

THE ECONOMIC IMPACT OF PRETERM BIRTH



 EconomicsCenter

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Introduction

From 2009 through 2013, on average, nearly 11,000 babies a year have been born to mothers residing in Hamilton County.¹ Nearly half of all households with children have recently experienced the birth of a child in the past six years.²

Yet, too many of these individual stories of new life include the costly dimension of preterm births. More than 1,500 children a year in Hamilton County are born preterm, meaning that every day, at least four babies are born before they are ready.

What is a preterm birth? Babies born prior to reaching a gestational age of 37 weeks are considered to be preterm. The annual number of viable³ preterm births in Hamilton County can be divided into three categories:

- 1,190 moderate to late preterm births (32 through 36 weeks),
- 180 very preterm births (28 through 31 weeks), and
- 95 extremely preterm births (23 through 27 weeks).

Hamilton County's preterm birth rate – this includes all categories of birth with a gestational age less than 37 weeks – is markedly higher than both the Ohio and national rates, as shown in the table below. The County rate for very or extremely preterm births (gestational age less than 32 weeks) is dramatically higher than the state and national rates.

	Hamilton County	Ohio	US
All preterm births (<37 weeks)	13.7%	12.3%	11.7%
Very or extreme preterm births (<32 weeks)	3.1%	2.6%	2.0%

Preterm births are associated with higher rates of infant deaths, both prior to and after initial hospital discharge. Ross Meyer, Vice President of Community Impact for United Way of Greater Cincinnati, has observed: "Infant mortality is an indicator of overall community health. Our rate (of more than 100 infant deaths a year) speaks very poorly for us as a community." Reducing the preterm birth rate, especially at the spectrum of the lowest gestational ages, is a key step in addressing Hamilton County's infant mortality problem. In addition, certain factors that are associated with preterm births are also risk factors for stillbirths.

¹ Ohio Department of Health (ODH), Live Birth File for Hamilton County, 2009-2013.

² Approximately 45%, based on Census Bureau's 2012 American Community Survey data sample.

³ Babies born prior to a gestational age of 23 weeks (30 to 40 a year) have a very high mortality rate, so births that occur prior to this time are generally considered to be pre-viable or not viable.

Costs of Preterm Birth

The number of premature births in Hamilton County is a persistent problem. Not only do preterm births affect the newborn and his or her family, they also create lasting economic impacts on society. Numerous studies have examined the cost of preterm births, but the challenge in reviewing these studies is the range of approaches to counting this cost. One of the most detailed analyses of initial hospitalization costs was carried out by Phibbs and Schmidt (2006). Because this analysis contains data on costs for each week of gestational age, it was possible to apply these findings to the data on Hamilton County births. The costs were also adjusted to 2012 dollars, based on the latest national cost-to-charge ratios.

Healthcare/Initial Hospitalization Costs

In the five years from 2009 through 2013, the initial hospital costs associated with preterm births in Hamilton County are estimated to have exceeded \$493 million, or more than \$98 million annually. Most of these costs are a result of expensive interventions such as neonatal intensive care. While the cost of these births would average less than \$3,400 if the newborns were full term, the net extra cost ranges from \$19,600 for moderate and late preterm to \$454,500 for extremely preterm birth. After netting out the expected costs for full term births, the annual figure still exceeds \$93 million. Of this total, more than three fourths is attributable to care for babies who are very or extremely preterm.

Table 2: Average Annual Initial Hospital Costs of Preterm Births in Hamilton County

	Total cost	Cost at term	Net extra cost
Moderate or late preterm	\$23,280,000	\$4,042,000	\$19,238,000
Very preterm	\$32,060,000	\$596,000	\$31,464,000
Extreme preterm	\$43,266,000	\$320,000	\$42,946,000
Total preterm	\$98,606,000	\$4,958,000	\$93,648,000

Education Costs

In addition to these initial hospitalization costs, children born preterm often require more resources for healthcare, social services, and education throughout their childhood. As adults, they also tend toward lower income and occupation levels than those who are born at full term.

A New York study (Buck, 2000) determined that extreme prematurity was associated with a significant increase in risk of grade repetition (33% v 18%), special education placement (20% v 5%), and use of school-based rehabilitation services (47% v 18%). A British study (Mangham, 2009), which estimated various costs throughout childhood for extreme, very, and all preterm births, found that education costs for preterm children born at 23-27 weeks were about three times those for preterm children born at 28-33 weeks, and the differential was even greater when compared to the costs for all preterm children.

Combining these research findings with data from the Ohio Department of Education about Hamilton County school district expenditures and enrollment in both public and charter schools (113,597 and 8,787, respectively), and with Census Bureau data on private school enrollment (33,922), produces the cost estimates in the table below. This shows that the economic impact of preterm births on the cost of K-12 education in Hamilton County is \$13 million per year.

Table 3: Annual K-12 Educational Costs of Preterm Births in the Hamilton County

	Extreme preterm (<28 weeks)	Very preterm (28-31 wks)	Moderate and late preterm (32-36 wks)	All preterm (<37 weeks)
Share of students	1.13%	2.38%	10.1%	13.6%
Estimated students	1,769	3,722	15,710	21,201
Extra cost per student	\$3,451	\$974	\$217	\$619
Total cost	\$6,104,700	\$3,623,500	\$3,405,000	\$13,133,200
Share of extra costs	46.5%	27.6%	25.9%	100.0%

It is noteworthy that, although the number of students who were extremely preterm births is quite small, the average cost per student is so high that this group accounts for nearly half of the total extra cost incurred because of preterm births. Additionally, as large as these costs are, they do not include all education-related costs associated with preterm births. Two examples of such expenditures would be funding for the Ohio Bureau for Children with Medical Handicaps and spending on early intervention programs for children whose learning disabilities are identified prior to kindergarten.

Educational Attainment and Earnings Costs

One recent study (Heinonen, 2013) found that, compared to those born full term, even those who were born late preterm (34 to 36 weeks) were 31 percent more likely to not obtain college degrees, 65 percent more likely to work in lower-level occupations, and 33 percent more likely to earn lower incomes.⁴ No similar research appears to exist about very, extremely, and moderate preterm groups; however, even if their relationship to the full term group were no worse than the results for the late preterm category, application of these findings to Hamilton County reveals substantial costs in both educational attainment and earnings.

Overall, nearly 226,000 of Hamilton County’s 537,000 residents who are 25 or more years old have a college degree (Associate’s or higher). Based on the findings of this study, and conservatively

⁴ These results control for father’s occupational category in childhood, gender, birth year, birth order, mother’s age and BMI, and birth weight relative to gestational age. Further, this study found that those who were born late preterm were 52 percent more likely than those born at full term to be downwardly mobile compared to their father’s occupational category, and 29 percent less likely to be upwardly mobile.

assuming that 11 percent of Hamilton County adults were born preterm,⁵ Hamilton County residents have 4.35 percent fewer degrees (10,265 degrees), because of preterm births.

Table 4: College Degrees for Hamilton County Residents, Age 25+

	Lacking degree	Degree	Age 25+ population
Full term	56.0%	44.0%	478,081
Odds ratio (preterm v. full term)	1.31		
Preterm	73.4%	26.6%	59,089
Fewer degrees due to preterm birth	4.35%		10,265

Given the clear relationship between education and earnings, it is to be expected that there is also a loss of earned income for this segment of the population.

The same research study (Heinonen, 2013) also found that those who were born at 34-36 weeks were 33 percent more likely to have an income in the bottom third of all earners. As adults, they were also 23 percent less likely to be in the top third of earners. As a result, total earned income by Hamilton County residents is estimated to have been \$295 million less in 2013 because of preterm births.

Table 5: "Lost" Income for Hamilton County Residents, Age 25+

	Income group			Total workers
	Bottom 1/3	Middle 1/3	Top 1/3	
Income range	Up to \$22,300	\$22,301 - 50,700	\$50,701 or more	
Average earned income	\$9,300	\$35,900	\$105,500	
Full term	32.2%	33.6%	34.2%	323,055
Odds ratio (preterm v. full term)	1.33		0.77	
Preterm	42.8%	30.9%	26.3%	39,928
"Lost" income due to preterm birth		\$25,969,300	\$268,837,800	\$294,807,100

While \$295 million is quite substantial, this number represents 1.62 percent of the total \$18.2 billion aggregate earned income of Hamilton County residents. It does, however, account for an estimated 14.7 percent of the earned income of those born preterm. In light of the skills gap and workforce shortage issues that are receiving increasing attention at the local, state, and national levels, these lifetime impacts also serve to constrain community economic growth because fewer workers are available for high-skill, high-wage jobs.

⁵ This is based on the average of the 1981-2012 US preterm birth rates from the *National Vital Statistics Reports*, which is 11.19%. This figure is rounded down to the 11% assumption to account for preterm infant deaths.

Modifiable Behaviors That Contribute to Preterm Birth

The risks and costs of preterm birth are not beyond our control. While there are numerous influences that can play a role in a baby's preterm birth, Cradle Cincinnati's Advisory Board identified smoking during pregnancy and short spacing between pregnancies as two specific modifiable behaviors to focus on because they are highly associated with the likelihood of preterm birth.

Smoking

Maternal smoking constitutes a behavior that significantly increases preterm birth risks. Smoking is also associated with other adverse outcomes for the infant, including being smaller than average for a particular gestational age, low birth weight, and death. Due to these negative outcomes associated with smoking, it has been the subject of considerable research.

A very recent study (Ko, 2014) measured the effects of parental smoking during pregnancy on preterm birth. Babies born to women who were heavy smokers (more than 20 cigarettes per day) showed significantly higher preterm birth rates and shorter gestational age than those born to non-smokers or to light (1-10 per day) or moderate (11-20 per day) smokers, particularly after the first trimester. Heavy smokers during the second and third trimesters also had babies with a considerably shorter average gestational age, 36.5 weeks, compared to 38.4 weeks for those who did not smoke.

	Preterm birth rate		
	Prior to pregnancy	First trimester	2 nd /3 rd trimester
Non-smoker	8.2%	8.3%	8.3%
Light smoker	9.5%	10.5%	9.8%
Moderate smoker	11.3%	13.2%	11.7%
Heavy smoker	19.2%	21.4%	27.3%

Source: Ko, et al (2014)

A similar study (Kyrklund-Blomberg, 2005) examined the impact of smoking during pregnancy on the likelihood of extremely or very preterm births (prior to a gestational age of 32 weeks). These investigators found that women who smoked 10 or more cigarettes a day had a 190 percent higher rate of extremely or very preterm births (odds ratio of 2.9 with a 95% confidence interval of 1.5-5.7) compared to nonsmokers. The study also reported that those who smoked 1-9 cigarettes a day had a 40 percent higher rate, but for these light smokers, the small sample size resulted in an odds ratio range of 0.8-2.4, so an effect could not be substantiated.

However, a recent larger study (Aliyu, 2010), found that women who are light smokers during pregnancy do, in fact, have a 21 percent higher preterm birth rate (95% CI: 1.18-1.24) compared to nonsmokers.

A related study (Salihi, 2003) focused on the number of infant deaths attributable to maternal smoking during pregnancy. When adjusted for a range of characteristics, infants of mothers reporting smoking during pregnancy showed a 40 percent higher rate of mortality than those of nonsmokers.

The findings in the literature on smoking and preterm birth are also found in Hamilton County. Four out of five mothers-to-be are non-smokers (80.2%), and, as shown in Table 7, nonsmokers have a higher rate of full term births. This rate decreases steadily as pre-pregnancy smoking increases. The increase in the preterm rate is most noticeable and steady in moderate to late preterm births; smaller numbers of extremely and very preterm births contribute to more uneven rates in those categories.

Cigarettes Per day	Preterm births			Full term
	Extreme: < 28 wks	Very: 28-31 wks	Mod-late: 32-36 wks	
0	1.1%	1.2%	9.5%	88.2%
1-9	1.1%	2.2%	11.6%	85.0%
10-19	1.4%	2.3%	10.5%	85.8%
20+	1.3%	2.0%	12.8%	83.9%

Table 8 compares the relationship of preterm birth to second trimester smoking, the association between smoking and gestational age becomes much more pronounced. This is particularly true for heavy smokers – those who report consuming 20 or more cigarettes per day.

Cigarettes per day	Preterm births			Full term
	Extreme: < 28 wks	Very: 28-31 wks	Mod-late: 32-36 wks	
0	1.1%	1.3%	9.5%	88.2%
1-9	1.3%	2.4%	13.0%	83.3%
10-19	1.3%	2.0%	13.1%	83.6%
20+	1.4%	2.6%	14.8%	81.2%

Research consistently shows that expectant mothers who continue to smoke during pregnancy– over 6,000 in Hamilton County in the past five years – are at a considerably increased risk of delivering their child preterm. Maternal education regarding the consequences of smoking while pregnant may encourage women to quit or at least reduce their smoking habits, leading to an increase in the gestational age of infants at time of delivery and a reduction in the likelihood of infant death.

Fortunately, the rate of smoking by Hamilton County expectant mothers decreases during pregnancy. As shown in Table 9, many women quit smoking after becoming pregnant (8.5%). Even among those who continue smoking during pregnancy (11.3%), more than 30 percent cut back from being

moderate or heavy smokers to being light (<10 cigarettes per day) smokers. On the other hand, more than half of those who continue to smoke are either moderate (10-19 cigarettes per day) or heavy (20+ cigarettes per day) smokers throughout their pregnancy (5.8% of all mothers-to-be).

Table 9: Smoking by Hamilton County Mothers-to-Be, 2009-2013

	5-year total	Annual average	
Non-smoker prior to pregnancy	43,211	8,642	80.2%
Smoked prior to pregnancy	10,684	2,137	19.8%
Quit during pregnancy	4,594	919	8.5%
Reduced to light smoker while pregnant	1,886	377	3.5%
Light smoker	1,056	211	2.0%
Moderate smoker	2,115	423	3.9%
Heavy smoker	1,033	207	1.9%

Spacing

Short interpregnancy interval (IPI), an inadequate length of time between the end of one pregnancy and the beginning of the next, is associated with increased preterm birth risks. The rate of preterm births is substantially higher in women with an IPI of less than 18 months, as demonstrated in a meta-analysis (Conde-Agudelo, 2006) that included numerous studies of the effects of short IPIs on perinatal outcomes. This analysis also found that higher rates of fetal and neonatal death are associated with short IPIs.

A more recent study (DeFranco, 2014) examined six years of live births in Ohio. It found that women with an IPI less than 12 months are more than twice as likely to have preterm births.

Table 10: Interpregnancy Interval by Gestational Age

	<37 wk	37-38 wk	39 wk	≥40 wk
IPI <12 months	20.1%	33.2%	29.8%	16.9%
IPI 12-17 months	10.2%	46.3%	21.7%	21.8%
IPI 18+ months	7.7%	29.8%	39.3%	23.2%

Source: DeFranco et al, 2014

The findings in the literature on spacing and preterm birth also hold true for Hamilton County, where 20 percent of non-firstborn births during 2009 through 2013 have an IPI of less than 12 months. Women who become pregnant within a year of a previous birth have a markedly lower rate of full term births than those with a longer IPI. As shown in Table 11, short spacing between pregnancies also increases the probability of preterm births in all gestational age ranges.

IPIs of less than 12 months result in rates of extremely preterm and pre-viable births that are nearly twice as high as when the IPI is 12 months or longer. Intervals of less than 12 months also result in

rates of very preterm and moderate to late preterm births that are significantly higher than when the IPI is 12 months or longer.

Table 11: Hamilton County Gestational Age by Interpregnancy Interval, 2009-2013

IPI	N	Preterm births			Full term
		Extreme: < 28 wks	Very: 28-31 wks	Mod-late: 32-36 wks	
<12 months	6,175	1.7%	2.0%	13.2%	83.1%
12+ months	24,598	0.9%	1.3%	9.7%	88.1%

Women with an IPI of 24-35 months had the lowest rate of extremely and very preterm births. By comparison, those with IPIs of less than 12 months were twice as likely to give birth at 23-31 weeks, as shown in the following table. The Hamilton County results presented in this table also indicate that most of the benefit of longer spacing can be achieved with an IPI of 12-23 months.

Table 12: Hamilton County Odds Ratios for Short IPIs

IPI	N	23-31 weeks	Full term	23-31 wk odds ratio
<12 months	6,175	3.14%	83.1%	1.98
12-23 months	8,366	1.70%	88.9%	1.07
24-35 months	5,472	1.59%	89.3%	-

Changes in just these two behaviors – smoking and spacing – can markedly reduce the preterm birth rate and the resulting risks and costs. Jim Schwab, President and CEO of Interact for Health, notes: “Behavior changes can have a long term positive impact as well as immediate benefits. It goes beyond just the impacts on the baby.” By combining this information about smoking and spacing with the estimates previously presented about the costs of preterm birth, it is possible to estimate the potential savings in Hamilton County by reducing the preterm birth rates.

Potential Savings

Another calculation, following the same approach used earlier, shows that making a small change in preterm births can have a substantial impact on these costs in Hamilton County. If the gestational age for all of preterm births had been increased by one week, these initial hospitalization costs could have been reduced by more than \$25 million a year, a 27 percent decrease.

	Estimated net actual cost	Adjusted cost	Estimated savings	Percent savings
Moderate/late preterm	\$19,238,000	\$8,224,000	\$11,014,000	57.3%
Very preterm	\$31,464,000	\$23,210,000	\$8,254,000	26.2%
Extreme preterm	\$42,946,000	\$36,654,000	\$6,292,000	14.7%
Total preterm	\$93,648,000	\$68,088,000	\$25,560,000	27.3%

There is a known close association of both smoking and spacing behaviors with preterm birth. The analysis that follows assumes that this relationship is a causal one.

Smoking Intervention Savings

As described earlier and shown in Table 9, out of nearly 11,000 births each year, an average of 1,218 expectant mothers (11.3%) continue to smoke during pregnancy. If all of these women matched the behavior of the more than 2,100 women who quit smoking by their second trimester, the number of preterm births would be reduced by more than 20 percent and the average gestational age would increase.

Gestational age	Current	Births shifted to next group	Remaining	Annual savings
<28 weeks	16	2	14	\$551,934
28-31 weeks	31	8	25	\$1,271,374
32-36 weeks	169	47	130	\$760,715
Total preterm	216		169	\$2,584,023

Achieving this goal is expected to reduce the cost of these births by more than 13 percent (from \$19.5 million to \$16.9 million), saving nearly \$2.6 million in initial hospital costs.

Spacing Intervention Savings

Currently, 20 percent of all non-firstborn births (1,235 of 6,155 annually) in Hamilton County are to mothers who had interpregnancy intervals of less than 12 months. By modestly shifting this spacing to 12 to 23 months, substantial benefits would be expected.

Increasing the spacing between pregnancies is estimated to eliminate 34 percent of preterm births currently occurring in this group. It should also reduce the numbers of extremely and very preterm births by 52 and 42 percent, respectively.

Table 15: Potential Annual Hospitalization Savings by Eliminating Short IPIs

Gestational age	Current	Births shifted to next group	Remaining	Annual savings
<28 weeks	21	11	10	\$3,035,637
28-31 weeks	24	21	14	\$3,337,356
32-36 weeks	163	71	113	\$1,149,165
Total preterm	208		137	\$7,522,159

Achieving this goal is expected to reduce the cost of these births by more than one-third (from \$20.5 million to \$13.0 million), saving \$7.5 million in initial hospital costs.

Other Savings

Similarly, educational costs can be avoided by reducing the number and severity of preterm births. The changes described above – extending the gestational age of all preterm births by one week – would yield an estimated savings of \$3.2 million annually (24.5% of the current cost). In addition, the longer term gains in educational attainment and income would provide further benefits to the community.

High stillbirth rates accompany high preterm birth rates, further adding to cost. Therefore, reducing preterm births would have the supplemental benefit of fewer stillbirths. In addition, this would mean avoiding the other types of costs that are associated with stillbirths, particularly those related to grief, which are not examined here.

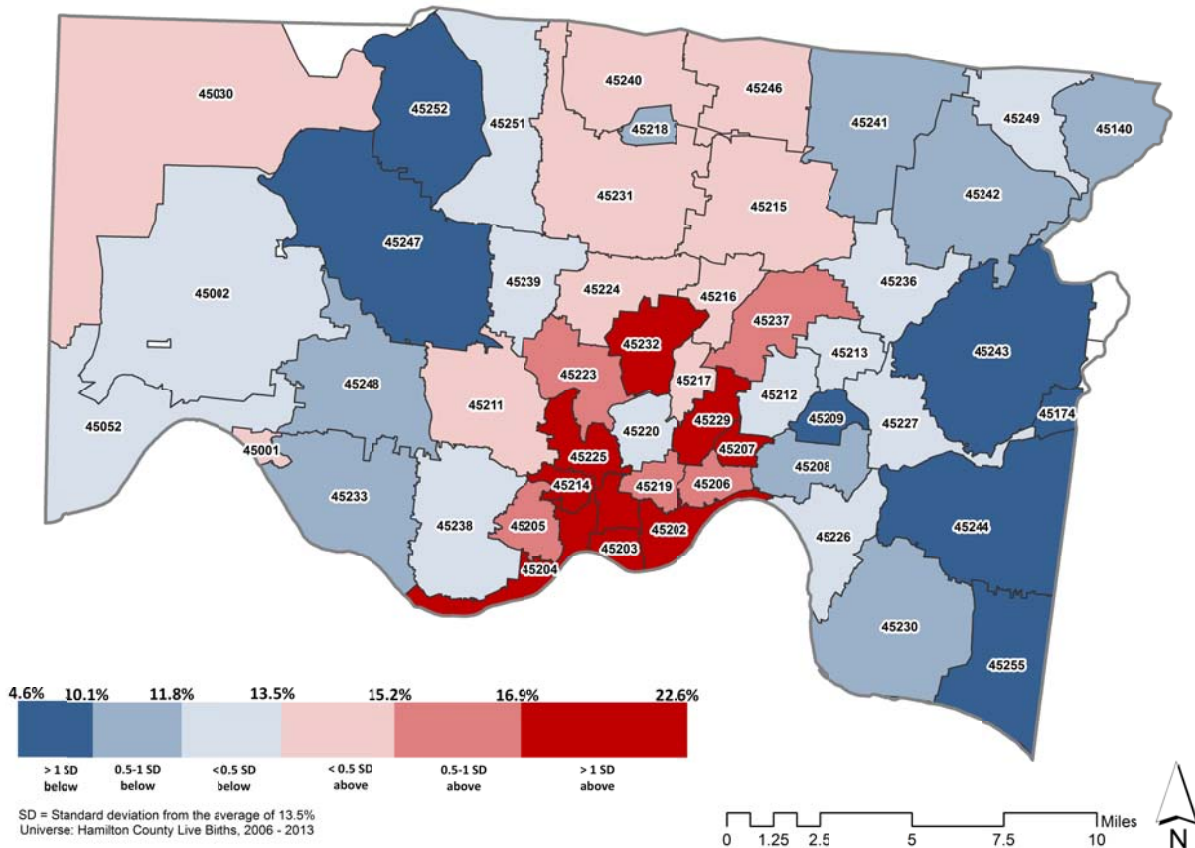
One of the challenges in designing programs to change these behaviors is that one third of all mothers-to-be receive no prenatal care during the first trimester. This includes one in fourteen who report having no prenatal visits and one in twelve who delay until the sixth month or later. For example, when compared to women who have their first prenatal visit in the first trimester, women who receive no prenatal care are more than three times as likely to be moderate or heavy smokers throughout their pregnancy and one third less likely to quit or reduce smoking. However, effective interventions, which could reduce infant deaths and save millions of dollars annually, may not be achieved easily or quickly. Intervention efforts are needed throughout Hamilton County.

Geography of Preterm Birth

Every part of Hamilton County faces the challenges of preterm birth, although the degree and risk varies. As Cincinnati City Councilmember Wendell Young describes it: "The issue extends to the entire community. There are people who don't get prenatal care or condition themselves for pregnancy in the first place, and so the risks are increased. We are dealing with behaviors that can be changed and conditions that are treatable or preventable."

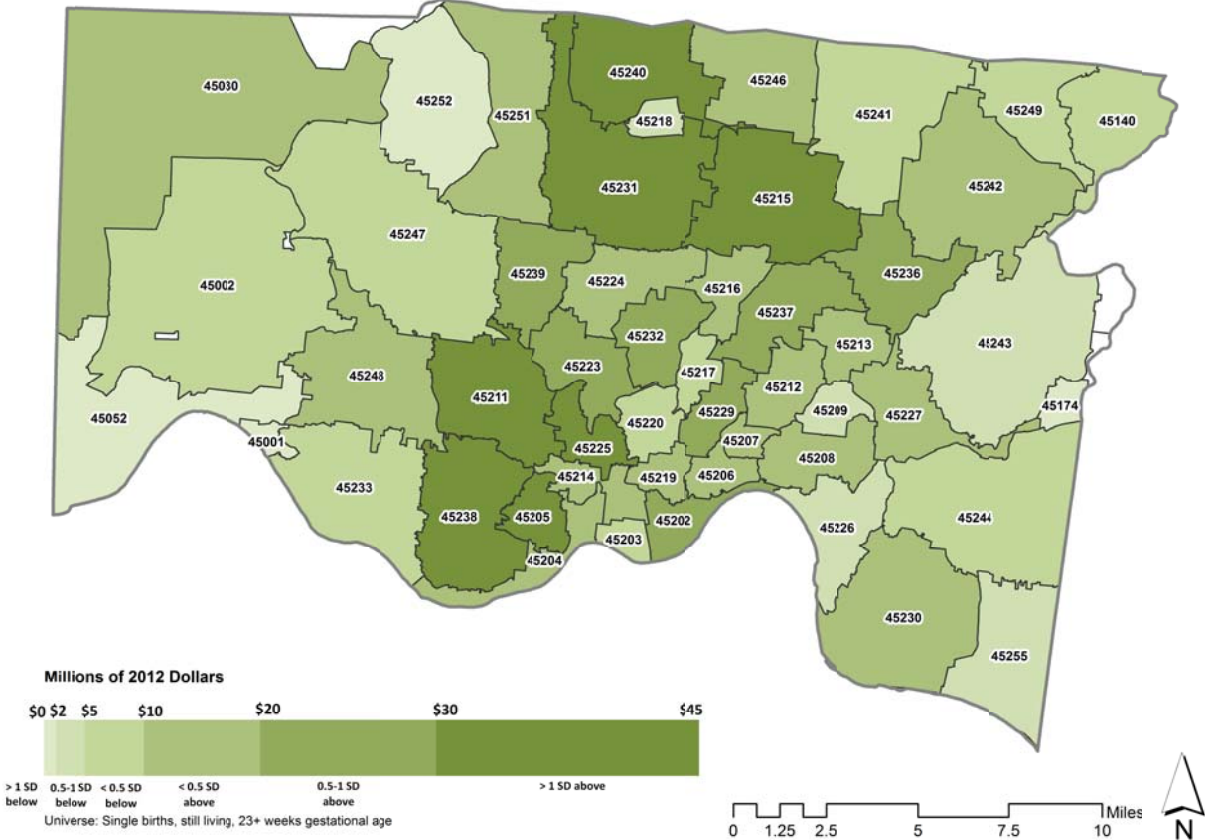
As the following map illustrates, the rate of preterm births exceeds 10 percent in almost all of Hamilton County, with only those shown in the darkest blue having lower rates. While ZIP Codes in the lightest blue are doing better than the County as a whole, they are still worse than the national average (11.7%). Altogether, a large majority of ZIPs (70%) exceed the national preterm birth rate. The ZIPs with the highest rates tend to have lower incomes and lower rates of private insurance coverage. Even in several ZIPs with rates below 10 percent, the number of such births has averaged at least ten per year over the past eight years.

Births at 23 - 36 Weeks as a Percent of Total Births



Throughout Hamilton County, there are babies, mothers, families, and communities that are adversely affected by preterm births. Although the geographic picture shows that more preterm births and associated costs occur among residents of the City of Cincinnati and the northern suburbs, the economic impacts are substantial in nearly all ZIP Codes.

Aggregate Cost of Preterm Births, 2006 - 2013



Only a few ZIP Codes (typically with small populations and births) do not have multi-million-dollar aggregate cost figures. Even in ZIPs with average annual household incomes above \$60,000 (e.g., 45030, 45248, 45242, 45208, and 45230), these costs are estimated to have exceeded \$10 million from 2006 through 2013.

Conclusion

“For the average taxpayer, the concern is about cost, and the (health insurance) cost is huge. There are also incalculable costs. Who are we losing when a child dies? A community leader? A Nobel prize winner? And these deaths lead to a need to care for the survivors. As citizens, it is to be hoped that we care about people, about our neighbors, not just money.” – Cincinnati City Councilmember Wendell Young

“The success of NICUs should not lead us to see them as the only solution to infant mortality or as an adequate moral response to our children’s health needs. We should constantly remind ourselves that the need for so much intensive care for so many babies is a sign of political, medical, and moral failure in developing ways to address the problems that sustain an epidemic of prematurity.” – John D. Lantos, MD, Director of the Children's Mercy Bioethics Center in Kansas City

This study has more closely examined some of the costs associated with preterm births in three major categories. The first of these – initial hospital costs – is widely recognized, while the other two – education and income – are usually overlooked. This illustrates why a fuller accounting of the costs of preterm births is so important. Recognition of how expensive preterm births are can motivate more people to get involved in addressing this challenge. This subject should be of concern to the entire community because of who incurs these costs – not only families, but also employers and taxpayers.

Finally, this analysis reveals two important points for community leaders. First, preterm births are costly to Hamilton County. The \$93.6 million average annual initial hospital cost of preterm births during the past five years is equivalent to 17 percent of the current County budget and City of Cincinnati general fund budget combined (about \$550 million). The \$13 million additional cost to the K-12 educational system is also substantial. The longer term costs of preterm birth extend to adulthood, and they have adverse effects on community economic growth.

Second, these costs are not entirely unavoidable. Particular modifiable behaviors, especially smoking and inadequate spacing between pregnancies, contribute significantly to Hamilton County’s high rate of preterm birth. By effectively targeting efforts to change these behaviors, costs can be reduced, with benefits accruing not only to the mothers and babies directly, but also to citizens and businesses throughout the community.

Dr. James M. Greenberg, Director of Neonatology at Cincinnati Children’s Hospital Medical Center, has asserted that “Many of our greatest challenges as a community can be linked to our preterm birth problem. It reflects underlying societal failures and drives the perpetuation of those failures.” The findings of this study affirm his conclusion that the work of addressing the problems of education, poverty, and disparity in Hamilton County should “start by reducing preterm birth.”

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