EFFECTIVENESS OF THE PATHWAYS COMMUNITY HUB MODEL IN REDUCING LOW BIRTH WEIGHT AMONG HIGH-RISK PREGNANT WOMEN

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by

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Table of Contents

List of Figures

List of Tables

DEDICATION

This dissertation is dedicated to my late father, Stephen Chiyaka, who left a void never to be filled in our lives. You taught me the value of hard work. You gave me enough pieces to carry myself with grace and dignity.

Thank you for that.

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Chapter 1

Introduction

Low birth weight (LBW) is the second leading cause of infant deaths in the United States (Lau, Ambalavanan, Chakraborty, Wingate, & Carlo, 2013). It is the single most important factor affecting neonatal mortality and is a determinant of post-neonatal mortality. Infant mortality has been used as an indicator of the population health status and to predict the health of the next generation (Reidpath & Allotey, 2003). In 2013, infant mortality rates in the United States were 25 times higher for infants born with low birth weight (50.26 per 1,000) when compared to those born with normal weight (2.05 per 1,000) (Mathews, MacDorman, & Thoma, 2015). Also, infants born with very low birth weight (VLBW) (less than 1,500grams), had an infant mortality rate more than 100 times higher than those born with normal weight (Mathews et al., 2015). Prevention of LBW can result in a significant reduction in morbidity and mortality rates. Although survival of children born with LBW has improved, the rate of disability among preterm survivors has not decreased (Goldenberg & Culhane, 2007). Besides reporting higher rates of depression and inattention/hyperactivity, preterm survivors are more likely to have poor physical health, neuromotor disfunction, and impairments of social skills and intelligence, when compared to full-term survivors (Sullivan, Msall, & Miller, 2012).

In the United States, the cost of preterm/LBW hospital admissions in 2007 totaled $5.8 billion, accounting for 47% of the costs for all infant hospitalizations (Russell et al., 2007). The economic burden of low birth weight extends beyond hospitalization costs as families continue to

endure emotional and financial burdens. The estimated societal economic burden of preterm birth in 2007 was $26.2 billion annually or $51,000 per infant born preterm or with LBW (IOM, 2007). The total cost per infant born preterm or with LBW included an estimated cost of $11,200 which was a result of foregone productivity activities in the household and labor market because of the disabling conditions of the children (Hodek, von der Schulenburg, & Mittendorf, 2011). Thus, it is important to recognize the broader and long-term impacts of preterm and low birth weight to families and to the health system and the need to address associated risk factors.

Interventions and programs centered on care coordination seek to improve birth outcomes by addressing social support needs and other social determinants of health, while also improving access to comprehensive antenatal care (Haines et al., 2007; Thomas et al., 2017). Current care coordination approaches in health care are moving toward integrated health systems which have been shown to improve access to health care, quality of care, and continuity of services in high risk populations (Armitage, Suter, Oelke, & Adair, 2009). Primary care, which requires inter-sectorial linkages between health and social policies, assumes an integrated view with the rest of the health system (Valentijn, Schepman, Opheij, & Bruijnzeels, 2013). Intentional efforts to build relationships across sectors through addressing social support and other social determinants of health and developing integrated and intensive cross-disciplinary services for high-risk pregnant women have shown positive impact on women's health (Thomas et al., 2017).

Community health workers (CHWs) play a unique and valuable role in care coordination programs within communities identified as underserved through working with health care service providers in providing access to care. Several studies have reported that CHWs help improve individuals' abilities to better manage their health conditions and help them access and navigate the healthcare system (Bielaszka-DuVernay, 2011; Martinez & Knickman, 2010). CHWs have

also been shown to improve the patient's knowledge and understanding of self-management practices, enhance access and care coordination, and build patient and family support (Hill-Briggs, 2003; Witmer, Seifer, Finocchio, Leslie, & O'Neil, 1995). Their increased use has been primarily based on their success in improving chronic disease management, reducing emergency room visits, hospitalizations, hospital re-admissions, and cost savings (Bielaszka-DuVernay, 2011; Gibbons & Tyus, 2007). Additionally, they have been shown to be effective in improving maternal and child health outcomes through community advocacy, pregnancy education, creation of family focused care plans, and conducting group support sessions on infant feeding (Barnes-Boyd, Fordham Norr, & Nacion, 2001; Caulfield et al., 1998; Graham, Frank, Zyzanski, Kitson, & Reeb, 1992). Compared with other health workers, CHWs are a less expensive alternative with regard to salary, incentives, and training costs (Vaughan, Kok, Witter, & Dieleman, 2015) and over the last decade in the United States, there has been an increased use of CHWs as care coordinators in linking low-income high-risk populations to health care and social services.

Additionally, there is increasing recognition that social determinants of health, including transportation, safety, housing, personal relationships, and food security have significant impacts on clinical outcomes to society (Harris & Wallace, 2012; Mirambeau, Wang, Ruggles, & Dunet, 2013; Redding et al., 2015). Addressing a single risk factor or a smaller subset may only provide temporary or partial improvement towards the individual's physical, social, and behavioral health and most studies have addressed only a few risk factors. However, using a strategy like the Pathways Community HUB model that comprehensively identifies and addresses individually modifiable risk factors like the social determinants of health and appropriate use of care may result in improved health outcomes and consequently improved quality of life (Harris & Wallace, 2012; Harrison, Pope, Coberley, & Rula, 2012; Redding et al., 2015; Saatci et al., 2010).

The Pathways Community HUB model is an example of a care coordination program that utilizes CHWs to reach out to at risk populations. The model uses a community wide approach that addresses medical, social, and behavioral risk factors in order to improve population health. The risk factors are addressed with "Pathways" – a standardized approach that identifies, defines, and resolves at risk individuals' needs by connecting them to community-based culturally proficient services (Zeigler, Carter, Redding, Leath, & Russell, 2014). Each of the identified Pathway represents one risk factor that is tracked from start to completion to a measurable outcome. Twenty Pathways for pregnant women have been in use and these include Adult Education, Health Insurance, Medication Assessment, Behavioral Health, Housing, Medication Management, Developmental Referral, Immunization Referral, Postpartum, Developmental Screening, Immunization Screening, Pregnancy, Education, Lead Screening, Smoking Cessation, Employment, Medical Home, Social Services Referral, Family Planning, and Medical Referral. At risk individuals can have multiple Pathways and the Pathways are deemed complete only when an identified risk factor is resolved. Under the Pathways Community HUB model, the HUB links different care coordination agencies operating in one community together and tracks outcomes across the region but does not itself provide care coordination services.

The uniqueness of the HUB model is in its ability to comprehensively address the breadth of risks of clients; utilize a centralized process that reduces duplication of services; track clients using a database; and having payments tied to outcomes (Zeigler, Redding, Leath, & Carter, 2014). Additionally, the HUB model promotes quality care through home visiting, identifying health, social and behavioral risk factors, assuring through Pathways that each risk factor is addressed, and linking payment to outcome performance (Rockville Institute, 2018; Zeigler, Carter, et al., 2014; Zeigler, Redding, et al., 2014). The Pathways HUB model is comprised of three primary

components (Rockville Institute, 2018). First, core Pathways – these are the measurement tools used to define the problem to be addressed, the desired measurable outcome, and the key intervention steps to achieve the outcome. Second, is the community HUB - a regional point of registry and outcome tracking that networks together health care providers, social service agencies, and health care payers that implement these Pathways. Pathway payment is the third component that relates to the payment for care coordination that is based on outcomes instead of activities.

The growth of the Pathways HUB model has become fertile soil for studies that seek to assess the effectiveness and economic impact of care coordination programs. Additionally, the impact of interventions on population health is vital and decision-makers can use economic evaluations to assess and potentially improve the performance of health systems. Some studies have examined the economic impact and health outcomes of using the care coordination approach and results have been favorable. For example, Whitley, Everhart, and Wright (2006) established that the return on investment of a care coordination program that utilizes CHWs was $2.28 for every dollar invested on outreach programs. Additionally, a lifestyle modification program coordinated by CHWs for low-income Hispanic adults with type 2 diabetes showed that the program was cost effective when compared to usual care (Brown et al., 2012). In addition, an economic evaluation of care coordination programs demonstrated that some of the programs are cost effective (Redding et al., 2015; Ryabov, 2014). However, across the different studies (Brown et al., 2012; Johnson et al., 2012; Redding et al., 2015; Ryabov, 2014; Segal, Nguyen, Schmidt, Wenitong, & McDermott, 2016; Whitley et al., 2006), there is a considerable variability in the approach used, model inputs used and reporting of study results. Among the studies that I reviewed in the context of this work, only two studies assessed cost-effectiveness and reported incremental cost effectiveness ratios (Brown et al., 2012; Ryabov, 2014). Incremental cost-effectiveness ratio

(ICER) is the difference in cost between two possible interventions divided by the difference in the effect. Other studies have focused on the payer/provider perspective (Redding et al., 2015; Whitley et al., 2006) while in other studies, the perspective was not specified (Ryabov, 2014; Segal et al., 2016). Other studies that have reported cost effectiveness suffer the same methodological challenges such as not specifying the perspective, only focusing on the payer/provider perspective, and not reporting the incremental cost-effectiveness ratio (Fedder, Chang, Curry, & Nichols, 2003; Felix, Mays, Stewart, Cottoms, & Olson, 2011; Johnson et al., 2012; Mirambeau et al., 2013; Redding et al., 2015; Whitley et al., 2006). This lack of consistency across cost-effectiveness studies severely limits the comparability of study results as recommended by the Panel on Cost-effectiveness in Health and Medicine (Sanders et al., 2016).

Established in 1993 by the U.S. Public Health Service, the Panel on Cost-effectiveness in Health and Medicine (PCHM) was charged with assessing the current state of the science of cost-effectiveness analysis and with providing recommendations for conducting studies in order to improve their quality and encourage their comparability (Gold, 1996; Siegel, Weinstein, Russell, & Gold, 1996). In 2016, updated and expanded recommendations of the original panel were published (Sanders et al., 2016). Some of the key recommendations included the concept of a reference case and a set of standard methodological practices that all cost-effectiveness analyses should follow to improve quality and comparability of studies (Carias et al., 2018; Sanders et al., 2016).

Even though the Panel on Cost-effectiveness in Health and Medicine developed the framework to standardize the use of economic evaluation, a review of studies on care coordination demonstrated a substantial variability in the methods used (Phillips & Chen, 2002). It is evident that thorough estimates of costs, outcomes, and effectiveness of care coordination programs are

needed to aid policy makers in assessing the feasibility of program implementation, the costs of public programs relative to benefits they achieve, and the extent to which programs can provide the greatest return on minimum dollar investment. Through cost-effectiveness, information such as estimates of relative values of different approaches to improving health and/or life expectancy is shared with decision makers at different levels including public or private, federal, state, or local to identify strategies that best serve their programmatic and financial objectives (Gold, 1996).

Redding et al. (2015) investigated the relationship between participation in the Pathways HUB program and birth outcomes, and found that pregnant women who participated in the Pathways HUB program were less likely to have a LBW child than similar (propensity score matched) women who did not participate in this program. They also estimated that each dollar spent on Pathways Community HUB program yielded a long-term cost saving of $5.59, and assessed the adequacy of prenatal visits, and found no difference between program participants and non-participants. Prenatal care utilization has been shown to be associated with positive birth outcomes (Ayoola, Nettleman, & Stommel, 2010; Berg, Callaghan, Syverson, & Henderson, 2010) and there is evidence supporting its important role in maintaining maternal and fetal health (Oakley, Harvey, Yoon, & Luck, 2017).

This study builds on the foundational work by Redding et al. (2015) in order to yield additional insights on ways to improve birth outcomes for at risk populations. First, using a more recent HUB data with an enhanced sample size, a more thorough assessment of the effectiveness of the Pathways HUB program in preventing LBW births is performed drawing on approaches similar to those employed by Redding et al. (2015). Second, in addition to low birth weight births, an assessment and comparison of pre-term births is performed. Because pre-term birth is a key factor contributing to LBW births (Russell et al., 2007; Vintzileos, Ananth, Smulian, Scorza, &

Knuppel, 2002), there is value in knowing whether or not participation in the Pathways Community HUB program affects pre-term birth rates as well as LBW births. The Redding et al. (2015) study did not address the impact of the HUB model on preterm births. Third, drawing on a larger and more recent sample, the study will also assess whether participation in the program yields enhanced pre-natal care utilization in comparison to the prenatal care received by a propensity-score matched sample of similar pregnant women from the same geographic area of Ohio. In so doing, the study is expected to yield improved information on the mechanisms through which the Pathways Community HUB program may affect LBW births. Finally, the current work will go beyond Redding et al., by seeking to address and expound other "mechanisms" by which the Pathways Community HUB model achieves its results including the duration of participation in the program. Reduction in preterm births, improved prenatal care utilization, and increased duration in program are some of the mechanisms that can lead to better low birth weight rates.

Study Objectives

The study's overall objective is to assess the effectiveness of the Pathways Community HUB approach. The specific aims are:

a) Assess the effectiveness of the Pathways Community HUB approach in reducing low birth weight.

Hypothesis 1: The Pathways Community HUB intervention approach reduces low birth weight births (particularly when clients enter the program early in their pregnancy).

Outcome: Low birth weight

b) Assess the effectiveness of the Pathways Community HUB approach in reducing preterm births.

Hypothesis 2: The Pathways Community HUB intervention approach reduces preterm births.

Outcome: Preterm birth

c) Assess the effectiveness of the Pathways Community HUB approach in improving prenatal care utilization.

Hypothesis 3: The Pathways Community HUB intervention increases prenatal care utilization among high-risk pregnant women.

Outcome: Prenatal care utilization

d) Suggest future directions for evaluating the cost-effectiveness of the Pathways Community HUB approach in reducing low birth weight

Likely expected outcomes from the study include:

a) Estimates of the total number of low birth weight and preterm births averted due to participation in the Pathways HUB program.

b) An estimate of the extent to which Pathways HUB participants are better served by pre-natal care than are non-participants.

In addition, by contributing a) and b) above, we can provide insights regarding mechanisms through which the Pathways HUB achieves results.

Significance of the Study

The HUB model is an example of an approach that operationalizes a comprehensive approach in addressing social determinants of health (SDOH) and other risk factors to improve health outcomes. Social determinants of health (SDOH) are increasingly becoming important in the development of public health policies and programs. The social environment, physical environment, and health services affect a wide range of health risks and outcomes (Centers for

Disease Control & Prevention, 2010). This study enhances the understanding of risk and risk mitigation and their impact on outcomes. The study results will contribute to the state and federal level decision makers who are responsible for Medicaid programs and may wish to know where investments of public funds will have an impact in reducing low birth weight among high risk groups.

The study will also take a more detailed look at mechanisms by which improved birth outcomes are achieved by investigating preterm births and by looking deeper into prenatal care utilization using a data set with a larger sample size. Duration of participation in the program is one of the mechanisms that can potentially impact the success of the program. In so doing, this holds the potential to provide further documentation of the effectiveness of the Pathways Community HUB approach and how it may reduce low birth weight among low-income high-risk pregnant women.

Furthermore, the HUB model targets high-risk populations of most interest to Health and Human Services (HHS) and Centers for Medicare and Medicaid (CMS). Besides providing a holistic approach in addressing risk, the HUB model also supports community partnerships between providers and non-medical social support groups. The study will also provide a significant methodological contribution in assessing the effectiveness of the Pathways HUB model. Analyses performed should provide further evidence and supplement existing evaluations of the Pathways HUB model for improving birth outcomes (Redding et al., 2015), and provide greater certainty regarding estimated outcomes using most recent data and a bigger sample size.

The Ohio Medicaid program is currently contracting with some of the managed care plans participating in the Pathways HUB model such as Buckeye Community Health Plan, Molina Healthcare of Ohio, UnitedHealthcare Community Plan, CareSource, and Paramount Advantage.

The success of the model has potential direct and indirect benefits to many including service providers, payers, and policy makers.

a) Service providers

While this study will not directly evaluate the effects of using CHWs, the success of the Pathways HUB model is hinged on them as they are pivotal in helping patients navigate the health care system with outcomes such as reduction of emergency department utilization, unwarranted inpatient admissions, fewer hospital readmissions. Additionally, the HUBs and the HUB network may benefit from confirmation of recent findings and from learning more about the mechanisms through which their programs achieve impact especially by improving early access to prenatal care and prenatal care utilization and reducing preterm births.

b) Payers (Private Insurers and Center for Medicare & Medicaid Services)

Medicaid covers reproductive healthcare services such as family planning, prenatal services, childbirth and postpartum services without costs sharing. Furthermore, Medicaid beneficiaries are more likely to experience adverse birth outcomes and have high prevalence of smoking and illicit drug use compared to those on other health insurances (Anum, Retchin, & Strauss III, 2010; Krieger, Connell, & LoGerfo, 1992). Medicaid financed about 43% of all births in the United States in 2016 (Martin, Hamilton, Osterman, Driscoll, & Drake, 2018) Resultantly, any efforts that seek to address underlying risk factors and improve health outcomes will go a long way in reducing the cost burden on Medicaid. The success of the HUB model can result in better health outcomes and potentially in savings for both private insurers and the Center for Medicare and Medicaid Services (CMS). There might be potential in creating favorable payments early prenatal visits, particularly in the early stages of pregnancy.

c) Policy makers

The Pathways HUB model is an example of an approach that hinges on collaboration to make seamless systems of care and referrals across organizations including hospitals, health centers, community-based organizations, and insurers. The success of the program may result in expanded programming and policies that comprehensively address issues leading to negative birth outcomes. Through this study, an assessment of the health impacts of low birth weight is performed. Furthermore, this study will contribute towards the knowledge base on how CHWs can help improve health outcomes, increase access to health care, and control medical costs through reimbursement through Managed Care Contracts currently being used in the Pathways HUB model. The study will also help other states facing challenges in advancing CHW initiatives to potentially gain insights from the experiences of other programs across the country. Building on the success of the Pathways HUB model, efforts to establish sustainable funding mechanisms through Medicaid can be boosted throughout the country.

Chapter 2

Literature Review

Introduction

This chapter provides an overview of previous research on low birth weight, its causes, consequences, and efforts to tackle the problem and other negative birth outcomes. The first part of the chapter gives a brief description of low birth weight and preterm birth in the United States. It further describes some of the risk factors for low birth weight. The next section focuses on some of the intervention strategies that have been implemented in trying to reduce negative birth outcomes including the use of different care coordination approaches. Finally, a brief overview of economic evaluations of care coordination programs is given, followed by a brief description of the Community Health Access Project (CHAP). I close with a description of gaps in the literature relating to care coordination and particularly in regard to the Pathways Community HUB care coordination model and the mechanisms through which it may achieve beneficial impacts on birth outcomes and mortality.

Low Birth Weight in the United States

Low birth weight (LBW), a term typically used for any infant weighing less than 2,500 grams (5 pounds, 8 ounces) at birth, is a known risk factor for infant morbidity and mortality and chronic health problems in later life (March of Dimes, 2014; Mathewson et al., 2017; McCormick, 1985). Birth before 37 weeks of gestation, also known as preterm birth, is the leading cause of death for newborn babies born in the United States (Tanne, 2017).

Preterm birth result in low birth weight and babies who survive preterm birth are at risk of lifelong disabilities   (Goisis, Remes, Barclay, Martikainen, & Myrskylä, 2017). The LBW rate in the United States for the year 2017 was 8.3% indicating an increase of about 3.4% since 2014 following a steady decline from 2007 through 2014 (Hamilton, Osterman, Driscoll, & Rossen, 2018). Across all races, Black Americans continue to register significantly higher LBW rates averaging 13.4% over the period 1989 – 2017 (Figure 2.1).
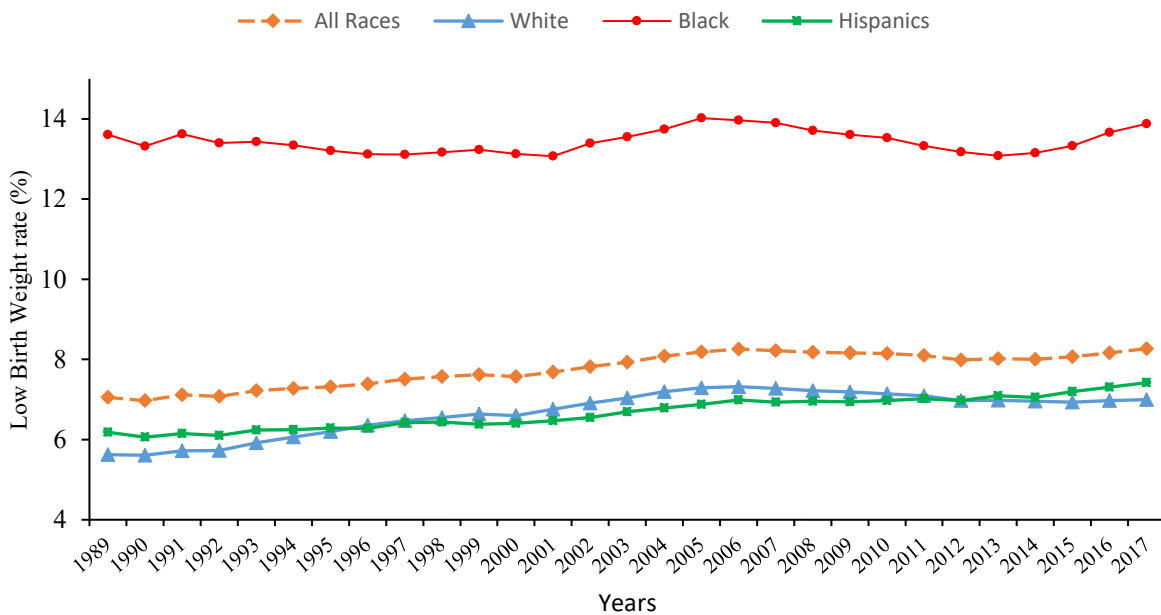
Figure 2.1: Trends of low birth weight rates in the United States, 1989-2017

(Source: Hamilton et al., 2018)

Low birth weight is associated with several long-term negative health outcomes including neurologic outcomes such as cerebral palsy, blindness, deafness, and hydrocephaly (Goldenberg & Culhane, 2007). Furthermore, long term chronic conditions such as hypertension, diabetes, and heart disease have been shown to be associated with LBW (Barker, 1999; Goldenberg & Culhane,

2007). Infants born with LBW have a high utilization of health care. A study on the cost of hospitalization for preterm and low birth weight infants in the United States showed that in 2001, 8% of infant hospital stays included a diagnosis of preterm birth or low birth weight and the cost of these admissions represented 47% of the costs of all infant hospitalizations (Russell et al., 2007).

Risk factors for low birth weight

Fetal growth restriction and preterm/premature birth (birth before 37 weeks), are the most common reasons why babies may be born with low birth weight (Goldenberg & Culhane, 2007). However, there are certain characteristics that make some women more likely than others to have a low birth weight baby because of their influence on the overall health. Even though the quantitative effects of the different factors that have independent effects on LBW are not clear, what is evident is that causes of LBW are multifactorial (Kramer, 1987). There are many factors that influence LBW and they range from socio-demographic factors; medical risk factors; and environmental and behavior risk factors.

Race and Ethnicity – There is convincing evidence to suggest that belonging to different racial groups is strongly associated with low birth weight and the rates are highest among infants born to non-Hispanic Black women (de Bernabé et al., 2004; Goldenberg & Culhane, 2007). In 2017, 13.9 percent of babies born to non-Hispanic Black women were low birth weight compared with 7.4 percent of Hispanic, and 7.0 percent of non-Hispanic White (Hamilton, Martin, & Osterman, 2017). The reported LBW rate for non-Hispanic Black infants was almost twice that of non-Hispanic White infants. Among distinct groups in the United States, Black women have an elevated risk of LBW.

Educational level – Mother's highest level of education has been shown to be associated with pregnancy outcomes. In particular, decreasing educational level is associated with an increased risk of LBW (Longo et al., 1999).

Mother's age – Maternal age also influences rates of adverse birth outcomes. In 2012, low birth weight rates were highest among mothers aged less than 20 years and among mothers aged between 35 and 40 years (de Bernabé et al., 2004; Hussaini, Holley, & Ritenour, 2011; Restrepo-Méndez et al., 2015). Teen mothers are more likely to have short cervix and small uterine volume which is associated with LBW (Gibbs, Wendt, Peters, & Hogue, 2012). For the adolescent mothers, it has been reported that the adverse birth outcomes could be due to a number of factors including low income, being single, inadequate prenatal care, and lower antenatal maternal weight (Roth, Hendrickson, Schilling, & Stowell, 1998). For women aged 35 year s and above, pre-existing medical conditions, obstetrical history, and maternal social characteristics have been hypothesized to have an impact on birth weight (Ales, Druzin, & Santini, 1990; Berkowitz, Skovron, Lapinski, & Berkowitz, 1990).

Marital status – A systematic review of studies that considered marital status of the mother and its effect on birth weight showed that unmarried women were 1.46 times more likely to deliver a low birth weight baby when compared to married mothers (Shah, Zao, & Ali, 2011).

Maternal smoking – Smoking during pregnancy can significantly increase chances of having a premature baby. According to the Surgeon General Report (Health & Services, 2004), women who smoke cigarettes are nearly twice as likely to give birth to a low birth weight baby when compared to those women who do not smoke. Smoking during pregnancy has been shown to be associated with adverse pregnancy outcomes including preterm birth and fetal growth restriction (Ding et al., 2017). Passive smoke from other smoking family members and smoke at the work place also

negatively affects the infant (Ko et al., 2014). Additionally, smoking increases the incidence of miscarriage (de Bernabé et al., 2004).

Alcohol consumption – Increased alcohol consumption especially during the first trimester may result in Fetal alcohol syndrome (FAS). A multicenter study on the effects of maternal drinking on birth outcomes showed that maternal drinking significantly lowered birth weight and smoking had a modification effect on the relationship (Lazzaroni et al., 1993). The risk of low birth weight among pregnant women who consume alcohol increases if the women also smoke.

Drug use – Use of drugs during pregnancy has also been shown to be associated with low birth weight. Infants born to mothers who use two or more psychoactive drugs were shown to significantly have lower birthweight, head circumference, and length (Coles, Platzman, Smith, James, & Falek, 1992). While there is variance in the effects of individual drugs, total avoidance of the drugs is encouraged by health professionals.

Lack of access to health care – Despite increased efforts in granting more access to care for underserved populations, this issue continues to be topical in all discussions that seek to improve birth outcomes. Early access to prenatal care allows for early detection of abnormalities in the pregnancy. However, barriers to early prenatal care may include limited financial resources or lack of health insurance, failure to secure appointment when needed, and transportation issues (Ayers et al., 2018; Gonthier et al., 2017; Shah, Revere, & Toy, 2018). Maternal education is strongly associated with birth outcomes (Currie & Moretti, 2003). The mother's highest level of education is associated with her ability to prioritize prenatal care due to multiple competing economic, health, and behavioral health factors.

Other Risk factors

When prenatal complications are left untreated, they can be severe enough to cause death of the mother, newborn, or both. Preterm labor, not gaining enough weight during pregnancy, having a low birth weight baby on the previous pregnancy, and chronic health conditions like high blood pressure and diabetes are some of the key risk factors in having a low birth weight baby (Blencowe et al., 2013). Excessive uterine stretch, intrauterine infection, decidual hemorrhage, and maternal or fetal stress are the major factors leading to preterm birth. Furthermore, certain medical conditions including high blood pressure, urinary tract infections, diabetes and gestational diabetes, and certain developmental abnormalities in the fetus can place a woman at a higher risk for preterm labor. However, early prenatal visits can help reduce the risk from certain medical conditions by controlling existing conditions such as diabetes and high blood pressure and reducing the fetus' risk of complications (Martin et al., 2018).

Prenatal Care

Prenatal care (PNC) is an important preventive health service for pregnant women and their unborn children (Wally, Huber, Issel, & Thompson, 2018). Substantial evidence from research exists which demonstrates an association between receipt of prenatal care and improved pregnancy outcomes (Kogan et al., 1998; McDonald & Coburn, 1988; Wally et al., 2018). A better understanding of the relationship between prenatal care services and pregnancy outcomes could be achieved through accurate measurement of prenatal care utilization. Inadequate prenatal care is associated with increased pregnancy complications and negative birth outcomes (Maupin et al., 2004; Vintzileos et al., 2002). The Centers for Disease Control and Prevention (CDC) recommends that pregnant women should receive early PNC during their pregnancy in order to receive adequate medical services (Centers for Disease Control and Prevention, 2018). However, in 2017, about 24

percent of women who delivered a live birth infant did not receive PNC during the first trimester (Hamilton et al., 2018). Furthermore, timing of prenatal care entry varied greatly by race. Non-Hispanic Black (66.6 percent) had a significantly lower first trimester prenatal care initiation rate compared to non-Hispanic White (82.5 percent) (Hamilton et al., 2018).

One of the objectives of Healthy People 2020 is to increase the proportion of pregnant women receiving early (beginning first trimester) and adequate prenatal care to at least 77% (Office of Disease Prevention and Health Promotion, 2018). Different indices to assess adequacy of prenatal care utilization have been developed but the Adequacy of Prenatal Care Utilization (APNCU) index stands out as the most comprehensive approach since it combines timing of prenatal care and number of visits while accounting for gestational age (Kotelchuck, 1994). APNCU index comprises of four categories: inadequate, intermediate, adequate and adequate plus. Key attributes of the index are that it accounts for the month when prenatal care began, and number of prenatal care visits received while adjusting for the length of pregnancy (gestational age) (Wally et al., 2018). Because of its comprehensiveness, the APNCU index can be used to evaluate prenatal care efforts (Osterman & Martin, 2018).

Intervention Strategies and Programs aimed at reducing LBW in the United States

Tertiary prevention efforts aimed at improving health outcomes by promoting positive health behaviors and outcomes for populations in medically underserved communities have continued to take center stage. Specifically, for women in the childbearing age groups, several strategies that seek to reduce preterm birth (a precursor of LBW) and LBW have been identified. Some of the strategies that would significantly reduce negative pregnancy outcomes include improving access to preconception care services; identifying and offering access to effective treatments to prevent preterm births; discouraging non-medically indicated deliveries before 39 weeks; prevention of

unintended pregnancies and achieving optimal birth spacing; and reducing multiple gestations (Shapiro-Mendoza et al., 2016).

There are many policies in the United States that are not specifically related to pregnancy outcomes but can be woven together to improve access to care for women. However, some of these policies can be linked to one of the specific factors affecting pregnancy outcomes or a group of factors at the national, state, or local level. The Women, Infants and Children (WIC) Supplemental Nutrition program is a collaborative effort between the Health and Human Services (HHS) and United States Department of Agriculture (USDA) and it seeks to expand access to healthy foods in low income communities. The Title X Family Planning program is another federally funded program that seeks to improve access to family planning education and services to women. Receipt of family planning education would likely reduce unintended pregnancies which are significantly associated with preterm births, low birth weight, and infant mortality. The Healthy Start Initiative and the Title V Maternal and Child block Grant Program have also been designed to help improve the health of women of childbearing age. Because of variations in coverage and benefits, the Medicaid program at federal and state levels, is leading efforts to improve the quality of a continuum of services including prenatal care, birth, postpartum visits, and baby well visits. It is the major source of health insurance coverage for pregnant women.

The most recent and largest overhaul of the U.S. health system came in 2010 with the signing of the Patient Protection and Affordable Care Act (ACA) into law. One of the key goals of ACA is to reduce health disparities by addressing health care affordability and availability through prevention and early detection, health care access and coordination, insurance coverage and continuity, and diversity and cultural competency (ACA, 2010). Some of the preventive health care services particularly important for women in the Health Reform are prenatal care visits,

20

tobacco counselling and cessation intervention, alcohol screening and counseling, iron deficiency and gestational diabetes screening, and breastfeeding support.

Furthermore, the ACA also strengthened the adoption of patient centered medical homes (PCMH) in order to enhance patient access to primary care and provide well organized health services that emphasize on prevention and chronic care management (Davis, Abrams, & Stremikis, 2011). More importantly, ACA included Medicare and Medicaid demonstrations and programs with the objective of improving care coordination and transitional care. These included Accountable Care Organizations, Healthcare Innovation Awards, Medicare Community-based Care Transitions Program, Medicaid Health Homes for Chronic Conditions, and many more (Emmer, 2013). This expansion of services, premised on quality and patient centeredness, contributed towards the incorporation of CHWs into health care teams so as to help engage patients in their health care encounters, assist them in identifying community resources and improve their self-efficacy thereby redefining the health care system to focus on holistic, preventive, patient-centered efforts (Allen, Escoffery, Satsangi, & Brownstein, 2015; Islam et al., 2015; Shah, Kaselitz, & Heisler, 2013).

Several intervention strategies aimed at reducing low birth weight have been used including routine prenatal care, comprehensive prenatal care, and health promotion. Nutritional interventions in the United States have had mixed results with regards to their impact on low birth weight. Some studies have shown that nutritional counselling programs have had minimal effects on low birth weight (Goldenberg & Culhane, 2007; Goldenberg & Rouse, 1998; Kramer, 2005). Other randomized trials have demonstrated that combinations of home visiting, patient education, case management, and nutritional counselling can result in better pregnancy outcomes (Hobel et al., 1994; Olds, Henderson, Tatelbaum, & Chamberlin, 1986). However, in some developing

countries where near starvation diets are common, the nutritional supplements have resulted in improved birth outcomes. Other programs that seek to reduce adverse health behaviors such as the use of drugs, alcohol, or tobacco have not registered much improvements in terms of preterm birth and growth restriction (Goldenberg & Rouse, 1998).

Care Coordination

Coordination of care holds the potential for improving quality and reducing costs in the American healthcare system (IOM, 2001). Different care coordination approaches exist, and the models vary widely in structure and style. However, central across these models is the goal of improving health outcomes and the use of a patient navigator or a community health worker in connecting different communities to their needs (Fortier et al., 2015; Meyers et al., 2010; Press, Michelow, & MacPhail, 2012; Wagner, Sandhu, Coleman, Phillips, & Sugarman, 2014). After the Congress's enactment of the Affordable Care Act (ACA) in 2010, there have been deliberate efforts to refine care coordination models particularly moving toward pay for performance financing schemes (ACA, 2010; Blumenthal, Abrams, & Nuzum, 2015).

The Affordable Care Act provided an opportunity to shape the future of healthcare delivery and payment systems premised on improving health outcomes, reducing healthcare spending, and improving patient experiences. Delivery and payment models such as the Patient-Centered Medical Home, Accountable Care Organizations, Direct Patient Contracting, Episode based Payment Initiatives, and other care models developed by the Center for Medicare and Medicaid Innovation (CMMI) are all meant to meet the complex needs of patients, improve quality of care, and reduce cost (Abrams et al., 2015; American College of Physicians, 2019; Centers for Medicare and Medicaid Services, 2019). However, the success of specific reform models may be depended on the target population and its settings (Bao, Casalino, & Pincus, 2013).

Community Health Workers and their Role in Care Coordination

Community Health Workers (CHWs) act as a link between the community they serve and the formal health services in all aspects of health development. They are known by several different names which include lay health advisers, *promotoras*, lay health workers, peer educators, patient navigators, health advocates, and community health representatives. According to the American Public Health Association (2009), CHWs are "frontline public health workers who are trusted members of and/or have an unusually close understanding of the community they serve". Elsewhere, they have been described as outreach workers who help to implement programs that promote, maintain, and improve individual and community health (Islam et al., 2015; Martinez & Knickman, 2010). CHWs also assist through linking people to key services and helping address the economic, social, and environmental needs of individuals and the communities through linkages to key services (Perez & Martinez, 2008). Facilitating access to care, as well as addressing language and cultural barriers are some of the integral roles they can play (Natale-Pereira, Enard, Nevarez, & Jones, 2011).

Community Health Workers help individuals in the communities they serve to access and navigate the health and social service system and they are central in community wide efforts to identify and address causes of poor health through a range of activities that include outreach, social support, community education, and health counseling (Viswanathan et al., 2010). Employed by health care delivery organizations, including the Federal government and its agencies and other organizations that utilize care coordination, CHWs facilitate access to timely primary and preventive care. They have been shown to be effective in different situations which range from chronic disease management, maternal and child health, and research involving minority groups (Andrews, Felton, Wewers, & Heath, 2004; Brownstein et al., 2007; Islam et al., 2015; Islam et al., 2013). There has been increased involvement of CHWs in disease management especially

chronic diseases including diabetes (Fedder et al., 2003; Shah et al., 2013; Spencer et al., 2011), hypertension (Brownstein et al., 2007), depression, and cancer (Zonderman, Ejiogu, Norbeck, & Evans, 2014). States like New York and Connecticut have begun integration of CHW certification in health plans and Oregon created Coordinated Care Organizations which are required to employ CHWs (Centers for Disease Control and Prevention, 2019). Additionally, the State Public Health Actions to Prevent and Control Diabetes, Heart Disease, Obesity, and Associated Risk factors and Promote School Health is a CDC initiated program that promotes integration of CHWs into the public health workforce (Centers for Disease Control & Prevention, 2011). CHWs help patients meet goals around chronic disease management through provision of community outreach, chronic disease educational programs, healthy eating, and linking patients and providers.

A systematic review of randomized controlled trials using CHWs established that CHWs are effective in addressing health issues among several racial and ethnic populations, help improve screening of breast cervical cancer, improve blood pressure control, and eating habits (Gibbons & Tyus, 2007). Elsewhere, CHWs helped improve interpersonal communication skills that promote trust, providing social support to their clients and in guiding patients toward behavior change (Katigbak, Van Devanter, Islam, & Trinh-Shevrin, 2015).

There is an increased recognition of CHWs as a critical workforce. The United States Department of Labor estimates that 47,880 individuals were employed as CHWs in the whole country in 2014 and in 2017, the number was 54,760 indicating a growth of about 14% over the three years. The major industries with the highest employment rates for this group are Individual and Family Services; Local Government; and Outpatient Care Centers. The Patient Care and Affordable Care Act (ACA) recognize the importance of CHWs and several states have established a mechanism to reimburse for services provided by CHWs and hence recognizing them as part of

the integral health care delivery system in the U.S. (ACA, 2010). As of June 2016, 25 states (including DC) had laws addressing CHW workforce, seven states had laws authorizing Medicaid reimbursement for CHW services and six states had developed laws authorizing certification of CHWs (Centers for Disease Control & Prevention, 2016).

Furthermore, Section 5101 of the Act identifies CHWs as a part of the health professionals for representation on the National Health Care Workforce Commission. This has allowed CHWs to be incorporated into health care teams so as to help engage patients in their health care encounters, assist them in identifying community resources and improve their self-efficacy thereby redefining the health care system to focus on holistic, preventive, patient-centered efforts (Allen et al., 2015; Islam et al., 2015; Shah et al., 2013). Another section of ACA (SEC. 5313) defines a Community Health Worker and lists their roles and provisions for grants programs in which they can participate in. Specifically, the section calls for grants to programs that use CHWs to promote positive health behaviors among underserved populations in communities they reside in. The last section (SEC. 5403) establishes grants for training and placement of CHWs into jobs through the grant for Area Health Education Centers. Implementation of the provisions of the ACA has led to the recognition of CHWs as key players in the promotion of integrated health systems.

Community health Workers have been shown to help increase access to healthcare in underserved populations through outreach, health promotion and disease prevention services (Witmer et al., 1995). Several studies that utilized CHWs have shown a significant decrease in emergency room visits and admissions through the emergency room (Bielaszka-DuVernay, 2011; Fedder et al., 2003). Other studies have shown that CHW programs result in improvements in patients' use of preventive services including mammography and cervical cancer among low

income and immigrant women (Andersen, Hager, Su, & Urban, 2002; Andersen et al., 2000; Mock et al., 2007).

In a randomized controlled trial of community health worker intervention for type 2 diabetes management (Spencer et al., 2011), the researchers showed that individuals who interacted with community health workers had better diabetes self-management behavior. Another study where CHWs provided point of service screening, education and care coordination indicated an improved coronary heart disease (CHD) risk factor control among the clients (Krantz et al., 2013). In a separate study by Balcázar et al. (2016), they showed that community health workers were able to reach out to community members who previously did not have diagnosis of cardiovascular disease risk factors and this was based on the CHWs' knowledge of the communities' cultural norms, barriers and opportunities. Elsewhere, community health workers have been used to help clients to follow treatment plans, fill out insurance applications, work towards disease management goals, help clients find transportation and even accompanying them to appointments (Bielaszka-DuVernay, 2011). Community health worker interventions may vary depending on the employing agency and how the CHWs were selected and trained (O'Brien, Squires, Bixby, & Larson, 2009).

A review of outcomes and costs of CHW interventions showed that effectiveness of CHWs relative to alternative interventions is varied (Viswanathan et al., 2010). The Clinical Community Health Worker Initiative (CCHWI) is a Mississippi based program that seeks to link patients to CHWs for enhanced support in managing their chronic conditions. Under this initiative, CHWs offer informal counselling on medication adherence, tobacco cessation, healthy nutrition, and physical activity and they also help by arranging transportation, assisting patients with scheduling appointments and helping patients prepare for medical visits. Over the period 2011-2014, the

program showed some improvements that include increasing patients with controlled blood pressure by 2.9%, increasing patients with high cholesterol who are effectively managed by 8.7% and the percentage of patients at increased risk of cardiovascular events who were taking aspirin increased by 15.8% (CDC, 2015).

In a multi-site study by (Gaziano et al., 2015), they showed that Community Health Workers are able to integrate screening and referrals and they managed to do screenings in community sites or at the homes of community participants. The researchers also demonstrated that use of CHWs resulted in more community members who did not have previous diagnosis of the disease risk factors receiving health care services. This was made possible because community health workers draw on their in-depth knowledge of the community's cultural norms, barriers and opportunities. They have been shown to be effective in culturally relevant programs for hypertension control that involve multidisciplinary teams particularly in high-risk minority populations (Brownstein et al., 2007).

Economic Evaluation of Care Coordination Intervention Programs

The need for evidence on costs and benefits of care coordination programs is on the rise due to their increased use in linking communities with health care and social services. As the use of CHWs in care coordination programs continues to influence health outcomes through prevention and navigation of the health system, the economic impacts accrue in terms of savings in health care costs due to more efficient use of the health system. In comparison to other health care professionals, CHWs are relatively inexpensive to train, hire and supervise (Witmer et al., 1995).

Economic evaluation is a systematic attempt to identify, measure, and compare all the relevant costs and outcomes of alternative interventions (Drummond, Sculpher, Claxton, Stoddart,

& Torrance, 2015). Economic evaluation methods that include cost-analysis, cost-benefit analysis, and cost-effectiveness analysis have been used for evaluation and decision making in public health interventions. A cost-analysis study focuses on determining the monetary values of resources used to deliver prevention services. Such studies enable program managers to identify program resources that contribute the most to overall costs and they provide useful information about the startup and implementation costs of a prevention program. On the other hand, cost-benefit analysis (CBA) incorporates both costs and health outcomes and it places monetary values on health outcomes allowing costs to be weighed against benefits. The major concern about CBA is the requirement that health outcomes and suffering be valued of which it might be difficult to place dollar value on human life and human suffering (Muennig & Bounthavong, 2016). Cost-effectiveness analysis (CEA) compares costs and effectiveness of two or more prevention strategies and results from CEA are used to answer questions about whether a specific program produces outcomes that are worth program investment or which of several related programs is the most cost-effective. In using this approach, monetary and health outcomes are measured separately. CEA can be used to compare the cost per number of vaccine-prevented illnesses averted or cost per number low birth weight avoided.

Different economic evaluation methods have been used among different care coordination intervention programs. Existing literature has demonstrated that care coordination programs that involve CHWs can produce cost savings at various levels. Return on investment (ROI) has been used to show the potential financial benefits of an investment from the investor's perspective, usually the federal government. Studies to evaluate the ROI of care coordination programs have shown that a minimum return on investment of at least $2.28 per $1 spent on a community-based intervention can be achieved (Redding et al., 2015; Whitley et al., 2006). In other studies targeting

28

individuals with hypertension (Jafar et al., 2011), and individuals at risk of cardiovascular diseases (Allen et al., 2011), cost savings were achieved when using CHWs. A lifestyle intervention program among diabetic individuals showed that using Community Health Workers in care coordination programs was a cost-effective strategy (Lawlor et al., 2013). Similarly, a randomized controlled trial on depression intervention for low income Hispanics with diabetes comorbidity showed that using CHWs was a cost-effective approach (Hay, Katon, Ell, Lee, & Guterman, 2012).

Even though there has been heterogeneity in methods and results among economic evaluation studies, intervention programs involving CHWs have shown potential to offer good value for money invested in delivering essential health and social services to underserved communities (Vaughan et al., 2015). They play a pivotal role in addressing the drivers of health care costs and improving quality of care (Martinez & Knickman, 2010). Cost effectiveness and cost-benefit analyses have demonstrated that it can be cost-efficient to use CHWs in community interventions.

Although different studies have established a positive return on investment and the cost-effectiveness of using CHWs in community interventions, the cost utility analysis has not been rigorously evaluated (Mirambeau et al., 2013; Redding et al., 2015; Whitley et al., 2006). Additionally, the economic evaluation studies reviewed have considered the federal government perspective (Mirambeau et al., 2013), or insurer's perspective which usually ignores costs met by beneficiaries. Ignoring such costs would result in an incomplete reflection of the resource costs associated with an intervention (Gold, 1996; Sanders et al., 2016). It is a fact that the perspective taken in an economic analysis can have a noteworthy influence in how an intervention is assessed and the results obtained and interpreted.

Cost is key in selecting community interventions and it is important to get a true estimate of the resource costs associated with an intervention (Gorsky, 1996). Additionally, the point of view or perspective used in a study determines the costs and health effects to be considered. Different perspectives of economic evaluations in public health intervention methods include patients, providers, health payers, government, and societal. The societal perspective is the viewpoint for conducting a cost-effectiveness analysis that incorporates all costs and health effects regardless of who incurs the costs and who obtains the effects (Sanders et al., 2016). It considers all resources associated with the intervention regardless of who pays and enhances the study comparability throughout the health care delivery system (Sanders et al., 2016). Most importantly, the costs do not only include medical and other resources, but also the time of patients and unpaid caregivers. Table 2.1 shows some examples of costs included for different study perspectives.

Table 2.1: Examples of costs included for different study perspectives

Perspective	Costs			
	Physician time	Medication	Patient Travel	Time off work
Societal	●	●	●	●
Healthcare Payer	●	●		
Healthcare Provider	●			
Individual		●	●	●

Using the societal perspective enables cost-effectiveness results to be compared with other interventions since it includes costs, benefits, and harms that may extend beyond the payer or provider directly involved in the decision (Boyle, Torrance, Sinclair, & Horwood, 1983; Byford & Raftery, 1998; Gorsky, 1996). Several economic evaluation studies have demonstrated that care coordination interventions can achieve cost savings or are cost effective from the payer or provider

perspective (Fedder et al., 2003; Felix et al., 2011; Johnson et al., 2012; Mirambeau et al., 2013; Redding et al., 2015; Whitley et al., 2006).

Additionally, cost-utility analysis (CUA)-an extension of cost-effectiveness analysis, has been used to assess the economic impact of interventions. It compares costs and benefits as cost per standardized measure such as quality adjusted life year (QALY) and care coordination programs are generally designed to address a patient's quality of life as a desirable outcome (Allen et al., 2011). Reporting cost per QALY is preferred because QALYs are not disease specific. According to Pinkerton and Holtgrave (1998), "QALYs explicitly incorporate possible intervention effects on morbidity and impaired physical, mental, and emotional functioning and reductions in mortality" which allows for potential applicability to wider class health promotion interventions. To allow for comparison across studies, the Panel on Cost-effectiveness recommended the use of quality adjusted life years (QALYs) (Sanders et al., 2016). Despite the existence of these recommendations that seek to serve as a point of reference for investigators who seek comparability with other analyses in the literature, few care coordination intervention studies have reported cost per quality adjusted life year saved (Brown et al., 2012).

The Community Health Access Project (CHAP)

The Pathways Community HUB program in Richland, Ohio, known as the Community Health Access Project (CHAP), is one example of a care coordination program that uses a comprehensive risk factor approach to address barriers in low birth weight prevention. It is the pioneer Pathways Community HUB project launched in 1999. The Pathways Community HUB model has developed from this work and currently has a level II national Certification offered through the Pathways Community HUB Institute (PCHI), a not for profit organization focused on the quality Standards of model fidelity as well as research, technical support and model

improvement. Approximately 35 communities within eight states are involved in operating or developing a PCHI Certified Pathways Community HUB. PCHI grants Level 2 certification designation to HUBs that demonstrate 100 percent compliance with the certification requirements. It is a way of standardizing and formalizing the implementation of the Pathways Community HUB model of care coordination. As the model has grown, private business enterprises have developed data collection and reporting solutions including Care Coordination Systems (CCS) offering an internet-based care management database system.

According to the 2010 United State Census Bureau, Richland County has a total population of 124,475 people. Of this population, 87.3% were identified as White, and 9.4% were identified as Black or African American. Individuals of Hispanic or Latino origins constitute about 2% of the population. Females constitute 49.4% of the population and about 19% of the total population are persons aged 65 years and above. The per capita income was $22,520 and the median household income was $42,849 both in 2016 dollars. The infant mortality rate in Richland County stood at 6.7 infant deaths per 1,000 live births in 2017 and the mortality rate for black infants was 15.6, nearly three times more than that for white infants (5.3 per 1,000 live births) (Ohio Department of Health, 2017). According to the County Health Rankings 2018, Richland County ranks 57 out of 88 counties in Ohio on overall health outcomes. According to the Ohio Department of Health, Richland County had a low birth weight rate of 8% compared to 9% for the state. Further breakdown of the low birth weight rate by race shows that African Americans in Richland County had the highest rate of 14% compared to 7.8% for the White population in the same county. The reported rate for the African American community is consistent with the national average of 13.88% for the year 2017 (Hamilton et al., 2017).

The Pathways Community HUB model and its impacts on birth Outcomes: Gaps in our Understanding

Literature related to the assessment of the Pathways Community HUB model is limited. A recent study assessed the impact of the Pathways HUB program on the Neonatal Intensive Care Unit (NICU) and showed that program participants were less likely to be admitted to the NICU (Lucas & Detty, 2018). The HUB model and CHAP have demonstrated impact as a viable strategy for improving birth outcomes (Redding et al., 2015), but the sample size was small and the data are now a decade old. For this reason, it is valuable to investigate it further, both to verify its impact and to better understand some of the mechanisms with which it achieves those impacts. The CHAP is one of the few level II certified HUBs, so it is a reasonable choice with regard to assessing not only this case, but also other HUBs implemented with full fidelity to the HUB model. With improved understanding of the model and mechanisms with which it aids accomplishment of positive birth outcomes, we enhance our ability to invest public resources in ways that yield positive impacts in Mansfield area, among other HUBs, and perhaps through other care coordination efforts as well.

Even though the current study is in part a replication of the Redding et al, the two studies are different in many ways. In their matching procedure, Redding et al., (2015) used only 6 variables (age, race, education, marital status, census tract, delivery year). In the current study, four more variables (WIC, gestational diabetes, smoking, previous preterm birth) are included in the propensity matching procedure. Additionally, in the Redding et al., (2015) analysis, they adjusted separately for non-modifiable risk factors. In this study, the model is adjusted for all risk factors available. With regard to prenatal care utilization, it is not entirely clear how it was assessed in Redding et al., (2015). However, in the current study, there is a detailed assessment of the

Kotelchuck index (Kotelchuck, 1994) in addition to a direct measures of the extent of prenatal care utilization. There is also an assessment of how period of program participation is related to birth outcomes. In addition to low birth weight, preterm birth is also assessed as an additional outcome. In the Redding et al. (2015) article, they highlighted that the CHAP program could potentially reduce LBW delivery through multiple mechanisms and this study thus seeks to explore on some of those possible mechanisms such as duration in program and preterm births. Despite findings of the Redding et al. (2015) we know little or nothing about the effects of duration of participation on low birth weight and other birth outcomes.

Chapter 3

Methods

The present analyses utilize the standard methods of assessing effectiveness of the Pathways Community HUB intervention program aimed at reducing low birth weight among high-risk pregnant women. Birth outcomes for participants in the Pathways Community HUB model intervention program are compared to birth outcomes for pregnancies from a similar group of pregnant women as determined by the propensity scoring method. As mentioned in the hypotheses outlined in Chapter 1, it is envisioned additional support flowing from participation in the Pathways HUB model positively affects prenatal service utilization and birth weight outcomes. Additionally, it is anticipated that participation in the Pathways HUB program reduces the prevalence of pre-term births and increases the likelihood of adequate prenatal care utilization.

Assessing the effectiveness of the Pathways HUB model

Using propensity score matching from a control group and an intervention group, an estimate of the number of preterm births and low birth weight births averted by participation in the HUB Pathways Program is obtained. Furthermore, the adequacy and timing of prenatal care utilization will also be assessed. Infants born prematurely are more likely to die from birth complications and premature birth is the most frequent cause of infant mortality. An estimate of preterm births averted will be determined from the intervention group and compared to an estimate from the propensity-matched group using the risk difference or the absolute risk difference

(Kim, 2017; Tripepi, Jager, Dekker, Wanner, & Zoccali, 2007). The risk difference provides a measure of the public health impact and it focuses on the number of cases that could potentially be averted by participating in the Pathways HUB program. These estimates will add to existing evidence regarding the impact of the HUB model on LBW by using the most recent data available and including other variables (duration of program participation) and outcomes like preterm births and prenatal care utilization to help us understand more fully the mechanisms through which the Pathways Community HUB program achieves the birth outcomes it does.

Data and Data Sources

Data for the HUB participants is available through the Care Coordination Systems (CCS) database that provides a resource for a comprehensive and coordinated system of community health. The database captures information about all pregnant women enrolled into the CHAP program. The information includes socio-demographics, dates of first and last prenatal visits, Pathways opened, interactions with CHWs, and their health outcomes. Additionally, all infant characteristics are captured in the database and are linked to the mother through a unique client identification number.

The target population for CHAP consists of pregnant women at any gestational age within identified high risk census tracts. Using community health workers, a network of local churches and community-based organizations, women at risk of delivering low birth weight infants are referred and enrolled into the program if they meet eligibility criteria. The program focuses on residents in census tracts with high low birth weight rate and high poverty rates. Data for this study came from women who participated in the Pathways Community HUB program a.k.a Community Health Access Project (CHAP) in Richland County, Ohio during the years 2014, 2015, 2016, and 2017. The data were downloaded from the Care Coordination Systems (CCS) database, an internet-

based database system used for documenting activities and tracking of clients who participate in the program. Sample included those who had singleton live births during the period. Over the 4-year study period, 434 pregnant women participated in the CHAP program. Among these, 61 cases were excluded from further analysis because they were lost to follow up and did not have the final outcome of interest, another 30 cases were excluded from the study because they could not be matched with birth certificate data. Because I could not match these 30 cases to birth certificate data from ODH, I assumed that these clients were not in the ODH pool for the census tracts used in this study. In addition, 28 cases were excluded because they had delivered twins and others had missing information on key covariates. A sample size of 315 women from the CHAP group was used for final analysis (see Figure 3.1).

Birth certificate data were obtained from the Ohio Department of Health and matching to identify CHAP participants from the control group was based on mother's maternal age, infant birth weight and census tract. The Ohio Department of Health Vital Statistics Department operates a statewide system for the registration of births, deaths, fetal deaths, and other vital records. The Ohio Department of Health, local health departments, and other providers furnish data to the Ohio Department of Health Vital Statistics. Data provided included dates of first and last prenatal visits and gestational age at delivery. First prenatal visit date was subtracted from last prenatal visit date to estimate gestational age between the two visits. Gestational age between the two visits was then subtracted from gestational age at delivery to estimate gestational age at first prenatal visit. The study received Institutional Review Board (IRB) approval from the Ohio Department of Health Human Subjects Institutional Review Board and from the Kent State University IRB. Appendix A has a listing of variables that were used in the analysis.
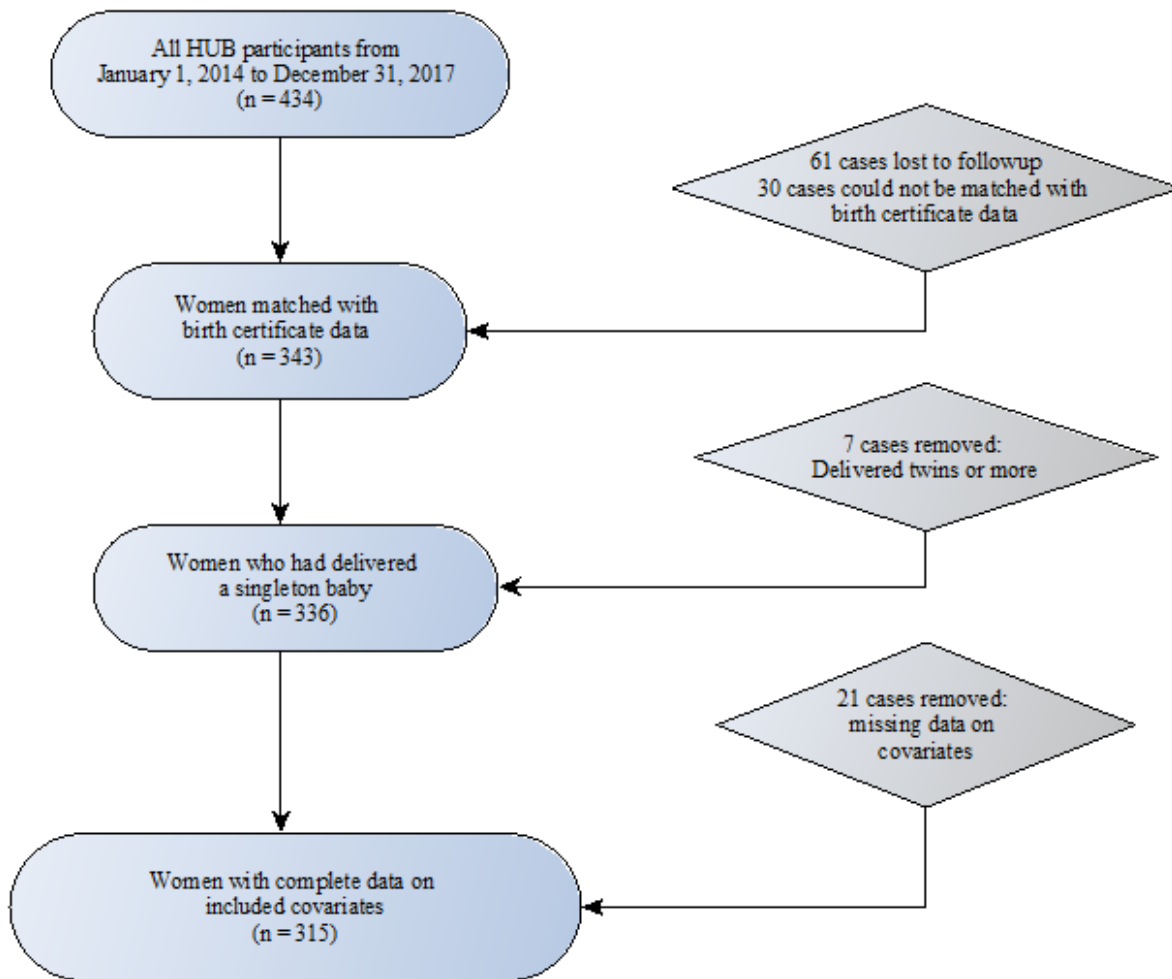
Figure 3.1: Flow chart of intervention group client selection

The inclusion criteria included having delivered a singleton live birth, no missing data points (complete case for both groups) and being matched to a case in the control group. In total, 3,896 subjects met the study criteria before propensity matching. These comprised of 315 individuals in the CHAP group (treatment group) and 3,581 individuals who were not in the treatment group. After propensity score matching, the final sample size obtained was 630 comprising of 315 CHAP participants and 315 non-CHAP participants. The matching factors were

maternal age, race, highest level of education attained, marital status, baby year of birth, previous preterm birth, smoking status, gestational diabetes, participation in Women, Infants and Children (WIC) program, and the Census tract. Exact matching on infant birth year was required to avoid duplication or matching on the same individual who had at least two pregnancies spaced within the four-year study period. Also, matching on census tract was exact given the disparities in birth outcomes moving from one census tract to another within the same geographical region.

Study Participants

Non-Pathways HUB participants. The comparison sample in this study is drawn from the same county (Richland) where the Pathways Community HUB program was implemented. Participants in this group were identified from the electronic medical records kept by the Ohio Department of Health, Bureau of Vital Statistics. As described in more detail in the "Statistical Analyses" section, propensity score analysis was used to construct the comparison group similar to the intervention group, with the exception being that they did not participate in the Pathways Community HUB program. The Ohio Resident Live Births, managed by the Ohio Department of Health, has records for all births occurring in the state and has measures that relate to maternal and infant characteristics. Using a technique called Propensity Score Matching (PSM), data from the Ohio Department of Health was matched with the program data based on census tract, year of delivery, and other key characteristics of pregnant women that significantly affect pregnancy outcomes.

According to the American College of Obstetricians and Gynecologists guidelines (ACOG, 2012), once a woman suspects that they are pregnant, they are encouraged to contact their health care provider for confirmation of pregnancy, pregnancy registration, and their first prenatal care visit usually by 10-12 weeks' gestational age. The health care provider can be an

obstetrician/gynecologist, family practice doctor, certified nurse-midwife, or a family nurse practitioner. Once pregnancy has been confirmed by the health care provider, the first clinic visit must include comprehensive history, laboratory work, physical exam, a check for infections, and education on how to maintain a healthy pregnancy. Laboratory results may have an influence on subsequent visits as this will promote a discussion of the management plan. For a typical uncomplicated pregnancy, recommended visits are once a month during the first 28 weeks of pregnancy, twice a month in weeks 28 to 36 of pregnancy and weekly after 36 weeks resulting in a minimum of 14 visits during a full-term pregnancy (ACOG, 2012). During their first checkup visit, they get a physical exam, get blood tests, urine tests, blood pressure check, and also a check for cancer and for other infections. An ultrasound can also be done to confirm pregnancy and determine due date. Depending on the assessed risks and the nature and severity of the problems, the frequency of visits should be individualized. In addition to these guidelines, the Centers for Disease Control and Prevention (CDC) also recommends that all women should be screened for HIV, hepatitis B, syphilis, and chlamydial infection during the first trimester (CDC, 2019; Koumans et al., 2012).

Pathways Community HUB participants This is a retrospective study spanning a 4-year period from January 2014 to December 2017. The Pathways HUB database has information about all pregnant women who participated in the program. The database tracks all clients from when they are enrolled into the program until they are discharged. In this study, clients who participated in the program and were discharged after a live birth were considered. Once a pregnant woman has been enrolled in the program, the Pregnancy Pathway remains open and is classified as completed when the participant delivers an infant. In total, 434 women participated in the HUB program over the 4-year period. The outcome is defined as giving birth to a live baby and, depending on the

weight of the baby at birth, birthweight is classified as either low birth weight or normal weight. Only singleton births were included in the final analysis. Women meeting the study criteria were successfully matched to a live singleton birth from the Ohio Department of Health, Bureau of Vital Statistics.

Outcomes

a) *Low Birth Weight*

Birth weight was measured in grams and dichotomized into a categorical variable. Infants who weighed less than 2,500 grams at birth were categorized as low birth weight and infants weighing 2,500 grams or more were categorized as normal birth weight.

b) *Preterm Birth*

Infants were classified as either preterm or full term. Infants born at gestational age less than 37 weeks were categorized as preterm and infants born during or after the 37th week were categorized as full term (Hamilton et al., 2018).

c) *Prenatal Care Utilization*

The Adequacy of Prenatal Care Utilization (APNCU) Index was used to assess utilization of prenatal care (Kotelchuck, 1994). Time of initiation of prenatal care, number of prenatal visits made by each woman, and the length of pregnancy in weeks were used in the calculation of the index. The index utilizes the ratio of observed to expected visits in assessing adequacy of utilization. Inadequate – prenatal care begun after the 4th month or received less than 50% of recommended visits, intermediate – prenatal care begun by the 4th month and received 50-79% of recommended visits, adequate – prenatal care begun by the 4th month and received 80% - 109% of recommended visits, and adequate plus – prenatal care begun by the 4th month and received 110% or more of recommended visits. Adequate care was defined as prenatal care beginning within the

first 4 months of pregnancy and having attended at least 80% of the American College of Obstetricians and Gynecologists (ACOG) recommended number of visits (Oakley et al., 2017).

Sample Size Estimation

To determine the sample size, I conducted a power analysis for dichotomous variables in SAS version 9.4. Assuming a low birth weight prevalence of 15% in the population being studied, a sample of at least 211 participants in each group is needed to detect an odds ratio of 2.2 with a power of 90% at 95% level of confidence (two tails). As a result, a minimum sample of 422 (211 HUB participants and 211 controls) was considered adequate for final analysis with a 1:1 matching.

Statistical Analysis

In this study, propensity score analysis is used. It is a rigorous method used for assessing causality in the absence of random assignment. A propensity score is a number between zero and one that represents the predicted probability that an individual is in a particular group. It is defined as the conditional probability of treatment assignment given the individual's observed baseline characteristics (Austin, 2011; d'Agostino, 1998). Considering that the Pathways Community HUB intervention program did not have a control group, any claim on its effectiveness must rely on observational data which may address the issue of selection bias when estimating average program effects. For example, women who report high use of prenatal services may be different in some systematic way from those who report lower use of services and these systematic differences may explain why the two groups differ in their behavior. Therefore, estimates of program effects on low birth weight are likely to be biased if confounders are not controlled for.

Propensity score matching allows for adjusting estimates of program effects for selection bias. This approach has many advantages including the ability to estimate treatment effects without

the need to model the relationship between outcomes and covariates; it is more robust to model misspecification when compared to linear regression; and a single propensity score can be used for adjusting several different outcomes for selection bias simultaneously (Yanovitzky, Zanutto, & Hornik, 2005). Propensity score adjustment method is a two-stage method. The first stage involves selection of the confounder pool or independent variables and the second stage involves the estimation of the propensity scores. In implementing the propensity score matching approach, I was informed by the general procedure described by Yanovitzky et al. (2005).

Step 1: Selecting confounder pool

In estimating propensity score, only confounders should be included (Yanovitzky et al., 2005). There are many variables that are associated with low birth weight and preterm birth and in this study, the following were identified as confounders: mother's age, race, highest level of education, marital status, census tract, delivery year, participation in the WIC program, gestational diabetes, smoking, and previous preterm birth.

Step 2: Estimating propensity scores

A logistic regression model was used to estimate propensity scores, which in our case represent the probability that the mother participates in the Pathways HUB program based on her observed covariates. The outcome is whether one participates in the program or not and the predictors are the variables listed above. At this stage, the distribution of the estimated propensity scores for the treated and control groups is checked using overlapping histograms to allow for comparison of the two groups.

Step 3: Creating Treatment/Control Groups using Matching

To create the treatment and control groups, I used propensity scores estimated from the previous step. A one-to-one optimal matching procedure was used. Using this approach minimizes

the global distance measure and the algorithm reconsiders all previously made matches before making the current match.

Step 4: Testing Group Balance

This step assesses the balance between the treatment and control groups among all the confounding variables identified after matching has been completed. This is achieved by estimating the standardized differences which are computed by dividing the mean difference by an estimate of its standard deviation. In this study, the maximum absolute standardized difference of 0.2 (Cohen, 2013; Lakens, 2013)was used and any absolute standardized differences that are less than or equal to 0.2 indicate balance on the covariates.

Step 5: Assessing Treatment Effect

The final step involves an assessment of the treatment effect. In this study, a logistic regression model adjusted for the propensity score was used to estimate the effect of participating in the CHAP program on low birth weight and preterm birth. In estimating treatment effects using observational data, the propensity score method is preferred to the regression method because the propensity score model can be easily assessed for adequate specification, enables the examination of baseline covariates by assessing degree of overlap, and it allows for the separation of study design (matching procedure) from analysis of the study (Austin, 2011). Since LBW and preterm birth are dichotomous, the treatment effect was assessed using the logistic regression adjusted for the propensity score as an additional covariate. Including the propensity score as an additional covariate has been shown to produce similar results to covariate adjustment (d'Agostino, 1998; Elze et al., 2017; Rosenbaum & Rubin, 1983). In fact, Rosenbaum and Rubin (1983) showed that univariate adjustment of the propensity score and multivariable adjustment resulted in the same point estimate of the treatment effect.

To estimate the number of low birth weight deliveries or preterm births that could potentially be averted by participating in the Pathways Community HUB care coordination program, I used the risk difference or the absolute risk difference since both outcomes were dichotomous. All analyses were conducted in SAS 9.4 (SAS Institute, Cary, NC, USA). Tests were conducted at the significance level of $\alpha = .05$.

Baseline characteristics

The control group included 3,581 women before matching who had delivered a live baby in Richland County, Ohio during the period 2014 – 2017 and had not participated in the CHAP program. Intervention group consisted of 315 women who participated in the CHAP program during the same period.

Table 3.1 contains descriptive statistics of background covariates which are used to match the CHAP and non-CHAP individuals. An important step in propensity score analysis is to assess similarity of covariate distribution or balance of the measured covariates between the intervention group and the comparison group before matching is performed to understand the distribution of the variables and assess their differences. An assessment of group balances of the CHAP and non-CHAP groups using standardized mean differences calculated as the difference in the proportions/means across groups divided by the standard deviation within the treatment group is performed. Variables with standardized mean differences greater than 0.2 are considered different across the two groups (Cohen, 2013). Additionally, p-values of less than 0.05 indicated statistically significant difference between the two groups assessed using chi-square for categorical variables and t-tests for continuous variables.

Table 3.1: Distribution of characteristics of CHAP clients and all non-CHAP clients before matching

Characteristic	CHAP (n=315)	Non-CHAP (n=3,581)	p-value	Standardized Differences
Age (mean, std)	24.2 (5.2)	26.3 (5.5)	<.0001	0.413
Race				
African American	164 (52.1)	368 (10.3)	<.0001	1.011
White	151 (47.9)	3213 (89.7)		
Highest level of education				
Less than high school	91 (28.9)	670 (18.7)	<.0001	0.241
High school graduate	156 (49.5)	1250 (34.9)	<.0001	0.299
Any college	68 (21.6)	1661 (46.4)	<.0001	0.542
Marital Status				
Married	43 (13.7)	1835 (51.2)	<.0001	0.877
Not married	272 (86.4)	1746 (48.8)		
Year of birth				
2014	54 (17.1)	877 (24.5)	0.0303	0.182
2015	92 (29.2)	923 (25.8)		0.077
2016	83 (26.4)	905 (25.3)		0.025
2017	86 (27.3)	876 (24.5)		0.065
Previous Preterm birth				
Yes	55 (17.5)	178 (5.0)	<.0001	0.404
No	260 (82.5)	3403 (95.0)		
Smoking				
Yes	101 (32.1)	1069 (29.9)	0.4117	0.048
No	214 (67.9)	2512 (70.1)		
Gestational Diabetes				
Yes	14 (4.4)	349 (9.8)	0.0019	0.208
No	301 (95.6)	3232 (90.2)		
WIC				
Yes	235 (74.6)	1709 (47.7)	<.0001	0.574
No	80 (25.4)	1872 (52.3)		
Census Tract				
400	28 (8.9)	135 (3.8)	<.0001	
500	41 (13.0)	165 (4.6)		
600	40 (12.7)	155 (4.3)		
700	49 (15.6)	127 (3.6)		
800	12 (3.8)	127 (3.6)		
900	15 (4.8)	208 (5.8)		
1000	28 (8.9)	289 (8.1)		
1100-1900*	48 (15.4)	864 (24.3)		
2101-3100*	54 (17.3)	1489 (41.6)		

*2101-3100 (2101, 2102, 2200, 2400, 2600, 2700, 2900, 3100)

*1100-1900 only excludes 1700

p-values were calculated using the Student's t-test or chi-square test.

There were 315 CHAP participants included in the study and 3,581 non-CHAP participants. The average age of the CHAP group was 24.2 years compared to 26.3 years for the non-CHAP group. Most of the study population (CHAP) were African American (52.1%), high school graduates (49.5%), not married (86.4%), non-smokers (67.9%), and participated in WIC program (74.6%). All covariates showed rather large and statistically significant initial differences between the CHAP and non-CHAP groups except smoking status, which showed no statistical significance between the comparison groups (

Table 3.1).

Matching procedure

Propensity scores were estimated for each individual using logistic regression model. The propensity score is the probability of being a CHAP participant, conditional on selected confounders. The dependent variable was whether one participated in the CHAP program or not.
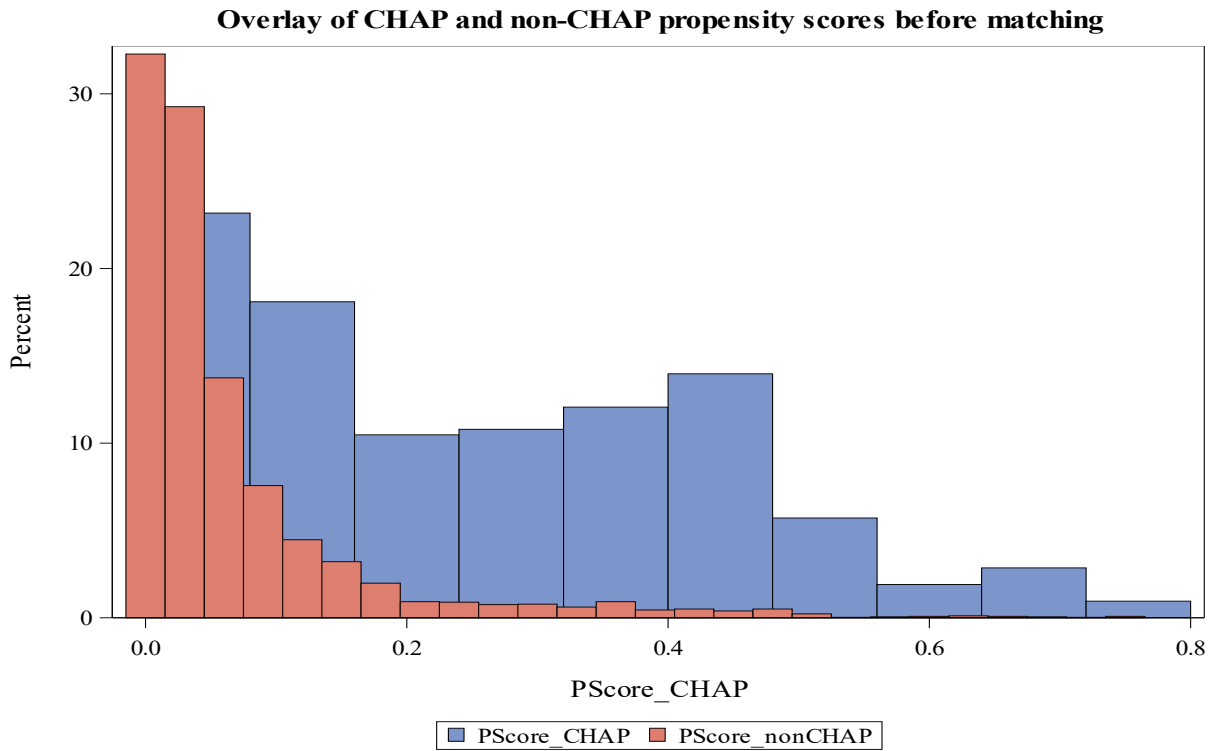
Figure 3.2: Distribution of propensity scores for CHAP and non-CHAP participants before matching

Using the logit of the estimated propensity scores, one case from the CHAP group was matched to one case from the control group for a 1:1 match. In total, 315 women who participated in the CHAP program were matched with 315 women who did not participate in the CHAP program.

Overlay of CHAP and non-CHAP propensity scores after matching
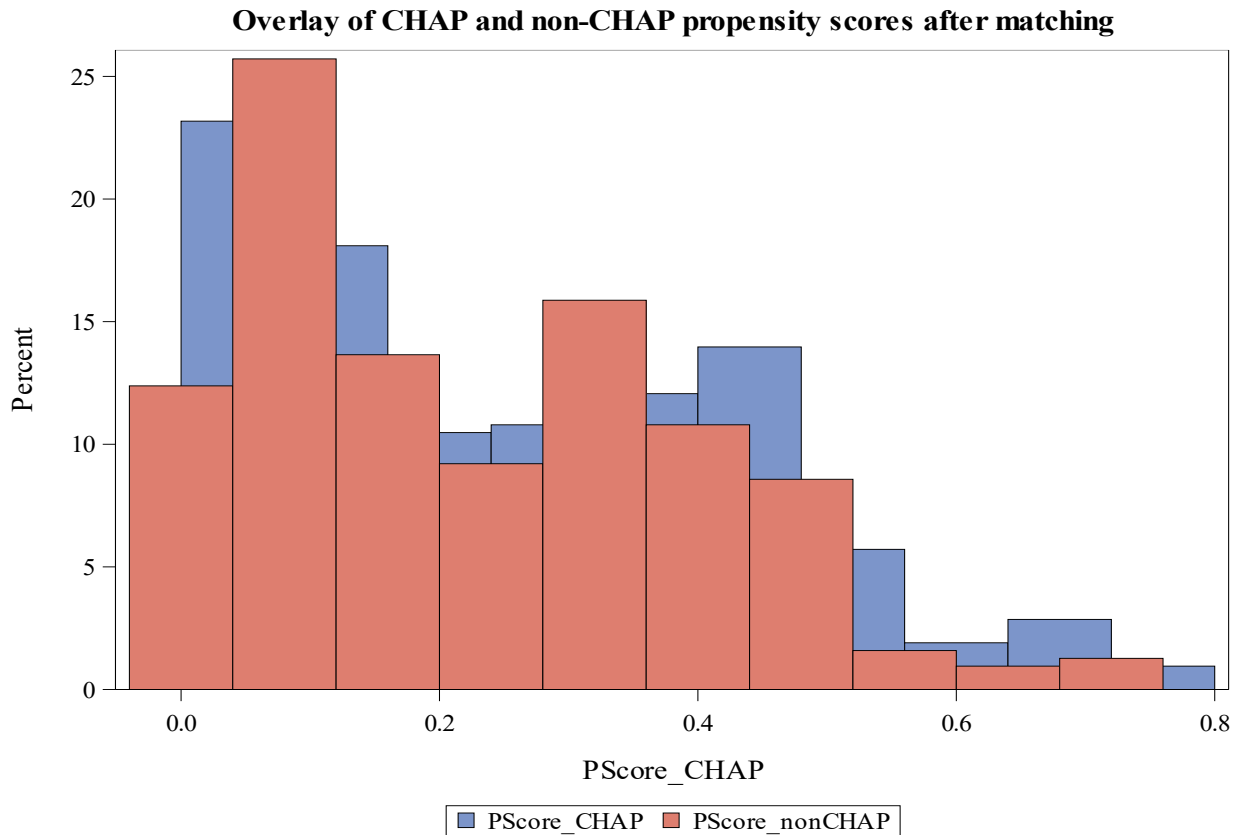
Figure 3.3: Distribution of propensity scores for CHAP and non-CHAP participants after matching

The estimated propensity scores for matched clients ranged from 0.005822 to 0.763004 for CHAP clients and from 0.005927 to 0.745878 for the non-CHAP clients. After establishing the propensity score model, an assessment of the degree of overlap of the propensity score (PS) was done by creating stacked histograms of the PS by distribution by participation in the intervention. **Error! Reference source not found.** compares the distribution of the propensity scores between CHAP and non-CHAP participants in the original sample (before matching). **Error! Reference**

50

source not found.3 compares the distribution of the propensity scores between CHAP and non-CHAP participants after matching. The distribution from Figures 3.3 demonstrates that the range of the propensity scores is similar between CHAP and non-CHAP clients. The comparability between the two populations after matching is dependent on the degree of overlap of distributions between the treatment groups. Generally, individuals in the CHAP group tend to have higher propensity scores compared to non-CHAP participants. However, the range of propensity scores in the two groups is broadly similar. As a result, for each CHAP client, there was a non-CHAP client with a comparable propensity score. Suitable matches were found for all the 315 CHAP participants. In the matched sample, the propensity score distribution appears to be similar.

Assessing Covariate Balance after matching

Optimal matching on the baseline propensity score created 315 matched pairs. Propensity score matching succeeded in removing bias between the CHAP and non-CHAP groups. After matching, covariate balance was assessed using p-values and standardized mean differences. Table 3.2 shows the descriptive statistics of the covariates after matching. Noticeably, the propensity score matching reduced that initial bias on confounders turning initial differences between exposure to HUB program and control group into non-significant ones. Treatment groups are considered balanced on the measured confounders if standardized mean differences are less than about 0.2 after adjustment (Cohen, 2013; Lakens, 2013). Therefore, differences of less than 0.2 for all measured confounders mean that balance has been achieved. Results in Table 3.2 demonstrate a high degree of balance of client characteristics across the treatment groups.

Table 3.2: Characteristics of CHAP clients and all non-CHAP clients after matching

Characteristic	CHAP (n=315)	Non-CHAP (n=315)	p-value	Standardized Difference
Age (mean, std)	24.16 (5.15)	24.13 (5.28)	0.9513	0.005
Race				
African American	164 (52.1)	159 (50.5)	0.6902	0.032
White	151 (47.9)	156 (49.5)		
Highest level of education				
Less than high school	91 (28.9)	89 (28.3)	0.8600	0.014
High school graduate	156 (49.5)	143 (45.4)	0.2996	0.083
Any college	68 (21.6)	83 (26.4)	0.1613	0.112
Marital Status				
Married	43 (13.7)	48 (15.2)	0.5709	0.045
Not married	272 (86.4)	267 (84.8)		
Year of birth				
2014	54 (17.1)	54 (17.1)	1.000	0.000
2015	92 (29.2)	92 (29.2)		0.000
2016	83 (26.4)	83 (26.4)		0.000
2017	86 (27.3)	86 (27.3)		0.000
Previous Preterm birth				
Yes	55 (17.5)	38 (12.1)	0.0562	0.153
No	260 (82.5)	277 (87.9)		
Smoking				
Yes	101 (32.1)	114 (36.2)	0.2747	0.087
No	214 (67.9)	201 (63.8)		
Gestational Diabetes				
Yes	14 (4.4)	12 (3.8)	0.6887	0.032
No	301 (95.6)	303 (96.2)		
WIC				
Yes	235 (74.6)	248 (78.7)	0.2207	0.098
No	80 (25.4)	67 (21.3)		
Census Tract				
400	28 (8.9)	28 (8.9)	1.000	0.000
500	41 (13.0)	41 (13.0)		
600	40 (12.7)	40 (12.7)		
700	49 (15.6)	49 (15.6)		
800	12 (3.8)	12 (3.8)		
900	15 (4.8)	15 (4.8)		
1000	28 (8.9)	28 (8.9)		
1300-1900*	41 (13.1)	41 (13.1)		
2101-3100*	54 (17.3)	54 (17.3)		

*1300-1900 only excludes 1700
*2101-3100 includes 2101, 2102, 2200, 2400, 2600, 2700, 2900, 3100

A comparison of matched units suggests that the treatment and comparison groups are not significantly different (Table 3.2). The next step is to assess the treatment effect on low birth weight, preterm birth, and utilization of prenatal care.

Chapter 4

Findings

A central outcome of interest was whether or not the baby was born with low birth weight (LBW) – less than 2,500 grams. Relatedly, other outcomes like preterm birth and adequacy of prenatal care utilization were also assessed. This section summarizes findings related to the replication of the Redding et al. (2015) with improvements as described. It also offers insights on potential mechanisms of impact based on duration in program, prenatal care utilization, and effects on preterm births.

To assess the effect of Community Health Access Project (CHAP) participation on low birth weight, covariate adjustment using the propensity score was performed. Binary logistic regression was the model of choice for predicting LBW and preterm birth from exposure (CHAP vs non-CHAP) controlling for the propensity score (Austin, 2011; Lanehart et al., 2012; Shadish & Steiner, 2010).

Assessing the effect of CHAP participation on low birth weight.

The overall incidence of low birth weight for the 630 participants was 10.48% (66/630). Among the 315 CHAP participants, 27 women (8.57%) delivered babies with low birth weight (less than 2,500 grams), whereas 12.38% from the non-Chap group's births were low birth weight

(Figure 4.1). Participation in the Pathways Community HUB program resulted in a significant decrease in low birth weight rate within the group.
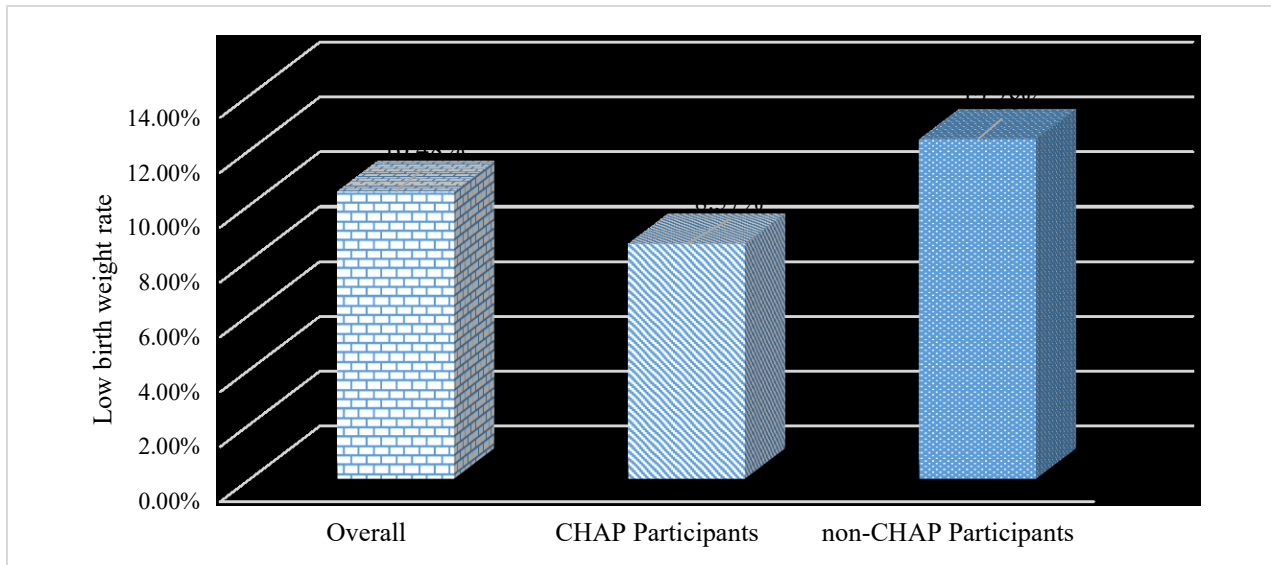
Figure 4.1: Incidence of low birth weight for the CHAP group, non-CHAP group and the overall sample

The unadjusted logistic regression model showed no significant differences of the odds of low birth weight between the CHAP and non-CHAP group (Table 4.1). However, after adjusting the model for the propensity score, CHAP participants were 43% less likely to have low birth weight deliveries compared to non-CHAP participants (OR = 0.572, 95% CI=0.335 0.979).

Table 4.1: Estimated Odds Ratio for Low Birth Weight

Variable	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio* (95% CI)
CHAP vs non-CHAP	0.664 (0.395 1.113)	0.572 (0.335 0.979)

*Model adjusted using the propensity score.
CI: Confidence Interval

Table 4.2 shows a summary of the proportions of low birth weight across different characteristics for the two groups. A comparison between the CHAP and non-CHAP group

55

indicates that CHAP results are stronger in all areas. The incidence of low birth weight is lower in the CHAP group across all characteristics assessed when compared to the non-CHAP group. This suggests that the intervention reduced the incidence of LBW deliveries among a wide range of participants. Within the CHAP group, participants with higher low birth weight incidence were more likely to be non-white, had less than high school education, were not married, were smokers and were non-WIC beneficiaries. The same pattern was observed for non-CHAP participants with the exception of smoking status which showed non-smokers with a higher rate.

Table 4.2: Proportions of low birth weight in CHAP and non-CHAP group by different characteristics

Characteristic	CHAP n (%)	Non-CHAP n (%)
Race		
White	10 (6.6)	14 (9.0)
Non-White	17 (10.4)	25 (15.7)
Education		
Less than high school	11 (12.1)	14 (15.7)
High school graduate	13 (8.3)	18 (12.6)
Some college	3 (4.4)	7 (8.4)
Marital Status		
Married	2 (4.7)	3 (6.3)
Not Married	25 (9.2)	36 (13.5)
Smoking status		
Smokers	9 (8.91)	13 (11.40)
Non-Smokers	18 (8.41)	26 (12.94)
WIC		
Yes	16 (6.8)	26 (10.5)
No	11 (13.8)	13 (19.4)

An assessment of the effect of trimester of first prenatal appointment on the incidence of LBW stratified by treatment status was also performed. Figure 4.2 shows the distribution of low birth weight proportions for the CHAP and non-CHAP groups categorized by trimester of first prenatal appointment. Evidently, participating in the HUB program and receipt of early prenatal care significantly lowers the chance of delivering a low birth weight baby. Among CHAP participants, receipt of first prenatal appointment in the first trimester was significantly associated

with low incidence of LBW (P < 0.0). Additionally, CHAP participants who had their first prenatal appointment in the second and third trimester were respectively, 7 times and 8.3 times more likely to deliver a low birth weight baby compared to those who had the first prenatal care visit in the first trimester. On the other hand, among non-CHAP participants, there was no association between LBW rates and trimester of receipt of first prenatal appointment or visit.

The difference in the incidence of low birth weight between the CHAP group and non-CHAP group is very small for those who had their first prenatal appointment in the third trimester (Figure 4.2). Clearly, the difference between the two groups increases with early receipt of prenatal care. Even though the program appears to be registering lower incidence of low birth weight when pregnant women get the first prenatal visits during the second and third trimester, the benefits are more pronounced for those who had their first prenatal visit in the first trimester (Figure 4.2).
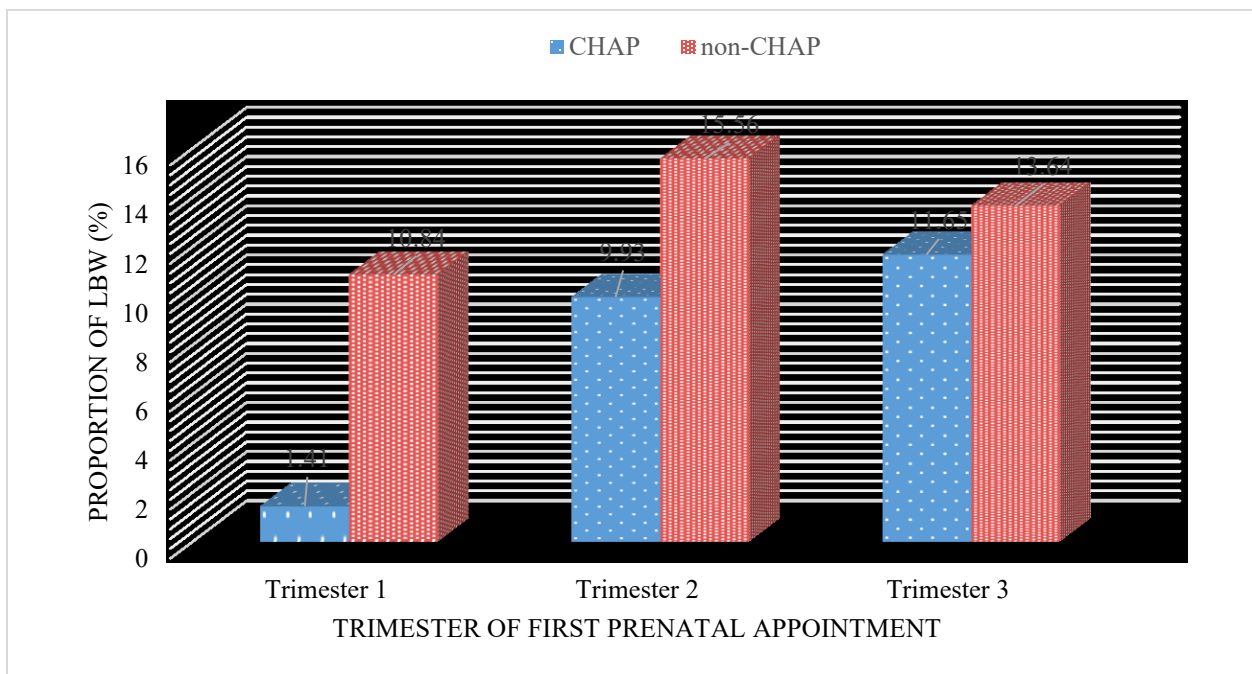
Figure 4.2: Comparison of LBW proportions by trimester of first prenatal appointment between the CHAP and non-CHAP group

Pregnant women are normally expected to start receiving prenatal care services as soon as pregnancy is confirmed. For CHAP participants, some enrolled into the program early in their pregnancy and remained in the program until they had delivered a baby, and these participants are more likely to get full benefits of participating in the program. Individuals included in the analysis are those who have participated in the program and had a documented delivery. Notably, CHAP is a community intervention program, where participant enrollment into the program is continuous and the duration of participation in the program varies depending on the time of entry into the program. Some women are enrolled into the program late in their pregnancy and they would spend a few days to weeks before delivery. In addition, some are enrolled early in their pregnancy but may have preterm birth. For example, a pregnant woman may enroll into the program at a gestational age of 22 weeks and then prematurely delivers at 27 weeks. This means that even though the woman enrolled into the program during her second trimester, she did not receive the full benefits of the program beyond 5 weeks of participation. Therefore, duration of participation in the program appears to have an effect on program outcomes – particularly on whether the baby is low birth weight or not.

To understand how duration of participation in the program or time between first prenatal visit and delivery impacted different outcomes, duration in program measured in weeks was assessed with respect to different birth outcomes. Among the 315 study participants, period of participation in the program varied from a few days to about 37 weeks. About 30% of CHAP participants spent at most 10 weeks in the program. On the other hand, more than 62% of the program participants spent at least 13 weeks (equivalent to one trimester) in the program, with 10% of them spending more than 29 weeks while enrolled in the program.

Table 4.3: Distribution of participants by duration in program and the associated low birth weight proportions

		[b]Low birth weight proportion	
Period in Program (weeks)	[a]Participants	CHAP	Non-CHAP
0	4	0.25	0.00
1	4	0.25	0.75
2	8	0.125	0.00
3	10	0.40	0.40
4	10	0.20	0.20
5	10	0.20	0.10
6	13	15.4	23.1
7	12	0.083	0.00
8	4	0.25	0.00
9	12	0.083	0.25
10	8	0.00	0.00
11	14	0.071	0.143
12	8	0.00	0.25
13	9	0.111	0.00
14	11	0.273	0.00
15	16	0.125	0.063
16	17	0.059	0.118
17	14	0.00	0.143
18	11	0.00	0.00
19	7	0.143	0.143
20	4	0.00	0.00
21	6	0.00	0.00
22	11	0.00	0.364
23	5	0.20	0.40
24	6	0.00	0.00
25	15	0.067	0.067
26	9	0.00	0.00
27	6	0.00	0.00
28	10	0.00	0.00
29	10	0.00	0.10
30	5	0.00	0.00
31	13	0.00	0.00
32	5	0.00	0.60
33	2	0.00	0.50
34	1	0.00	0.00
35	3	0.00	0.333
36	1	0.00	0.00
37	1	0.00	0.00

Notes:
[a]Shows the count of participants who participated for a specified period. The indicated number is the same for the CHAP and non-CHAP group.
[b]Indicates the proportion of LBW births for the given number of participants.

Table 4.3 shows the distribution of participants based on duration in program and the proportions of low birth weight among these participants. For example, the first row shows four women from the CHAP group who spent less than a week in the program and the proportion of low birth weight among the four. Additionally, the last column shows the proportion of the matched set (non-CHAP) and their respective low birth weight proportion. From the table, it is noted that women from the CHAP program who spent at least 26 weeks in the program did not deliver a low birth weight baby.

Figure 4.3 is a line graph of low birth weight proportion versus duration in program for the CHAP and non-CHAP groups generated using data from Table 4.3. The x-axis represents the duration in program or the time between receipt of first prenatal services and delivery of baby. Overall, the proportion of CHAP participants (blue dotted line) is lower than the proportion of non-CHAP participants (orange continuous line) and the difference between the two groups increases with increased duration in program.
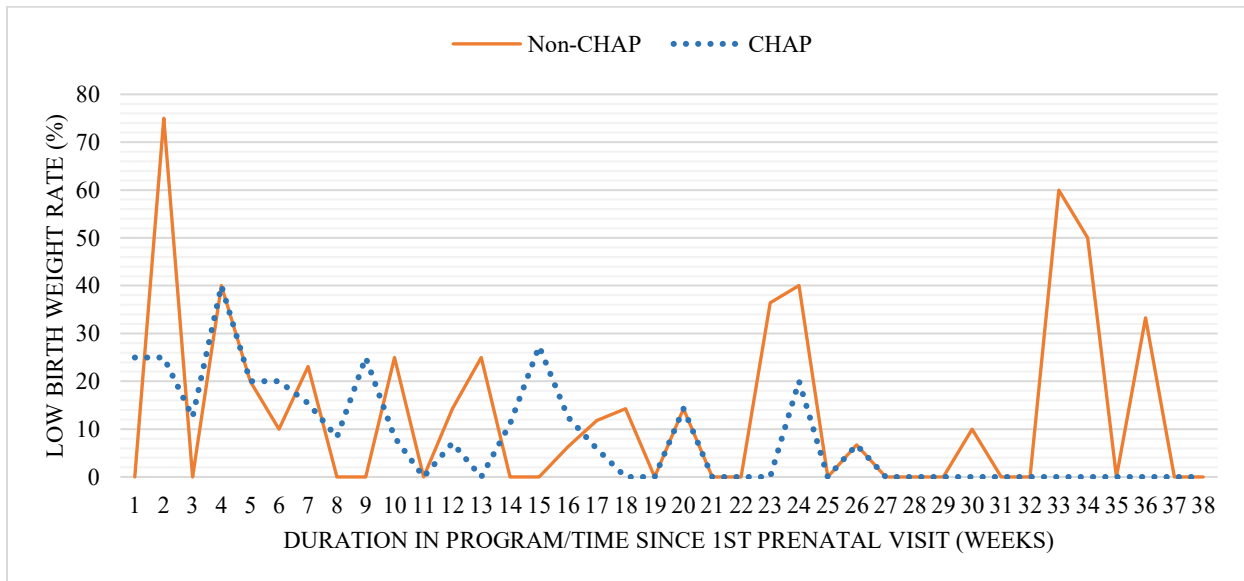

Figure 4.3: Line graph showing low birth weight rate versus duration in program/time between receipt of first prenatal services & delivery for the CHAP and non-CHAP groups

Low birth weight births averted

The risk difference was used to estimate the number of low birth weight births averted because of the Pathways Community HUB program. It is the difference in risk of low birth weight between the CHAP group and the non-CHAP group (Irwig, Irwig, Trevena, & Sweet, 2008). Risk difference is the amount of risk which decreased or increased due to the presence of the exposure (Pathways HUB program) compared to when the exposure is not there (Kim, 2017). In this study, an estimate of the risk difference was 3.81% (Table 4.4). This means that for every 100 pregnant women enrolled in the Pathways Community HUB program, about four low birth weight births would be averted.

Table 4.4: Table showing the risk difference estimate of low birth weight

| | Outcome | | |
Exposure	Low Birth Weight	Normal Weight	Total
Treatment group (CHAP)	27	288	315
Control group (non-CHAP)	39	276	315

Control group low birth weight rate = 12.38%
Treatment group low birth weight rate = 8.57%
Absolute risk reduction or risk difference = 12.38% - 8.57% = 3.81%

Assess the effectiveness of the Pathways Community HUB approach in reducing preterm births.

Preterm/premature birth happens before 37 weeks of pregnancy and can be a result of different risk factors including previous preterm birth, being pregnant with twins or more, and many other medical risk factors. The impact of the CHAP program on preterm birth (Yes/No) was assessed using a logistic regression model adjusted for the propensity score (Table 4.5). Notably, CHAP participants were 36% less likely to deliver preterm (OR = 0.640; 95% CI=0.407 1.007). However, participation in the Pathways Community HUB program did not reach significance,

although the trend was in the direction of preventing preterm birth for women participating in the program.

Table 4.5: Estimated Odds Ratio for Preterm Births

Variable	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio* (95% CI)
CHAP vs non-CHAP	0.703 (0.452 1.094)	0.640 (0.407 1.007)

*Model adjusted using the propensity score.
CI: Confidence Interval

Table 4.6 shows the incidence of preterm births in the CHAP group and the associated risk rates. An estimated of the risk difference is calculated based on the figures presented in the table.

Table 4.6: Table showing the risk difference estimate of preterm birth

	Outcome		
Exposure	Preterm birth	Normal birth	Total
Treatment group (CHAP)	40	275	315
Control group (non-CHAP)	54	261	315

Control group preterm birth rate = 17.14%
Treatment group preterm birth rate = 12.70%
Absolute risk reduction or risk difference = 17.14% - 12.70% = 4.44%

An estimate of the risk difference indicated that for every 100 pregnant women enrolled in the Pathways Community HUB program, about five preterm births are averted, although due to the lack of statistical significance – this result should be viewed with caution.

Assess the effectiveness of the Pathways Community HUB approach in improving prenatal care utilization

Prenatal care helps ensure the birth of a healthy baby with minimal risk to the mother. It is an ongoing evaluation of the health status of the mother and the fetus and represents a series of assessments and interventions during pregnancy. According to the American College of Obstetrics

and Gynecology (ACOG), typical intervals for prenatal visits for first time women with uncomplicated pregnancies are every 4 weeks until 28 weeks of gestation, every 2 weeks from 28 to 36 weeks, and then weekly until delivery.

Table 4.7: Summary of prenatal care visits for CHAP and non-CHAP groups with varying period of participation

Duration in program	N	CHAP Mean (SD)	Non-CHAP Mean (SD)	p-value
No minimum duration	315	11.65 (5.03)	11.23 (5.46)	0.3098
At least one week	311	11.70 (5.43)	11.25 (5.05)	0.2851
At least two weeks	307	11.75 (5.44)	11.26 (5.05)	0.2521
At least three weeks	299	11.92 (5.38)	11.20 (5.00)	0.0926
At least four weeks	289	12.08 (5.36)	11.18 (5.00)	0.0375*
At least five weeks	279	12.27 (5.31)	11.20 (5.06)	0.0150*
At least six weeks	269	12.22 (5.20)	11.18 (5.11)	0.0191*
At least seven weeks	256	12.34 (5.12)	11.24 (5.14)	0.0154*
At least eight weeks	244	12.33 (5.12)	11.30 (5.17)	0.0276*
At least nine weeks	240	12.37 (5.11)	11.26 (5.18)	0.0191*
At least 10 weeks	228	12.41 (5.16)	11.29 (5.22)	0.0219*
At least 11 weeks	220	12.46 (5.19)	11.29 (5.27)	0.0192*
At least 12 weeks	206	12.41 (5.06)	11.34 (5.40)	0.0373*

Note: I stopped varying duration of program participation at 12 weeks based on our sample size calculation that required a minimum of 211 participants in each group in order to detect statistical difference.
*Indicate p-values less than .05

Prenatal care visits for the CHAP and non-CHAP groups were assessed. Table 4.7 shows average prenatal care visits classified according to duration in program or time between first prenatal visit and delivery. Evidently, as the duration in program or the period between first prenatal visit and delivery increased, the average number of prenatal visits also increased. Additionally, the average number of visits for CHAP participants is greater than that of non-CHAP participants over the period between first visit and delivery. Comparing the two groups, the average prenatal visits for the CHAP participants were statistically significantly higher among

those who spent at least four weeks in the program or time between first prenatal visit and delivery as shown in Table 4.7. Prenatal care is a major indicator of health care utilization among pregnant women. Our results show that even though program participants are more likely to access care during pregnancy, a distinct difference in utilization is noticed when women spend at least four weeks in the program.

Unlike number of prenatal visits, the Adequacy of Prenatal Care Utilization (APNCU) index assesses two dimensions of prenatal care – when prenatal care began (adequacy of initiation of care) and the number of prenatal visits or use of services from when prenatal care began until delivery (adequacy of received services). It is a composite measure based on the number of prenatal visits made, trimester prenatal care began, and the gestational age of the newborn. Classification of adequacy of received services is based on the ratio between the actual number of prenatal visits and the expected number of visits for the period between when care began and the delivery date. The ratio is grouped into four categories – inadequate (received less than 50% of expected visits), intermediate (50%-79%), adequate (80%-109%), and adequate plus (110% or more).

Table 4.8: Adequacy of prenatal care utilization index (APNCUI) for CHAP and non-CHAP groups

Adequacy of Prenatal Care Utilization	Group		p-value
	CHAP	Non-CHAP	
	n (%)	n (%)	
Adequate plus (110% or more)	21 (6.7)	25 (7.9)	0.0001
Adequate (80%-109%)	175 (55.6)	145 (46.0)	
Intermediate (50%-79%)	36 (11.4)	120 (38.1)	
Inadequate (less than 50%)	83 (26.4)	25 (7.9)	

Table 4.8 shows the summary of results for the adequacy of prenatal care utilization index for CHAP and non-CHAP participants. A combined 62.3% CHAP participants received adequate and adequate plus care compared to 53.9% non-CHAP participants who had the same utilization.

Based on the results of chi-square test, adequacy of prenatal care utilization index showed a statistically significant relationship with treatment status ($P < 0.0001$). However, more CHAP participants (26.4%) received inadequate care compared to non-CHAP participants (7.9%). This is due to the fact that timing of first prenatal visit is used in the calculating the Adequacy of Prenatal Care Utilization index and as a result, more CHAP clients are classified as having received inadequate care due to their late entry into the program.

Chapter 5

Discussion

The high rates of infant mortality in the United States continue to haunt the positive efforts centered on addressing the issue. This problem is further compounded by some common areas of health disparities and concerns varying across different population groups in the areas of morbidity and mortality. Minority groups have low prenatal care utilization rates, higher incidence of low birth weight and are more likely to experience adverse birth outcomes (Hamilton et al., 2018). These racial disparities require culturally, and environmentally appropriate innovative community-based strategies. The Pathways Community HUB model is an example of a care coordination model that utilizes community resources and helps high risk groups to comprehensively address both clinical services and social services in order to overcome barriers to health care (Zeigler, Redding, et al., 2014). Overall, the model utilizes existing community resources, helps alleviate effects of "silos" and fragmentation in the system, focuses on common metrics to identify and track risks through a holistic community care coordination approach, and pays for measurable outcomes.

The objectives of the current study were: 1) To assess the effectiveness of the Pathways Community HUB approach in reducing low birth weight; 2) To assess the effectiveness of the Pathways Community HUB approach in reducing preterm births; 3) To assess the effectiveness of the Pathways Community HUB approach in improving prenatal care utilization; and 4) To suggest future directions for evaluating the cost-effectiveness of the Pathways Community HUB approach in reducing low birth weight.

Discussion of study findings

The main findings in this study have demonstrated that participation in the Pathways Community HUB care coordination program significantly reduces the odds of delivering a low birth weight baby. The HUB program appears to be successfully addressing low birth weight, an important risk factor of infant mortality (Hamilton et al., 2018). This result is consistent with the findings from Redding et al. (2015). Despite lack of statistical significance between participation in the program and preterm births, the results may also be interpreted to suggest that the program may also have beneficial effects in reducing preterm births. With regard to prenatal care utilization, the Pathways HUB program participants had better utilization of prenatal care services compared to the non-program participants.

Clearly, the current study findings largely confirm Redding et al. (2015) results of the potentiality of the Pathways HUB program in reducing "persistent" health inequalities. Moreover, the study also amplifies those findings with more detailed assessment of how an individual's duration in program can influence the birth outcomes and prenatal care utilization. The inclusion of preterm birth as one of the outcomes in the study marks another unique contribution. In their study, (Redding et al., 2015) highlighted that there are other "multiple mechanisms" by which the HUB program can impact birth outcomes. In this study, those other mechanisms are explored, and we learn some insights from this process.

The study's findings suggest that the program's emphasis on prenatal care is important. CHAP participants who had their first prenatal appointment in the first trimester of pregnancy had significantly lower low birth weight incidence in comparison to those who had enrolled later. In line with the American Academy of Pediatrics (AAP) and the American College of Obstetricians and Gynecologists (ACOG) recommendations, accessing early prenatal care services especially

during the first trimester improves the chances of a healthy pregnancy (ACOG, 2012). Women who receive prenatal services during the first trimester of their pregnancy are more likely to have better pregnancy outcomes, and it appears that early entry into the Pathways HUB program enables participants to take advantage of these effects.

Related to the issue of early enrollment, duration of participation in the program had an influence on the outcomes of the program participants. The measure of duration in program was based on the number of weeks an individual had spent in the program from enrollment until delivery. Focusing on program duration provides us with the opportunity to assess program influence on the outcomes of interest. It should be noted that the CHAP program is a community program and any pregnant woman who has at least any of the risk factors such as not having a medical home or health insurance, being unemployed, being a smoker or drug user or having social services problems like lack of housing is enrolled in the program. Resultantly, there are some women who get enrolled just a few weeks before delivery and may not fully benefit from the program. From the current study, 36 women spent at most four weeks in the program before delivery. This potentially dampens efforts to identify problems or complications early in the pregnancy and may undercut the effectiveness of the program in reducing low birth weight births.

The impact of duration in program cannot be overemphasized given its relationship with prenatal care utilization. Individuals who enroll early into the program are likely to have improved utilization of prenatal care services. Higher exposure to program resources, especially working with a dedicated community health worker, to help the high-risk pregnant women navigate the system and mitigate some of their risks results in better outcomes. Thus, early program enrollment, implies early reception of prenatal care - a key component in better pregnancy outcomes. A further assessment of prenatal care utilization using the number of prenatal visits and the Kotelchuck

Index emphasized the fact that the program is getting more people into receiving prenatal care. None of the program participants who received adequate plus care according to the Kotelchuck Index, for example, delivered a low birth weight baby and only one program participant who received adequate plus care, delivered a preterm baby.

The Pathways Community HUB program has proven its ability to improve health outcomes by achieving one of its goals of reducing low birth weight deliveries among high risk pregnant women. Reduction of low birth weight rate has a huge impact on the family, the society, and on Medicaid savings. Being born normal weight implies that the infant will have an average hospital stay of 3.4 days at a cost of about $3,200 compared to an average length of stay of 17.7 days at an average cost of $27,200 when they are born with low birth weight (Kowlessar, Jiang, & Steiner, 2013). Given that Medicaid was the source of payment for about 43% of all births in 2016, any low birth weight delivery averted will result in immediate savings of costs related to hospital stays (Martin et al., 2018). Furthermore, there are lifetime health and economic benefits of being born with normal weight. For those born with normal weight, the chances of getting some chronic diseases are significantly reduced (Hack et al., 2005) and it is associated with improved quality of life (Saigal et al., 1994; Zwicker & Harris, 2008).

While the current study did not show statistical significance on preterm births, the results nevertheless suggest that there may be a relationship between participation in the CHAP program and reduced likelihoods of preterm births. Further inquiry to substantiate this suggestion would seem to be appropriate. Such research might also seek to account for how other modifiable risk factors such as lack of transportation, alcohol consumption, tobacco use, and substance abuse could influence preterm births. In addition, genetic influence, multiple pregnancies, infections and chronic conditions including diabetes and high blood pressure have also been identified as the

common causes of preterm births (Althabe, 2012), and might also be accounted for in future work in this area. Thus, the ability to manage and control chronic conditions can only be achieved if pregnant women present early in their pregnancy for health care checkup. However, 77.5% of CHAP participants had their first interaction with the health care system either in the second or third trimester. This appears detrimental to the impact of the program and can bring attention to the importance of early client identification efforts. It also suggests that HUB programs may want to undertake efforts to identify and enroll clients early in their pregnancies.

The U.S. Department of Health and Human Services (HHS) and the Centers for Disease Control and Prevention (CDC) identified five strategies aimed at reducing preterm birth and complications (Shapiro-Mendoza et al., 2016). The strategies include 1) improving access to pre-conception services for women of childbearing ages; 2) identification and offering treatment to women at risk of preterm delivery; 3) reduction of non-medically indicated deliveries; 4) avoiding unintended pregnancies and attaining optimal birth spacing; and 5) reduction in multiple gestations. While the strategy of avoiding multiple gestations can be difficult to implement, the first four strategies can be adopted and implemented in multiple ways. The Pathways HUB model appears to incorporate the second strategy. At the core of the model is improving access to care by identifying individuals at risk of adverse health outcomes and help them navigate the healthcare system and link them to social services within their communities. If the program is implemented with fidelity, women at risk of preterm delivery or low birth weight are identified early and they receive the necessary care, but this has not always been the case with the HUB program. The Pathways HUB program connects women to relevant social services within their communities to receive support for smoking cessation and for other risky behaviors such as alcohol consumption and drug use during pregnancy. Through social services Pathways, women are connected to

different organizations such as WIC, the CMS Strong Start for Mothers and Newborn Initiative, and home visiting programs that provide pregnancy and after delivery information to help improve the wellness of the mother and the infant.

One of the objectives of the Healthy People 2020 is an increase in early and adequate prenatal care (Healthy People 2020, 2019). The current study results showed that about 62% of HUB participants received adequate and adequate plus care compared to about 54% recorded for non-HUB participants. However, more women in the CHAP group, 26% received inadequate care compared to 8% for non-HUB participants. This difference may be attributable to HUB participants who enroll in the program relatively late and do not receive health care services early in the pregnancy as recommended by ACOG. Besides using number of visits and gestational age, the Adequacy of Prenatal Care Utilization Index also utilizes timing of initiation of prenatal care in assessing adequacy of prenatal care utilization (Kotelchuck, 1994). Resultantly, despite having more clinical visits among CHAP participants, individuals who start receiving care in the third trimester or late in their pregnancy are more likely to be classified as having received inadequate care. On the one hand, less than 10% from both the intervention group and the control group received adequate plus care. Watson, Hernandez, and Thompson (2018) argue that women who receive adequate plus care have an elevated risk of adverse birth outcomes and are expected to record more prenatal visits compared to those with reduced risk. Women with elevated risk are more likely to be referred for more clinical services resulting in increased use of prenatal care services. According to the American College of Obstetricians and Gynecologists, early prenatal care is critical as it focuses on screening, addressing maternal risk factors and provision of health education. While prenatal visit count is an important indicator of prenatal care utilization, timing and content of visits play a major role in providing adequate care (Kotelchuck, 1994).

In one of the previous studies, (Redding et al., 2015), the authors suggested that "CHAP may reduce LBW delivery among high risk women through multiple mechanisms". The current study sought to explore other possible mechanisms that could potentially impact birth outcomes. It showed intensive utilization of care as measured by the high number of prenatal care visits among program participants irrespective of timing of enrollment. Thus, more aggressive efforts towards early enrollment into the program could potentially contribute towards the reduction of low birth weight rates and improve prenatal care utilization. An assessment of length of program participation showed that on average, individuals who spent at least 25 weeks in the program had lower low birth weight rate.

The Value of Cost-effectiveness Research

In the future, performing cost-effectiveness analysis of the Pathways Community HUB care coordination program will go a long way in comparing the health benefits and costs associated with the intervention. The approach will help us understand the tradeoffs of costs and benefits as assessed using the incremental cost-effectiveness ratio (ICER). Furthermore, using quality adjusted life years (QALYs) as one of the outcomes gives policy makers an opportunity to compare ICERs for different interventions and be able to identify those interventions that bring the greatest value. Additionally, using the QALY measure would allow us to assess how the new intervention improves the quality and/length of life for program beneficiaries and enables comparison of the efficiency of health interventions for different conditions. Therefore, it is natural that cost-effectiveness analysis be done for an intervention program like the Pathways HUB program that is showing a lot of promise in improving health.

In order to assess the cost-effectiveness of the Pathways HUB program, there are two important components that must be established from program data. One of the components is the

effectiveness of the intervention in reducing low birth weight. Evidently, findings from the current study have demonstrated that the intervention is effective in reducing low birth weight deliveries. Estimates of the risks of low birth weight delivery from both the intervention group and control group were established. The second important component is establishing the relevant costs of participating in the program. Using the societal perspective, major cost categories to be considered would include costs of implementing the program, costs associated with travel expenses or childcare and patient. Other parameters such as QALYs saved can be estimated from literature as they allow for the comparability of results across economic evaluation studies (Pinkerton & Holtgrave, 1998). Additionally, other input parameters for evaluating the cost-effectiveness of the model can be estimated from literature.

Implications

Increasingly, non-clinical factors are being recognized as important in affecting health outcomes. To overcome barriers to healthcare, the Pathways HUB model supplements clinical services with social services for those most at risk (Zeigler, Redding, et al., 2014). Through this approach, risk factors in a continuum of medical, social, and behavioral risks are comprehensively addressed (Redding et al., 2018). Different initiatives aimed at addressing social determinants of health within and outside of the healthcare system exist and the Medicaid delivery system and payment reform initiatives are now seeking to achieve that. In 2017, a total of 19 states required Medicaid managed care plans to screen for and/or provide referral for social needs (Artiga & Hinton, 2018). A 2018 study in 10 states that had introduced payment and delivery reforms and had the largest Medicaid enrollment showed that housing, behavioral health, substance abuse and nutrition/food security were the most commonly targeted areas of new effort (Rosenbaum et al., 2018). This is a clear demonstration of the commitment of different states in addressing social

determinants of health and supporting changes across the health delivery system. Therefore, states may want to look at the Pathways program as a way to address non-medical risk factors such as housing, smoking, health insurance, substance use and many others are tracked and included in the care of program participants.

As noted previously, the Pathways HUB model uses the value-based payments approach through contracting with Medicaid Managed Care organizations (MMCOs) – at least in Ohio. In the case of the Pregnancy Pathway, a payment is made upon successful delivery of recommended prenatal services and an additional bonus for delivery of a healthy birthweight baby (McGinnis, Crumley, & Chang, 2018). Use of MMCOs has enhanced the sustainability of the Pathways Program by paying for costs related to services provided by CHWs (Chiyaka et al., 2019). The adoption of the value-based payment model allows linking of performance and payment and formation of community partnerships to coordinate care and align efforts (Zeigler, Carter, et al., 2014; Zeigler, Redding, et al., 2014). By using the model, health care providers and social services departments can collaborate with community-based organizations to comprehensively mitigate risk and improve health outcomes.

Distinctively, the Pathways HUB model of payment is tied to confirmed risk mitigation in social, behavioral, and medical domains. The CHAP program currently tracks 20 Pathways covering medical, social, and behavioral risk factors and the contracted MMCOs are paying for most of the risks. For example, a client who is found to be lacking access to medical care, housing and behavioral health interventions has a specific Pathway assigned for each of these risks. When the client is confirmed to have been connected to medical care, established safe housing and shown up for the behavioral health care treatment appointment, each of these Pathways are marked completed and invoices for payment can be submitted. The model is different from those that use

Health Effectiveness Data and Information Set (HEDIS) measures with a focus on medical risks only (NCQA, 2019) since the Pathways HUB program also tracks and pays for non-medical risk factors. As stated earlier, in light of the documented positive health outcomes, other states may want to consider expanding funding to mitigate health, social, and behavioral risks through the state Medicaid program.

Prenatal care can reduce the risk of pregnancy complications. Pregnant women with certain medical conditions would benefit from prenatal care by reducing the risk of medical complications or mortality. The current study suggests that with better prenatal care utilization, low birth weight can be reduced. During clinical prenatal visits, the health status of the woman and the fetus is assessed, and pregnancy related health education is offered. Other prenatal visits can be used to educate the pregnant women about health risks. In the case of the Pathways HUB model, an "Education Pathway" is opened for every woman enrolled in the program. Through this Pathway, CHWs use standard curriculum from Ohio's Help Me Grow program – an innovative home visiting model that promotes early prenatal and well-baby care (Ohio Department of Health, 2019). Other women enrolled through the Moms and Babies First program use a research based home visiting curricula from Florida State University Partners for a Healthy Baby (Florida State University, 2019). These education modules seek to promote positive health outcomes for both the mother and the infant. For better results, prenatal care must be accessed early in the pregnancy. Healthy People 2020 goal is to have 77.9% of pregnant women receive care in their first trimester of pregnancy (Osterman & Martin, 2018). However, certain subpopulations like the African Americans are significantly less likely to achieve this goal. Therefore, the targeted efforts of the HUB model towards these high-risk groups can potentially help women receive early and adequate prenatal

care. Furthermore, program management might consider creating favorable payments for early prenatal enrollment of clients in addition to overall prenatal care utilization.

The U.S. Department of Health and Human Services seeks to recognize the important contributions of CHWs in improving access to care and support prevention efforts. Even though in this study there was no direct evaluation of the impact of community health workers, per se, on birth outcomes, the Pathways HUB program's success is centered on them as they interact with all pregnant women and help them access different services. The overall success of the program also underlines the potential importance of CHWs in community-based interventions. Integration of CHWs into the workflows of health care organizations and recognition of CHWs as part of the system can have health benefits to at-risk populations. In the Pathways HUB program, CHWs help facilitate client access of the community social service system and/or connects them with the health care providers. The findings from this study suggest that use of CHW services may potentially result in better health outcomes and better utilization of prenatal care services.

One of the key lessons from this study is the capability of the Pathways Community HUB care coordination model to comprehensively address social, behavioral, and health risk factors in achieving better health outcomes. It suggests that given the interconnectedness of risk factors, incorporating approaches that modify social determinants of health such as housing, transportation, job opportunities, and access to health care services can potentially result in improved health outcomes. The HUB model enhances coordination and collaboration of agencies, health care providers, professional organizations, local community organizations, and other stakeholders and utilizes an internet-based care management database system to track each identified risk factor to a measurable outcome (Zeigler, Redding, et al., 2014). The centralized system avoids duplication

of services across different community organizations. Thus, through the HUB model, it appears possible that community resources may be used more effectively and efficiently.

In 2013, the Centers for Medicare and Medicaid Services (CMS) expanded the reimbursement for preventive services to allow state Medicaid agencies the option to reimburse for additional community-based preventive services (Centers for Medicare Medicaid Services, 2013). The Community Preventive Services Task Force (2015) also identified utilization of CHWs in team-based care models as an effective intervention to improve chronic disease outcomes especially in cardiovascular disease, diabetes cervical cancer, colorectal cancer, and breast cancer (Community Preventive Services Task Force, 2019). The evidence presented in the current study about the HUB model supports the idea that using CHWs to reduce LBW among high risk pregnant women may be a viable approach to improving health outcomes for at-risk populations.

Limitations

The current study has limitations that should be considered when interpreting study results. First, the CHAP program helped participants to get access to community resources including housing assistance, utility assistance, transportation, food assistance, and connection to Help me Grow/Early Head Start programs. On the contrary, no data was available with regards to these services for the control group and therefore, the study did not specifically measure how improved social support from the CHAP program impacts birth outcomes. Second, the study is based on a single site in Ohio. Even though the characteristics of program participants may be similar in other settings where HUB services are provided, the environmental factors may be significantly different with changing geographical settings.

Third, the CHAP program currently follows up on clients up to the 30-day postpartum visit period. The program does not follow up clients further than that. However, in order to assess other

long-term outcomes such as infant and maternal mortality, the clients need to be followed up to at least the first birthday of the infant. This limited our ability to assess other outcomes such as infant mortality rates especially among program participants. If more resources can be put towards follow up of program participants at least until the first birthday of the infant the program would benefit a lot in documenting some of its long-term benefits resulting from averted low birth weight and preterm births.

Fourth, information obtained from birth certificate data does not include trimester at first visit. As a result, this was estimated using the date of first prenatal visit, date of last prenatal visit and estimated gestation at birth. This can potentially underestimate or overestimate the adequacy of prenatal care utilization index where trimester of first prenatal visit is a key contributing variable.

Fifth, although the propensity matching scoring procedure is a very useful procedure in reducing selection bias, it is possible that some selection bias remained due to some unmeasured covariates. There are many risk factors associated with low birth weight and preterm birth but because of using observational data, inclusion of more risk factors is limited by the number of factors measured in the data.

Future Research

The current study focused only on one site. Since the Pathways Community HUB program has been in implemented in more than five states, further studies that account for more varied geographical regions are warranted as they may be able to capture different client, program, and other characteristics in assessing outcomes. Additionally, the Pathways HUB model is a very promising innovative comprehensive model that compensates based on risk reductions achieved. The Evidence Based Prevention and Intervention Support Center (EPISCenter) have set a criterion

for an evidence based program (Evidence Based Prevention and Intervention Support Center, 2015). The program should demonstrate effectiveness in rigorous scientific evaluations and in large studies through multiple replications. Further, replications in larger studies with more diverse populations would be helpful in determining if the findings in this work can be further generalized.

Conclusion

Federal policy has embraced the implementation of innovative community led interventions. The Pathways HUB model uses a central HUB system and works in collaboration with community organizations and health care providers to identify and mitigate risks while paying for measurable outcomes. This study has demonstrated that the HUB model is effective in improving birth outcomes and - in so doing - also suggests that the program may have longer term health benefits on infants. The current findings contribute to the evidence base in support of the Pathways Community HUB model in reducing low birth weight and further suggests that it may improve prenatal care utilization among high risk pregnant women – particularly when clients are identified and engaged in the program early in their pregnancies.

References

Abrams, M., Nuzum, R., Zezza, M., Ryan, J., Kiszla, J., & Guterman, S. (2015). The Affordable Care Act's payment and delivery system reforms: a progress report at five years. *Issue brief (Commonwealth Fund), 12*, 1-16.

ACA. (2010). Patient Protection and Affordable Care Act. *USC § 18001*.

ACOG, C. o. O. P. (2012). *Guidelines for perinatal care*: Am Acad Pediatrics.

Ales, K., Druzin, M., & Santini, D. (1990). Impact of advanced maternal age on the outcome of pregnancy. *Surgery, gynecology & obstetrics, 171*(3), 209-216.

Allen, C. G., Escoffery, C., Satsangi, A., & Brownstein, J. N. (2015). Strategies to Improve the Integration of Community Health Workers Into Health Care Teams: "A Little Fish in a Big Pond". *Prev Chronic Dis, 12*, E154. doi:10.5888/pcd12.150199

Allen, J. K., Himmelfarb, C. R. D., Szanton, S. L., Bone, L., Hill, M. N., & Levine, D. M. (2011). COACH trial: a randomized controlled trial of nurse practitioner/community health worker cardiovascular disease risk reduction in urban community health centers: rationale and design. *Contemporary clinical trials, 32*(3), 403-411.

Althabe, F. (2012). *Born too soon: the global action report on preterm birth*: World Health Organization.

American College of Physicians. (2019). Delivery and Payment Models.   Retrieved from https://www.acponline.org/practice-resources/business-resources/payment/delivery-and-payment-models

Andersen, M. R., Hager, M., Su, C., & Urban, N. (2002). Analysis of the cost-effectiveness of

    mammography promotion by volunteers in rural communities. *Health Educ Behav, 29*(6),

    755-770.

Andersen, M. R., Yasui, Y., Meischke, H., Kuniyuki, A., Etzioni, R., & Urban, N. (2000). The

    effectiveness of mammography promotion by volunteers in rural communities. *Am J Prev*

    Med, 18(3), 199-207.

Andrews, J. O., Felton, G., Wewers, M. E., & Heath, J. (2004). Use of community health

    workers in research with ethnic minority women. *J Nurs Scholarsh, 36*(4), 358-365.

Anum, E. A., Retchin, S. M., & Strauss III, J. F. (2010). Medicaid and preterm birth and low

    birth weight: the last two decades. *Journal of women's health, 19*(3), 443-451.

Armitage, G. D., Suter, E., Oelke, N. D., & Adair, C. E. (2009). Health systems integration: state

    of the evidence. *Int J Integr Care, 9*, e82.

Artiga, S., & Hinton, E. (2018). Beyond health care: the role of social determinants in promoting

    health and health equity. *Health, 20*, 1-10.

Austin, P. C. (2011). An introduction to propensity score methods for reducing the effects of

    confounding in observational studies. *Multivariate behavioral research, 46*(3), 399-424.

Ayers, B. L., Purvis, R. S., Bing, W. I., Rubon-Chutaro, J., Hawley, N. L., Delafield, R., . . .

    McElfish, P. A. (2018). Structural and socio-cultural barriers to prenatal care in a US

    Marshallese community. *Maternal and child health journal*, 1-10.

Ayoola, A. B., Nettleman, M. D., & Stommel, M. (2010). Time from pregnancy recognition to

    prenatal care and associated newborn outcomes. *Journal of Obstetric, Gynecologic &*

    Neonatal Nursing, 39(5), 550-556.

Balcázar, H. G., de Heer, H. D., Wise Thomas, S., Redelfs, A., Rosenthal, E. L., Burgos, X., & Duarte, M. O. (2016). Promotoras can facilitate use of recreational community resources: the Mi Corazón Mi Comunidad Cohort Study. *Health promotion practice, 17*(3), 343-352.

Bao, Y., Casalino, L. P., & Pincus, H. A. (2013). Behavioral health and health care reform models: patient-centered medical home, health home, and accountable care organization. *The journal of behavioral health services & research, 40*(1), 121-132.

Barker, D. J. P. (1999). Fetal origins of cardiovascular disease. *Annals of medicine, 31*(sup1), 3-6.

Barnes-Boyd, C., Fordham Norr, K., & Nacion, K. W. (2001). Promoting infant health through home visiting by a nurse-managed community worker team. *Public Health Nurs, 18*(4), 225-235.

Berg, C. J., Callaghan, W. M., Syverson, C., & Henderson, Z. (2010). Pregnancy-related mortality in the United States, 1998 to 2005. *Obstetrics & Gynecology, 116*(6), 1302-1309.

Berkowitz, G. S., Skovron, M. L., Lapinski, R. H., & Berkowitz, R. L. (1990). Delayed childbearing and the outcome of pregnancy. *New England Journal of Medicine, 322*(10), 659-664.

Bielaszka-DuVernay, C. (2011). Vermont's Blueprint for medical homes, community health teams, and better health at lower cost. *Health Aff (Millwood), 30*(3), 383-386. doi:10.1377/hlthaff.2011.0169

Blencowe, H., Cousens, S., Chou, D., Oestergaard, M., Say, L., Moller, A.-B., . . . Lawn, J.

    (2013). Born too soon: the global epidemiology of 15 million preterm births.

    Reproductive health, 10(1), S2.

Blumenthal, D., Abrams, M., & Nuzum, R. (2015). The affordable care act at 5 years: Mass

    Medical Soc.

Boyle, M. H., Torrance, G. W., Sinclair, J. C., & Horwood, S. P. (1983). Economic evaluation of

    neonatal intensive care of very-low-birth-weight infants. *N Engl J Med, 308*(22), 1330-

    1337. doi:10.1056/NEJM198306023082206

Brown, H. S., 3rd, Wilson, K. J., Pagan, J. A., Arcari, C. M., Martinez, M., Smith, K., &

    Reininger, B. (2012). Cost-effectiveness analysis of a community health worker

    intervention for low-income Hispanic adults with diabetes. *Prev Chronic Dis, 9*, E140.

    doi:10.5888/pcd9.120074

Brownstein, J. N., Chowdhury, F. M., Norris, S. L., Horsley, T., Jack, L., Jr., Zhang, X., &

    Satterfield, D. (2007). Effectiveness of community health workers in the care of people

    with hypertension. *Am J Prev Med, 32*(5), 435-447. doi:10.1016/j.amepre.2007.01.011

Byford, S., & Raftery, J. (1998). Perspectives in economic evaluation. *BMJ, 316*(7143), 1529-

    1530.

Carias, C., Chesson, H. W., Grosse, S. D., Li, R., Meltzer, M. I., Miller, G. F., . . . Whitham, H.

    K. (2018). Recommendations of the Second Panel on Cost Effectiveness in Health and

    Medicine: A Reference, Not a Rule Book. *American journal of preventive medicine,*

    54(4), 600-602.

Caulfield, L. E., Gross, S. M., Bentley, M. E., Bronner, Y., Kessler, L., Jensen, J., . . . Paige, D.

    M. (1998). WIC-based interventions to promote breastfeeding among African-American

Women in Baltimore: effects on breastfeeding initiation and continuation. *J Hum Lact, 14*(1), 15-22. doi:10.1177/089033449801400110

CDC. (2019). Screening recommendations.   Retrieved from

https://www.cdc.gov/nchhstp/pregnancy/screening/index.html

Centers for Disease Control & Prevention. (2010). Establishing a holistic framework to reduce

inequities in HIV, viral hepatitis, STDs, and tuberculosis in the United States. *Atlanta:*

CDC.

Centers for Disease Control & Prevention. (2011). Addressing chronic disease through

community health workers: a policy and systems-level approach. *Issue brief*.

Centers for Disease Control & Prevention. (2016). *State Law Fact Sheet: A Summary Of State*

Community Health Worker Laws. Retrieved from

https://www.cdc.gov/dhdsp/pubs/docs/SLFS-Summary-State-CHW-Laws.pdf

Centers for Disease Control and Prevention. (2018, September 15, 2017). Pregnancy and prenatal

care.

Centers for Disease Control and Prevention. (2019). Including Community Health Workers

(CHWs) in State Health System Transformations.   Retrieved from

https://www.cdc.gov/dhdsp/pubs/toolkits/chw-ta-including.htm

Centers for Medicare and Medicaid Services. (2019). Innovation Models.   Retrieved from

https://innovation.cms.gov/initiatives/#views=models

Centers for Medicare Medicaid Services. (2013). Medicaid and Children's Health Insurance

Programs: essential health benefits in alternative benefit plans, eligibility notices, fair

hearing and appeal processes, and premiums and cost sharing; exchanges: eligibility and

enrollment. Final rule. *Federal register, 78*(135), 42159.

Chiyaka, E., Hoornbeek, J., Filla, J., Redding, M., Falletta, L., Birmingham, L., & Ferguson, P. (2019). Using the Pathways Community HUB Care Coordination model to address chronic illnesses: A case study. *Ohio Journal of Public Health, 2*(1).

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*: Routledge.

Coles, C. D., Platzman, K. A., Smith, I., James, M. E., & Falek, A. (1992). Effects of cocaine and alcohol use in pregnancy on neonatal growth and neurobehavioral status. *Neurotoxicology and teratology, 14*(1), 23-33.

Currie, J., & Moretti, E. (2003). Mother's education and the intergenerational transmission of human capital: Evidence from college openings. *The Quarterly journal of economics, 118*(4), 1495-1532.

d'Agostino, R. B. (1998). Propensity score methods for bias reduction in the comparison of a treatment to a non-randomized control group. *Statistics in medicine, 17*(19), 2265-2281.

Davis, K., Abrams, M., & Stremikis, K. (2011). How the Affordable Care Act will strengthen the nation's primary care foundation. *Journal of general internal medicine, 26*(10), 1201.

de Bernabé, J. V., Soriano, T., Albaladejo, R., Juarranz, M., Calle, M. a. E., Martínez, D., & Domínguez-Rojas, V. (2004). Risk factors for low birth weight: a review. *European Journal of Obstetrics & Gynecology and Reproductive Biology, 116*(1), 3-15.

Ding, M., Yuan, C., Gaskins, A. J., Field, A. E., Missmer, S. A., Michels, K. B., . . . Chavarro, J. (2017). Smoking during pregnancy in relation to grandchild birth weight and BMI trajectories. *PloS one, 12*(7), e0179368.

Drummond, M. F., Sculpher, M. J., Claxton, K., Stoddart, G. L., & Torrance, G. W. (2015). *Methods for the economic evaluation of health care programmes*: Oxford university press.

Elze, M. C., Gregson, J., Baber, U., Williamson, E., Sartori, S., Mehran, R., . . . Pocock, S. J.

    (2017). Comparison of propensity score methods and covariate adjustment: evaluation in

    4 cardiovascular studies. *Journal of the American College of Cardiology, 69*(3), 345-357.

Emmer, S. (2013). Care Coordination Under the Affordable Care Act: Opportunities and

    Challenges for Geriatric Care Managers. *Journal of Aging Life Care*(Fall 2013).

Evidence Based Prevention and Intervention Support Center. (2015). Defining Evidence Based

    Programs.   Retrieved from http://www.episcenter.psu.edu/ebp/definition

Fedder, D. O., Chang, R. J., Curry, S., & Nichols, G. (2003). The effectiveness of a community

    health worker outreach program on healthcare utilization of west Baltimore City

    Medicaid patients with diabetes, with or without hypertension. *Ethn Dis, 13*(1), 22-27.

Felix, H. C., Mays, G. P., Stewart, M. K., Cottoms, N., & Olson, M. (2011). The Care Span:

    Medicaid savings resulted when community health workers matched those with needs to

    home and community care. *Health Aff (Millwood), 30*(7), 1366-1374.

    doi:10.1377/hlthaff.2011.0150

Florida State University. (2019). Center for Prevention and Early Intervetion Policy.   Retrieved

    from https://cpeip.fsu.edu/

Fortier, M. E., Fountain, D. M., Vargas, M., Heelan-Fancher, L., Perron, T., Hinic, K., & Swan,

    B. A. (2015). Health care in the community: Developing academic/practice partnerships

    for care coordination and managing transitions. *Nursing Economics, 33*(3), 167.

Gaziano, T. A., Abrahams-Gessel, S., Denman, C. A., Montano, C. M., Khanam, M., Puoane, T.,

    & Levitt, N. S. (2015). An assessment of community health workers' ability to screen for

    cardiovascular disease risk with a simple, non-invasive risk assessment instrument in

Bangladesh, Guatemala, Mexico, and South Africa: an observational study. *Lancet Glob Health, 3*(9), e556-563. doi:10.1016/S2214-109X(15)00143-6

Gibbons, M. C., & Tyus, N. C. (2007). Systematic review of U.S.-based randomized controlled trials using community health workers. *Prog Community Health Partnersh, 1*(4), 371-381. doi:10.1353/cpr.2007.0035

Gibbs, C. M., Wendt, A., Peters, S., & Hogue, C. J. (2012). The impact of early age at first childbirth on maternal and infant health. *Paediatric and perinatal epidemiology, 26*, 259-284.

Goisis, A., Remes, H., Barclay, K., Martikainen, P., & Myrskylä, M. (2017). Advanced maternal age and the risk of low birth weight and preterm delivery: a within-family analysis using Finnish population registers. *American journal of epidemiology, 186*(11), 1219-1226.

Gold, M. (1996). Panel on cost-effectiveness in health and medicine. *Medical care, 34*(12), DS197-DS199.

Goldenberg, R. L., & Culhane, J. F. (2007). Low birth weight in the United States. *Am J Clin Nutr, 85*(2), 584S-590S.

Goldenberg, R. L., & Rouse, D. J. (1998). Prevention of premature birth. *New England Journal of Medicine, 339*(5), 313-320.

Gonthier, C., Estellat, C., Deneux-Tharaux, C., Blondel, B., Alfaiate, T., Schmitz, T., . . . Ravaud, P. (2017). Association between maternal social deprivation and prenatal care utilization: the PreCARE cohort study. *BMC pregnancy and childbirth, 17*(1), 126.

Gorsky, R. D. (1996). A method to measure the costs of counseling for HIV prevention. *Public Health Rep, 111 Suppl 1*, 115-122.

Graham, A. V., Frank, S. H., Zyzanski, S. J., Kitson, G. C., & Reeb, K. G. (1992). A clinical trial to reduce the rate of low birth weight in an inner-city black population. *Fam Med, 24*(6), 439-446.

Hack, M., Taylor, H. G., Drotar, D., Schluchter, M., Cartar, L., Andreias, L., . . . Klein, N. (2005). Chronic conditions, functional limitations, and special health care needs of school-aged children born with extremely low-birth-weight in the 1990s. *JAMA, 294*(3), 318-325.

Haines, A., Sanders, D., Lehmann, U., Rowe, A. K., Lawn, J. E., Jan, S., . . . Bhutta, Z. (2007). Achieving child survival goals: potential contribution of community health workers. *Lancet, 369*(9579), 2121-2131. doi:10.1016/S0140-6736(07)60325-0

Hamilton, B. E., Martin, J. A., & Osterman, M. J. (2017). Births: Provisional Data for 2016. *Natl Vital Stat Rep*, 1-21.

Hamilton, B. E., Osterman, M. J., Driscoll, A. K., & Rossen, L. M. (2018). Births: Provisional data for 2017.

Harris, J. R., & Wallace, R. B. (2012). The Institute of Medicine's new report on living well with chronic illness. *Prev Chronic Dis, 9*, E148. doi:10.5888/pcd9.120126

Harrison, P. L., Pope, J. E., Coberley, C. R., & Rula, E. Y. (2012). Evaluation of the relationship between individual well-being and future health care utilization and cost. *Popul Health Manag, 15*(6), 325-330. doi:10.1089/pop.2011.0089

Hay, J. W., Katon, W. J., Ell, K., Lee, P.-J., & Guterman, J. J. (2012). Cost-effectiveness analysis of collaborative care management of major depression among low-income, predominantly Hispanics with diabetes. *Value in Health, 15*(2), 249-254.

Health, U. D. o., & Services, H. (2004). The health consequences of smoking: a report of the

   Surgeon General.

Healthy People 2020. (2019). 2020 Topics and Objectives: Maternal, Infant, and Child Health.

   Retrieved from https://www.healthypeople.gov/2020/topics-objectives

Hill-Briggs, F. (2003). Problem solving in diabetes self-management: a model of chronic illness

   self-management behavior. *Ann Behav Med, 25*(3), 182-193.

Hobel, C. J., Ross, M. G., Bemis, R. L., Bragonier, J. R., Nessim, S., Sandhu, M., . . . Mori, B.

   (1994). The West Los Angeles preterm birth prevention project: I. program impact on

   high-risk women. *American Journal of Obstetrics and Gynecology, 170*(1), 54-62.

Hodek, J. M., von der Schulenburg, J. M., & Mittendorf, T. (2011). Measuring economic

   consequences of preterm birth - Methodological recommendations for the evaluation of

   personal burden on children and their caregivers. *Health Econ Rev, 1*(1), 6.

   doi:10.1186/2191-1991-1-6

Hussaini, S. K., Holley, P., & Ritenour, D. (2011). Reducing low birth weight infancy: Assessing

   the effectiveness of the Health Start Program in Arizona. *Maternal and child health

   journal, 15*(2), 225-233.

IOM. (2007). Societal Costs of Preterm Birth. In R. E. Behrman & A. S. Butler (Eds.), *Preterm

   Birth: Causes, Consequences, and Prevention*. Washington (DC): National Academies

   Press.

Irwig, L., Irwig, J., Trevena, L., & Sweet, M. (2008). Chapter 18, Relative risk, relative and

   absolute risk reduction, number needed to treat and confidence intervals *Smart Health

   Choices: Making Sense of Health Advice*. London: Hammersmith Press.

Islam, N., Nadkarni, S. K., Zahn, D., Skillman, M., Kwon, S. C., & Trinh-Shevrin, C. (2015).

    Integrating community health workers within Patient Protection and Affordable Care Act

    implementation. *J Public Health Manag Pract, 21*(1), 42-50.

    doi:10.1097/PHH.0000000000000084

Islam, N. S., Zanowiak, J. M., Wyatt, L. C., Chun, K., Lee, L., Kwon, S. C., & Trinh-Shevrin, C.

    (2013). A randomized-controlled, pilot intervention on diabetes prevention and healthy

    lifestyles in the New York City Korean community. *J Community Health, 38*(6), 1030-

    1041. doi:10.1007/s10900-013-9711-z

Jafar, T. H., Islam, M., Bux, R., Poulter, N., Hatcher, J., Chaturvedi, N., . . . Cosgrove, P. (2011).

    Cost-effectiveness of community-based strategies for blood pressure control in a low-

    income developing country: findings from a cluster-randomized, factorial-controlled trial.

    Circulation, 124(15), 1615-1625.

Johnson, D., Saavedra, P., Sun, E., Stageman, A., Grovet, D., Alfero, C., . . . Kaufman, A.

    (2012). Community health workers and medicaid managed care in New Mexico. *J

    Community Health, 37*(3), 563-571. doi:10.1007/s10900-011-9484-1

Katigbak, C., Van Devanter, N., Islam, N., & Trinh-Shevrin, C. (2015). Partners in health: a

    conceptual framework for the role of community health workers in facilitating patients'

    adoption of healthy behaviors. *Am J Public Health, 105*(5), 872-880.

    doi:10.2105/AJPH.2014.302411

Kim, H.-Y. (2017). Statistical notes for clinical researchers: Risk difference, risk ratio, and odds

    ratio. *Restorative dentistry & endodontics, 42*(1), 72-76.

Ko, T.-J., Tsai, L.-Y., Chu, L.-C., Yeh, S.-J., Leung, C., Chen, C.-Y., . . . Hsieh, W.-S. (2014).

    Parental smoking during pregnancy and its association with low birth weight, small for

gestational age, and preterm birth offspring: a birth cohort study. *Pediatrics & Neonatology, 55*(1), 20-27.

Kogan, M. D., Martin, J. A., Alexander, G. R., Kotelchuck, M., Ventura, S. J., & Frigoletto, F. D. (1998). The changing pattern of prenatal care utilization in the United States, 1981-1995, using different prenatal care indices. *JAMA, 279*(20), 1623-1628.

Kotelchuck, M. (1994). An evaluation of the Kessner adequacy of prenatal care index and a proposed adequacy of prenatal care utilization index. *American journal of public health, 84*(9), 1414-1420.

Koumans, E. H., Rosen, J., van Dyke, M. K., Zell, E., Phares, C. R., Taylor, A., . . . Schrag, S. (2012). Prevention of mother-to-child transmission of infections during pregnancy: implementation of recommended interventions, United States, 2003-2004. *American Journal of Obstetrics and Gynecology, 206*(2), 158. e151-158. e111.

Kowlessar, N., Jiang, H., & Steiner, C. (2013). Hospital Stays for Newborns, 2011. HCUP Statistical Brief# 163. Agency for Healthcare Research and Quality, Rockville, MD.

Kramer, M. S. (1987). Determinants of low birth weight: methodological assessment and meta-analysis. *Bulletin of the world health organization, 65*(5), 663.

Kramer, M. S. (2005). Maternal nutrition and adverse pregnancy outcomes: lessons from epidemiology. *Nestle Nutr Workshop Ser Pediatr Program, 55*, 1-10; discussion 11-15. doi:10.1159/000082589

Krantz, M. J., Coronel, S. M., Whitley, E. M., Dale, R., Yost, J., & Estacio, R. O. (2013). Effectiveness of a community health worker cardiovascular risk reduction program in public health and health care settings. *Am J Public Health, 103*(1), e19-27. doi:10.2105/AJPH.2012.301068

Krieger, J. W., Connell, F. A., & LoGerfo, J. P. (1992). Medicaid prenatal care: a comparison of use and outcomes in fee-for-service and managed care. *American journal of public health, 82*(2), 185-190.

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Frontiers in psychology, 4*, 863.

Lanehart, R. E., de Gil, P. R., Kim, E. S., Bellara, A. P., Kromrey, J. D., & Lee, R. S. (2012). *Propensity score analysis and assessment of propensity score approaches using SAS procedures.* Paper presented at the SAS Global Forum: Statistics and Data Analysis.

Lau, C., Ambalavanan, N., Chakraborty, H., Wingate, M. S., & Carlo, W. A. (2013). Extremely low birth weight and infant mortality rates in the United States. *Pediatrics, 131*(5), 855-860. doi:10.1542/peds.2012-2471

Lawlor, M. S., Blackwell, C. S., Isom, S. P., Katula, J. A., Vitolins, M. Z., Morgan, T. M., & Goff Jr, D. C. (2013). Cost of a group translation of the diabetes prevention program: healthy living partnerships to prevent diabetes. *American journal of preventive medicine, 44*(4), S381-S389.

Lazzaroni, F., Bonassi, S., Magnani, M., Calvi, A., Repetto, E., Serra, G., . . . Pearce, N. (1993). Moderate maternal drinking and outcome of pregnancy. *European journal of epidemiology, 9*(6), 599-606.

Longo, D. R., Kruse, R. L., LeFevre, M. L., Schramm, W. F., Stockbauer, J. W., & Howell, V. (1999). An investigation of social and class differences in very-low birth weight outcomes: a continuing public health concern. *Journal of health care finance, 25*(3), 75-89.

Lucas, B., & Detty, A. (2018). *Improved birth outcomes through health plan and community HUB partnership*. Retrieved from BuckeyeHealthPlan.com:

March of Dimes. (2014). Preterm birth and low birth weight. Retrieved November 4, 2017

Martin, J. A., Hamilton, B. E., Osterman, M. J., Driscoll, A. K., & Drake, P. (2018). Births: final data for 2016.

Martinez, J., & Knickman, J. (2010). Community health workers: A critical link for improving health outcomes and promoting cost-effective care in the era of health reform. *Community the State of New York Health. Retrieved December, 30*, 2011.

Mathews, T., MacDorman, M. F., & Thoma, M. E. (2015). Infant mortality statistics from the 2013 period linked birth/infant death data set. *Natl Vital Stat Rep, 64*(9), 1-28.

Mathewson, K. J., Chow, C. H., Dobson, K. G., Pope, E. I., Schmidt, L. A., & Van Lieshout, R. J. (2017). Mental health of extremely low birth weight survivors: A systematic review and meta-analysis. *Psychol Bull, 143*(4), 347-383. doi:10.1037/bul0000091

Maupin, J., R, Lyman, R., Fatsis, J., Prystowiski, E., Nguyen, A., Wright, C., . . . Miller, J., J. (2004). Characteristics of women who deliver with no prenatal care. *The Journal of Maternal-Fetal & Neonatal Medicine, 16*(1), 45-50.

McCormick, M. C. (1985). The contribution of low birth weight to infant mortality and childhood morbidity. *New England Journal of Medicine, 312*(2), 82-90.

McDonald, T. P., & Coburn, A. F. (1988). Predictors of prenatal care utilization. *Social Science & Medicine, 27*(2), 167-172.

McGinnis, T., Crumley, D., & Chang, D. I. (2018). *Implementing Social Determinants of Health Interventions in Medicaid Managed Care: How to Leverage Existing Authorities and Shift to Value Based Purchasing*. Retrieved from

https://www.academyhealth.org/sites/default/files/implementing_sdoh_medicaid_manage
d_care_may2018.pdf

Meyers, D., Peikes, D., Genevro, J., Peterson, G., Taylor, E. F., Lake, T., . . . Grumbach, K.
(2010). The roles of patient-centered medical homes and accountable care organizations
in coordinating patient care.

Mirambeau, A. M., Wang, G., Ruggles, L., & Dunet, D. O. (2013). A cost analysis of a
community health worker program in rural Vermont. *J Community Health, 38*(6), 1050-
1057. doi:10.1007/s10900-013-9713-x

Mock, J., McPhee, S. J., Nguyen, T., Wong, C., Doan, H., Lai, K. Q., . . . Bui-Tong, N. (2007).
Effective lay health worker outreach and media-based education for promoting cervical
cancer screening among Vietnamese American women. *Am J Public Health, 97*(9), 1693-
1700. doi:10.2105/AJPH.2006.086470

Muennig, P., & Bounthavong, M. (2016). *Cost-effectiveness analysis in health: a practical
approach*: John Wiley & Sons.

Natale-Pereira, A., Enard, K. R., Nevarez, L., & Jones, L. A. (2011). The role of patient
navigators in eliminating health disparities. *Cancer, 117*(15 Suppl), 3543-3552.
doi:10.1002/cncr.26264

NCQA. (2019). HEDIS and Performance Measurement.   Retrieved from
https://www.ncqa.org/hedis/

O'Brien, M. J., Squires, A. P., Bixby, R. A., & Larson, S. C. (2009). Role development of
community health workers: an examination of selection and training processes in the
intervention literature. *Am J Prev Med, 37*(6 Suppl 1), S262-269.
doi:10.1016/j.amepre.2009.08.011

Oakley, L. P., Harvey, S. M., Yoon, J., & Luck, J. (2017). Oregon's coordinated care

    organizations and their effect on prenatal care utilization among Medicaid enrollees.

    Maternal and child health journal, 21(9), 1784-1789.

Office of Disease Prevention and Health Promotion. (2018). Maternal, Infant, and Child Health.

    Retrieved from https://www.healthypeople.gov/node/4833/data_details

Ohio Department of Health. (2019). Help me grow.   Retrieved from

    https://odh.ohio.gov/wps/portal/gov/odh/know-our-programs/help-me-grow/help-me-

    grow

Olds, D. L., Henderson, C. R., Tatelbaum, R., & Chamberlin, R. (1986). Improving the delivery

    of prenatal care and outcomes of pregnancy: a randomized trial of nurse home visitation.

    Pediatrics, 77(1), 16-28.

Osterman, M., & Martin, J. (2018). SystemTiming and Adequacy of Prenatal Care in the United

    States, 2016. *National vital statistics reports: from the Centers for Disease Control and*

    Prevention, National Center for Health Statistics, National Vital Statistics System, 67(3),

    1-14.

Perez, L. M., & Martinez, J. (2008). Community health workers: social justice and policy

    advocates for community health and well-being. *Am J Public Health, 98*(1), 11-14.

    doi:10.2105/AJPH.2006.100842

Phillips, K. A., & Chen, J. L. (2002). Impact of the US panel on cost-effectiveness in health and

    medicine. *American journal of preventive medicine, 22*(2), 98-105.

Pinkerton, S. D., & Holtgrave, D. R. (1998). Assessing the cost-effectiveness of HIV prevention

    interventions *Handbook of economic evaluation of HIV prevention programs* (pp. 33-43):

    Springer.

Press, M. J., Michelow, M. D., & MacPhail, L. H. (2012). Care coordination in accountable care organizations: moving beyond structure and incentives. *The American journal of managed care, 18*(12), 778-780.

Redding, M., Hoornbeek, J., Zeigler, B. P., Kelly, M., Redding, S., Falletta, L., . . . Bruckman, D. (2018). Risk Reduction Research Initiative: A National Community–Academic Framework to Improve Health and Social Outcomes. *Population health management.*

Redding, S., Conrey, E., Porter, K., Paulson, J., Hughes, K., & Redding, M. (2015). Pathways community care coordination in low birth weight prevention. *Matern Child Health J, 19*(3), 643-650. doi:10.1007/s10995-014-1554-4

Reidpath, D. D., & Allotey, P. (2003). Infant mortality rate as an indicator of population health. *J Epidemiol Community Health, 57*(5), 344-346.

Restrepo-Méndez, M. C., Lawlor, D. A., Horta, B. L., Matijasevich, A., Santos, I. S., Menezes, A. M., . . . Victora, C. G. (2015). The association of maternal age with birthweight and gestational age: a cross-cohort comparison. *Paediatric and perinatal epidemiology, 29*(1), 31-40.

Rockville Institute. (2018, 2017). Achieving better care, better outcomes, at lower cost. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10688568

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika, 70*(1), 41-55.

Rosenbaum, S., Gunsalus, R., Velasquez, M., Jones, S., Rothenberg, S., & Beckerman, J. Z. (2018). Medicaid Payment and Delivery Reform: Insights from Managed Care Plan Leaders in Medicaid Expansion States.

Roth, J., Hendrickson, J., Schilling, M., & Stowell, D. W. (1998). The risk of teen mothers having low birth weight babies: implications of recent medical research for school health personnel. *Journal of School Health, 68*(7), 271-275.

Russell, R. B., Green, N. S., Steiner, C. A., Meikle, S., Howse, J. L., Poschman, K., . . . Petrini, J. R. (2007). Cost of hospitalization for preterm and low birth weight infants in the United States. *Pediatrics, 120*(1), e1-9. doi:10.1542/peds.2006-2386

Ryabov, I. (2014). Cost-effectiveness of Community Health Workers in controlling diabetes epidemic on the US–Mexico border. *Public Health, 128*(7), 636-642.

Saatci, E., Tahmiscioglu, G., Bozdemir, N., Akpinar, E., Ozcan, S., & Kurdak, H. (2010). The well-being and treatment satisfaction of diabetic patients in primary care. *Health Qual Life Outcomes, 8*, 67. doi:10.1186/1477-7525-8-67

Saigal, S., Feeny, D., Furlong, W., Rosenbaum, P., Burrows, E., & Torrance, G. (1994). Comparison of the health-related quality of life of extremely low birth weight children and a reference group of children at age eight years. *The Journal of pediatrics, 125*(3), 418-425.

Sanders, G. D., Neumann, P. J., Basu, A., Brock, D. W., Feeny, D., Krahn, M., . . . Ganiats, T. G. (2016). Recommendations for Conduct, Methodological Practices, and Reporting of Cost-effectiveness Analyses: Second Panel on Cost-Effectiveness in Health and Medicine. *JAMA, 316*(10), 1093-1103. doi:10.1001/jama.2016.12195

Segal, L., Nguyen, H., Schmidt, B., Wenitong, M., & McDermott, R. A. (2016). Economic evaluation of Indigenous health worker management of poorly controlled type 2 diabetes in north Queensland. *Med J Aust, 204*(5), 1961e-1969.

Shadish, W. R., & Steiner, P. M. (2010). A primer on propensity score analysis. *Newborn and Infant Nursing Reviews, 10*(1), 19-26.

Shah, J. S., Revere, F. L., & Toy, E. C. (2018). Improving Rates of Early Entry Prenatal Care in an Underserved Population. *Maternal and child health journal*, 1-5.

Shah, M., Kaselitz, E., & Heisler, M. (2013). The role of community health workers in diabetes: update on current literature. *Curr Diab Rep, 13*(2), 163-171. doi:10.1007/s11892-012-0359-3

Shah, P. S., Zao, J., & Ali, S. (2011). Maternal marital status and birth outcomes: a systematic review and meta-analyses. *Maternal and child health journal, 15*(7), 1097-1109.

Shapiro-Mendoza, C. K., Barfield, W. D., Henderson, Z., James, A., Howse, J. L., Iskander, J., & Thorpe, P. G. (2016). CDC Grand Rounds: Public Health Strategies to Prevent Preterm Birth. *MMWR Morb Mortal Wkly Rep, 65*(32), 826-830. doi:10.15585/mmwr.mm6532a4

Siegel, J. E., Weinstein, M. C., Russell, L. B., & Gold, M. R. (1996). Recommendations for reporting cost-effectiveness analyses. *JOURNAL-AMERICAN MEDICAL ASSOCIATION, 276*, 1339-1341.

Spencer, M. S., Rosland, A. M., Kieffer, E. C., Sinco, B. R., Valerio, M., Palmisano, G., . . . Heisler, M. (2011). Effectiveness of a community health worker intervention among African American and Latino adults with type 2 diabetes: a randomized controlled trial. *Am J Public Health, 101*(12), 2253-2260. doi:10.2105/AJPH.2010.300106

Sullivan, M. C., Msall, M. E., & Miller, R. J. (2012). 17-year outcome of preterm infants with diverse neonatal morbidities: Part 1—Impact on physical, neurological, and psychological health status. *Journal for Specialists in Pediatric Nursing, 17*(3), 226-241.

Tanne, J. H. (2017). Preterm and low weight births rise again in the US: British Medical Journal
Publishing Group.

Thomas, M., Hutchison, M., Castro, G., Nau, M., Shumway, M., Stotland, N., & Spielvogel, A.
(2017). Meeting Women Where They Are: Integration of Care As the Foundation of
Treatment for At-Risk Pregnant and Postpartum Women. *Matern Child Health J, 21*(3),
452-457. doi:10.1007/s10995-016-2240-5

Tripepi, G., Jager, K., Dekker, F., Wanner, C., & Zoccali, C. (2007). Measures of effect: relative
risks, odds ratios, risk difference, and 'number needed to treat'. *Kidney international,
72*(7), 789-791.

Valentijn, P. P., Schepman, S. M., Opheij, W., & Bruijnzeels, M. A. (2013). Understanding
integrated care: a comprehensive conceptual framework based on the integrative
functions of primary care. *Int J Integr Care, 13*, e010.

Vaughan, K., Kok, M. C., Witter, S., & Dieleman, M. (2015). Costs and cost-effectiveness of
community health workers: evidence from a literature review. *Hum Resour Health, 13*,
71. doi:10.1186/s12960-015-0070-y

Vintzileos, A. M., Ananth, C. V., Smulian, J. C., Scorza, W. E., & Knuppel, R. A. (2002). The
impact of prenatal care on neonatal deaths in the presence and absence of antenatal high-
risk conditions. *American Journal of Obstetrics and Gynecology, 186*(5), 1011-1016.

Viswanathan, M., Kraschnewski, J. L., Nishikawa, B., Morgan, L. C., Honeycutt, A. A., Thieda,
P., . . . Jonas, D. E. (2010). Outcomes and costs of community health worker
interventions: a systematic review. *Med Care, 48*(9), 792-808.
doi:10.1097/MLR.0b013e3181e35b51

Wagner, E. H., Sandhu, N., Coleman, K., Phillips, K. E., & Sugarman, J. R. (2014). Improving care coordination in primary care. *Medical care, 52*, S33-S38.

Wally, M. K., Huber, L. R. B., Issel, L. M., & Thompson, M. E. (2018). The Association Between Preconception Care Receipt and the Timeliness and Adequacy of Prenatal Care: An Examination of Multistate Data from Pregnancy Risk Assessment Monitoring System (PRAMS) 2009–2011. *Maternal and child health journal, 22*(1), 41-50.

Watson, A., Hernandez, L., & Thompson, D. (2018). *Adequacy of prenatal care utilization index and adverse birth outcomes, Florida 2016*. Office of State Surgeon General Retrieved from http://www.flhealthcharts.com/Charts/documents/AdHocReports/PNCAdequacy0814201 8.pdf.

Whitley, E. M., Everhart, R. M., & Wright, R. A. (2006). Measuring return on investment of outreach by community health workers. *J Health Care Poor Underserved, 17*(1 Suppl), 6-15. doi:10.1353/hpu.2006.0015

Witmer, A., Seifer, S. D., Finocchio, L., Leslie, J., & O'Neil, E. H. (1995). Community health workers: integral members of the health care work force. *Am J Public Health, 85*(8 Pt 1), 1055-1058.

Yanovitzky, I., Zanutto, E., & Hornik, R. (2005). Estimating causal effects of public health education campaigns using propensity score methodology. *Evaluation and program planning, 28*(2), 209-220.

Zeigler, B., Carter, E., Redding, S., Leath, B., & Russell, C. (2014). Care Coordination: Formalization of Pathways for Standardization and Certification. *Summarized in*

Innovations Exchange Team, Zeigler BP, Redding SA. Formalization of the Pathways Model Facilitates Standards and Certification.

Zeigler, B. P., Redding, S. A., Leath, B. A., & Carter, E. L. (2014). Pathways community HUB: a model for coordination of community health care. *Popul Health Manag, 17*(4), 199-201. doi:10.1089/pop.2014.0041

Zonderman, A. B., Ejiogu, N., Norbeck, J., & Evans, M. K. (2014). The influence of health disparities on targeting cancer prevention efforts. *Am J Prev Med, 46*(3 Suppl 1), S87-97. doi:10.1016/j.amepre.2013.10.026

Zwicker, J. G., & Harris, S. R. (2008). Quality of life of formerly preterm and very low birth weight infants from preschool age to adulthood: a systematic review. *Pediatrics, 121*(2), e366-e376.

Appendix A

Operational Definitions of Study Variables

Variable	Value	Definition
Low birth weight	Binary	Birth weight below 2,500 grams
Preterm birth	Binary	Giving birth before 37 weeks of pregnancy
Prenatal care utilization	Categorical	Use of healthcare services during pregnancy (inadequate, intermediate, adequate, adequate plus)
Census Tract	Categorical	Small subdivisions of a county
Maternal Age	Continuous	Mother's age
Mother's Race	Binary	Mother's race (White, non-White)
Marital Status	Binary (Yes/No)	Mother's marital status
Education Level	Categorical	Mother's highest level of education (less than high school, high school graduate, some college)
Previous Preterm Birth	Binary	Mother has a history of preterm births
Gestational Diabetes	Binary	Mother developed gestational diabetes during pregnancy
Infant Birth Year	Categorical (4 levels)	Infant date of birth year (2104, 2015, 2016, 2017)

Infant Birth Weight	Continuous	Infant's birth weight in grams
Gestation	Continuous	Age of pregnancy
Prenatal visits	Continuous	Number of interactions with health system
Trimester at First Prenatal Visit	Categorical	Trimester at which the first prenatal visit was done (Trimester 1, Trimester 2, Trimester 3)
Maternal Smoking	Binary	Whether mother is a smoker or not
Received WIC	Binary	Did mother receive WIC for herself?