visits during the prenatal, postnatal, and neonatal periods. Healthy Families Allegheny provides weekly nurse home visits to about 29 families with children age zero to three years annually in Braddock, McKeesport, Clairton, and Homestead, following an evidence-informed approach.

Other home visiting options in Allegheny County largely utilize evidence-informed or promising practices in their work, giving the county a large capacity for home visiting. Healthy Start, the largest home visiting program, serves about 1,000 families annually. Participants receive monthly visits that includes assistance with accessing other health and social services; support with immunizations, well-baby visits, and other medical services; postpartum depression screening and referrals as needed; and prevention education on topics such as childbirth, diet, smoking, and breastfeeding using the evidence-informed Nurturing Parenting curriculum. Three Early Head Start programs together serve about 500 families annually, with each using a different promising or evidence-informed curriculum or approach to weekly home visits, screenings and assessments, and health education.

Education Programs

Cribs for Kids operates in Allegheny County and provides the only dedicated program related to safe sleep education. About 1,000 cribs are distributed annually by 47 partner organizations. Other efforts to promote safe sleep practices are integrated into programs such as enhanced prenatal care, home visiting programs, doula programs, and others.

In Allegheny County, there is not a dedicated program or public awareness campaign focused on smoking behavior during and after pregnancy. Smoke exposure efforts for Allegheny County families are integrated into other programs, including enhanced prenatal care, home visiting, and doula programs, among others.

Allegheny County has one dedicated accident prevention program, with other accident prevention efforts integrated into other programs, such as enhanced prenatal care, home visiting, and doula programs. The Safety Center operates at the Children’s Hospital of Pittsburgh and offers resources, home safety assessments, and hands-on training on installing car seats. It serves
families of Children’s Hospital patients and walk-ins. A new mobile safety center is serving communities throughout the county.

Table 10 summarizes details of Allegheny County health promotion and education intervention offerings, including information on program components, capacity, and reach.

**Table 10. Allegheny County Health Promotion and Education Interventions**

<table>
<thead>
<tr>
<th>Program Components</th>
<th>Capacity and Reach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Home Visiting Programs</strong></td>
<td></td>
</tr>
<tr>
<td>Allegheny Link</td>
<td>Centralized intake and referral hotline for home visiting programs (prenatal to age six)</td>
</tr>
<tr>
<td>Nurse-Family Partnership</td>
<td>Weekly nurse home visits that include maternal mental health screening, child developmental screening, and parent education and support using an evidence-based model (prenatal to age two)</td>
</tr>
<tr>
<td>Public Health Nurse Home Visiting Program</td>
<td>Monthly home visits (prenatal, postnatal, and pediatric) using an evidence-informed model (prenatal to age three)</td>
</tr>
<tr>
<td>Healthy Families Allegheny</td>
<td>Weekly nurse home visits that include parental mental health screening, child developmental screening, and parent education and support (ages zero to three)</td>
</tr>
<tr>
<td>Healthy Start</td>
<td>Monthly home visits that include connections to health and social services, support for well-baby care, depression screening and referral, and health prevention and education (prenatal to age two)</td>
</tr>
<tr>
<td>Early Head Start</td>
<td>Allegheny Intermediate Unit: Weekly nurse home visits that include birth planning, pre- and postnatal care, screening, and referrals using a “promising” curriculum (prenatal to age three)</td>
</tr>
<tr>
<td></td>
<td>Family Foundations: Weekly home visits that include parent education, supports, and referrals using an evidence-informed curriculum; bimonthly play groups (ages</td>
</tr>
</tbody>
</table>
### Program Components

<table>
<thead>
<tr>
<th>Program Components</th>
<th>Capacity and Reach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Council of Three Rivers American Indian Center: Weekly home visits that include developmental screenings, education, and family support (prenatal to age three)</td>
<td>Serves about 100 families annually</td>
</tr>
</tbody>
</table>

### Education Programs

<table>
<thead>
<tr>
<th>Education Programs</th>
<th>Program Components</th>
<th>Capacity and Reach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cribs for Kids</td>
<td>Crib giveaways, distribution of safe sleep materials, and public service announcements</td>
<td>About 1,200 cribs distributed annually by 47 partner organizations</td>
</tr>
<tr>
<td>Safety Center</td>
<td>Education and resources at the hospital (or by mobile safety center), home safety assessments</td>
<td>Serves families of Children’s Hospital patients and walk-ins</td>
</tr>
</tbody>
</table>

### Support and Referrals

Allegheny County has a wide range of supports and referral options that span the prenatal, neonatal, and postnatal periods. As noted in Chapter 3, many of these efforts offer health promotion and education in addition to support and referrals. While some of these options align with support and referral interventions that have shown positive effects on behavior or knowledge, only care coordination has emerging evidence of effectiveness in improving birth and infant outcomes.

### Care Coordination

Pregnant women in Allegheny County with Medicaid coverage can access maternity care coordination, which has emerging evidence of improving outcomes such as birth weight, preterm births, NICU stays, and infant mortality, through the managed care organization providing their health care services. The UPMC Health Plan maternity program passively enrolls all pregnant women after receiving an Obstetrical Needs Assessment Form from the health care provider. After determining medical risk based on the form, nurse care managers conduct targeted outreach, assess needs, and develop a care plan together with the pregnant woman. The program serves about 3,000 women annually across UPMC’s commercial, Medicaid, and Children’s Health Insurance Plan insurance products.

Gateway Health Plan’s MOM Matters maternity care program provides education and support to pregnant women on Medicaid. The program includes help accessing prenatal care and referrals to resources and programs, including nurse home visits, smoking cessation programs, and other community-based services.
Pregnancy and Postpartum Support

Support for women during pregnancy and the postpartum period can take different forms, including doulas, center-based support, and technology-based support. While there is little evidence of the effectiveness of prenatal or postnatal doula support on birth or infant outcomes, doulas typically offer a range of education and support resources during the pregnancy and postpartum periods that target risk behaviors or practices. Community doulas from the UPMC Department of Family Medicine’s Birth Circle program support more than 500 women annually through prenatal and neonatal home visits, ongoing phone and text contact, and continuous birth support. Several smaller doula programs, including Every Child and the Allegheny Health Network’s newly created Immigrant Health Program, provide similar services to at-risk pregnant or postpartum women.

Across Allegheny County, ACDHS operates 28 Family Support Centers that provide a range of services to families with children, including health promotion and education as well as more concrete supports and referrals. Services specific to pregnant or postpartum women include support accessing health care, prenatal care, home visiting, and evidence-based or evidence-informed parenting programs. Together, the Family Support Centers serve about 6,000 children and families annually across all the programs and services. Other center-based pregnancy and postpartum support efforts include the Genesis Center, which provides pregnancy testing; classes on pregnancy, childbirth, breastfeeding, and parenting; and baby clothing or equipment to about 1,000 women annually. Genesis House is an eight-bed maternity care facility for pregnant women who need shelter. Baby Promise, which operates out of Homewood Children’s Village, offers education, resources, and support to expectant parents and parents of young children.

Pregnant women in Allegheny County have access to Text4baby and its weekly information texts through local partners such as ACHD, Healthy Start, and the UPMC Health Plan. However, there is no information about local enrollment or usage. Currently serving about 300 families delivering at several local hospitals, NurturePA is a text-based mentoring program focused on the neonatal and postnatal periods. In addition to sending weekly informational texts, NurturePA mentors engage in text-based discussions with the new mothers and provide additional resources and referrals as needed.

Breastfeeding and Nutrition Support

Specific support for breastfeeding in Allegheny County includes public education efforts and a donor milk bank; most educational resources related to supporting breastfeeding are integrated into other programs, including enhanced prenatal care, home visiting, and doula programs, among others. ACHD formed the Allegheny County Breastfeeding Coalition and in 2017 launched its Sustaining Breastfeeding Together public awareness campaign. Allegheny County is also home to the Mid-Atlantic Mothers’ Milk Bank, which provides donated breast milk to more than 500 babies in the region. ACHD administers the federally funded WIC program, which
provides vouchers redeemable for infant formula and nutritious foods for pregnant and breastfeeding women, as well as nutrition education, breastfeeding support, and referrals to other health and social services. In 2016, 25 percent of all births in Allegheny County were to women enrolled in WIC (Nagy, 2018).

Behavioral Health Services

The available behavioral health services and supports in Allegheny County range from hospital- and clinic-based programs to residential addiction treatment programs and outpatient mental health services. The hospital- and clinic-based programs available in Allegheny County include Allegheny Health Network’s Perinatal Hope program and Magee’s Pregnancy Recovery Center, both of which provide coordinated outpatient care for pregnant women struggling with addiction. The Children’s Institute of Pittsburgh’s neonatal abstinence syndrome program provides care coordination during the prenatal period, inpatient services during the neonatal period, and outpatient services during the postnatal period.

Residential treatment is available to about 100 mothers with substance abuse disorders and their families annually through Sojourner House and its inpatient residential treatment program and Motivation Opportunities Mentoring Spirituality program, which provides housing and supportive services. At the Pennsylvania Organization for Women in Early Recovery, pregnant women with addiction can receive support through a halfway house program, a range of outpatient services, and an in-home substance abuse assessment and mentoring program. Familylinks’ two Family Treatment Centers prioritize pregnant women for its residential treatment program.

Two outpatient clinics situated within hospitals offer services specifically geared toward women with perinatal depression or other mental health issues. At West Penn Hospital, the Alexis Joy D’Achille Center for Women’s Behavioral Health provides an outpatient program, partial hospitalization program, or full hospitalization depending on severity level for women with depression or bipolar disorder during the prenatal or neonatal period. At Magee, the offerings at Women’s Behavioral Health Services include a full range of psychiatric consultation, consultation, and treatment programs, as well as psychotherapy and psychoeducation classes.

Family Support

Family support often takes the form of programs for the partners of pregnant women or new mothers. In Allegheny County, Healthy Start and the Allegheny Intermediate Unit offer programs aimed at fathers, and Healthy Start also offers life skills classes for pregnant women and their partners.

Table 11 summarizes details of Allegheny County support and referral intervention offerings, including information on program components, capacity, and reach.
<table>
<thead>
<tr>
<th>Program Components</th>
<th>Capacity and Reach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Care Coordination</strong></td>
<td></td>
</tr>
<tr>
<td>UPMC Health Plan Maternity Program</td>
<td>Support, education, and linkages to community resources during pregnancy provided by registered nurse care managers or social workers either by telephone or in person with frequency based on risk and need; postpartum follow-up one week after delivery</td>
</tr>
<tr>
<td>MOM Matters Program</td>
<td>Support and coordination provided by maternity team members including facilitating prenatal care, linkages to community resources, nurse home visits, transportation assistance, and referrals to smoking quit line</td>
</tr>
<tr>
<td><strong>Pregnancy/Postpartum Support</strong></td>
<td></td>
</tr>
<tr>
<td>Birth Circle</td>
<td>Doula provides prenatal home visiting, ongoing weekly contact, continuous birth support, and postpartum home visiting (second trimester to six weeks postpartum)</td>
</tr>
<tr>
<td>Every Child</td>
<td>Doula attends prenatal visits, conducts home visits, and coordinates with birth doula (second trimester to six weeks postpartum)</td>
</tr>
<tr>
<td>Allegheny Health Network Immigrant Health Program</td>
<td>Doulas (prenatal, birth, postpartum) and community health workers for Latino, Bhutanese, and Somali women</td>
</tr>
<tr>
<td>Family Support Centers</td>
<td>28 neighborhood-based centers that offer a range of services, including support in accessing health care, prenatal care, home visiting, and parenting programs that use evidence-based or evidence-informed models</td>
</tr>
<tr>
<td>Genesis House</td>
<td>Assistance in finding permanent housing after delivery, counseling sessions, classes on prenatal care, parenting, smoking cessation, and child and infant</td>
</tr>
<tr>
<td>Program Components</td>
<td>Capacity and Reach</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>first aid and CPR</td>
<td></td>
</tr>
<tr>
<td>Genesis Centers</td>
<td>Serves about 1,000 clients annually across two centers, one of which is in Pittsburgh</td>
</tr>
<tr>
<td>Pregnancy testing, maternity and infant clothing, educational classes for pregnant women and expectant fathers, distribution of baby equipment and essentials</td>
<td></td>
</tr>
<tr>
<td>Baby Promise</td>
<td>Serves five cohorts of about 8 to 10 participants annually</td>
</tr>
<tr>
<td>Eight-week course to provide education and training in pregnancy, child development, health, safety, and other topics for expectant parents and parents of children ages zero to five</td>
<td></td>
</tr>
<tr>
<td>NurturePA</td>
<td>Serves about 270 families annually</td>
</tr>
<tr>
<td>Weekly text messages sent by mentor, ongoing text-based conversations with resources and referrals as needed (birth to age three)</td>
<td></td>
</tr>
<tr>
<td>Text4baby</td>
<td>Local partners include ACHD, Healthy Start, and UPMC Health Plan</td>
</tr>
<tr>
<td>Text messages sent three times per week with information timed to baby’s due date or birth date (pregnancy to age one)</td>
<td></td>
</tr>
<tr>
<td>Breastfeeding and Nutrition Support</td>
<td></td>
</tr>
<tr>
<td>Allegheny County Breastfeeding Coalition</td>
<td>Public education campaign Sustaining Breastfeeding Together</td>
</tr>
<tr>
<td>Mid-Atlantic Mother’s Milk Bank</td>
<td>Provides breast milk to NICUs throughout the region</td>
</tr>
<tr>
<td>WIC</td>
<td>Nutrition education, education on health risk behaviors, and limited referrals to health and social services (pregnant women, postpartum women up to 12 months, infants and children with medical risk up to age five)</td>
</tr>
<tr>
<td>Serves about 25 percent of all births annually in Allegheny County</td>
<td></td>
</tr>
<tr>
<td>Behavioral Health Services</td>
<td></td>
</tr>
<tr>
<td>Perinatal Hope</td>
<td>Services provided at West Penn Hospital with plans to expand into Jefferson Hospital, Forbes Hospital, and the Federal North location</td>
</tr>
<tr>
<td>Case management, care coordination, group prenatal care using an evidence-based model, peer and family support, transitional and follow-up care, and linkages to community and social services</td>
<td></td>
</tr>
<tr>
<td>Program Components</td>
<td>Capacity and Reach</td>
</tr>
<tr>
<td>---------------------------------------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>Pregnancy Recovery Center</td>
<td>Buprenorphine conversion during pregnancy or postpartum period through weekly appointments (pregnancy to six months postpartum)</td>
</tr>
<tr>
<td>Neonatal Abstinence Program</td>
<td>Care coordination, inpatient services, feeding support, and outpatient services</td>
</tr>
<tr>
<td>Sojourner House</td>
<td>Inpatient residential treatment: Up to six months in housing, evidence-based treatment, counseling, and linkages to community resources</td>
</tr>
<tr>
<td>Sojourner Moms: Recovery housing, case management, and job readiness, life skills, and parenting education</td>
<td>Serves about 50 families annually</td>
</tr>
<tr>
<td>Pennsylvania Organization for Women in Early Recovery</td>
<td>Halfway house program: Residential treatment with psychiatric and health care services</td>
</tr>
<tr>
<td></td>
<td>Outpatient program: Partial hospitalization, intensive outpatient programming, counseling, therapy, and resource coordination</td>
</tr>
<tr>
<td></td>
<td>In-home services: Drug and alcohol assessment and mentoring</td>
</tr>
<tr>
<td>Familylinks’ Family Treatment Centers</td>
<td>Counseling; substance abuse/HIV education, counseling, and support; employment counseling; linkages to social services; and case management</td>
</tr>
<tr>
<td>Alexis Joy D’Achille Center for Women’s Behavioral Health</td>
<td>Treatment options for perinatal depression, including weekly therapy appointments, an intensive outpatient program, and partial or full hospitalization</td>
</tr>
<tr>
<td>Magee Women’s Behavioral Health Services</td>
<td>Preconception evaluation and counseling, comprehensive psychiatric assessment, consultation on use of medication during pregnancy and postpartum, individual psychotherapy, couples therapy, and stress and coping classes</td>
</tr>
<tr>
<td>Family Support</td>
<td>Program Components</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Healthy Start Fatherhood Program</td>
<td>Male Initiative Program: Six-week curriculum offered at three locations</td>
</tr>
<tr>
<td></td>
<td>Fatherhood Support Groups: Peer support and education</td>
</tr>
<tr>
<td>Allegheny Intermediate Unit Responsible</td>
<td>Monthly meetings, case management, group activities, mentoring, and home visits</td>
</tr>
<tr>
<td>Fatherhood Program</td>
<td>using evidence-based curriculum</td>
</tr>
<tr>
<td>Healthy Start Life Skills Classes</td>
<td>Ten-week course on life skills that provides training, tools, and resources to</td>
</tr>
<tr>
<td></td>
<td>participants and partners</td>
</tr>
</tbody>
</table>

**Summary of Available Programs, Services, and Supports**

Allegheny County’s array of programs, services, and supports span medical-setting interventions, health promotion and education, and support and referral efforts, which can be used during both the prenatal and postnatal stages of care, with relatively few appropriate for delivery in the preconception period (Figure 8). The county offers the three intervention types with the strongest direct evidence for improving birth outcomes: group prenatal care, home visiting, and care coordination. Further, many of options available to pregnant and postpartum women in the county align with approaches that address some of the behavioral risk factors for poor outcomes.
Figure 8. Summary of Programs, Services, and Supports (as of 2018)

**Medical Setting**
- **Preconception/interconception care**
  - One Key Question
  - PATH
- **Prenatal care/enhanced prenatal care**
  - Healthy Beginnings Plus
  - FQHCs
  - Centering Pregnancy
  - The Midwife Center

**Health Promotion and Education**
- **Home visiting programs**
  - Healthy Start
  - Early Head Start
  - Nurse-Family Partnership
  - Public Health Nurse Home Visiting Program
  - Allegheny Link

- **Education programs**
  - Healthy Start
  - Early Head Start
  - Nurse-Family Partnership
  - Public Health Nurse Home Visiting Program
  - Allegheny Link
  - Healthy Families Allegheny

- **Accident prevention**
  - The Safety Center
  - *Accident prevention is integrated into many other programs, services, or supports

*Accident prevention is integrated into many other programs, services, or supports

*Education programs are integrated into many other programs, services, or supports

The Safety Center

IMPLICIT ICC
One Key Question
PATH
<table>
<thead>
<tr>
<th>Support and Referrals</th>
<th>Preconception</th>
<th>Prenatal</th>
<th>Neonatal</th>
<th>Postneonatal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Care coordination</td>
<td>UPMC Health Plan Maternity Program Gateway Health Program MOM Matters Program</td>
<td>UPMC Health Plan Maternity Program Gateway Health Program MOM Matters Program</td>
<td>Birth Circle Every Child AHN Immigrant Health Program</td>
<td>Birth Circle Every Child AHN Immigrant Health Program</td>
</tr>
<tr>
<td>Pregnancy/postpartum support</td>
<td>Text4baby NurturePA</td>
<td>WIC Mid-Atlantic Mother’s Milk Bank Allegheny County Breastfeeding Coalition</td>
<td>WIC Mid-Atlantic Mother’s Milk Bank Allegheny County Breastfeeding Coalition</td>
<td>WIC Mid-Atlantic Mother’s Milk Bank Allegheny County Breastfeeding Coalition</td>
</tr>
<tr>
<td>Breastfeeding support</td>
<td>Sojourner House POWER Familylink’s Family Treatment Centers The Alexis Joy D’Achille Center Magee Women’s Behavioral Health Services Perinatal Hope Pregnancy Recovery Center NAS Program</td>
<td>Sojourner House POWER Familylink’s Family Treatment Centers The Alexis Joy D’Achille Center Magee Women’s Behavioral Health Services Perinatal Hope Pregnancy Recovery Center NAS Program</td>
<td>Sojourner House POWER Familylink’s Family Treatment Centers The Alexis Joy D’Achille Center Magee Women’s Behavioral Health Services Perinatal Hope Pregnancy Recovery Center NAS Program</td>
<td>Sojourner House POWER Familylink’s Family Treatment Centers The Alexis Joy D’Achille Center Magee Women’s Behavioral Health Services Perinatal Hope Pregnancy Recovery Center NAS Program</td>
</tr>
<tr>
<td>Behavioral health services</td>
<td>Behavior Support Services</td>
<td>Behavior Support Services</td>
<td>Behavior Support Services</td>
<td>Behavior Support Services</td>
</tr>
<tr>
<td>Family support</td>
<td>Healthy Start Fatherhood Program AIU Responsible Fatherhood Program Healthy Start Life Skills Classes</td>
<td>Healthy Start Fatherhood Program AIU Responsible Fatherhood Program Healthy Start Life Skills Classes</td>
<td>Healthy Start Fatherhood Program AIU Responsible Fatherhood Program Healthy Start Life Skills Classes</td>
<td>Healthy Start Fatherhood Program AIU Responsible Fatherhood Program Healthy Start Life Skills Classes</td>
</tr>
</tbody>
</table>
To determine the effectiveness of select programs, services, and supports available in Allegheny County, we used the IMPreSrv database, which links multiple administrative data sources at the individual level over the study period of 2003 to 2013. The IMPreSrv database allows us to report details on birth outcomes within Allegheny County during the study period, summarize the various risk and contextual factors associated with the range of birth outcomes, and describe the prevalence of the interventions within the IMPreSrv database. Understanding these details and factors will prove useful in applying the causal inference framework, discussed in later chapters.

Birth Outcomes

The IMPreSrv database includes a total of 155,218 births and 1,008 infant deaths (representing 0.65 percent of births) described in the death certificate data in Allegheny County over the study period. Of the infant deaths, 48 percent occurred within the first 24 hours of birth, and 27 percent occurred between 1 and 27 days after the delivery (Figure 9). The remaining 24 percent of infant deaths happened from 28 days to one year after birth. This distribution suggests that the major underlying causes of infant mortalities are preconception or prenatal factors, a finding that points to the importance of focusing on women’s health and cumulative risk well before pregnancy (Lu and Halfon, 2003).
We also examined the timing of infant mortality by race (Table 12). While the percentages of deaths within the first 24 hours were similar for black and white infants, a higher percentage of white infants died between 1 and 27 days of birth and a higher percentage of black infants died between 28 days and one year of birth.

Table 12. Timing of Infant Mortality by Race

<table>
<thead>
<tr>
<th>Timing of Infant Mortality</th>
<th>Overall (n = 1,008)</th>
<th>Black (n = 415)</th>
<th>White (n = 504)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First 24 hours</td>
<td>48%</td>
<td>49%</td>
<td>45%</td>
</tr>
<tr>
<td>1–27 days</td>
<td>27%</td>
<td>23%</td>
<td>33%</td>
</tr>
<tr>
<td>28 days–1 year</td>
<td>24%</td>
<td>28%</td>
<td>17%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Death certificate records show that prematurity and fetal growth accounted for a total of 27 percent of infant deaths during the ten-year study period (Figure 10). Because prematurity and fetal growth are also outcomes associated with prenatal and preconception factors, this suggests that there may be opportunities to intervene during the prenatal and preconception periods for a majority of infant deaths. Other causes of death included congenital disorders (17 percent); complications of pregnancy, labor, and delivery (14 percent); SIDS or other ill-defined causes
(12 percent); and perinatal respiratory or cardiovascular disorders (9 percent). The remaining 21 percent of infant deaths were caused by other factors, including perinatal infections, fetal blood disorders, fetal digestive disorders, or accidental injuries.

**Figure 10. Causes of Infant Mortality in the Infant Mortality Prediction System with Intervention Management Database**

We also examined the causes of infant mortality by race (Table 13). Overall, a higher percentage of black infants had prematurity and fetal growth, congenital disorders, and SIDS as the cause of death. At the same time, a higher percentage of white infants had complications of pregnancy, labor, and delivery and perinatal respiratory and cardiovascular disorders as the cause of death.

**Table 13. Causes of Infant Mortality by Race**

<table>
<thead>
<tr>
<th>Cause of Infant Mortality</th>
<th>Overall (n = 1,008)</th>
<th>Black (n = 415)</th>
<th>White (n = 504)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prematurity and fetal growth</td>
<td>27%</td>
<td>29%</td>
<td>22%</td>
</tr>
<tr>
<td>Congenital disorders</td>
<td>17%</td>
<td>20%</td>
<td>15%</td>
</tr>
<tr>
<td>Complications of pregnancy, labor, or delivery</td>
<td>14%</td>
<td>9%</td>
<td>19%</td>
</tr>
</tbody>
</table>
## Cause of Infant Mortality

<table>
<thead>
<tr>
<th>Cause of Infant Mortality</th>
<th>Overall (n = 1,008)</th>
<th>Black (n = 415)</th>
<th>White (n = 504)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIDS or other ill-defined causes</td>
<td>12%</td>
<td>17%</td>
<td>9%</td>
</tr>
<tr>
<td>Perinatal respiratory or cardiovascular disorders</td>
<td>9%</td>
<td>6%</td>
<td>11%</td>
</tr>
<tr>
<td>Other</td>
<td>21%</td>
<td>19%</td>
<td>23%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Even when the underlying risk factors do not result in an infant mortality, infants may still have poor outcomes. Almost 13,500 births, representing 8.7 percent of all deliveries, were low birth weight births. Further, more than 17,000 births, representing 11 percent all deliveries, were preterm births. The rates of both low birth weight births and preterm births peaked in 2008 and then declined substantially in 2009 (Figure 11). Low birth weight births continued to decline through the end of the study period in 2013, whereas the rate of preterm births leveled out during that period.

**Figure 11. Trends in Birth Outcomes in the Infant Mortality Prediction System with Intervention Management Database**

![Graph showing trends in birth outcomes](image)

**Risk and Contextual Factors**

Across birth outcomes, the prevalence of different maternal health-related risk factors, such as gestational diabetes, anemia, hypertension, and pre-pregnancy obesity, varied (Figure 12). Among low birth weight and preterm births, hypertension was more prevalent than any other maternal health risk factor.
Similarly, rates of poor birth outcomes varied for mothers with different health-related risk factors (Figure 13). The infant mortality rate among pregnant women with infections was 15.2 per 1,000 and with hypertension was 11.7 per 1,000, and women with pre-pregnancy obesity and anemia all had similar rates around 8.0 per 1,000. In contrast, the infant mortality rate among pregnant women with gestational diabetes was much lower at 2.4 per 1,000 births. Among all births, pregnant women with hypertension had far higher rates of low birth weight (209 per 1,000) and pre-term births (266 per 1,000) than did pregnant women with the other maternal health risk factors. For these other factors (anemia, obesity, and infections), the rate of low birth weight deliveries ranged from 85.3 per 1,000 for pre-pregnancy obesity to 126.6 per 1,000 for infections, and the preterm birth rate ranged from 115 per 1,000 for pre-pregnancy obesity and anemia to 156 per 1,000 for gestational diabetes. For the maternal health risk factors, birth outcomes also varied by race (Table 14).
Figure 13. Maternal Health Risk Factors in the Infant Mortality Prediction System with Intervention Management Database

Table 14. Maternal Health Risk Factors by Race in the Infant Mortality Prediction System with Intervention Management Database

<table>
<thead>
<tr>
<th>Maternal Health Risk Factors</th>
<th>Infant Mortality Rate</th>
<th>Low Birth Weight Birth Rate</th>
<th>Preterm Birth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall</td>
<td>Black</td>
<td>White</td>
</tr>
<tr>
<td>Gestational diabetes</td>
<td>2.4</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Anemia</td>
<td>8.7</td>
<td>10.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Hypertension</td>
<td>11.7</td>
<td>15.3</td>
<td>10.1</td>
</tr>
<tr>
<td>Pre-pregnancy obesity</td>
<td>7.4</td>
<td>14.2</td>
<td>4.3</td>
</tr>
<tr>
<td>Infections</td>
<td>15.2</td>
<td>18.0</td>
<td>12.8</td>
</tr>
</tbody>
</table>

NOTE: NR = not reported because of small sample size.

For maternal behavior risk factors, substance abuse was documented for about 4 percent of deliveries and smoking during pregnancy for 6 percent of deliveries. The infant mortality rate among women with any substance abuse during pregnancy was 18.3 per 1,000 births, whereas the rate among women who smoked during pregnancy was 9.3 per 1,000 (Figure 14). Among all
births, the rates of low birth weight and preterm births were close to 215 per 1,000 among women with any substance abuse during pregnancy and around 150 per 1,000 births among women who smoked during pregnancy. Birth outcomes also varied by race for the different maternal behavior risk factors (Table 15).

**Table 15. Maternal Behavior Risk Factors by Race in the Infant Mortality Prediction System with Intervention Management Database**

<table>
<thead>
<tr>
<th>Maternal Behavior Risk Factors</th>
<th>Infant Mortality Rate</th>
<th>Low Birth Weight Birth Rate</th>
<th>Preterm Birth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall</td>
<td>Black</td>
<td>White</td>
</tr>
<tr>
<td>Any substance abuse</td>
<td>18.3</td>
<td>23.2</td>
<td>15.3</td>
</tr>
<tr>
<td>Smoking during pregnancy</td>
<td>9.3</td>
<td>15.0</td>
<td>7.4</td>
</tr>
</tbody>
</table>
Finally, related to the maternal and infant context, 7 percent of deliveries were to women younger than 20 years old, and 8 percent of women gave birth less than 1.5 years from a previous birth. Among births to teen mothers, the infant mortality rate was 10.3 per 1,000 (Figure 15). The infant mortality rate was 13.8 per 1,000 births when a previous birth had occurred less than 1.5 years before. Among all births, rates of preterm births and low birth weight births were higher among births with less than a 1.5-year interval in comparison with births to mothers less than 20 years of age. It is important to note that substance abuse and smoking are both likely to be underreported in the birth certificate data. For the factors related to the maternal and infant context, birth outcomes also varied by race (Table 16).

**Figure 15. Factors Related to the Maternal and Infant Context in the Infant Mortality Prediction System with Intervention Management Database**
Table 16. Maternal and Infant Context by Race in the Infant Mortality Prediction System with Intervention Management Database

<table>
<thead>
<tr>
<th>Maternal and infant context</th>
<th>Infant Mortality Rate</th>
<th>Low Birth Weight Birth Rate</th>
<th>Preterm Birth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall</td>
<td>Black</td>
<td>White</td>
</tr>
<tr>
<td>Maternal age &lt;20</td>
<td>10.3</td>
<td>13.9</td>
<td>6.1</td>
</tr>
<tr>
<td>Birth interval &lt;1.5 years</td>
<td>13.8</td>
<td>22.7</td>
<td>11.2</td>
</tr>
</tbody>
</table>

Intervention Participation

Within the IMPreSlv database are data describing the usage of some of the programs, services, and supports outlined in Chapter 5 (Table 17). These were the only interventions for which we had participation information from any of the data sources that fed into the IMPreSlv database. For all of the other programs, services, and supports described in Chapter 5, we were not able to obtain data to link into the IMPreSlv database.

Table 17. Description of Intervention Data Available in the Infant Mortality Prediction System with Intervention Management Database

<table>
<thead>
<tr>
<th>Medical-Setting Interventions</th>
<th>Available in IMPreSlv</th>
<th>Data Source(s)</th>
<th>Description</th>
<th>Time Period(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preconception/interconception care</td>
<td>✓</td>
<td>MARS, MOMI</td>
<td>Preconception exam within year of conception Any vaccinations Genetic counseling Contraceptive counseling</td>
<td>Preconception</td>
</tr>
<tr>
<td>Prenatal care</td>
<td>✓</td>
<td>Vital statistics, MARS, MOMI</td>
<td>One or more prenatal visits per month during pregnancy First prenatal visit during the first trimester</td>
<td>Pregnancy</td>
</tr>
<tr>
<td>Enhanced prenatal care</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doula support</td>
<td>✓</td>
<td>Vital</td>
<td>Doula present at birth</td>
<td>Birth</td>
</tr>
<tr>
<td>Available in IMPreSIV</td>
<td>Data Source(s)</td>
<td>Description</td>
<td>Time Period(s)</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------</td>
<td>-------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>statistics</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Health Promotion and Education

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Available</th>
<th>Data Source(s)</th>
<th>Description</th>
<th>Time Period(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home visiting programs</td>
<td>✔️</td>
<td>DW, Healthy Start, Nurse-Family Partnership</td>
<td>Healthy Start Nurse-Family Partnership Early Head Start</td>
<td>Preconceptiona Pregnancy Postpartum</td>
</tr>
<tr>
<td>Safe sleep education</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accident prevention</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Support and Referrals

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Available</th>
<th>Data Source(s)</th>
<th>Description</th>
<th>Time Period(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Care coordination</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pregnancy or postpartum support</td>
<td>✔️</td>
<td>DW</td>
<td>Family Support Center</td>
<td>Preconception Pregnancy Postpartum</td>
</tr>
<tr>
<td>Breastfeeding and nutrition support</td>
<td>✔️</td>
<td>DW</td>
<td>WIC</td>
<td>Preconceptiona Pregnancy Postpartum</td>
</tr>
<tr>
<td>Behavioral health services</td>
<td>✔️</td>
<td>DW</td>
<td>Drug and alcohol services Mental health support services</td>
<td>Preconceptiona Pregnancy Postpartum</td>
</tr>
<tr>
<td>Family support</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a Some of the interventions have eligibility criteria that specify that a woman must be pregnant to receive services (see Chapter 5). In the IMPreSIV database, participation in these interventions during the preconception period may be for an earlier pregnancy.*

Figure 16 shows the correlation in participation in the interventions detailed in the IMPreSIV database using Pearson’s correlation to describe how frequently we observed women participating in multiple interventions. As we would expect, there was a strong correlation between participating in preconception/interconception care and prenatal care (0.72). There were also correlations varying from moderate to strong between all of the interventions in the health promotion and education category and the support and referral category. For example, the correlation between home visiting and Family Support Center was 0.32, and the correlation
between WIC and income benefits was 0.55. However, what this figure shows most starkly is that there is almost no correlation between the medical-setting interventions and the others. This indicates that women who receive services like WIC or home visiting are very infrequently also receiving prenatal care or the different types of preconception/interconception care and leads to the conclusion that there is a significant lack of coordination across these types of services or benefits.

**Figure 16. Correlation of Intervention Participation**

![Diagram showing correlation between different interventions.](image)

**NOTE:** An X indicates when the correlation between the two interventions is 0.0 (or near 0.0).

Birth outcomes for women participating in the interventions available in the IMPreSIV database varied overall and by race (Table 18). The following sections summarize birth outcomes for each intervention category.
Table 18. Intervention Participation by Race in the Infant Mortality Prediction System with Intervention Management Database

<table>
<thead>
<tr>
<th>Medical-Setting Interventions</th>
<th>Infant Mortality Rate</th>
<th>Low Birth Weight Birth Rate</th>
<th>Preterm Birth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall</td>
<td>Black</td>
<td>White</td>
</tr>
<tr>
<td>Any preconception/interconception care</td>
<td>11.0</td>
<td>14.5</td>
<td>9.0</td>
</tr>
<tr>
<td>Prenatal care (one or more exams per month)</td>
<td>2.9</td>
<td>6.0</td>
<td>2.3</td>
</tr>
<tr>
<td>Prenatal care (first-trimester exam)</td>
<td>4.0</td>
<td>8.8</td>
<td>2.9</td>
</tr>
<tr>
<td>Doula support</td>
<td>2.5</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Health Promotion and Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any home visiting programs</td>
<td>9.5</td>
<td>10.8</td>
<td>5.3</td>
</tr>
<tr>
<td>Support and Referrals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family Support Centers</td>
<td>10.8</td>
<td>10.9</td>
<td>10.6</td>
</tr>
<tr>
<td>WIC</td>
<td>5.7</td>
<td>7.8</td>
<td>4.1</td>
</tr>
<tr>
<td>Any behavioral health services</td>
<td>9.9</td>
<td>13.7</td>
<td>6.9</td>
</tr>
</tbody>
</table>

NOTES: NR = not reported because of small sample size. For all deliveries, the infant mortality rate was 6.49 per 1,000 live births, the low birth weight birth rate was 86.52 per 1,000, and the preterm birth rate was 109.61 per 1,000.

Medical-Setting Interventions

The IMPreSiV database provides some limited information about three medical-setting interventions that women may have received. As noted earlier, preconception care can consist of a variety of preventive screenings and services that occur one year before conception. The MARS and MOMI data include information on some of these, including preconception examinations, vaccinations, genetic counseling, and contraceptive counseling, but only for those women receiving care within the UPMC system. Overall, for 6 percent of all deliveries, women received one or more of these services within the UPMC system. Among these deliveries, infant mortality rates ranged from 10.2 per 1,000 live births for contraceptive counseling to 13.7 per 1,000 for genetic counseling, with all of the rates well above the average rate for Allegheny County (see Figure 17 note), indicating that women at high risk of infant mortality received preconception/interconception care (Figure 17). Similarly, the rate of low birth weight among
women who received any preconception care (132.4 per 1,000), preconception examinations (192.2 per 1,000), and contraceptive counseling (98.2 per 1,000) and the rate of preterm births for women with any preconception care (175.1 per 1,000) and preconception examinations (257.6 per 1,000) were higher than the average rates for Allegheny County (see Figure 17 note).

**Figure 17. Preconception Care in the Infant Mortality Prediction System with Intervention Management Database**

![Bar chart showing rates per 1,000 for various outcomes with intervention and without.](image)

Figure 17: Preconception Care in the Infant Mortality Prediction System with Intervention Management Database

NOTE: For all deliveries, the infant mortality rate was 6.49 per 1,000 live births, the low birth weight birth rate was 86.52 per 1,000, and the preterm birth rate was 109.61 per 1,000.

Overall, prenatal care was prevalent for the deliveries during the study period, with 75 percent of women receiving one or more prenatal care visits and 78 percent having at least one prenatal care visit during the first trimester. Poor birth outcomes were similar for both measures of prenatal care (one or more exams per month, first-trimester exam) at 4 or under per 1,000 for infant mortality, in the low 70s per 1,000 for low birth weight, and 89 to 95 per 1,000 for preterm births, and well below the rates across all deliveries (Figure 18).
NOTE: For all deliveries, the infant mortality rate was 6.49 per 1,000 live births, the low birth weight birth rate was 86.52 per 1,000, and the preterm birth rate was 109.61 per 1,000.

During the study period, birth doulas were present for 4 percent of deliveries. At 2.5 per 1,000 live births, the infant mortality rate among those having a birth doula was below the rate across all deliveries in Allegheny County (Figure 19). Likewise, the low birth weight rate of 46.3 per 1,000 and the preterm birth rate of 63.1 per 1,000 for women who had a birth doula were both below the rates across all deliveries (see Figure 19 note).
NOTE: For all deliveries, the infant mortality rate was 6.49 per 1,000 live births, the low birth weight birth rate was 86.52 per 1,000, and the preterm birth rate was 109.61 per 1,000.

Health Promotion and Education

As described earlier, health promotion and education efforts such as home visiting are widely available in Allegheny County for families at risk for poor outcomes. For 7 percent of the deliveries during the study period, families had received home visiting through Healthy Start, the Nurse-Family Partnership, or Early Head Start. (For the Nurse-Family Partnership, the IMPreS1v database only includes participation for 2012 and 2013, so the numbers are very low.) Rates of poor birth outcomes among those receiving any home visiting were 9.5 per 1,000 live births for infant mortality, 132.5 per 1,000 for low birth weight, and 142.5 per 1,000 for preterm birth, which were all well above the rates across all deliveries in Allegheny County (Figure 20).
NOTES: For all deliveries, the infant mortality rate was 6.49 per 1,000 live births, the low birth weight birth rate was 86.52 per 1,000, and the preterm birth rate was 109.61 per 1,000.

**Support and Referrals**

Support and referral efforts available to women during pregnancy or the postpartum period include programs and services provided through Family Support Centers and WIC. For 5 percent of all deliveries documented in the IMPreSIV database, families had participated in programming at a Family Support Center; for 30 percent of deliveries, families had received WIC services at some point before or after delivery. The rates of poor birth outcomes for those receiving these supports exceeded the average rates across all deliveries in Allegheny County (Figure 21).
NOTE: For all deliveries, the infant mortality rate was 6.49 per 1,000 live births, the low birth weight rate was 86.52 per 1,000, and the preterm birth rate was 109.61 per 1,000.

Behavioral health services represent another category of support and referrals available to families in Allegheny County. This category includes ACDHS’s drug and alcohol program, which provides a range of assessment, treatment, and recovery services, and its mental health program, which coordinates and supports mental health services. Families of 15 percent of the deliveries during the study period had participated in ACDHS-funded substance abuse or mental health services at some point before delivery or during the postpartum period. Across the two different types of behavioral health services, the rates of poor birth outcomes were similar (Figure 22). However, relative to all deliveries, those who received behavioral health services experienced much higher rates of poor birth outcomes (see Figure 22 note).
NOTE: For all deliveries, the infant mortality rate was 6.49 per 1,000 live births, the low birth weight birth rate was 86.52 per 1,000, and the preterm birth rate was 109.61 per 1,000.

Summary

The ten-year span of data reported in the IMPreSIV database and the breadth of intervention data included allowed us to report granular information on birth outcomes within Allegheny County over this time period. The database also allowed us to summarize the various risk and contextual factors associated with the range of birth outcomes and describe the participation rates in the medical- and community-setting interventions. This information informs the analysis described in the subsequent chapters, as we examine the effectiveness of interventions for women with different risk factors (e.g., substance use disorders) in order to facilitate individualized referrals to the interventions that will help the most for a specific risk profile.
This chapter focuses on understanding the factors related to engagement with the programs, services, and supports for which there are participation data in the IMPreS1v database—the second step of the causal inference framework, as described in Chapter 2. As noted earlier, the first step in our causal inference framework involved building on the work performed by the University of Pittsburgh team and predicting infant mortality. The additional predictions of infant mortality generated during this step fit the three types of data described in Chapter 2 (reportable information, potentially reportable information, and health care information) and the different time periods of our analysis (preconception, pregnancy, and postdelivery). Appendix C describes additional results of the predictions of infant mortality and intervention participation.

In our predictive modeling, we used several methods, including machine learning algorithms, synthetic sampling, and cross-validation, to increase the accuracy of the predictions. The machine learning algorithms enabled us to identify agnostically the most important predictive variables and how they should be combined to maximize the accuracy of our predictive models. Synthetic sampling enabled us to adjust for imbalance in rare outcomes such as infant mortality and participation in some of the interventions. Cross-validation enabled us to test the accuracy of our models using data that were not involved in generating the models. See Appendix B for more details on the methods that we employed in predictive modeling.

In this chapter, we first describe the sets of predictors included in the analysis. Then we describe which predictors of participation are most important for each intervention in the IMPreS1v database. Finally, we describe the accuracy of the models of intervention participation. Here we focus on our preferred models using the health care type of data, or the full set of available predictors. Additional details on the accuracy of the predictive models and how the models compare across data types can be found in Appendix C.

Potential Predictors of Intervention Participation

As described in Chapter 2, there are three data types included in the database:

- **Reportable data** include information that originates from birth certificate records that women could self-report to a health care or community-based social service provider.
- **Potentially reportable** data include information on major maternal diagnostics and current medications that women could possibly report to a health care or community-based social service provider, in addition to the reportable data.
• **Health care data** include information that could potentially inform a health care provider’s decisions, such as detailed maternal diagnostic histories, fetal ultrasounds, and toxicology reports that exist within electronic medical records, in addition to the reportable data and potentially reportable data.

For each intervention with participation data available in the IMPreSIV database, we estimated predictive models using each data type (Table 19). We did this for both methodological and practical reasons. Methodologically, by estimating the effects using different data types, we are changing the inputs and thereby testing the sensitivity of the results. Practically, since community-based social service providers and health care providers have access to different information, the different data types reflect the information each type of provider may be able to obtain.

With these predictors, missing data could be handled by excluding observations with missing values, imputing the missing values, altering the interpretation of the variable, or interpreting the missing values as themselves conveying information. For our analyses, we treated missing data differently depending on the type of data (reportable, potentially reportable, and health care data) in the IMPreSIV database. For example, for diagnostic information in the health care data, we altered the interpretation of the variable because it is not possible to distinguish between not having the condition and not being tested for the condition. Consequently, we interpret the diagnostic variables as indicating either a positive diagnosis or the lack of a positive diagnosis. For missing values in the health care data, such as ultrasounds and toxicology tests, we interpret the missing values as themselves conveying the information that the tests were not performed. Additional details on the treatment of missing data can be found in Appendix B.
<table>
<thead>
<tr>
<th>Categories of Predictors</th>
<th>Data Types</th>
<th></th>
<th>Data Types</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reportable</strong></td>
<td><strong>Potentially Reportable</strong></td>
<td><strong>Health Care</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Parental characteristics ($K = 112$) | Mother’s/father’s race  
Mother’s/father’s education  
Mother’s/father’s age  
Marital status  
Insurance status | | |
| Maternal health risk factors and behaviors ($K = 212$) | Pre-pregnancy body mass index  
Diabetes  
Hypertension  
Smoking  
Previous C-section | Previous miscarriage  
Anemia  
Autoimmune disease  
Substance abuse  
Vaccination history | |
| Pregnancy and delivery observations and diagnostics ($K = 721$) | Child gender  
Single or multiple birth  
Labor induction  
Delivery complications  
Maternal weight gain | Fetal intolerance  
Prenatal prescriptions | Placental abnormality  
Fetal growth  
Amniotic fluid measures  
Blood tests  
Toxicology reports |
| Postdelivery observations and diagnostics ($K = 161$) | NICU admission  
Apgar scores  
Birth weight  
Gestational length | Postpartum depression  
Child diagnostics  
Child prescriptions | Child blood tests |
| Socioenvironmental risk factors ($K = 192$) | Local income levels  
Local cost of living  
Local demographics  
Local air quality  
Year of birth | | |
| Other interventions (not the intervention of interest)$^a$ | Prenatal care  
Home visiting  
Pregnancy and postpartum support  
Breastfeeding and nutrition support  
Behavioral health services | Preconception and interconception care  
Prescriptions | |

$^a$ The number of other interventions is not listed here because it varies by specification and time period. For example, when predicting participation in behavioral health services during pregnancy, we include participation in other interventions during preconception and postdelivery. On the other hand, when predicting behavioral health service participation after delivery, we add indicators of other intervention participation postdelivery, as well as preconception and during pregnancy.
Predictors of Intervention Participation

When using the predictive models of intervention participation to understand which women are more likely to participate, it is important to understand which pieces of information are driving the prediction. In this section, we describe which predictors are more important or useful to predict the outcome using a method called relative importance. In this context, relative importance is a measure from 0 to 100 that describes which factors are strongly correlated to participation in the intervention. The factor with the strongest correlation receives a score of 100 and the correlations of all other factors are measured in relative terms. See Appendix B for more details on the relative importance method.

Here, we describe the results of the predictive models of participation for each intervention category. Given the volume of results to present, we have placed the results for the important predictors of receipt of income, medical, and other benefits in Appendix C.

Medical-Setting Interventions

Within the medical-setting category of interventions, we examined the relative importance of specific predictors of utilization of any preconception/interconception care, any prenatal care, and birth doulas.

Preconception/interconception care includes a preconception exam, any vaccinations, genetic counseling, and contraceptive counseling within one year of conception. Overall, the predictors that were most correlated with receiving preconception/interconception care within the UPMC system related to diagnoses or clinical findings, including genitourinary system disorders and unclassified abnormal clinical and laboratory findings (Figure 23). These results suggest that visiting a health care provider for other reasons is correlated with receiving preconception/interconception care. Additional important predictors included a socioeconomic factor (the local cost of rent in the mother’s residential area) and factors related to the type of medical insurance.
Prenatal care is defined as either receiving the first prenatal exam during the first trimester or receiving one or more prenatal exams per month during pregnancy. The most important predictor of participation in any prenatal care was marital status, but the result does not indicate the direction of the correlation (Figure 23). In other words, the relative importance measure simply means that being married was an important predictor of prenatal care, not that married women were more or less likely to receive prenatal care. Other important predictors of receiving any prenatal care were the race or ethnicity of the father, insurance status, and mother’s smoking behavior. Finally, missing birth interval information was another important predictor. Birth interval is recorded in the birth certificate data for all deliveries in the IMPreSiv data. In this case, the inability to report when the mother last gave birth was correlated with other socioeconomic risk factors. For instance, women with less than a high school education were more likely than more educated women to have missing birth interval information.
Doula support is defined as having a doula present at the delivery. The most important predictor of doula support was giving birth at a facility other than either of the region’s two large health care systems (UPMC and the Allegheny Health Network). Several of the other important predictors of receiving support from a birth doula were related to prenatal care, socioenvironmental risk factors, and maternal smoking (Figure 25).  

12 The doula support results presented here and in Chapters 8 and 9 rely only on the reportable data type. With the reportable data type, our predictive models are more accurate than those using the potentially reportable and health care data types. This is unique for doula support. Because the potentially reportable and health care data types describe only births that occurred at UPMC’s Magee-Womens Hospital, the differences in the accuracies of the models suggest that doula support is provided in a different way at Magee-Womens Hospital from how it is provided throughout the rest of Allegheny County.
Within the health promotion and education category of interventions, the IMPReSIV database includes information on home visiting programs, including Healthy Start, the Nurse-Family Partnership, and Early Head Start. The most important predictors of participation in any of these home visiting programs were demographic or socioeconomic factors, including whether the mother also receives income benefits such as Supplemental Security Income or Temporary Assistance for Needy Families; the mother’s marital status; the race or ethnicity of both the mother and the father; and insurance status (Figure 26).
Support and Referrals

Within the support and referrals category of interventions, we examined the relative importance of specific predictors of participation in pregnancy and postpartum support, breastfeeding and nutrition support, and behavioral health services.

For pregnancy and postpartum support, the IMPreS1v database includes information on the mother’s involvement with Family Support Centers. It is important to note that Family Support Centers offer a wide array of services for parents, some of which pertain to pregnant or postpartum women but many of which do not. Further, each Family Support Center offers its own unique mix of services depending on the needs of the families being served. From the database, we only know that a mother engaged at a Family Support Center. We do not know which Family Support Center or which services the mother received among those offered. Given that Family Support Centers exist in neighborhoods where the majority of residents have low socioeconomic status, it is not surprising that the factors most correlated with involvement with a Family Support Center were demographic and socioeconomic factors, including the receipt of income benefits like those provided through the Supplemental Nutrition Assistance Program, or participation in other interventions like the breastfeeding and nutrition support offered by WIC (Figure 27). Other important predictors of utilizing Family Support Centers were the mother’s marital status, race or ethnicity, and insurance status.
For breastfeeding and nutrition support services, the IMPreSIv database has data on WIC utilization. As expected given the income eligibility requirements of WIC, the most important predictors of receiving WIC were socioeconomic and demographic factors (Figure 28).

Specifically, the mother’s marital status, receipt of income benefits, insurance status, race or ethnicity, and education were important predictors of participation.
For behavioral health services, we observed participation in substance abuse programs and utilization of mental health services paid for by ACDHS, not including services reimbursed through Medicaid. The strongest predictor of receiving this subset of behavioral health services is receiving medical-related benefits such as those provided through Medicaid or the Medical Assistance Transportation Program. Other important predictors of participation in behavioral health services are marital status, participation in WIC, and mother’s smoking behavior. Having private health insurance also emerged as an important predictor (Figure 29).

**Figure 29. Relative Importance of Predictors of Participation in Behavioral Health Services**

- Mother’s smoking: ever
- Insurance: Private
- Intervention: WIC
- Married
- Receives medical benefits

**Accuracy of Intervention Participation Predictions**

More important for the causal inference framework than the importance of specific predictors is the overall accuracy of the predictive models. Practically, more-accurate predictive models allow us to better inform providers of the interventions women are most likely to utilize. Methodologically, greater accuracy in the predictive models enables us to control for selective intervention participation. The most common and accepted measure of model accuracy is the AUC scores, which combine the true positive rate and false positive rate into one measure ranging from 0 to 1. An AUC score of 1 describes a perfect predictive model; an AUC above 0.9 is considered excellent; and an AUC of 0.5 means that the predictive model is 50 percent accurate—that is, that the predictive model is no better than flipping a coin. See Appendix B for more details on AUC scores.

Overall, the accuracy of the predictions of participation for our preferred models was quite high for nearly all interventions we examined (Figure 30). Each model used the health care data type, meaning the maximum set of information, and included participation at any time point. For
five of the seven interventions analyzed, the AUC scores of our predictive models were greater than 0.9. The models most accurately predicted participation in behavioral health services, followed closely by Family Support Centers. While the AUC scores for preconception/interconception care (0.75) and doula support (0.80) were the least accurate, they still represent fairly accurate models when compared with other studies (J. Lee, 2017; Cooper, Minneci, and Deans, 2018).

**Figure 30. Accuracy of Intervention Participation Models**

Appendix C provides results that compare the accuracy of the models across data types (reportable, potentially reportable, and health care) and time of participation (preconception, prenatal, and postdelivery).

**Summary**

The IMPreSlv database provides the opportunity to explore a wide array of possible predictors of participation in different programs, services, and supports for pregnant and postpartum women, including parental characteristics, maternal health and behavioral risk factors, pregnancy, delivery and postdelivery observations and diagnostics, and socioenvironmental risk factors. While there was some variation across interventions in which predictors emerged as the most important, many of them were demographic or socioeconomic characteristics such as maternal marital status or education level. Because most of these programs, services, and supports target high-risk women and families, these results are not unexpected and suggest that the interventions are successfully engaging with the women and families they most want to reach.

The accuracy of the predictions of intervention participation facilitates our accounting for selective participation in the next step in the causal inference framework. As the accuracy of our models of intervention participation increase, we are better able to explain participation, which reduces the likelihood that the estimated intervention effects are biased. Health care and
community-based social service providers can also utilize the accurate predictions of intervention participation to better understand which women are most likely to use specific interventions and direct them to programs, services, and supports to meet their needs. Overall, the models produced very accurate predictions of the utilization of prenatal care, home visiting, Family Support Centers, WIC, and behavioral health services. However, our predictive models of preconception/interconception care and doula support were the least accurate, meaning that there is more unexplained variation in participation in these interventions. As a result, in the next step of our causal inference framework, the estimated effects of preconception/interconception care and doula support are more likely to be biased by unexplained, selective participation.
In this chapter, we present the main results of our analysis of the interventions’ causal effects on infant mortality, the third step in the causal inference framework. To estimate the effectiveness of the interventions available in Allegheny County, we combined the predictions of infant mortality with the predictions of participation in the interventions using the DML approach introduced by Chernozhukov et al. (2018). Intuitively, we estimate causal effects by comparing the outcomes of infants born to women with nearly identical risks that only differ by their participation in the interventions, which our predictive models explain. We also stratify our estimates of the interventions’ effects by predicted risk of infant mortality using the endogenous stratification method (Abadie, Chingos, and West, 2018). This approach allows us to describe intervention effectiveness for those births at greatest risk of infant mortality. Because infant mortality is a relatively rare event, these estimates by risk level provide the clearest understanding of the effects of the interventions.

This combination of methods is novel and uniquely suited to our context because while the IMPreSIV database is large and has many data sources, the data it contains are observational data. In other words, none of the interventions was randomly assigned, which is the typical standard for calling an effect “causal.” However, performing randomized control trials of all the interventions in Allegheny County that could potentially reduce the risk of infant mortality would have been expensive, time consuming, and possibly unethical. The methodological complexity and assumptions represent the tradeoff for not being able to randomly assign participants to interventions to test their effectiveness. As described in Appendix B, the methods that we employ in our causal inference framework are complex, involving multiple machine learning algorithms and econometric methods used in combination. However, these methods enable us to interpret our estimates as causal with only one reasonable assumption, conditional unconfoundedness. This assumption means that our predictions of infant mortality and intervention participation account for enough of what underlies infant mortality risk such that the unexplained portion is random and unrelated to the intervention. Generally, we consider this a reasonable assumption given the breadth of the IMPreSIV database and how accurately our models are able to explain infant mortality and intervention participation.

13 The ethics of randomized control trials are commonly discussed throughout many fields of research. The main question is whether it is ethical to withhold potentially effective interventions from research subjects in order to satisfy scientific objectives (Hellman and Hellman, 1991).
There are a number of considerations that help in the interpretation of the results we present in this chapter.

First, because infant mortality is the outcome, negative estimates imply that the intervention reduced the risk of infant mortality.

Second, our estimates of each intervention’s effects are stratified by the predicted risk of infant mortality for each decile of predicted risk from 10 percent to 90 percent. Because our objective is to determine intervention effectiveness and facilitate the targeting of resources to those at risk of infant mortality, we focus on and present the estimated interventions’ effects for those with a greater than 50 percent predicted risk of infant mortality.

Third, for each intervention and predicted risk level, we present both the point estimate and the confidence interval. In the figures in this chapter, the dot represents the point estimate (i.e., the midpoint, or “best guess,” within the confidence interval) and the lines extending out in both directions from the dot represent the confidence interval (i.e., the range of values that is likely to contain the unknown, true effect). The point estimate and the confidence interval are different, complementary ways of describing the estimate of the true, and unknown, causal effect. Because the confidence interval is a range of values, it expresses the uncertainty surrounding the “best guess.” More uncertainty means a larger confidence interval; less uncertainty means a smaller confidence interval. Typically, there is less uncertainty when there are more observations. In our discussion of the results, we focus on the point estimates as the midpoints of the confidence intervals, but we do not mean to minimize the uncertainty described by the confidence intervals.

Fourth, we describe the statistical significance of the estimated effects. When an estimate is statistically significant at the 95-percent threshold, there is a 5-percent chance that we wrongly conclude that an effect exists when there is none.

Finally, although larger negative effects indicate more effective reduction of infant mortality risk, even small effects are important. This is because of the terminal and dichotomous nature of the infant mortality outcome. For example, an estimate of −1 percent would mean that the intervention led to nine fewer infant deaths among the 155,218 births in Allegheny County between 2003 and 2013, which, though small, is still important. Further, since infant mortality is dichotomous, it does not describe other important and continuous measures of infant health and development, such as developmental delays. If the results show that an intervention has a small or null effect on infant mortality, the effects could be much larger for other outcomes related to infant health or development. As such, when interpreting the results of these causal inference models, it is important to keep in mind that they only relate to infant mortality. Relatedly, some of the interventions examined, such as behavioral health services, are not designed to reduce infant mortality. If our estimates show that these interventions reduce the risk of infant mortality, these effects should be considered unexpected benefits to the main objectives of the intervention.

The main results presented in this chapter leverage the health care data type, or the maximum data available. Since the predictive models using the health care data are the most accurate, we are more confident that the conditional unconfoundedness assumption holds for estimates that
rely on the health care data and therefore can be interpreted as causal. However, this means that the estimates are based on the sample of births that occurred within a UPMC facility, as opposed to all births in the county. In Appendix C we compare the results by data type and show how the estimates using the reportable data type differ between UPMC and non-UPMC facilities. Figure 31 shows the distribution in the births at UPMC and non-UPMC facilities.

**Figure 31. Distribution of Births in the Infant Mortality Prediction System with Intervention Management Database**

For each intervention, we also show how the effects vary by time period (i.e., preconception, prenatal, and postdelivery). Further, if the intervention category includes multiple programs (e.g., home visiting includes Healthy Start and Early Head Start), we show the effects of each specific program separately in addition to the combined effect (e.g., any home visiting).

Additional details of the methods we employ are described in Appendix B, and Appendix C contains additional results, including estimated effects by data type (reportable, potentially reportable, and health care), estimates of the effects of income (e.g., Temporary Assistance for Needy Families), medical-related benefits (e.g., Medicaid and medical assisted transportation), and other benefits (e.g., assisted housing). The limitations section of Chapter 10 has a fuller discussion of the limitations of our methods (including the conditional unconfoundedness assumption, missing data, selective observation, and multiple hypothesis testing).
Medical-Setting Interventions

The medical-setting interventions described in the IMPreSIv database include preconception/interconception care, prenatal care, and doula support. While preconception/interconception care can take many forms, the IMPreSIv database includes information on whether the mother had a preconception exam, any vaccinations, genetic counseling, or contraceptive counseling within one year of conception. Preconception exams are reported in the vital statistics data, but we observed the other types of preconception/interconception care only if the services were received at UPMC-affiliated facilities. Prenatal care is reported in the vital statistics data and describes either receiving the first prenatal exam during the first trimester or receiving one or more prenatal exams per month during pregnancy. Doula support is also reported in the vital statistics data and describes having a doula present at birth.

Preconception/Interconception Care

We estimate that the effects of preconception/interconception care are quite large for each level of risk (Figure 32). Overall, the results indicate that preconception/interconception care effectively reduces the risk of infant mortality. Moreover, the pattern by risk level suggests that the effectiveness of preconception/interconception care increased as the predicted risk of infant mortality grows. On the low end, for those with a (predicted) 50-percent or greater likelihood of infant mortality, our estimate indicates that preconception/interconception care significantly reduced the risk of infant mortality by 5 percent. Note that the confidence interval surrounding this point estimate is small, indicating less uncertainty. The estimated effects grew to nearly 25 percent for those with a 90-percent or greater likelihood of infant mortality. The confidence interval surrounding this estimate is larger, indicating greater uncertainty. This pattern of larger confidence intervals at higher levels of predicted risk will generally hold for each intervention examined because the number of observations decreases as the risk level increases. In other words, because there are fewer observations with a predicted risk greater than 90 percent than there are at the 50-percent risk level, there is greater uncertainty surrounding the estimates at higher risk levels.
While these estimates of the effects of preconception/interconception care were large and statistically significant, they are the least reliable among all the interventions for two reasons. First, three of the four types of preconception/interconception care were observed only for those who received services at a UPMC-affiliated facility. Vaccinations, genetic counseling, and contraceptive counseling were also offered by other health care providers, such as FQHCs, Planned Parenthood, and Adagio Health, which offer health care services to all people regardless of their health insurance status, and the IMPreSIV database does not include information from these health care providers. Since there may be differences between these other health care providers and UPMC-affiliated providers, it is likely that the women observed receiving preconception/interconception care had lower overall risk profiles than the women whose preconception/interconception care we did not observe because it was received from other health care providers. This means that our estimates likely represent upper bounds of the true effects of preconception/interconception care. In other words, if we observed all preconception/interconception care obtained by women in Allegheny County, we would expect the estimates to be smaller. Second, as noted earlier, the prediction of participation in preconception/interconception care was the least accurate of the interventions examined (0.75 AUC for preconception/interconception care vs. 0.90 AUC or higher for almost all of the other interventions). This means that, relative to the other interventions we studied, we are less confident that our methods are sufficiently accounting for selective utilization of the intervention and that our estimates represent causal effects.

Figure 32. Causal Effects of Preconception/Interconception Care on Infant Mortality
We also examined the effects for different time periods and found that there were no significant differences between the estimated effects of the preconception/interconception care by timing of infant mortality (death within 24 hours, death from day 2 to day 27, and death from day 28 to day 365). This suggests that preconception/interconception care may have been similarly effective for births at risk of mortality within 24 hours, mortality from day 2 to day 27, and mortality from day 28 to day 365. However, since infant mortality in specific time periods is even less frequent than infant mortality overall, the smaller number of observations within each time period means that the uncertainty surrounding the estimates is larger, making it more difficult to detect statistically significant differences (see Appendix C for results).

By separately estimating the effects of specific services, we see suggestive evidence that, in fact, the previous results represent upper bounds of the effects of preconception/interconception care services (Figure 33). We see this by comparing the estimates of services selectively observed only at UPMC-affiliated facilities—contraceptive counseling, genetic testing, and vaccinations—with the estimates of the effects of preconception exams, which were observed for all women. The estimates for contraceptive counseling, genetic testing, and vaccinations are clustered, large, and increasing as the risk of infant mortality grows. In contrast, the estimated effects of preconception exams are near zero and generally not statistically significant.

**Figure 33. Causal Effects of Specific Types of Preconception/Interconception Care on Infant Mortality**

![Figure 33: Causal Effects of Specific Types of Preconception/Interconception Care on Infant Mortality](image)

NOTE: Vaccinations, genetic counseling, and contraceptive counseling were only
observed for those who received services at a UPMC-affiliated facility.

**Prenatal Care**

The overall pattern of the results shows that the estimated effectiveness of prenatal care increased as the predicted risk of infant mortality grew (Figure 34). On the low end, for those with a greater than 50 percent likelihood of infant mortality, prenatal care was estimated to significantly reduce the risk of infant mortality by 7.2 percent. The estimated effect of prenatal care reached 26.3 percent for those with a greater than 90 percent likelihood of infant mortality. While these results looked similar to the effects of preconception/interconception care, we are more confident that the estimates reflect the causal effects of the intervention because we did not selectively observe prenatal care, and our predictive models of prenatal care were more accurate (0.91 AUC) than the models of preconception/interconception care.

![Figure 34. Causal Effects of Prenatal Care on Infant Mortality](image)

By separately estimating the effects of regular prenatal care and early prenatal care, we see that most of prenatal care’s reduction to the risk of infant mortality is driven by receiving regular prenatal care, specifically receiving one or more exams per month during pregnancy (Figure 35). For infants with a greater than 50 percent likelihood of mortality, the estimated effect of receiving one or more prenatal exams per month was a reduction in the risk of infant mortality of 8.4 percent, with the effect growing to a 37.9-percent reduction in the risk of infant mortality at the highest risk level. Early prenatal care, which means receiving the first prenatal exam during the first trimester, reduced the risk of infant mortality marginally but not significantly at the
highest and three lowest risk levels. For infants with a greater than 80 percent likelihood of mortality, early prenatal care significantly reduced the risk of infant mortality by 4.5 percent.

**Figure 35. Causal Effects of Specific Types of Prenatal Care on Infant Mortality**

When looking at effectiveness by timing of infant mortality, there were no significant differences between the effects of the prenatal care by type of infant mortality (death within 24 hours, death from day 2 to day 27, and death from day 28 to day 365). As with preconception/interconception care, this could indicate that prenatal care was similarly effective for births at risk of mortality during different time periods, or it could be a by-product of having fewer observations with which to detect statistically significant differences (see Appendix C for results).

**Doula Support**

The effectiveness of doula support (i.e., having a doula present at birth) in reducing the risk of infant mortality was similar to the effects of prenatal care: large and significant reductions across all risk levels (Figure 36). For those with a greater than 50 percent likelihood of infant mortality, doula support significantly reduced the risk of infant mortality by 4.3 percent. The effect of doula support increased dramatically to a 29.6-percent reduction for those with a greater than 90 percent likelihood of infant mortality. As noted earlier, doulas can offer support throughout the prenatal period, as well as during delivery. These estimates likely include both birth doulas and doulas who provided support during the prenatal period, because the
information comes from the vital statistics data, which report the type of attendant present at the birth.

Figure 36. Causal Effects of Doula Support on Infant Mortality

As with preconception/interconception care, the prediction of participation in doula support was less accurate (0.80), and consequently we are less confident that our methods sufficiently account for selective utilization of the intervention.

Again, there were no significant differences between the effects of the doula support by type of infant mortality (death within 24 hours, death from day 2 to day 27, and death from day 28 to day 365). This could indicate that doula support was similarly effective for births at risk of mortality during different time periods, or it could be a by-product of having fewer observations with which to detect statistically significant differences (see Appendix C for results).

Health Promotion and Education

Within the health promotion and education intervention category, the IMPeSIv database includes information on home visiting, including the Healthy Start, Early Head Start, and Nurse-Family Partnership programs.
Home Visiting

Overall, the results indicate that home visiting was effective for those at the highest risk of infant mortality (Figure 37). For those with a greater than 90 percent likelihood of infant mortality, the estimated effect of home visiting was a significant reduction in risk of 7.1 percent, although the confidence interval was quite large (ranging from 3.9 to 10.3 percent). At lower levels of risk, the effects of home visiting were not statistically different from zero.

**Figure 37. Causal Effects of Home Visiting on Infant Mortality**

![Causal Effects of Home Visiting on Infant Mortality](image)

We examined home visiting during pregnancy and after delivery to determine whether the effects of home visiting varied by when the intervention was received. Overall, the estimated effects of participating in home visiting during pregnancy was a reduction in the risk of infant mortality for each level of risk above 50 percent, with the effects ranging from 2.1 to 10.0 percent across the risk levels (Figure 38). However, the estimated effects of home visiting after delivery were not statistically significant, which would be expected since most infant mortality occurs at or shortly after birth. Thus, starting home visiting early, during pregnancy, may have an important benefit relative to starting home visiting after delivery, particularly for those most at risk of poor birth outcomes.
Looking at the effects for the specific home visiting programs, both Healthy Start and Early Head Start were estimated to statistically significantly reduce the risk of infant mortality across all levels of risk, with the largest estimated effect for those at highest risk of infant mortality (Figure 39). Participation in Early Head Start was estimated to significantly reduce infant mortality in the range of 2.7 to 34.1 percent, depending on the risk level. Participation in Healthy Start had more modest, but still significant, estimated reductions to the risk of infant mortality, ranging from 9.9 to 12.2 percent. Because there are few available years of data describing Nurse-Family Partnership participation in the IMPreSlv database, the number of observations was too limited to separately examine its effects.
When looking at effectiveness by timing of infant mortality, there were no significant differences between the effects of the home visiting by timing of infant mortality (death within 24 hours, death from day 2 to day 27, and death from day 28 to day 365). This could indicate that home visiting was similarly effective for births at risk of mortality during different time periods, or it could be a by-product of having fewer observations with which to detect statistically significant differences (see Appendix C for results).

Support and Referrals

Within the support and referral intervention category, the IMPreSv database includes participation information for pregnancy and postpartum support, breastfeeding and nutrition support, and behavioral health services. We defined pregnancy and postpartum support as receiving services or supports at a Family Support Center, breastfeeding and nutrition support as participation in WIC, and behavioral health services as receiving substance abuse or mental health services funded by ACDHS.

**Pregnancy and Postpartum Support**

The results of examining the estimated effects of receiving pregnancy or postpartum support offered at Family Support Centers suggest that this intervention significantly increased the risk of infant mortality at each risk level (Figure 40). While a null estimated effect could be explained
by the wide array of services and supports available at Family Support Centers, many of which are unrelated to pregnancy, and the differences across centers in the mix of services offered, this does not explain how Family Support Centers could increase the risk of infant mortality.

Figure 40. Causal Effects of Family Support Centers on Infant Mortality

To understand these counterintuitive estimated effects of Family Support Centers, we first examined whether women who used Family Support Centers experienced a substitution effect and utilized other, more effective interventions less often. These results showed that women who used Family Support Centers were less likely to receive prenatal care or publicly funded income benefits and medical-related benefits. However, women who used Family Support Centers were also more likely to participate in home visiting programs and WIC. Because women who used Family Support Centers were more likely to utilize some services and less likely to utilize others, the overall substitution effects of Family Support Centers are unclear (see Appendix C for more information on these results).

Next, we explored whether the duration of participation in the intervention explained the increase in risk for Family Support Centers. To test for this, we used the number of years of participation in Family Support Center services rather than a dichotomous measure of whether the family participated at all. The results indicated that for each risk level, as the length of participation increased, the risk of infant mortality also increased.

---

14 Computationally, these estimates were far more expensive to obtain because predicting the duration of intervention participation is more complex than predicting a yes-or-no outcome. Because of the computational complexity, the estimates required more data and computational resources to obtain.
participation in Family Support Center services increased, the risk of infant mortality decreased, with the magnitude of the estimated effect ranging from 0.3 to 1.5 percent across the risk levels (Figure 41). At the highest risk level, the estimated effect was not statistically significant because of the very large confidence interval. While these magnitudes were smaller than the estimates for other interventions, the interpretation of the estimates is different when using a continuous rather than a dichotomous measure of participation. For the dichotomous measure of participation, the estimates correspond to the average duration of participation. For example, a 7.1-percent decrease in infant mortality risk from home visiting implies that the effect results from participating in the intervention at the average rate. For a continuous measure of participation, the duration of participation explicitly corresponds to the actual, rather than average, duration of participation. For example, those with a predicted risk of infant mortality greater than 80 percent who participated in services at Family Support Centers for one year have a 1.5-percent reduced risk of infant mortality (Figure 41). Participating in Family Support Center services for two years doubled the effect to a 3-percent reduction in the risk of infant mortality (multiplying two years by 1.5 percent gives this estimate). Longer lengths of participation in Family Support Center services had the effect of reducing the risk of infant mortality, particularly among those at higher risk.

Figure 41. Causal Effects of Family Support Centers by Duration of Participation

---
expense and without a need to explain counterintuitive findings for other interventions, we only examined effectiveness by duration of participation for this intervention.
The difference between these two sets of results—participation or no participation versus duration of participation—indicates a problem of measurement. Measuring Family Support Center participation with a yes or no masks important variation that turns out to be associated with infant mortality. Stated differently, these two sets of results indicate that a substantial portion of Family Support Center participants do not really utilize the service or receive any benefits from it, while those who actually utilize the service receive benefits from it.

For the other interventions, we have shown the effects by the timing of the intervention (preconception, pregnancy, and postdelivery). Here, since the estimated effects of the participation duration indicated that early initiation with Family Support Centers yielded greater reductions to the risk of infant mortality, it is unnecessary to show those results. The duration results already indicated that the effects of Family Support Centers during preconception were greater than the effects during pregnancy and postdelivery.

We also compared the effects of Family Support Centers by timing of infant mortality (death within 24 hours, death from day 2 to day 27, and death from day 28 to day 365) and found only one statistically significant finding. The differences between the effect of Family Support Center participation in the postneonatal period (day 28 to day 365) and the two earlier periods are statistically significant. These results suggest that Family Support Center participation reduces the risk of postneonatal mortality (day 28 to day 365) more effectively than it reduces the risk of infant mortality during earlier periods. However, this is only true at the 50-percent predicted risk level. If the differences were significant at each risk level, then we could conclude that the effects of Family Support Centers differ by timing of infant mortality, but the results provide insufficient evidence for this conclusion (see Appendix C for results).

**Breastfeeding and Nutrition Support**

Breastfeeding and nutrition support, or WIC, was estimated to significantly reduce the risk of infant mortality across all risk levels of greater than 50 percent. Since most infant deaths occur shortly after birth, it is likely that the nutrition counseling drives this result. The estimated impact increased as the risk level increased, as did the size of the confidence interval (Figure 42). For those predicted at a greater than 50 percent likelihood of infant mortality, WIC was estimated to significantly reduce the risk of infant mortality by 2 percent. For the highest risk level, over 90 percent likelihood of infant mortality, WIC was estimated to reduce the risk of infant mortality by 11.6 percent, with a relatively large confidence interval ranging from 8.2 to 15.0 percent.
When looking at effectiveness by timing of infant mortality (death within 24 hours, death from day 2 to day 27, and death from day 28 to day 365), the estimates show no statistically significant differences. This could indicate that WIC was similarly effective for births at risk of mortality during different time periods, or it could be a by-product of having fewer observations with which to detect statistically significant differences (see Appendix C for results).

Note that we cannot examine variation in the effectiveness of WIC across different time periods of utilization (pregnancy and postdelivery) because of data limitations. We obtained information about WIC participation from vital statistics, which are recorded only at birth and child death. Consequently, the results should be interpreted as describing the effects of WIC during both pregnancy and postdelivery.

**Behavioral Health Services**

Overall, the receipt of any behavioral health services funded by ACDHS, including substance abuse and mental health services, were estimated to generally have only small to no reductions in infant mortality except at the highest level of infant mortality risk (Figure 43). Among those predicted to have a greater than 90 percent likelihood of infant mortality, behavioral health services were estimated to reduce infant mortality risk by 4.6 percent. This suggests that behavioral health services were reaching those most at risk for infant mortality and the efforts were having some impact. However, this estimate does have a relatively large confidence interval, indicating that the effect lies within the range of 1.0 to 8.2 percent. Since behavioral
health services are not designed to reduce the risk of infant mortality, the small estimated effects, only significant for those at the highest risk levels, are expected.

Figure 43. Causal Effects of Behavioral Health Services on Infant Mortality

We also examined whether the timing of the participation in behavioral health services affects the risk of infant mortality. The results were small and not significant across most of the time periods and risk levels, largely as a result of the smaller number of observations for participation in behavioral health services during specific time periods (Figure 44). However, for participation in behavioral health services before conception at the greater than 50 percent predicted risk level, the estimated effect is a statistically significant 1.5-percent reduction in infant mortality risk. Since the number of observations is greater at the 50-percent predicted risk level, there is less uncertainty with this estimate. Additionally, the estimate is significantly different from the estimated effect during pregnancy and postdelivery. Together these results indicate that for a broadly defined risk of infant mortality greater than 50 percent, earlier participation in behavioral health services is estimated to be more effective at reducing the risk of infant mortality than later participation.
The two ACDHS-funded behavioral health services in the IMPreSiV database are substance abuse programs and mental health services. Across the risk levels, mental health services were not estimated to have significant effects on the risk of infant mortality (Figure 45). For substance abuse services, the estimated effects were statistically significant for all but one level of risk above 50 percent. For those with a greater than 50 percent likelihood of infant mortality, the ACDHS-funded substance abuse programs were estimated to reduce risk by 1.2 percent, with the effectiveness gradually growing with the risk level. At the highest level of predicted risk, substance abuse services were estimated to decrease the risk of infant mortality by 5.7 percent.
We also examined how the effects of behavioral health services vary by timing of infant mortality (death within 24 hours, death from day 2 to day 27, and death from day 28 to day 365). The estimates indicate that behavioral health services were not significantly more or less effective by timing of infant mortality (see Appendix C for results).

For all of the estimated effects of behavioral health services, it is important to note that the IMPreS!v database includes only participation in ACDHS-funded behavioral health services, rather than the universe of behavioral health services available in Allegheny County. While this selective observation of ACDHS-funded behavioral health services is similar to the selective observation of preconception/interconception care, the implications may be different. For preconception/interconception care, the IMPreS!v database does not include care received at locations more likely to service high-risk women, meaning that the estimates likely represent upper bounds. For behavioral health services, however, the IMPreS!v database includes only services funded by ACDHS and not those funded by private insurance or Medicaid. Given the correlation between socioeconomic status and infant mortality risk, it may be that the women who participate in ACDHS-funded behavioral health services have higher overall risk profiles than the women who participate in behavioral health services funded by other sources. As a result, the estimated effects of behavioral health services may represent lower bounds. In other words, the actual effect could be larger if the database included the universe of behavioral health services.
services received by women in Allegheny County. And again, because behavioral health services are not designed with reducing infant mortality as objective, the relatively smaller effects of this type of intervention are expected and should be considered added benefits to the main objectives of the services.

**Summary and Discussion**

Our examination of the estimated effectiveness of different interventions for different levels of predicted risk of infant mortality found variation in effectiveness across risk levels, as well as differences by time period and for specific programs, services, and supports within an intervention category (Table 20).

<table>
<thead>
<tr>
<th>Medical-Setting Interventions</th>
<th>Significant Effects (% change) on the Risk of Infant Mortality by . . .</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Risk Level</td>
</tr>
<tr>
<td>Preconception/interconception care&lt;sup&gt;a&lt;/sup&gt;</td>
<td>All risk levels&lt;sup&gt;b&lt;/sup&gt; (−24.5% to −5%)</td>
</tr>
<tr>
<td>Prenatal care</td>
<td>All risk levels&lt;sup&gt;b&lt;/sup&gt; (−26.0% to −7.2%)</td>
</tr>
<tr>
<td>Doula support</td>
<td>All risk levels&lt;sup&gt;b&lt;/sup&gt; (−4.3% to −29.6%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Health Promotion and Education</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Home visiting</td>
<td>Risk &gt;90 (−7.1%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Support and Referrals</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

122
**Significant Effects (% change) on the Risk of Infant Mortality by . . .**

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Participation Time Period</th>
<th>Specific Programs</th>
</tr>
</thead>
</table>
| Pregnancy and postpartum support (Family Support Centers)
| All risk levels\(^\text{b}\) (+2% to +6.5%) | Not examined | Not examined |
| Breastfeeding and nutrition support (WIC)\(^\text{d}\) | All risk levels\(^\text{b}\) (−11.6% to −2%) | Not examined | Not examined |
| Behavioral health services | Risk >90% (−4.6%) | Preconception, risk >90% (−1.9%) | Mental health, >50% risk (−1.2%) Substance abuse (−5.7% to −1.2%) |

\(^{a}\) Estimates are likely upper bounds of the true effects.
\(^{b}\) “All risk levels” refers to all risk levels with greater than 50 percent predicted probability of infant mortality.
\(^{c}\) Estimates based on duration of participation show that the intervention reduces the risk of infant mortality.
\(^{d}\) Estimates are likely lower bounds of the true effects.

**Intervention category.** The results demonstrate that medical interventions, which are the most targeted to the health of the mother and baby, were estimated to have the largest impact. While our estimates of the effects of preconception/interconception care likely represent upper bounds, the estimated effects of prenatal care were similarly large and more reliably representative of the true effects because of the high accuracy of our predictive model. These results conform to the evidence base that shows strong evidence for improved birth outcomes for individual components of preconception/interconception care. Similarly, the estimated effects of doula support were large, but because our predictive models of doula support were less accurate than others, we are less confident that the estimates represent causal effects. These results add to the limited evidence on the effect of doulas on birth outcomes. Though the effects were smaller, home visiting and the three support and referral interventions exhibited significant effects on infant mortality, particularly at the highest levels of predicted risk. The significant effect for home visiting aligns with some of the evidence on the effectiveness of nurse home visiting on birth outcomes. These nonmedical interventions likely have larger effects on other outcomes, such as child development or maternal mental health, that are more directly tied to the objectives of each program.

**Risk level.** Generally, the estimated effectiveness of the interventions increased with the predicted risk of infant mortality. For the medical-setting interventions, the estimate of the effects ranged from 5- to 25-percent reductions in risk for preconception/interconception care across the risk levels, 7 to 26 percent for prenatal care across the risk levels, and 4 to almost 30
percent for doula support across the risk levels. The estimated effects of home visiting were null at lower risk levels but 7 percent at the highest risk level. Among the support and referral interventions, the estimated effects of Family Support Centers ranged from 0.3 to 1.5 percent per year across the risk levels using duration of participation in the intervention. The estimated effects of WIC range from 2 to nearly 12 percent across the risk levels, and the estimated effects of behavioral health services were null at lower risk levels but nearly 5 percent at the highest risk level. The range of estimated effects by risk level and the greater magnitudes of the effects at higher risk levels suggest the importance of the predictive modeling. Accurate predictive modeling is critical because it allows constrained resources to be targeted where they will be most effective.

**Time period.** Home visiting programs were estimated to significantly reduce the risk of infant mortality but only during pregnancy, not after delivery. Further, the effects of home visiting during pregnancy were magnified as the risk level increased. This indicates that earlier involvement in home visiting programs may pay off with better outcomes, particularly for those most at risk for poor birth outcomes. Behavioral health services also were estimated to have a significant effect on reducing infant mortality risk during the preconception period for those with a greater than 50 percent predicted risk of infant mortality. Overall, for those few interventions where it was appropriate to examine effects by time period, it appears that earlier involvement pays off with greater reductions to the risk of infant mortality.

**Specific interventions.** Across the intervention categories, the magnitudes of the estimated effects of specific interventions varied. For preconception/interconception care, three of the four interventions examined were estimated to significantly reduce infant mortality and at similar rates. For prenatal care, receiving one or more exams per month during the prenatal period was estimated to have a large significant effect, while the effects of receiving a first-trimester exam were generally insignificant. This suggests that consistent prenatal care may be more important to reducing the risk of infant mortality than early prenatal care, which is largely consistent with the evidence base that shows that more frequent and intensive visits reduce poor birth outcomes for high-risk women. For home visiting, Early Head Start was estimated to produce larger reductions to the risk of infant mortality than Healthy Start, particularly at higher levels of risk. These differences could reflect differences in program intensity (e.g., weekly vs. monthly home visits), the breadth of program offerings (e.g., services include prenatal care), or the approach used (e.g., program based on evidence-informed model). However, both of the programs were estimated to produce significant reductions to the risk of infant mortality, and the estimated effects of Healthy Start were larger than those of Early Head Start for those at lower risk of infant mortality. Among behavioral health services, the effects of mental health services were only estimated to be significant at the lowest risk level. The estimated effects of substance abuse services were larger and significant, particularly at higher levels of risk. It is important to note that the estimates for behavioral health services likely represent lower bounds, and these
programs are likely to generate significant gains to other outcomes, such as maternal health and child development.

Discussion

Overall, the results showed that medical interventions targeting maternal and child health were estimated to be the most effective, but other interventions work too. While some of the health promotion and education interventions and support and referral interventions are designed to achieve other objectives, they play an important role in community-based efforts to reduce infant mortality, particularly for those most at risk of poor birth outcomes. Since estimated intervention effects varied by risk level, the development of accurate predictions is critical for enabling the targeting of constrained resources to those most in need and those who receive the greatest benefits from the programs, services, and supports. Further, since earlier action was better for some interventions, the predictions of intervention participation can help get women involved as early as possible.

In the next chapter, we build on the theme of targeted interventions by examining the estimates of intervention effectiveness by specific risk factors. Additionally, we examine whether the combination of certain interventions generated greater reductions to the risk of infant mortality.
This chapter presents the results of our examination of the effects of the interventions on reducing infant mortality for subgroups of women with specific risk factors, as well as results describing the combined effects of multiple interventions. Together these results represent the fourth and final step of the causal inference framework. By building on the previous steps, the results of this analysis will enable individualized intervention recommendations so that women with specific risk profiles can be referred to the intervention or interventions that they will be most likely to use and that will most effectively reduce their risk of infant mortality.

For each intervention with participation information in the IMPreSlv database, we first explored the effects of interventions for women with specific demographic, behavioral, and reproductive history risk factors. Specifically, we examined the effects of the interventions by risk factors shown to be strongly predictive of infant mortality based on the predictive modeling work of the University of Pittsburgh team. However, examining all of the important risk factors was not possible because of interrelationships between the interventions and risk factors. For example, gestational length is an important predictor of infant mortality, but it is also a potential outcome of the interventions. The risk factors examined must be immutable characteristics (e.g., race) or observed before the interventions (e.g., preconception diagnoses) to ensure that the occurrence of the risk factor is not affected by the intervention (Abadie, Chingos, and West, 2018). Such demographic risk factors that predict infant mortality include mother’s age and race or ethnicity; available behavioral and reproductive history risk factors include maternal smoking history, substance abuse history, and number of previous pregnancies (specifically, first pregnancy).

Next, for each intervention, we explored how the effects of the interventions are altered when combined either with other interventions or with income, medical, or other benefit programs. Any given intervention is unlikely to address all the needs of those at risk of infant mortality, so some interventions may produce greater effects in combination. For example, women who received services at Family Support Centers may also have been involved with a home visiting program. In this case, we would expect both interventions to have independent effects and produce an even greater effect when combined.

We also examined the combined effects of certain benefit programs, including income benefits (e.g., the Supplemental Nutrition Assistance Program), medical benefits (e.g., Medicaid or medical assisted transportation), and other publicly funded benefits (e.g., assisted housing), because these programs may relax the economic or access constraints that women face and
thereby enable other interventions to be more effective.\textsuperscript{15} The timing of participation in the other intervention or benefit programs is important. For each intervention, we only examined how it combines with other interventions and benefits that women participate in during the same time period or in a previous time period. Because preconception/interconception care likely leads to prenatal care, for instance, we did not assess how the effects of preconception care are altered by prenatal care. However, for prenatal care, we examined how preconception/interconception care alters its effects because preconception/interconception care occurs before prenatal care.

There are a number of considerations that help in the interpretation of the results we present in this chapter.

First, the estimates presented in this chapter are more exploratory, with greater uncertainty than the estimates of intervention effectiveness in Chapter 8. The estimates of intervention effectiveness were derived using all of the observed participants for each intervention. In this chapter, the effects by risk factor were limited to those who participated in the intervention \textit{and} who also had the risk factor. For example, substance abuse is a relatively rare risk factor, meaning the estimates of the effects of the interventions for women with a substance abuse disorder will have greater uncertainty than our estimates of the general effect of the intervention for all women. Further, in this chapter, the estimated effects for different combinations of interventions were limited to women who were observed participating in the combination of interventions. For example, there are fewer women who participate in both home visiting and behavioral health services than who participate in those interventions individually. There were also some combinations of interventions for which there are too few observations for us to assess their combined effects (for reference, see Figure 16 in Chapter 6).

Second, the results in this chapter focus on those with a predicted risk of infant mortality greater than 50 percent. Focusing on those with a greater than 50 percent predicted risk of infant mortality means our estimates are also likely to be conservative. In other words, because each of the interventions was more effective among those at greater risk, they are likely to be more effective for those at greater risk who also have certain risk factors. However, because there are fewer observations at higher risk levels, these estimates also have more uncertainty. We only present the more conservative estimates for those with a predicted risk of infant mortality greater than 50 percent because we consider the issue of uncertainty to be important.

Third, the estimates in this chapter are derived using the health care data. This means that the sample of births considered are those that occurred within a UPMC facility.

\textsuperscript{15} In the previous chapter, we did not provide estimated intervention effects for the income, medical, and other benefit programs with participation information in the IMPreSIV database because these benefits are not specifically targeting pregnant or postpartum women or delivering services to them, although these results are presented in Appendix C.
Additional estimates of the effects of the interventions for women with additional risk factors (e.g., insurance status, previous poor pregnancy outcomes, maternal diabetes, maternal hypertension, maternal obesity, and others) are included in Appendix C.

Medical-Setting Interventions

The medical-setting interventions described in the IMPreSIV database include preconception/interconception care, prenatal care, and doula support. As noted earlier in this report, some types of preconception/interconception care were selectively observed only at UPMC-affiliated facilities.

Preconception/Interconception Care

We examined preconception/interconception care (i.e., preconception exam, contraceptive counseling, genetic counseling, or vaccinations) received within one year before conception, including care received by women with the specific risk factors and a greater than 50 percent predicted risk of infant mortality. Among the demographic risk factors examined, preconception care/interconception care was estimated to be most effective for teens, young adult women, and black women (Figure 46). The estimated effects for these groups were statistically significant and ranged from a 3.4- to 8.6-percent decrease in the risk of infant mortality. Among the behavioral and reproductive history risk factors, preconception/interconception care was estimated to significantly reduce infant mortality for first pregnancies by 8.8 percent and by 5.3 percent for women who had ever smoked. For opioid use disorder, the estimated effect of preconception care/interconception care was a significant increase in risk of infant mortality by about 10 percent. This finding may be related to the multiple hypotheses being tested, which can produce results that incorrectly appear to be statistically significant. It is also possible that women with substance abuse issues who received preconception/interconception care were less likely to receive prenatal care or other services during pregnancy because of their substance abuse issues.
NOTE: Three of the four types of preconception/interconception care were only observed for those who received services at a UPMC-affiliated facility.

**Prenatal Care**

For prenatal care, defined as receiving a first-trimester exam or receiving one or more exams per month during pregnancy, we also tested specific demographic, behavioral, and reproductive history risk factors for women with a greater than 50 percent predicted risk of infant mortality. For the demographic factors examined, prenatal care was estimated to be most effective for women ages 20 to 24 and black women (Figure 47). For women ages 20 to 24, the estimated effect of prenatal care was a significant reduction in risk of infant mortality by 7.0 percent. Black women who received prenatal care were estimated to have an 8.4-percent reduction in infant mortality risk. Among the behavioral and reproductive history factors, prenatal care was estimated to significantly decrease infant mortality risk only for women in a first pregnancy. For women with substance abuse issues, the lack of an intervention effect for prenatal care may be a by-product of fewer women being diagnosed with these issues during pregnancy because of the short time frame or because these women may be less likely to seek prenatal care for fear of mandated reporting or arrest.
Doula Support

For the demographic factors examined, doula support was most effective for Hispanic women (Figure 48). Among Hispanic women, doula support was estimated to significantly reduce risk of infant mortality by 19.6 percent, although the confidence interval for this estimated effect was quite large, ranging from 6.7 to 32.5 percent. Doula support was also effective for teens, young adult women, and black women. The estimated effects for these groups were statistically significant and ranged from a 3.7- to 6.3-percent decrease in the risk of infant mortality. Among the behavioral and reproductive history factors, doula support was estimated to significantly decrease infant mortality risk among women who ever smoked and women with an opioid use disorder, with estimated effects ranging from 3.2 to 9.0 percent.
Health Promotion and Education

Within the health promotion and education intervention category, the IMPReS database includes information on home visiting, including the Healthy Start, Early Head Start, and Nurse-Family Partnership programs.

Home Visiting

Of all the demographic risk factors considered for women with a greater than 50 percent predicted risk of infant mortality, home visiting was estimated to be most effective for teens and black women (Figure 48). The estimated effect for these groups was a statistically significant reduction in the risk of infant mortality of 5.7 percent for teens and 1.5 percent for black women. Among the behavioral and reproductive history factors, the evidence did not suggest that home visiting significantly reduced the risk of infant mortality.
When examining the effects of home visiting combined with other interventions and benefits, home visiting was estimated to be most effective when combined with other benefits that include assisted housing, significantly decreasing infant mortality risk by 2.1 percent (Figure 50). Additionally, home visiting combined with WIC, income benefits, and medical-related benefits was estimated to significantly reduce infant mortality risk by 1.3 to 1.7 percent, although the confidence intervals for these estimated effects were quite large.
Support and Referrals

Within the support and referral intervention category, the IMPreSIV database includes participation information for pregnancy and postpartum support (Family Support Centers), breastfeeding and nutrition support (WIC), and behavioral health services funded by ACDHS (substance abuse and mental health services).

Pregnancy and Postpartum Support

Across all the demographic, behavioral, and reproductive history factors examined for women with a greater than 50 percent risk of infant mortality, Family Support Centers were not estimated to significantly reduce the risk of infant mortality for any of the demographic, behavioral, or reproductive history risk factors examined (Figure 51).

Family Support Centers also were not estimated to have a significant effect on infant mortality risk when combined with home visiting, WIC, behavioral health services, or any of the benefit programs (Figure 52). While the findings indicate that the combination of Family Support Centers with other interventions and benefit programs did not generally result in reductions to the risk of infant mortality, the combined effect of Family Support Centers and home visiting was marginally significant ($p < .10$).
Breastfeeding and Nutrition Support

We examined breastfeeding and nutrition support in the form of ever receiving WIC benefits for women with the specific risk factors and a greater than 50 percent predicted risk of infant mortality (Figure 53). Among the demographic risk factors examined, WIC was estimated to be most effective for teens, young adult women, and black women, with statistically significant estimated effects ranging from 3.5 to 4.6 percent. When looking at the behavioral and reproductive history risk factors, WIC was estimated to significantly reduce the risk of infant mortality for first pregnancies and women who had ever smoked with effects between 2.7 and 4.2 percent. WIC was also estimated to significantly decrease infant mortality risk by 8.5 percent for women with opioid use disorder.
WIC was estimated to be very effective when combined with all of the other interventions and benefit programs (Figure 54). WIC combined with home visiting, Family Support Centers, and behavioral health services was estimated to have small but significant decreases in infant mortality risk ranging from 3.1 to 5.8 percent. Among the benefit programs, WIC was estimated to be very effective when combined with other benefits. The combination of WIC and other benefits was estimated to reduce infant mortality risk by 6.1 percent. Combining WIC with income benefits and medical-related benefits was estimated to reduce risk by 2.8 percent.
Behavioral Health Services

Across all of the demographic, behavioral, and reproductive history factors examined for women with a greater than 50 percent predicted risk of infant mortality, there was only a significant effect for behavioral health services. Among women with an opioid use disorder, behavioral health services were estimated to reduce the risk of infant mortality by 15.6 percent (Figure 55).

**Figure 55. Intervention Effects by Risk Factor: Any Behavioral Health Services**

Behavioral health services were not estimated to yield statistically significant effects on infant mortality risk when combined with any of the other interventions (Figure 56). However, the combination of behavioral health services with other benefits (which include housing assistance) was estimated to significantly reduce the risk of infant mortality by 3.1 percent.
Summary and Discussion

This fourth and final step of the causal inference framework built on the results of the previous steps and will enable the optimization of intervention recommendations. The results showed which groups of women will likely receive the greatest benefits from the interventions and how certain interventions and benefits work together to produce even greater reductions to the risk of infant mortality (Table 21). We also present results describing the effects of the interventions for women with additional risk factors in Appendix C.

### Table 21. Summary of Intervention Effectiveness by Risk Factor and by Other Interventions

<table>
<thead>
<tr>
<th>Interventions</th>
<th>Significant Effects (% change) on the Risk of Infant Mortality by . . .(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Demographic Risk Factors</td>
</tr>
<tr>
<td><strong>Medical Setting</strong></td>
<td></td>
</tr>
<tr>
<td>Preconception/interconception care</td>
<td>Teens (−8.6%)</td>
</tr>
<tr>
<td></td>
<td>Women 20–24 (−3.4%)</td>
</tr>
<tr>
<td></td>
<td>Black women (−4.1%)</td>
</tr>
<tr>
<td>Prenatal care</td>
<td>Women 20–24 (−7.0%)</td>
</tr>
<tr>
<td></td>
<td>Black women (−8.4%)</td>
</tr>
<tr>
<td>Doula support</td>
<td>Teens (−5.4%)</td>
</tr>
<tr>
<td></td>
<td>Women 20–24</td>
</tr>
</tbody>
</table>
Significant Effects (% change) on the Risk of Infant Mortality by...

<table>
<thead>
<tr>
<th>Interventions</th>
<th>Demographic Risk Factors</th>
<th>Behavioral and Reproductive History Factors</th>
<th>Combinations with Other Interventions/Benefit Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(-3.8%) Black women (-6.3%) Hispanic women (-19.6%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Health Promotion and Education**

**Home visiting**
- Teens (-5.7%)
- Black women (-1.5%)

**Support and Referrals**

**Pregnancy and postpartum support (Family Support Centers)**
- None

**Breastfeeding and nutrition support (WIC)**
- Teens (-3.6%)
- Women 20–24 (-3.9%)
- Black women (-4.6%)
- First pregnancy (-4.2%)
- Ever smoked (-2.7%)
- Opioid disorder (-8.6%)

**Behavioral health services**
- None
- Opioid disorder (-15.6%)
- Other benefits (-3.1%)

- WIC (-1.5%)
- Income benefits (-1.7%)
- Medical-related benefits (-1.3%)
- Other benefits (-2.1%)

- Home visiting (-4.5%)
- Family Support Centers (-5.8%)
- Behavioral health (-3.1%)
- Income benefits (-2.7%)
- Medical-related benefits (-2.8%)
- Other benefits (-6.1%)

---

---

**Risk factors.** Among the demographic factors considered, preconception care/interconception care and breastfeeding and nutrition support via WIC were estimated to be particularly effective interventions for teens, young adult women, and black women. Prenatal care was estimated to significantly decrease infant mortality risk for young adult women and black women, which conforms to the evidence that prenatal care has a strong impact for women at risk for poor birth outcomes. Home visiting was estimated to significantly reduce the risk for teens and black women, which is consistent with the evidence base showing positive effects of nurse home visiting on birth outcomes for younger teens (Olds et al., 1986). More broadly, many...
women, particularly those with low socioeconomic status, face multiple and concurrent risk factors. For these women, the estimates of increased effectiveness for most of the interventions suggest that the programs, services, and supports are reaching high-risk populations and having an impact. The findings related to these demographic risk factors were largely consistent across intervention categories, even when the populations served by the specific interventions were different. For example, home visiting and WIC target high-risk women, while preconception care/interconception care does not, yet the mother’s age and race played an important role in the estimated effectiveness for both interventions.

For the behavioral and reproductive history factors examined, all of the interventions except home visiting were estimated to significantly reduce infant mortality risk for women with a first pregnancy. The home visiting results differ from some home visiting evidence that found a significant decrease in infant deaths for women having their first child who received home visiting (Donovan et al., 2007). This suggests that there are opportunities to focus recruitment and engagement activities on first-time mothers across many different programs, services, and supports. For example, as noted in the inventory, the Nurse-Family Partnership is exclusively for first pregnancies. The lack of an estimated effect for home visiting may be related to timing, since home visiting was shown in the previous chapter to be more effective in the prenatal period. Women who are pregnant for the first time may not be aware of these programs until later in the pregnancy or after delivery.

A few of the interventions appeared to work well for women who had ever smoked, including preconception care/interconception care and WIC. For women who smoke, preconception/interconception care may provide an early opportunity, before the pregnancy, to address the well-established negative effects of smoking on birth defects, preterm birth, and low birth weight. WIC’s focus on providing vouchers for infant formula and nutritious foods, as well as nutrition education, breastfeeding support, and referrals to other health and social services, may have had spillover effects on smoking behavior for these women.

The estimated intervention effects for women with opioid use disorder worked in opposite directions for different interventions. On the one hand, the estimated effects of preconception/interconception care suggest an increased risk of infant mortality. But this should not be characterized as a causal link. As noted earlier, women with substance abuse issues who received preconception/interconception care may have been less likely to receive prenatal care or other services during pregnancy as a result of their substance abuse issues, thus negatively affecting birth outcomes. On the other hand, WIC and behavioral health services were estimated to reduce the risk of infant mortality for women with an opioid use disorder. Similar to its effect for smoking, the effect of WIC in reducing risk for women with opioid use disorder may represent the program’s general focus on nutrition and other factors that contribute to healthy development.

**Intervention and benefits combinations.** For many of the interventions, estimated effects were magnified when combined with other interventions. The estimated effects of home visiting
were enhanced by also having received WIC. Further, WIC, estimated to be very effective on its own, was estimated to be even more effective when combined with any of the other interventions. To some degree, these compound effects are expected, because many programs include referrals to other services and supports as part of their offerings. Nonetheless, particularly for the programs most focused on women’s health and pregnancy, the results show the importance of ensuring that women receive a range of different types of programs, services, and supports in order to address the multiple needs of those at greatest risk of infant mortality.

Most interventions were estimated to yield statistically significant effects on reducing infant mortality risk when combined with income and medical benefit programs. For home visiting and WIC, women who also received any of the three types of benefits—income, medical, and other—were estimated to have significant reductions in their risk of infant mortality. In these cases, the benefit programs likely enabled the interventions to be more effective by easing the financial, access, and other constraints faced by women with high risk of infant mortality. Similarly, the effects of behavioral health services were magnified when combined with other benefits, including assisted housing, which may help alleviate stressors.

Discussion

Overall, the findings presented here suggest that referrals to interventions could be tailored based on specific characteristics and patterns of involvement with other programs, services, and supports. Combined with the predictions of infant mortality risk, the results shed light on how to recommend specific interventions to women with specific risk factors. Further, the findings indicate how to leverage the availability of multiple interventions and combine them in order to enhance intervention effectiveness.
10. Recommendations and Next Steps

The research in this report described the range of programs, services, and supports in Allegheny County; demonstrated which factors predict risk of infant mortality and participation in interventions; and established the effectiveness of some interventions available in the county in reducing the risk of infant mortality. The IMPreSIv database built for this project is unique in its breadth of information: it includes all births in Allegheny County from 2003 to 2013, describing birth and infant outcomes, intervention participation, parental characteristics, maternal health risk factors and behaviors, pregnancy and delivery observations and diagnostics, postdelivery observations and diagnostics, and socioenvironmental risk factors. The quantity and quality of information in the IMPreSIv database enable the prediction of infant mortality, intervention participation, and intervention effectiveness at reducing infant mortality.

This study demonstrates that predictive models of infant mortality and intervention participation are possible, and that a causal inference analysis of the effects of the interventions is informative for the Richard King Mellon Foundation as it considers how best to improve the availability and implementation of the programs, services, and supports that are most effective in reducing infant mortality risk in Allegheny County. Risk assessment can focus health care and community-based social service provider attention on the women and children who are at greatest risk of infant mortality. It can also describe infant mortality risk and intervention participation after birth, during pregnancy, and even before conception. Our causal inference framework leverages these predictions to estimate the causal effects of interventions for different levels of risk. With this information, our causal inference framework also describes how effective the interventions are for women and children with different risk profiles, enabling optimized recommendations of the programs, services, and supports that will benefit them the most.

Together, these results help answer questions about who is at risk of poor birth outcomes, why they are at risk, which interventions they are likely to use, and which interventions will reduce their risk. Based on the findings of our literature review, environmental scan, and causal inference framework, we have developed ten recommendations to improve the quality of maternal and child health and reduce infant mortality in Allegheny County (Table 22).
**Table 22. Summary of Recommendations Based on Research Findings**

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Associated Research Findings</th>
</tr>
</thead>
</table>
| 1. Assess infant mortality risk early using information available at all points of assessment. | • Predictions of infant mortality risk are accurate.  
  • Even predictions using more limited data—either data available to community-based social service providers or only data available before conception—generate accurate predictions.  
  • The effectiveness of each intervention increases as the risk of infant mortality increases.  
  • Limited capacity for some of the interventions suggests that resources should be targeted to those at the highest risk of infant mortality.  
  • Interventions are most effective early on, including during the preconception period and pregnancy. |
| 2. Educate health care and community-based social service providers about available and effective interventions. | • Provider awareness of the availability and effectiveness of different types of interventions for a range of issues may be limited.  
  • Effectiveness of many interventions is magnified when combined with other interventions addressing different maternal needs.  
  • There is limited overlap between women who receive medical-setting interventions and those who receive non-medical-setting interventions. |
| 3. Tailor referrals based on risk and intervention effects for specific risk profiles. | • Many of the interventions are effective at reducing risk, but the effectiveness varies by level of predicted infant mortality risk.  
  • Certain interventions demonstrate greater effectiveness among women with certain risk factors.  
  • Length of participation in the intervention influences the degree to which some interventions are effective.  
  • Many of the interventions demonstrate combined effects, making them more effective when used together. |
| 4. Select referrals based on the likelihood of participation. | • Predictions of which interventions women are more likely to participate in are accurate.  
  • Across interventions, there is some variation in which factors are the most important in predicting participation. |
| 5. Support outreach and engagement activities to increase participation for women at risk of poor birth. | • Across the board, interventions are most effective for those at highest risk of infant mortality.  
  • Program staff and community-based social service providers cite engagement as a major concern and |
<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Associated Research Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>outcomes.</td>
<td>impediment to intervention effectiveness.</td>
</tr>
<tr>
<td></td>
<td>• Community initiatives in Baltimore, Cincinnati, and other localities focus on specific geographic locations and utilize client-centered approaches meant to maximize engagement.</td>
</tr>
<tr>
<td></td>
<td>• While largely untested in maternal and child health, engagement strategies based on behavioral economics and technology-based solutions may address some of the challenges to engagement.</td>
</tr>
<tr>
<td>6. Coordinate efforts across programs, services, and supports, and leverage existing contacts to facilitate referrals.</td>
<td>• Emerging evidence indicates that care coordination improves maternal and child health outcomes.</td>
</tr>
<tr>
<td></td>
<td>• Few women who receive medical interventions also receive community-based social services, and vice versa.</td>
</tr>
<tr>
<td></td>
<td>• Many women at high risk of infant mortality access community-based services, offering a point of contact to potentially improve access to medical services.</td>
</tr>
<tr>
<td>7. Increase participation in early and consistent preconception, interconception, and prenatal care.</td>
<td>• The major underlying causes of infant mortalities are prenatal, preconception, or life course factors.</td>
</tr>
<tr>
<td></td>
<td>• Consistent and comprehensive preconception/interconception and prenatal care results in some of the largest reductions in the risk of infant mortality.</td>
</tr>
<tr>
<td></td>
<td>• The benefits of preconception, interconception, and prenatal care are particularly pronounced among black women.</td>
</tr>
<tr>
<td></td>
<td>• Early and regular care addressing maternal health has potentially cascading effects for infant health.</td>
</tr>
<tr>
<td>8. Leverage opportunities to connect with women early during first pregnancies.</td>
<td>• Many interventions are particularly effective for first pregnancies.</td>
</tr>
<tr>
<td></td>
<td>• Consistently connecting with women during their first pregnancy may benefit outcomes for subsequent pregnancies.</td>
</tr>
<tr>
<td>9. Support the introduction or expansion of interventions that have demonstrated effectiveness in other settings and evaluate their effects in Allegheny County.</td>
<td>• Emerging evidence indicates that group prenatal care using approaches such as CenteringPregnancy improves birth outcomes.</td>
</tr>
<tr>
<td></td>
<td>• Doula support results in large reductions to the risk of infant mortality, particularly for Hispanic women.</td>
</tr>
<tr>
<td></td>
<td>• Without sufficient data, it is not possible to evaluate or fully understand the effects of some of the programs, services, and supports in Allegheny County.</td>
</tr>
</tbody>
</table>
### Recommendations

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Associated Research Findings</th>
</tr>
</thead>
</table>
| 10. Focus maternal education and outreach efforts on the link between risk behaviors and poor outcomes. | • Maternal smoking remains a concern, and substance abuse disorders have been growing among pregnant women.  
• Women with substance abuse disorders are less likely to receive any—let alone early and consistent—prenatal care.  
• Certain interventions, particularly WIC, demonstrate significant reductions in the risk of infant mortality for women who have ever smoked or who have substance abuse disorders. |

### Recommendations

1. **Assess Risk Early Using Available Information**

   Our results underscore the importance of accurately assessing individualized risk of infant mortality, identifying risk early, and flexibly assessing risk using information available at the time of assessment. The new risk assessment and referral tool that will be integrated into the electronic medical record systems of hospital systems serving Allegheny County as part of the next phase of this project will be an important first step in increasing capacity for early risk assessment using the information available at point of contact. It will also be important for community-based social service providers to access a version of the risk assessment and referral tool in order to help them understand the risks faced by the women they are serving and make appropriate referrals to other types of providers. Given the results showing that medical and nonmedical services were not often combined, only providing the risk assessment and referral tool to one type of provider will not maximize the use of Allegheny County’s existing programs, services, and supports that have the potential to further reduce the risk of infant mortality when combined.

   Building off the predictive models developed by the University of Pittsburgh team, we were able to accurately identify women at high risk of infant mortality. This is critical because the estimates show that interventions are most effective for women with the highest predicted risk of infant mortality. Identifying women most at risk for infant mortality, and doing so accurately, allows better matching of women with programs, services, and supports in order to maximize the reductions to infant mortality. Further, the risk assessment can support the allocation of sometimes limited intervention capacities and resources to those at the greatest risk.

   Our results indicate that the timing of the program, service, or support makes a difference. Across a range of interventions, from home visiting to behavioral health services, the interventions that resulted in the greatest reductions in the risk of infant mortality are those that women receive early. Since the results demonstrate that infant mortality can be accurately
predicted even with a limited set of information available either during pregnancy or preconception, the risk assessment should happen as early as possible so that high-risk women can be connected with the most appropriate interventions.

Finally, flexibility in the risk assessment based on the availability of information is important. We were able to develop predictive models that are responsive to the different types of information available to health care providers and community-based social service providers. While many health care providers will have access to a broader range of clinical information, such as ultrasounds, blood tests, and other diagnostic results that improve the accuracy of the predictive models, community-based social service providers will likely only have access to information directly reported by the woman being served. The integration of the risk assessment and referral tool into electronic medical systems and the availability of a web-based tool for community-based social service providers will facilitate utilization of all available information and enable accurate predictions of infant mortality risk.

2. Educate Health Care and Community-Based Social Service Providers on Available and Effective Interventions

Our analysis of the correlation in participation across the interventions in Allegheny County emphasizes the importance of educating health care and community-based social service providers across the spectrum on other available programs, services, and supports. The risk assessment and referral tool (see recommendation 1) will provide a start for this education process by suggesting referrals based on the patient’s risk profile. The care coordinator recommended (see recommendation 6) can also serve as an important resource to educate health care providers on the range of community-based programs, services, and supports available to address the needs of their patients.

When looking across intervention categories, we found virtually no correlation between the medical-setting interventions (preconception/interconception care, prenatal care, and doula support) and the non-medical-setting interventions in the health promotion and education category or the referral and support intervention category. This lack of correlation may reflect differences in socioeconomic status, since some of the non-medical-setting interventions (e.g., home visiting and WIC) have eligibility requirements related to family income, whereas the medical-setting interventions typically do not. It could also indicate a lack of awareness among health care providers of the availability and effectiveness of nonmedical interventions, or a lack of time to address issues beyond the reason the patient is seeking help. There are also likely differences in knowledge of community-based social services for different types of nonmedical providers. For example, providers at FQHCs may be more aware of these programs, services, and supports than health care providers within hospital systems.

We also found that effects were magnified for many of the community-based interventions when combined with other interventions addressing different maternal needs. For example, when women who received WIC also received home visiting, participated at a Family Support Center,
or accessed behavioral health services, there were significant decreases in risk of infant mortality. To some degree these compound effects are expected, since many programs include referrals to other services and supports as part of their offerings. Nonetheless, particularly for the programs most focused on women’s health and pregnancy, the results show the importance of ensuring that women receive a range of programs, services, and supports.

For these reasons, we recommend educating health care providers across Allegheny County on the range of programs, services, and supports available in the community that are effective, particularly for high-risk women, so that the nonmedical needs of their patients can be addressed. At the same time, community-based social service providers need to be informed about the range of medical services that may decrease risk for the women they serve. Together, the risk assessment and referral tool and the cross-system care coordinator will help all providers better understand the range of program, services, and supports with the potential to reduce infant mortality risk.

3. Tailor Referrals Based on Risk and Intervention Effects for Specific Risk Profiles

Our analysis of intervention effectiveness found that the interventions available in Allegheny County are generally effective in reducing the risk of infant mortality. We also found that the effects of the interventions vary by the predicted risk of infant mortality, with intervention effectiveness increasing along with the level of predicted risk. The risk assessment and referral tool (see recommendation 1) will help health care and community-based service providers to understand the individual risk profiles and make referrals to interventions based on the predicted risk of infant mortality.

Our analysis also demonstrated that some interventions were more effective than others at reducing the risk of infant mortality among women with certain risk profiles. For example, prenatal care (regular and early) resulted in the largest reductions to the risk of infant mortality among black women, and doula support generated the largest risk reductions among Hispanic women. Additionally, for women with opioid use disorders, behavioral health services were most effective at reducing risk of infant mortality, while preconception/interconception care was not effective (potentially because their substance use disorder made them less likely to receive prenatal care or other services during pregnancy).

Together these findings suggest that health care providers and community-based social service providers should use the risk assessment and referral tool to understand the risk profile of their client and tailor referrals to programs, services, and supports that may reduce her risk of infant mortality. The care coordinator (see recommendation 6) can help coordinate and facilitate these referrals so the women referred receive the recommended programs, services, and supports.

4. Select Referrals Based on the Likelihood of Participation

Our examination of the factors driving participation in different interventions highlights the importance of selecting referrals to the interventions with the highest likelihood of participation.
For both health care and community-based social service providers, the new risk assessment and referral tool that will be part of the next phase of this project will enable individualized referrals based on a woman’s risk profile and likelihood of participation in the intervention (see recommendation 1).

As with the prediction of infant mortality, we were able to produce accurate predictive models of intervention participation and demonstrate which specific maternal characteristics and risk factors are important predictors of participation in the different interventions. Further, many of the interventions are more effective when used in combination, likely in part because of the effect they have on participation (e.g., receiving benefits like housing assistance can reduce housing insecurity and improve participation in home visiting). We were also able to develop predictions based on timing. If a health care provider needs to refer to an intervention before conception, our predictive models only use information available during the preconception period.

Together, these findings suggest that health care providers and community-based social service providers should use the predictions of intervention participation that will be implemented in the risk assessment and referral tool to better understand which women are most likely to use specific interventions, and provide optimized referrals to additional programs, services, and supports as needed.

5. Support Outreach and Engagement Activities to Increase Participation for Women at Risk of Poor Birth Outcomes

As described in our review of the barriers to engagement, many women, particularly those with low socioeconomic status, face multiple and concurrent risk factors associated with infant mortality. For women involved with interventions in Allegheny County, our results show that intervention effectiveness increases with increasing risk, meaning that the programs, services, and supports in Allegheny County are reaching high-risk populations and having an impact. While the tailored referrals recommended are important, they are not enough to address the known challenges to outreach and engagement. We recommend the development of a client engagement grant program that gives community-based social service providers the opportunity to propose and implement evidence-based client-centered engagement strategies to enhance engagement in programs, services, and supports.

Establishing and maintaining engagement is often a struggle and can be an impediment to the effectiveness of the programs, services, and support being offered. Many local efforts to address infant mortality (e.g., Best Babies Zone and B’more for Healthy Babies) use a client-centered approach that meaningfully involves community members in developing strategies to maximize engagement in services (see Chapter 4 for more details). Although currently untested, there also may be technology-based solutions, such as mobile applications, that can increase engagement in existing program, services, and supports and thereby improve effectiveness.
Overall, the approach to boosting engagement should be tailored to the intervention to ensure that the strategies reflect the wants and needs of the families the intervention is designed to serve. For this reason, we recommend that the foundation support a client engagement grant program that provides grants to local community-based social service providers to implement new evidence-based engagement strategies that are tailored to the geographic area, target population, or program type. For example, community-based teams that focus on a specific geographic area and include community health workers have been effective in increasing engagement in communities such as Baltimore. Local providers should be given the opportunity to propose and implement evidence-based engagement strategies that fit with the needs of their clients and the objectives of their intervention.

6. Coordinate Participation and Leverage Existing Contacts

Educating health care and community-based social service providers is important but not sufficient to coordinate medical and nonmedical care and to ensure that the wide-ranging needs of high-risk women are met. Previous studies have demonstrated that care coordination in the health care setting can generate significant maternal and child health benefits. Following from this evidence, we recommend a care coordinator to provide a resource for both health care providers and patients to facilitate referrals across the medical and community-based settings. Programs such as the Pathways Community Hub model use community health workers to provide centralized referral and coordination of health and social services. In Allegheny County, a cross-system care coordinator working within participating health care systems could also facilitate feedback and communication across a range of health care and community-based social service providers in different settings. For example, a care coordinator would follow up on referrals from health care providers to community-based services so that all providers stay up to date on individual cases. Coordination across systems can also serve to identify potential capacity constraints or excess capacity to maximize the effectiveness of the available resources.

It is also important to leverage contacts from any existing entry point in order to begin the coordination of services to meet the wide-ranging needs of high-risk women. Women may not receive the medical-setting interventions because of their insurance status (e.g., upper income limits are lower for pregnant women than other adults), job insecurity, or lack of transportation and childcare. However, these women may also benefit from effective medical-setting interventions. Community-based programs, services, and supports offer natural points of contact with many high-risk women. As a result, the care coordinator should capitalize on these existing relationships and facilitate referrals to additional effective interventions.

7. Increase Participation in Early and Consistent Preconception, Interconception, and Prenatal Care

Our analysis found that preconception/interconception care and prenatal care are the most effective interventions among those examined, which is not surprising since these interventions
are directly linked to the health of the mother and baby. Further, this finding is supported by evidence that many of the underlying causes of infant mortalities are prenatal, preconception, or life course factors (see Chapter 1). We also observed that consistent prenatal care has a large effect on reducing infant mortality risk, consistent with the evidence base that shows that more frequent and intensive visits reduce poor birth outcomes (Krans and Davis, 2012). Based on these results, we recommend actively promoting early and consistent health care at these stages through the risk assessment and referral tool, the care coordinator, and the client engagement grant program.

Because our models demonstrate that infant mortality can be accurately predicted using a limited set of information available either during pregnancy or preconception, the risk assessment should be conducted as early as possible. Quantity also appears to matter for prenatal care, for instance, so earlier engagement with pregnant women to promote regular prenatal care visits can have a big impact. Further, the timing of delivery of the program, service, or support was found to make a difference for intervention effectiveness, which further emphasizes the importance of early identification of those at high risk of infant mortality.

The earlier that health care providers can use the risk assessment and referral tool, the sooner they can engage with women, particularly those at high risk of infant mortality, and begin to manage chronic conditions such as hypertension and obesity, provide education on topics such as nutrition, and address risk behaviors like smoking. With the help of recommended care coordinators, early and consistent interactions with health care providers will enable women to receive referrals and be connected with a range of community-based programs, services, and supports to mitigate other stressors.

Additionally, early identification is particularly important for certain subgroups so that they can be connected with the most appropriate interventions based on their risk profile. For example, we found that the benefits of preconception, interconception, and prenatal care were particularly pronounced among black women. For this group of women, if care can be initiated earlier and be delivered more consistently, then health care and community-based social service providers will be better able to address the chronic, long-term issues of maternal health that are major drivers of the disparities in infant mortality in Allegheny County.

8. Leverage Opportunities to Connect with Women During First Pregnancies

The findings indicate that many of the programs, services, and supports are particularly effective among women in their first pregnancies, emphasizing the importance of leveraging opportunities to engage with women before or during first pregnancies. Based on these results, we recommend that the client engagement grant program (see recommendation 4) be used to prioritize engagement strategies that focus on connecting with women during first pregnancies.

The increased effectiveness for first pregnancies in our results may be related to engagement (e.g., women may be more likely to engage more with interventions during first pregnancies because of the newness of and their unfamiliarity with their situation), or it could be because the
interventions are better suited to addressing first-pregnancy issues. Either way, connecting women to programs, services, and supports during their first pregnancies likely generates longer-term benefits that we could not observe in this study. Whether the interventions contribute to women feeling better informed about pregnancy and childbirth, address risky behaviors, provide breastfeeding support, or improve nutrition, the benefits of participating in the intervention during a first pregnancy are likely to extend to subsequent pregnancies.

Generally, outreach and engagement efforts for first-time mothers should focus on raising awareness; connecting them with the range of programs, services, and supports available in different settings; and supporting participation. Public education may be an avenue for actively raising awareness, whereas mobile applications may facilitate identifying, supporting, and increasing participation among first-time pregnant women. Overall, a client engagement grant program would allow community-based social service providers to propose and implement evidence-based engagement strategies that align with their intervention and the needs of women during first pregnancies who are seeking support.

9. Support the Introduction or Expansion of Interventions That Have Demonstrated Effectiveness in Other Settings and Evaluate Their Effects in Allegheny County

We recommend expanding or introducing some additional interventions that have demonstrated effectiveness in other settings.

For example, emerging evidence from other settings points to the effectiveness of group prenatal care programs, such as CenteringPregnancy, for reducing low birth weight and preterm births (Hill et al., 2016). CenteringPregnancy, which involves ten group prenatal visits with facilitated discussion, is currently available at both UPMC and the Allegheny Health Network. However, we were unable to test the effectiveness of enhanced prenatal care in Allegheny County because of a lack of data on program participation. Given the program’s theory and objectives, expanding enhanced prenatal care could be effective in reducing the risk of infant mortality in Allegheny County.

Based on our analyses, doula support, which provides women a companion and a knowledgeable information source throughout pregnancy and at childbirth, is another example of an intervention with the potential for impact on birth outcomes. Doula support is somewhat limited in Allegheny County, although one Medicaid managed care organization pays for doulas for its members (UPMC’s Birth Circle program). While we are unable to distinguish between doula support during pregnancy and birth doula support within the IMPReSiV database, we found that having a doula present at delivery significantly reduced the risk of infant mortality. This suggests that expanding capacity, access, and usage of doula support services has the potential to reduce infant mortality risk. Further, we found that doula support was particularly effective for Hispanic women, who make up 2.8 percent of the population in the city of Pittsburgh. With Allegheny County’s growing immigrant population, programs that provide doula support, such
as the Allegheny Health Network’s Immigrant Health Program, should be expanded so that culturally competent doulas can act as a bridge to medical care and community-based services.

10. Increase Knowledge and Awareness of Link Between Risk Behaviors and Poor Infant and Birth Outcomes

Some of the interventions worked well for women with certain behavioral risk factors, suggesting the importance of education and outreach efforts that increase knowledge and awareness of the link between these risk behaviors and poor infant and birth outcomes and coordinating care so that women can access needed services based on their risk profile.

Several interventions were particularly effective for the more prevalent maternal risk behaviors, including smoking and substance abuse disorders. For example, WIC reduced the risk of infant mortality among women who had ever smoked or who had substance abuse disorders. WIC’s focus on providing vouchers for infant formula and nutritious foods, as well as nutrition education, breastfeeding support, and referrals to other health and social services, may have had spillover effects on smoking and substance use behavior for these women, contributing to healthy development. Preconception/interconception care also reduced the risk of infant mortality among women who had ever smoked. This may be because preconception/interconception care gives health care providers an opportunity to address the well-established negative effects of smoking on birth defects, preterm birth, and low birth weight before the pregnancy. On the other hand, our results suggest that women with substance abuse issues who received preconception/interconception care may have been less likely to receive prenatal care or other services during pregnancy because of their substance abuse issues.

Overall, health care and community-based social service providers should leverage opportunities to build knowledge and awareness of the link between smoking and substance use and poor outcomes. For example, WIC program staff should focus education efforts on the effects of risk behaviors on healthy development and the link to poor birth and infant outcomes. Further, when women seek preconception/interconception care, health care providers should provide information about the importance of prenatal care. They should also address any concerns about accessing prenatal care among women with a history of substance abuse to potentially improve birth outcomes among this high-risk population. Finally, since access to treatment may also be a barrier, the care coordinator (see recommendation 6) should facilitate referrals and ensure access to treatment for those whose are identified as needing behavioral health services by the risk assessment and referral tool.

Limitations

Our approach has several limitations, including two types of missing data, selective observation, conditional unconfoundedness, and multiple hypothesis testing.
**Missing data.** While the IMPreSiv database offers a breadth and depth of data previously unavailable, there are still missing data. First, the health care data is limited to those births within the UPMC system. Our analysis of intervention effectiveness relies on the health care data type, which includes the deliveries documented in the MOMI database and the electronic medical records found in the MARS database. We do not have the same breadth of information describing women and their children at hospitals affiliated with other health care systems. With health care data for only half of the infant deaths recorded during the study period, the generalizability of the results to deliveries that occurred outside the UPMC system is uncertain. The best that we can do to assess the generalizability of our results is to use the reportable data and compare the effects among the UPMC sample and the non-UPMC sample. Appendix C describes this analysis, which, in general, shows minor differences between the size of the estimated effects but consistent overall results for both the UPMC and the non-UPMC samples. However, without additional data from the electronic medical records of other health care systems, we cannot fully discount the potential that our estimates of the interventions’ causal effects will differ in the non-UPMC population.

The IMPreSiv database also does not have participation data from all of the relevant interventions in the county. Some programs did not systematically collect participation data on their clients during the study period, or did not maintain the data available electronically. For other programs, we were unable to overcome logistical hurdles to execute data-sharing agreements in order to access participation data. For example, we did not observe participation in the CenteringPregnancy program. Similarly, while our inventory of available pregnancy and postpartum support includes programs like the Birth Circle and Text4baby, we were unable to include participation in these programs in the database. We also did not have data on many of the programs, services, and supports in the inventory in Chapter 5, so the coverage within any intervention category was limited. When we observed multiple programs within a category (e.g., home visiting), we showed that the effectiveness of different programs can differ. However, the results should not be interpreted as precise descriptions of the effects of specific programs that we could not observe.

**Selective observations.** There are also issues with selective observation within the IMPreSiv database. For example, three of the four types of preconception/interconception care that we examined (vaccinations, genetic counseling, and contraceptive counseling) were observed only for those who received services at a UPMC-affiliated facility. However, these services are also offered by other health care providers not included in the database, such as FQHCs, Planned Parenthood, and Adagio Health, all of which offer health care services to all people regardless of their ability to pay. Since there may be differences across health care providers in the patient population and mix of services offered, it may be that the women we observed receiving preconception/interconception care have lower overall risk levels than the women whose preconception/interconception care we did not observe. As a result, our estimates likely represent upper bounds of the effectiveness of preconception/interconception care.
Conditional unconfoundedness. The interpretation of our estimates relies on the assumption of conditional unconfoundedness. Conditional means that the information is included and controlled for in our models, and that by conditioning on all the covariates included in our models, we assume that receiving the intervention is essentially random. Given the methods used, this means we assumed that the unexplained part of our predictions of participation in each of the interventions was not correlated with infant mortality. Given the breadth of the IMPReSlv database and the general accuracy of our predictive models of intervention participation, we believe that conditional unconfoundedness is a reasonable assumption. For interventions with less accurate predictive models, we are less confident that the assumption is reasonable. Our models are least accurate for preconception/interconception care (AUC = 0.758) and for doula support (AUC = 0.804). Although these accuracy scores are reasonable, they suggest that there may be things that we are unable to account for that are correlated with both the intervention and the outcome. In these cases, we are less confident that the estimated effects represent true causal effects.

Multiple hypothesis testing. Our analyses tested many hypotheses; each of the estimated effects at different risk levels and among different women with different risk factors represents a hypothesis test. When multiple hypotheses are tested during analysis, this generally presents a problem for interpretation. For example, if we test 100 hypotheses and use a 95-percent confidence interval to determine statistical significance, we would expect that 5 percent of our results are incorrect. While estimates with marginal significance are the most likely to be incorrect, it is also possible that an estimate that is not marginally significant could be incorrect. Given that our study was designed to produce results that are relevant for a range of stakeholders in the community, we are not limited to a specific set of hypotheses. In a sense, this study is a combination of many studies. Consequently, we cannot recommend focusing too heavily on any one of the many hypotheses that we tested. We can be most confident in the lack of a statistical aberration for the results that contribute to an overarching pattern. For example, many of our results point to the effectiveness of early and consistent care in medical settings. This pattern suggests that interventions that address issues related to maternal health are among the most effective that we observed, a result that is corroborated by the fact that the majority of infant deaths are related to preconception and prenatal factors.

Next Steps

Our recommendations represent a nuanced response for efforts to prevent and reduce infant mortality in Allegheny County. As in other communities, most infant deaths in Allegheny County are due to prenatal and preconception factors related to maternal health. Maternal health is dependent on acute behaviors and stressors, as well as life course factors such as poverty, stress, and race. Consequently, each of our recommendations aims to improve maternal health through coordinated, consistent, and targeted efforts that are initiated as early as possible. The
earlier that health care and community-based service providers can engage with women, particularly those at high risk of poor birth outcomes, the better able they will be to manage the impacts of chronic conditions such as hypertension, eliminate or manage risk behaviors such as substance abuse, and connect women with a range of programs, services, and supports to address needs and mitigate other stressors. Further, consistent interactions will better enable health care and community-based social service providers to respond to acute issues that arise and that may increase the risk of infant mortality.

While there is no simple solution to infant mortality, the findings from this research produce great value for health care and community-based social service providers. Our findings will enable providers to tailor recommendations to specific programs, services, and supports based on the results of a risk assessment. Understanding how intervention effectiveness varies for women with different levels of predicted risks and specific risk profiles will further contribute to the ability to tailor recommendations depending on each woman’s unique circumstances. Our findings also identified increased effectiveness for certain combinations of interventions and the potential to expand some interventions to reach more women at risk of poor birth outcomes.

Together our results highlight the need to coordinate care across systems and develop new, perhaps technology-driven, approaches to increase engagement in programs, services, and supports.

Moving forward, it will be important to implement the recommendations and then assess their impact—how they are being implemented, their progress in improving birth and infant outcomes, and their sustainability—and the opportunities to build on successes. The integration of a risk assessment and referral tool into systems and practices in different health care and community service systems, support for care coordination between and among health care and community-based social services providers, and efforts to increase knowledge and engagement of women at risk for poor birth outcomes will be key drivers of impact in the community.

To assess the overall impact of these recommendations, it will be important to include a robust and ongoing evaluation of the implementation of the risk assessment and referral tool, the care coordination efforts, and the client engagement grant program to better understand what is working well and what needs adjustment. It will also be important to assess the impact of these efforts on preventing and reducing infant mortality by examining their impact on birth outcomes. The outcomes evaluation could also be expanded to address the more upstream causes such as maternal health. Further, the current evidence is somewhat limited for some of the approaches recommended for expansion (e.g., enhanced prenatal care and doula support) or introduction (e.g., mobile applications). When these are implemented, it will be important to examine their effectiveness, as well as update the models of risk and intervention effects with additional administrative data on intervention participation and the patient-centered and socioenvironmental data collected through mobile applications. Ultimately, if data show that the approaches recommended here prevent or reduce poor birth and infant outcomes in Allegheny County, then
these approaches can and should be implemented in other communities where the problem of infant mortality persists.

None of this work would have been possible without the support of local stakeholders. Throughout this phase of the project, we have benefited from the support and engagement of a broad range of stakeholders. The Richard King Mellon Foundation has been instrumental as a convener of various agencies, organizations, and community-based providers, bringing to the table several local health care systems with an interest in integrating the tools and insights from our work into their systems of care. As we move forward to the next phase of work, we will continue to rely on the support that we have received from all of the stakeholders who share the foundation’s vision of preventing and reducing infant mortality in Allegheny County.
References

AAP—See American Academy of Pediatrics.


ACHD—See Allegheny County Health Department.

ACOG—See American College of Obstetricians and Gynecologists.


Allegheny County Health Department, Plan for a Healthier Alleghany, 2015. Pittsburgh, Penn.: Allegheny County Health Department, April 2017. As of June 27, 2019: https://www.alleghenycounty.us/uploadedFiles/Allegheny_Home/Health_Department/Resources/Data_and_Reporting/Chronic_Disease_Epidemiology/Allegheny_County_PHA.pdf

AMCHP—See Association of Maternal and Child Health Programs.


Association of Maternal and Child Health Programs, *Forging a Comprehensive Initiative to Improve Birth Outcomes and Reduce Infant Mortality: Policy and Program Options for State Planning*, July 2012. As of June 10, 2019:

Association of State and Territorial Health Officials, *Perinatal Regionalization Fact Sheet*, 2014. As of June 10, 2019:
http://www.astho.org/Programs/ASTHO-Perinatal-Regionalization-Fact-Sheet/


BBZ—See Best Babies Zone.


Best Babies Zone, homepage, n.d. As of June 12, 2019:
http://www.bestbabieszone.org/


Carolan-Olah, 2016.

CDC—See Centers for Disease Control and Prevention.


City of Columbus, “CelebrateOne Home,” n.d. As of June 12, 2019: https://www.columbus.gov/celebrate-one/


Cradle Cincinnati, homepage, n.d. As of June 12, 2019: https://www.cradlecincinnati.org/


https://www.bmj.com/content/346/bmj.f3443


HHS, HRSA—See U.S. Department of Health and Human Services, Health Resources and Services Administration.


Parker, M. G., L. Burnham, W. Mao, B. L. Philipp, and A. Merewood, “Implementation of a Donor Milk Program Is Associated with Greater Consumption of Mothers’ Own Milk


SAMHSA—See Substance Abuse and Mental Health Services Administration.


Substance Abuse and Mental Health Services Administration, “NREPP Learning Center Evidence Summary: Substance Use Treatment for Pregnant and Postpartum Women,” 2017. As of June 10, 2019:


Terplan, M., S. Ramanadhan, A. Locke, N. Longinaker, and S. Lui, “Psychosocial Interventions for Pregnant Women in Outpatient Illicit Drug Treatment Programs Compared to Other Interventions,” *Cochrane Database of Systematic Reviews*, No. 4, 2015, Article No. CD006037.

Text4baby, “About Text4baby,” n.d. As of June 10, 2019:
https://partners.text4baby.org/index.php/about


WHAMGlobal, “Advisory Charts Steps to Make PA a Leader in Maternal, Child Health,” December 17, 2018. As of June 10, 2019:


