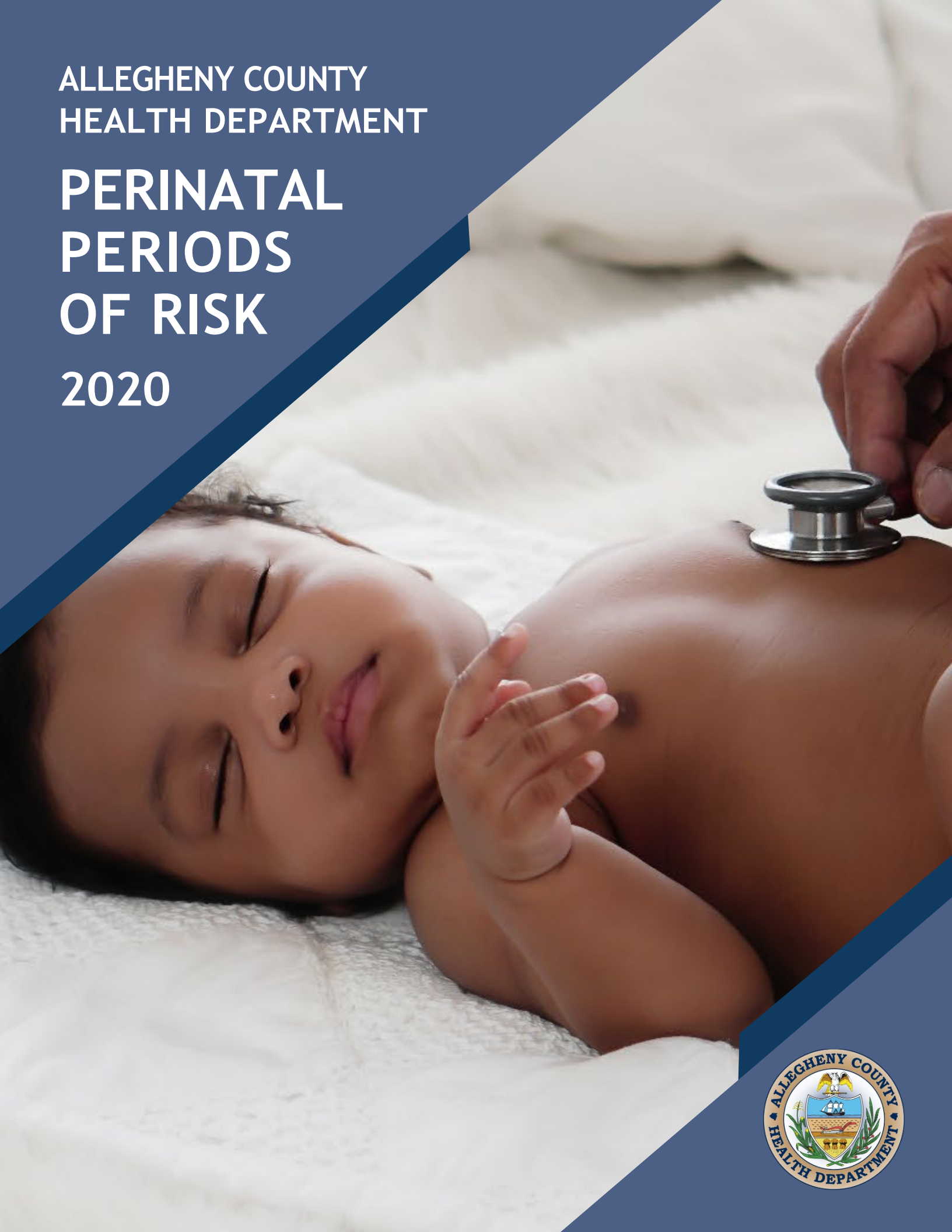
ALLEGHENY COUNTY
HEALTH DEPARTMENT

PERINATAL PERIODS OF RISK

2020



BACKGROUND

Infant mortality is an important marker of the overall health of a community, as it provides valuable information about maternal and infant health. High infant mortality rates can indicate broader issues surrounding health care and socioeconomic measures. In Allegheny County, significant and unacceptable disparities in infant mortality among race, socioeconomic status, and geography persist, despite an overall decline in infant mortality rates in recent years.

In 2019, the Black infant mortality rate was nearly **3 times higher** than the White infant mortality rate, despite the overall county rate meeting the Healthy People 2030 benchmark of 5.0 per 1,000 livebirths[1].

These disparities remain after accounting for socioeconomic status and educational attainment, as Black birthing people with college education still experience higher rates of infant mortality than White birthing people with less than high school education. The Perinatal Periods of Risk (PPOR) analytic approach can provide a better understanding of the complexity surrounding infant outcomes and mortality, while integrating community members and birthing people in the process to produce more equitable outcomes for birthing people and their babies.

BEST ALLEGHENY

In 2020, The Advancing Birth Equity Strategies Together (BEST) Allegheny Coalition received a grant from the Pennsylvania Department of Health to conduct a Perinatal Periods of Risk (PPOR) analysis. The BEST Allegheny Coalition is a committed group of stakeholders and community members that have displayed readiness and capacity for completing the full six-stage PPOR process and developing a community action plan. The objective of the BEST Allegheny project is to:

- *Use a data driven approach to assess excess infant mortality deaths by race and associated risk factors,*
- *Evaluate population and programmatic needs, and*
- *Implement interventions to reduce infant mortality.*

The PPOR process is part of this data-driven three-year initiative to reduce racial disparities in preterm births in Allegheny County.

INTRO TO PPOR

Perinatal Periods of Risk, or PPOR, is an analytic and community approach for investigating fetal and infant death at the local level. It reveals opportunities to reduce infant death. It was developed by CityMatCH[2] and CDC and consists of 6 steps:

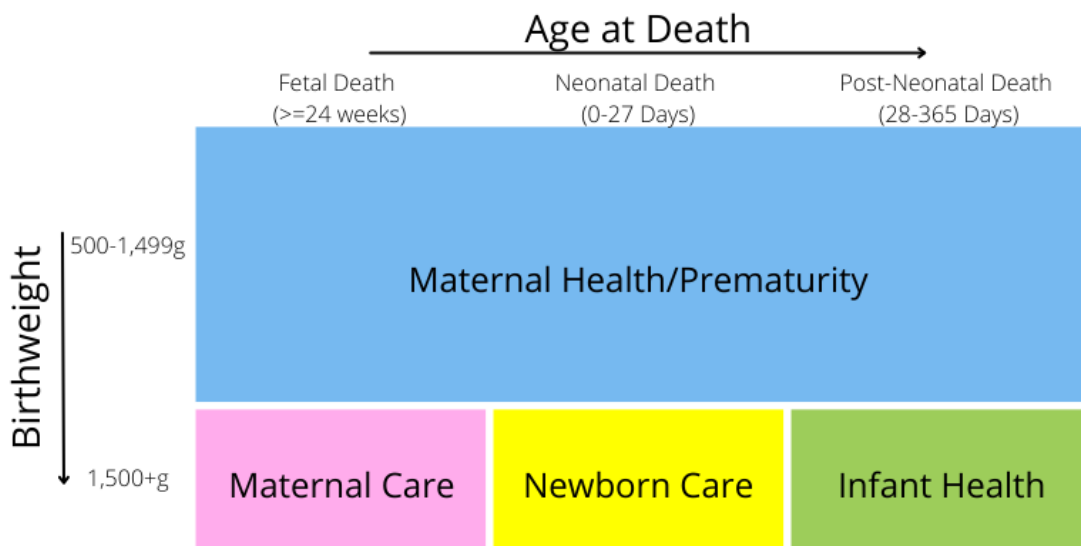
The data analysis step (2) has two phases, which are the focus of this report. This step provides a clearer picture of factors leading to infant death and provides insight into which factors may be driving disparities among birthing people. While this process is unlikely to reveal any new or unknown factors associated with infant death, it helps prioritize among known risk factors to create the most impact.

PPOR is a useful tool because it acknowledges the complexity of maternal health and infant mortality. Given that an infant's health is affected by many factors – including the birthing parent's health, access to health care long before pregnancy, social factors such as housing, and community factors and systems that surround parents. PPOR helps determine which contributors to infant mortality pose the greatest risk based on available data, leading to specific action steps.

THE PERIODS OF RISK

Fetal and infant death are related to both the infant's age at death and weight at birth, so this process uses both pieces of information. Periods of risk are determined by the combination of these factors. Throughout this report, each period of risk is associated with a different color: maternal health/prematurity (blue), maternal care (pink), newborn care (yellow) and infant health (green).

PPOR Framework by Age at Death and Birthweight



Age at death categories include fetal, neonatal, and post-neonatal deaths. Birthweight categories include infants less than 1,500 grams (~3.3 lbs) and 1,500 grams or greater. Infants less than 1,500g are considered very low birthweight (VLBW).

Among VLBW infants, the three age at death categories have similar causes of death and risk factors for infant mortality [3], so they are combined to form the maternal health/prematurity period of risk.

For the other three periods of risk, both age at death and weight at birth are used. Risk factors that affect an infant in one period differ from those in another period. Additionally, different and specific interventions are available to address each of the periods of risk.

PPOR STEP 2, DATA ANALYSIS

Phase 1

Compares infant mortality rates (IMR) in a target population for each period of risk with a reference population. The goal is to determine how many deaths were preventable in each period of risk. The reference population characterizes a population with the best birth outcomes.

Phase 2

Identifies pathways or mechanisms for preventable mortality and estimates the impact of removing or intervening on those risk and/or preventive factors. There is a different process for each period of risk, and this phase focuses on the periods of highest risk.

PHASE 1

The process and results from phase 1 of the data analysis step are outlined below.

Within this framework, the reference population should be the one with the best birth outcomes. Each target population is compared to the reference population to determine excess deaths.

TARGET POPULATIONS

- **Allegheny County:** Allegheny County maternal population (12-55 years, female*)
- **Black:** Non-Hispanic Black Allegheny County maternal population
- **White:** Non-Hispanic White Allegheny County maternal population

**Female as indicated on the birth certificate. Does not capture gender identity.*

PPOR Step 2: Data Analysis

Phase 1

Process

Results

STEP 01

Data Cleaning

Assess data quality, restrict study population by birthweight and gestational age, and assess sample size

For breakdown of final sample, see appendix (page 21)

All 2014-2018 fetal and infant deaths: **924**

→ *Missing birth certificate:* ***28***

Fetal and linked births/deaths: **896**

→ *Excluded:* ***444***
- *Implausible:* ***45***
- *Weight <3.3lbs or gestation <24 weeks:* ***399***

Final Sample: **452**

STEP 02

Select Reference Population

Represents birthing persons with the best outcomes for comparison to selected target groups

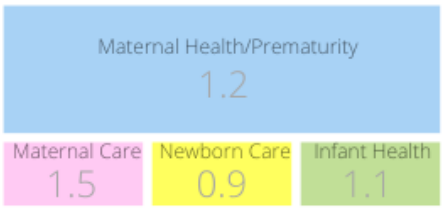
- Allegheny County resident
- Non-Hispanic White
- 20+ years old
- At least 13 years of education

STEP 03

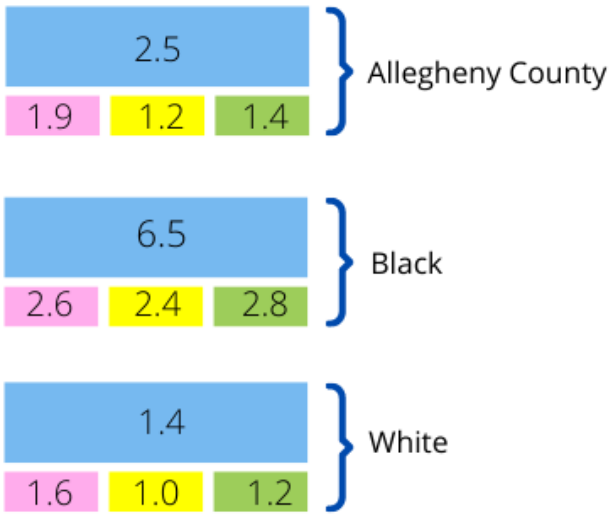
Calculate IMR for Each Target Group

IMR per 1,000 is calculated for each period of risk to compare to the reference group rates

$$IMR = \left(\frac{\#\ Deaths\ per\ Period}{Total\ Population\ per\ Period} \right) * 1{,}000$$



For more on IMR calculations, see appendix (page 23)



STEP 04

Determine Preventable Mortality

Subtracting the period-specific IMR for the target group from the reference groups determines excess, or preventable, deaths

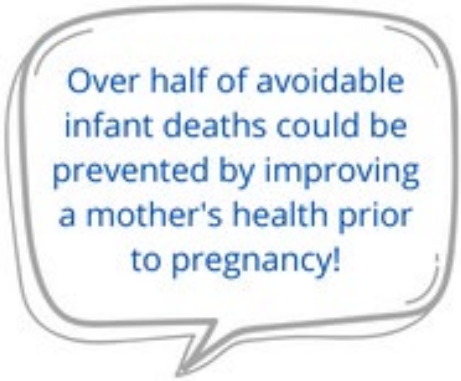
Preventable Deaths

Allegheny County	Black	White
134	107	17

Phase 1 Takeaways

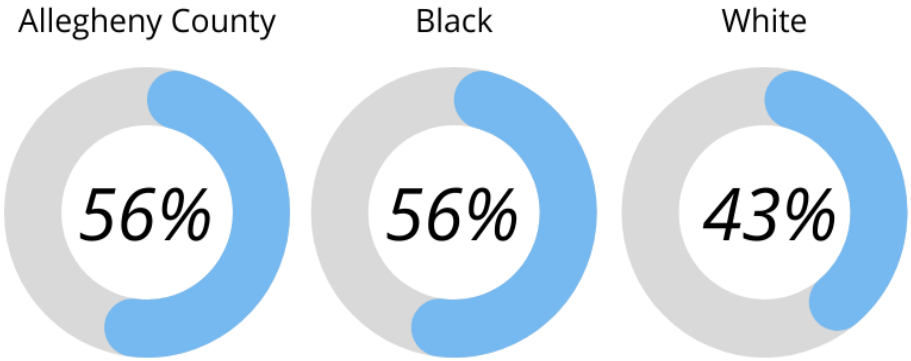
80% of all avoidable infant deaths were among the Black group, yet this population only represents 16% of the birthing population in Allegheny County

For each target population, the most *excess* deaths occurred in the maternal health/prematurity period of risk. This was also true for the White group, despite the highest fetal-infant mortality rate in the maternal care period. The Black group had the greatest excess mortality rate compared to all populations and for all periods of risk compared to the White group and Allegheny County. While the excess fetal-infant mortality rate was less than 1 per 1,000 when comparing the White group to the reference group, it was nearly 10 per 1,000 when comparing the Black group to the reference group.



Among the 134 preventable deaths in Allegheny County, there were 71 excess, or preventable, deaths in the maternal health/prematurity period of risk. For each group, this period of risk contained the greatest excess mortality. Excess deaths attributed to this period of risk suggests that pre-conception health, maternal health and behavior, and perinatal care should be considered when identifying factors driving both excess infant deaths and disparities between groups.

Percent of Excess Infant Deaths in Maternal Health/Prematurity Period



PHASE 2

The process and results from phase 2 of the analytic phase are outlined below.

While the purpose of Phase 1 is to identify the period of risk when excess deaths are occurring, the purpose of Phase 2 is to investigate *why* those excess deaths occur. This is done by identifying factors associated with excess infant mortality and estimating the impact of removing or intervening on those risk and preventative factors. This phase can also eliminate factors that are unlikely to be contributing to disparities in excess deaths.

While many factors can be associated with excess mortality in each period of risk, the PPOR process assists in prioritizing factors based on their impact. Phase 2 generally does not identify new, causal factors to infant mortality; rather, it uses well-established data to guide resource distribution to the most impactful interventions.

Each period of risk is associated with a different analytic approach.

Period of Risk	Methods
Maternal Health/Prematurity	Kitigawa analysis and examination of risk factors from both fetal and livebirth records
Maternal Care	Examination of fetal death risk factors on fetal records
Newborn Care	Examination of congenital anomalies and birth defects
Infant Health	Cause-specific death rate from Cause of Death (COD) on death certificate

This report focuses on the maternal health/prematurity and infant health periods of risk, as these periods had the greatest number of excess deaths.

PPOR Step 2: Data Analysis

Phase 2: Maternal Health/Prematurity

Process Period of Risk *Results*

STEP 01

Kitigawa

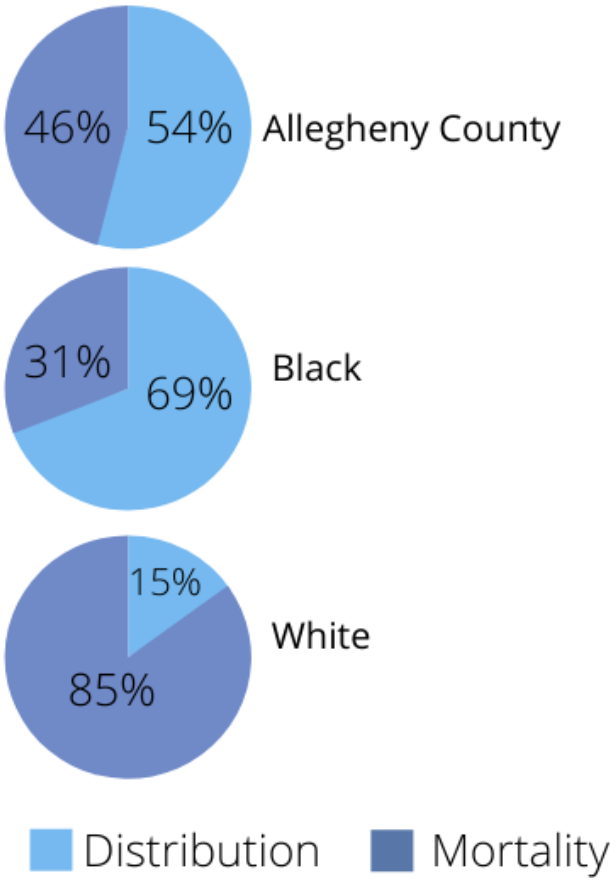
Is the difference in death rates between the target and reference group due to an excess of VLBW babies (**Distribution**) or a high death rate among those VLBW babies (**Mortality**)?

There are root causes associated with each category, and each has different risk factors to consider

Distribution	Mortality
Alcohol Use, Anemia, Intimate Partner Violence (IPV), Drug Abuse, Income, Maternal Age, Race, and Education, Previous Births (Parity), Twins/Triplets (Plurality), Insurance, Pregnancy Weight Gain, Prenatal Care, Previous Preterm Birth, STIs, Smoking, Unintended Pregnancy	C-Section, Birth Defects, Diabetes, Follow-Up Health Care, Hypertension, Infant and Maternal Medical Complications, Maternal Referrals, Medical Home and Management

Should the community examine impactful risk factors causing high rates of prematurity, or should they examine aspects of their perinatal care system that are responsible for higher birthweight-specific infant deaths?

DISTRIBUTION

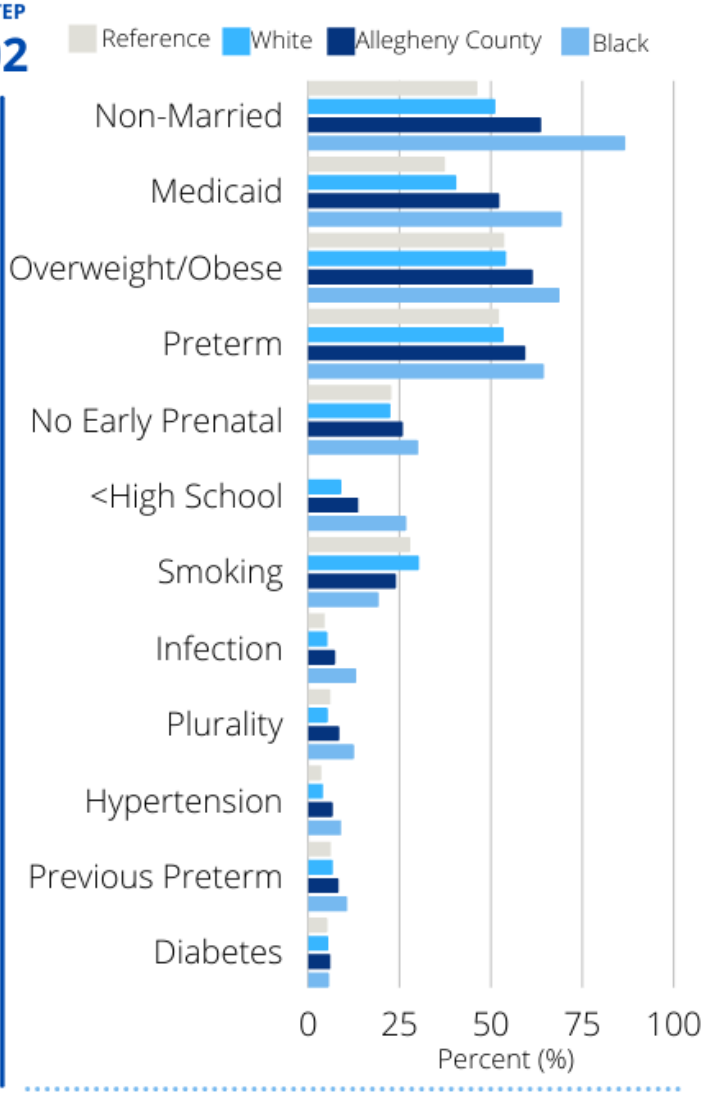


Birthweight distribution is responsible for the most excess deaths in both Allegheny County and the Black population. Since these groups experience disparities compared to the White and reference group, the next step is to examine factors related to VLBW.

STEP 02

Identify Factors Contributing to VLBW

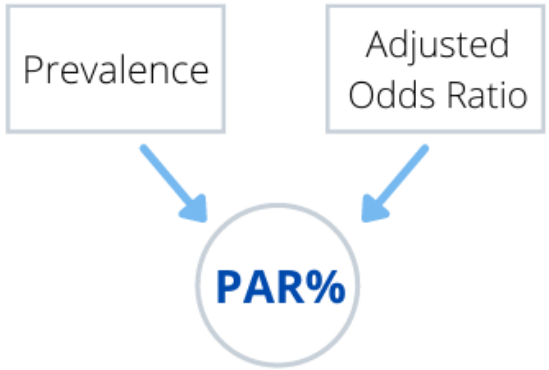
Among the risk factors available in the vital records data, how common are these factors in each group?



STEP 03

Calculate Impact

High prevalence does not necessarily mean the most impactful. Impact is calculated with Population Attributable Risk Percent (PAR%). This calculation uses both the prevalence of a risk factor and the strength of its association with VLBW. This metric captures the percentage of VLBW births that could have been prevented if that risk factor was eliminated or intervened on.



Odds ratio is adjusted for maternal age, education, and principal source of payment, which is used as a proxy for income

Impact Calculations by Group and Risk Factor: 2014-2018

	Reference		Allegheny County		Black		White	
	aOR*	PAR%	aOR	PAR%	aOR	PAR%	aOR	PAR%
Plurality	10.9	37.3	9.3	40.9	4.7	31.0	12.8	38.3
No Early Prenatal Care	1.7	15.7	0.5	-	<0.1	-	1.2	4.6
Non-Married	1.4	13.8	0.6	-	0.4	-	1.4	17.2
Overweight/Obese	1.5	20.6	1.4	18.1	1.3	17.4	1.1	6.5
Previous Preterm Birth	3.7	5.2	5.1	9.7	5.7	17.4	3.5	5.1
Smoking	1.3	2.2	1.3	3.3	1.2	2.4	1.3	3.2
Pre-Pregnancy Hypertension	2.0	1.4	5.2	6.9	5.6	12.7	2.8	2.5
Pre-Pregnancy Diabetes	<0.01	-	1.4	0.3	2.1	1.1	<0.1	-
Medicaid	1.3	1.5	1.4	3.7	0.9	-	1.0	0.2
<High School Education	-	-	0.9	-	0.4	-	1.7	2.5

**Adjusted OR: maternal age, education, and principal source of payment*
***Education not calculated for reference group since group is restricted to 13+ years of education*
****Negative PAR% not included in table*

IMPACT FINDINGS

- **Reference:** Plurality and having had a previous preterm birth were associated with the greatest risk (aOR) of VLBW births after adjustment. However, plurality and obesity had the greatest PAR% for this group.
- **Allegheny County:** Plurality and pre-pregnancy hypertension were associated with the greatest risk (aOR) of VLBW births after adjustment. However, plurality and obesity had the greatest PAR% for this group.
- **Black:** Having had a previous preterm birth and pre-pregnancy hypertension were associated with the greatest risk (aOR) of VLBW births after adjustment. However, plurality and obesity had the greatest PAR% for this group.

- **White:** Plurality and having had a previous preterm birth were associated with the greatest risk (aOR) of VLBW births after adjustment. However, plurality and marital status had the greatest PAR% for this group.

Disparities in prevalence for nearly all risk factors were observed when the target group was compared to the reference group. However, large disparities do not necessarily mean that risk factor would have the greatest impact if intervened on. For example, while disparities are significant for Medicaid use when compared to the reference group, impact calculations indicated minimal impact if intervened on for all groups.

For all groups, factors such as plurality, marital status, and high school education had the highest population attributable risk percentage (PAR%). However, when adjusting for age, educational attainment, and principal source of payment (often used as a proxy for income), **plurality, along with obesity, pre-pregnancy hypertension, and pre-pregnancy diabetes remained among the highest PAR% in groups with excess mortality (Black and Allegheny County). These impact findings highlight the importance of maternal health prior to conception.**

While plurality is not amenable to change, social conditions and medical settings in which birthing people deliver twins and triplets are amenable to change. Although there are interventions for conditions such as obesity and hypertension, it is these conditions in birthing people often develop prior to pregnancy. Factors such as stress may precede the development of these risk factors. Therefore, the adjusted impact findings point to the need to focus on maternal health prior to conception to reduce excess prematurity and infant mortality.

Addressing social determinants of health and the health of the birthing person prior to pregnancy can have the greatest impact on reducing preventable infant deaths and narrowing the gap between those with poor birth outcomes and those with good birth outcomes.

PHASE 2: INFANT HEALTH PERIOD OF RISK

While the greatest number of infant deaths occurred in the maternal health/prematurity period of risk, the infant health period of risk also had about **15%** of excess deaths for all groups. Therefore, understanding disparities in cause of death during this period can further inform efforts to prevent infant deaths.

The infant health period of risk included all Allegheny County livebirths with a birthweight of at least 1,500g from 2014-2018. For this period, the biologic method is determined by studying the underlying cause of death (COD) as captured on the death certificate. Each COD category has its own specific set of risk factors; therefore, further investigation can focus on specific underlying causes and their related risk factors.

Sleep-Related	Anomalies	Infection	Injury
Passive Smoke	Folic Acid Intake	Immunzations	Bedding
Sleep Position	Alcohol	Breastfeeding	Supervision
Breastfeeding	Drug Use	Passive Smoke	Environment
Bedding	Diabetes	Prenatal Care	Injury Type
Co-Sleep	Ultrasound	Maternal Age	
Maternal Age	Delivery Site	Infection Type	
Death Scene Investigation			

PPOR Step 2: Data Analysis

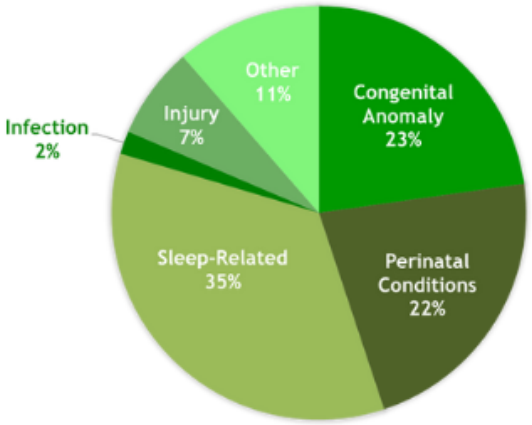
Phase 2: Infant Health Period of Risk

Process *Results*

STEP 01

Determine Underlying Cause of Death (COD)

Each COD category has its own set of risk factors. Understanding the leading COD can help direct resources to those risk factors.



Leading COD = **Unsafe Sleep**

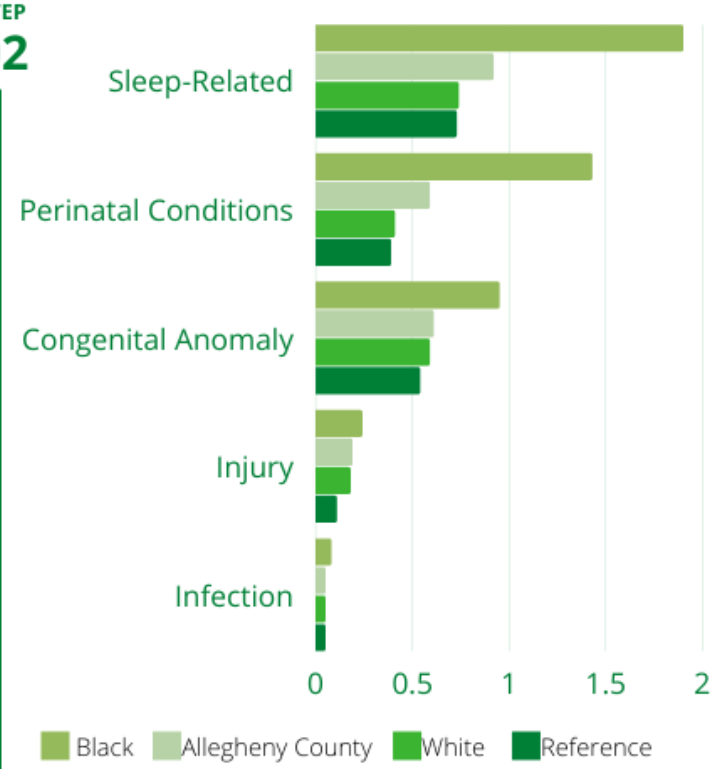
Total Deaths in this Period = **163**

STEP 02

Calculate Cause-Specific Mortality Rate (CSMR)

Calculate the CSMR for each cause of death category and for each target group

$$CSMR = \left(\frac{\#\ Deaths\ due\ to\ cause\ X}{\#\ Births\ >1{,}500g} \right) * 1{,}000$$



Highest CSMR is sleep-related for all groups, yet Black infants have the highest CSMR for all causes of death

STEP 03

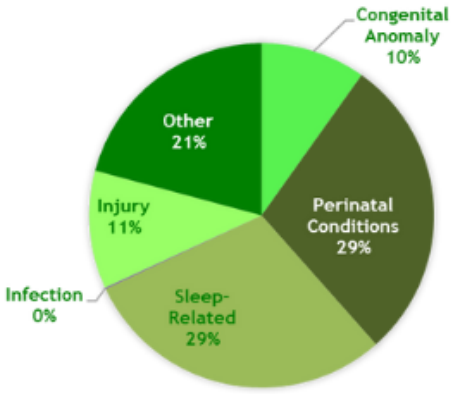
Determine EXCESS Mortality by COD

Compare the CSMR of each group to the reference group to determine the rate of excess, or preventable deaths in this period of risk.

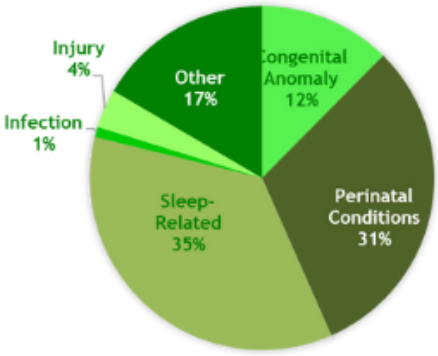
Excess CSMR=Target CSMR - Reference CSMR

The excess CSMR can then be used to determine the proportion of all excess deaths that fall into each COD category.

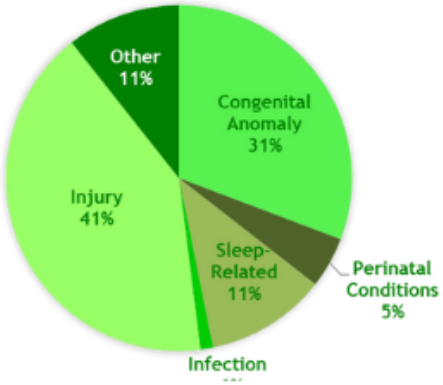
ALLEGHENY COUNTY
% EXCESS DEATHS



BLACK
% EXCESS DEATHS



WHITE
% EXCESS DEATHS



Sleep-related causes and perinatal conditions, such as short gestation or maternal complications, caused the majority of *excess* deaths in this period of risk for both Allegheny County and the Black population. In addition to focusing on safe sleep interventions, attention should be given to factors that lead to perinatal conditions. Those factors are explored in the maternal health period of risk.

SUMMARY

PPOR KEY FINDINGS:

- There were 134 preventable infant deaths in Allegheny County from 2014-2018.
- Over half of preventable deaths were in the maternal health/prematurity period of risk.
- Nearly 80% of preventable deaths were among the Black population.
- The maternal health/prematurity period of risk had the greatest Black-White disparity in infant deaths.
- Over half (56%) of excess infant deaths in the maternal health/prematurity period of risk in both Allegheny County and the Black population were from too many infants being born VLBW *(distribution)*
- Plurality, along with obesity, pre-pregnancy hypertension, and pre-pregnancy diabetes had the highest population attributable risk (PAR%) in groups with excess mortality *(Black and Allegheny County)*.
- The reduction in PAR% after adjustment for social determinants such as education and income indicate their influence on preventable infant mortality
- The infant health period of risk also contributed to preventable mortality, with the leading cause of death being sleep-related causes.
- The cause-specific mortality rate was highest among the Black population for all causes of death.

Given the high mortality rate in the infant health period of risk, sleep-related interventions, such as sleep position and bedding, should be addressed. However, since the goal of this analysis is prioritization, next steps should focus on the period of risk with the greatest excess mortality, which is the maternal health/prematurity period. Furthermore, birthweight distribution contributed more to excess mortality within this period; therefore, interventions should be targeted around factors that lead to VLBW. These data indicate that efforts to reduce excess

infant mortality, therefore reducing disparities in infant mortality, need to happen before and between pregnancies to prevent too many infants from being born prematurely.

The PPOR framework also provides an opportunity to address disparities in infant outcomes. While the maternal health/prematurity period of risk had the greatest number of preventable deaths at large, this period of risk also had the greatest disparity between Black and White populations. While periods or risk are prioritized in this process, populations with the greatest excess mortality should also be prioritized. Therefore, a life-course approach should be utilized for this period of risk, with a focus on the needs of Black birthing people, enhancement of systems that influence their health, and social and economic inequities due to racism that contribute to cumulative stress. Given that the survival of infants is considered an indicator of community health, improvement in factors related to maternal health and VLBW distribution can lead to better outcomes for mothers, infants, and the community at large.

TECHNICAL NOTES

More Allegheny County data on socioeconomic, demographic, and health outcomes can be found at:

https://www.alleghenycounty.us/Health-Department/Resources/Data-and-Reporting/Chronic-Disease-Epidemiology/Allegheny-County-Community-Indicators.aspx

METHODOLOGY SUPPLEMENT

The quality of the birth and death data presented in this report is directly related to the accuracy and completeness of the information collected through hospital and birthing centers. Therefore, missing data, underreporting, and potential misclassification may limit the interpretation of these analyses. Studies have verified the underreporting of items on the birth certificate[5-8] and suggested that the magnitude of underreporting may differ for mothers at the highest sociodemographic risk for adverse pregnancy outcomes[9]. Additionally, data quality may vary by birthing facility.

For Phase 2 of the analysis, the sample size is not high enough to investigate many causal pathways and the burden of risk factors or for multivariate modeling. Since the county level is being assessed, it can be difficult to reach an appropriate sample size depending on which risk factor is being analyzed. However, estimates from the literature can be used for comparison. Another limitation is that risk factors are analyzed depending on data availability. Many known risk factors for prematurity and infant death are not available in the vital records, so additional data sources are needed to assess those factors. The results are also dependent on data quality. It can be difficult to detect underreporting or misreporting, so the analysis is limited by the quality of our data. Self-reporting bias is also difficult to capture on the birth certificate. Also, the vital records data do not always capture the nuance of an individua's experience. For example, the marital status variable, which is sometimes used as a proxy for social support, may be coded as 'No', but that individual may feel they are in a supportive relationship despite not being married. Finally, this analysis excluded nearly half of all fetal and infant deaths that did not meet inclusion criteria. Given that most of these records were <1,500g, they would have been included in the maternal health/prematurity period of risk. Therefore, excluding them also excludes additional information about risk factors and may artificially decrease the mortality rates of that period. Further analyses can assess these excluded records separately.

Although this analysis suggests a focus on maternal health to reduce excess infant mortality and minimize disparities, available data sources do not capture all risk and preventative factors for prematurity and infant death. Therefore, community input and feedback are a necessary component to the PPOR framework, and data should be interpreted considering these limitations.

DATA PREPARATION

Vital records data were acquired for births, deaths, and fetal deaths from the Pennsylvania Department of Health for 2014-2018. The vital record files were linked to obtain information on both the infant and mother. The death files provide information such as cause of death, while birth files provide maternal information, such as education level, race, and insurance. PPOR also includes fetal deaths, which provide data elements related to both birth and death.

Data quality refers to the inclusion of all cases of infant death, the inclusion of all data items in each infant's record, and the accuracy and correct recording of those data items. If any of this information is missing, it can cause biased results. Therefore, data quality was assessed by identifying missing birthweight, unlinked infant deaths, and implausible birthweight and gestational age combinations. An algorithm provided by CityMatCH[26] was used to identify implausible birthweight records, which were excluded.

Implausible value algorithm:

gestation<20weeks and birthweight>=500g or

20<=gestation<24weeks and birthweight>=2,000g or

24<=gestation<28weeks and birthweight>=3,000g or

28<=gestation<32weeks and birthweight>=4,000g or

32<=gestation<47weeks and birthweight<1,000g and plurality=1

Among the 924 infant and fetal death files for Allegheny County from 2014-2018, 28 were excluded due to a missing birth certificate. Among the remaining 896 records, 399 were <500g and/or <24 weeks gestation, and 28 were implausible. Therefore, an additional 444 records were excluded, leaving 452 included in this analysis (49% of 2014-2018 Allegheny County fetal and infant death records).

For missing birthweight data, values were imputed based on an algorithm that estimates birthweight based on length of gestation. This allowed additional records to be included in analysis even with missing birthweight information. This imputation is recommended if roughly 5-10% of birthweight or gestational data is missing. About 6% (n=26) of included records were missing birthweight information, and about 2% (n=8) were missing gestation information, therefore they were imputed.

Imputation of missing birthweight:

Fetals:

Length of Pregnancy	Birthweight
≥32 weeks	≥ 1500g
24-31 weeks	< 1500g
≥ 24 weeks	≥ 500g

Livebirths:

Length of Pregnancy	Birthweight
≥ 31 weeks	≥ 1500g
22-30 weeks	< 1500g
NA	NA

Study population was also restricted by birthweight and gestational age, which define the four periods of risk. To minimize inconsistent reporting, fetal deaths with a birthweight less than 500 grams and less than 24 weeks gestation were excluded, and livebirths less than 500 grams were excluded. Reporting of an infant mortality less than 500g/24 weeks tends to be highly variable by physician, hospital, and community, so underreporting can be difficult to detect. In addition to removing inconsistently reported records, these cutoffs generally limit pregnancy events to those that are physically viable, assuming no underlying congenital defect or medical condition. Also, spontaneous and induced abortions and infant deaths without a corresponding birth certificate were not included since birth certificate information is needed (cite). Exclusion of unlinked deaths and deaths that did not meet the inclusion criteria can artificially decrease mortality rates.

Finally, an appropriate sample size is necessary to detect any statistically significant measures of association, especially in Phase 2 of the analytic phase. At least 60 deaths were needed in the time period of interest (2014-2018). This number, determined by CityMatCH, allows differentiation between real underlying changes or differences in random fluctuations. Therefore, 5 years of data were aggregated to assure sufficient counts.

PHASE 1

The reference population characterizes a mortality rate that should represent all populations, serving as the expected rate. This group should have at least 60 deaths for stable rates and should represent at least 15% of the maternal population. The data for this group should also be of sufficient quality since it is typically defined by variables such as race and education. A common reference group that meets these criteria includes non-Hispanic White, 20+ years of age, and high school educational attainment or higher[27]. For this analysis, the reference group consisted of Allegheny County residents at time of birth, non-Hispanic White, at least 20 years old, and at least 13 years of education. This population represented about 68% of the Allegheny County maternal population from 2014-2018 and contained a sufficient number of deaths. For additional analyses examining other reference groups with insufficient counts, external references can be used.

The quality of the demographic data used is important because it can affect the rate of the reference population, which would ultimately affect both which populations and which periods of risk display the greatest excess mortality.

After the reference group was selected, counts and feto-infant mortality rates were calculated for each period of risk among each population. The denominator for the feto-infant mortality rate includes all fetal deaths plus livebirths for the total population in the selected time period.

FIMR= $x = \frac{\text{Number of Fetal and Infant Deaths}}{\text{Number of Livebirths+Fetal Deaths}}$*1,000

The study populations used in this analysis included Allegheny County maternal population (12-55 years, female), non-Hispanic White Allegheny County maternal population, and non-Hispanic Black Allegheny County population. The rates of the reference population were subtracted from the rates of the study population to determine excess mortality. Those rates were then translated into counts for excess deaths. Finally, the proportions of excess deaths in each period of risk out of the total excess deaths were calculated.

Groups	Total Included	Denominator (Total 2014-2018 Population)
Allegheny County	452	63,805
Black	186	13,053
White	229	44,799
Reference	200	43,069

FIMR and Excess Mortality by PPOR Study Group and Period of Risk

	Maternal Health/Prematurity	Maternal Care	Newborn Care	Infant Health	Fetal-Infant Mortality Rate
Allegheny County	2.54	1.93	1.21	1.41	7.08
Reference Group	1.16	1.51	0.86	1.11	4.64
Excess Mortality	**1.38**	**0.42**	**0.35**	**0.30**	**2.44**

	Maternal Health/Prematurity	Maternal Care	Newborn Care	Infant Health	Fetal-Infant Mortality Rate
Black	6.51	2.60	2.37	2.76	14.25
Reference Group	1.16	1.51	0.86	1.11	4.64
Excess Mortality	**5.35**	**1.09**	**1.51**	**1.65**	**9.61**

	Maternal Health/Prematurity	Maternal Care	Newborn Care	Infant Health	Fetal-Infant Mortality Rate
White	1.36	1.63	0.96	1.16	5.11
Reference Group	1.16	1.51	0.86	1.11	4.64
Excess Mortality	**0.20**	**0.12**	**0.10**	**0.05**	**0.47**

PHASE 2

Maternal Health/Prematurity Period

The maternal health/prematurity period of risk is approached differently than other periods of risk. This is because the underlying cause of death information for fetal and infant deaths weighing less than 1,500g is not informative. Cause of death information in this weight range is complex and multi-factorial, and the information is frequently inaccurate and inconsistently reported[28]. Reporting can vary by the perinatal capability of the hospital reporting and/or the clinical training of the certifier. Therefore, the methodology for this period of risk uses the Kitigawa analysis[4]. This protocol determines whether excess deaths are due to birthweight distribution or birthweight-specific mortality. Birthweight distribution refers to the frequency of very low birthweight births (<1500g), and birthweight-specific mortality refers to the mortality rate of infants born very low birthweight.

The Kitigawa formula is broken down as follows:

$$\sum_{1}^{n}\left(\left(\frac{(P_{1n}+P_{2n})}{2}\times(M_{1n}-M_{2n})\right)+\left(\frac{(M_{1n}+M_{2n})}{2}\times(P_{1n}-P_{2n})\right)\right)$$

P_{1n} and **P_{2n}**= Rate of outcome in population 1 and 2 in category *n* of predictor

M_{1n} and **M_{2n}**= Proportion of population 1 and 2 in category *n* of predictor

- For the contribution of birthweight distribution, the difference in percentage of all live births in a birthweight category is multiplied by the average birthweight specific mortality rate for the same category, and estimates are then summed across birthweight categories.
- For the contribution of birthweight-specific mortality rates, the difference in mortality rates in each birthweight category are multiplied by the average percentage of all live births into that category, and estimates are summed across all birthweight categories.

The contribution of birthweight distribution and birthweight-specific mortality was calculated among both the maternal health/prematurity of risk and the entire PPOR population.

For each risk factor, crude and adjusted odds ratios (OR, aOR, respectively) were first calculated. The OR was calculated to quantify the strength of the relationship and was assumed to estimate relative risk (RR) given that the vital records data includes the majority of births in Allegheny County. Ratios were adjusted for age, education level, and primary payer. Next, population attributable risk percentage (PAR) was calculated.

PAR% = $100 * \frac{p*(aOR-1)}{1+(P*(OR-1))}$

**Where P=prevalence of risk factor and aOR=adjusted odds ratio*

The analysis is limited by the availability and quality of the provided data. Additionally, a small sample size may limit the power to detect a small attributable risk. The following table includes both crude and adjusted ORs in addition to the PAR% by group.

OR, adjusted OR, and PAR% for each risk factor by PPOR Study Group

	Reference Group			Allegheny County			White			Black		
	OR	aOR[1]	PAR%	OR	aOR	PAR%	OR	aOR	PAR%	OR	aOR	PAR%
Plurality	9.4	10.91	37.32	3.71	9.27	40.92	8.51	12.76	38.34	2.16	4.65	31.02
No Early Prenatal Care	1.49	1.71	15.73	1.4	0.48	-	0.44	1.18	4.56	1.36	<0.01	-
Non-married	0.7	1.35	13.78	1.2	0.57	-	0.94	1.41	17.15	0.96	0.35	-
Overweight/Obese	0.95	1.48	20.57	1.11	1.36	18.07	0.97	1.13	6.46	0.72	1.31	17.43
PPB[2]	3.83	3.67	5.21	4.93	5.11	9.73	3.7	3.49	5.06	4.07	5.7	17.42
Smoking	2.18	1.26	2.17	1.82	1.33	3.3	2.12	1.33	3.24	1.23	1.17	2.36
Hypertension (pre-pregnancy)	5.15	1.98	1.4	4.61	5.24	6.88	5.25	2.79	2.54	2.63	5.55	12.66
Diabetes (pre-pregnancy)	1.49	<0.01	-	3.5	1.4	0.27	2.26	<0.01	-	3.23	2.05	1.12
Medicaid	1.6	1.25	1.48	1.66	1.35	3.69	1.59	1.02	0.15	0.94	0.89	-
<High School Education	-	-	-	1.85	0.88	-	1.67	1.68	2.54	1.96	0.44	-
Previous C-Section	1.01	0.68	-	1.09	1.11	1.07	0.99	0.87	-	1.24	0.9	-
Maternal Infection	1.53	0.77	-	0.71	0.46	-	1.4	0.4	-	0.35	0.62	-

Adjusted ORs and 95% Confidence Intervals for Risk Factors by PPOR Group

	Reference		Allegheny County		Black		White	
	aOR*	CI	aOR	CI	aOR	CI	aOR	CI
Plurality	10.9	(6.5-18.3)	9.3	(6.1-14.2)	4.7	(1.7-12.4)	12.8	(7.7-21.1)
No Early Prenatal Care	1.7	(0.1-4.2)	0.5	(0.1-7.6)	<0.1	(<0.1->999.9)	1.2	(0.1-4.4)
Non-Married	1.4	(0.7-2.6)	0.6	(0.4-0.9)	0.4	(0.1-0.9)	1.4	(0.7-2.7)
Overweight/Obese	1.5	(0.8-2.6)	1.4	(0.8-2.1)	1.3	(0.6-2.9)	1.1	(0.7-2.0)
Previous Preterm Birth	3.7	(1.5-9.3)	5.1	(2.9-9.1)	(2.5-12.8)	17.4	3.5	(1.4-8.9)
Smoking	1.3	(0.6-2.6)	1.3	(0.8-2.2)	1.2	(0.5-2.6)	1.3	(0.7-2.6)
Pre-Pregnancy Hypertension	2.0	(0.5-8.2)	5.2	(2.7-10.2)	5.6	(2.2-13.8)	2.8	(0.9-9.0)
Pre-Pregnancy Diabetes	<0.01	(<0.1->999.9)	1.4	(0.2-10.2)	2.1	(0.3-15.8)	<0.1	(<0.1->999.9)
Medicaid	1.3	(0.7-2.4)	1.4	(0.9-2.0)	0.9	(0.5-1.6)	1.0	(0.6-1.9)
<High School Education	-	-	0.9	(0.4-1.9)	0.4	(0.1-1.5)	1.7	(0.6-5.1)

**Adjusted OR: maternal age, education, and principal source of payment*
***Education not calculated for reference group since group is restricted to 13+ years of education*
****Negative PAR% not included in table*

Infant Health Period

The CODs for this period of risk were obtained from the infant death certificate and were categorized based on the classification system used by CDC's Post-neonatal Mortality Surveillance System[5] ICD-10 codes provided in the death certificate were used to categorize records.

Cause of Death	ICD-10 Code
Congenital Anomaly	All 'Q'
Perinatal Conditions	All 'P'
Sleep-Related	'R95', 'R99', 'W84'
Infection	All 'J'
Injury	All 'V' and above, excludes 'W84'
All Other Causes	All others not listed

The infant health period of risk included all Allegheny County livebirths >= 1,500g from 2014-2018. This period of risk does not include fetal deaths. Frequencies for each COD category were first calculated for both the reference group and study populations. Then, the cause-specific mortality rate (CSMR) for each COD category was calculated each group.

Cause-Specific Mortality Rate (CSMR) $= \frac{Number\ of\ deaths\ due\ to\ cause\ x}{\text{Number of livebirths}\geq 1500g} * 1{,}000$

Counts less than 10 were censored. With the CSMR for both the reference and study groups, excess CSMR was calculated by subtracting the reference CSMR from the study group CSMR. The percent contribution of each COD category to the overall excess CSMR was then calculated by dividing the excess CSMR in the COD group by the overall excess CSMR.

There was a total of 163 infant deaths that were greater than or equal to 1,500g, therefore included in the infant health period of risk.

Given that less than 10 counts were censored for CSMR calculations, infection, injury, and 'all other' COD categories were censored for the White, Black, and reference groups. The infection category was censored

for the Allegheny County study group. The highest CSMR in each study group was sleep related (Figure 34). The Black sleep related CSMR was nearly double that of the reference group (1.9 per 1,000 and 0.7 per 1,000, respectively). There were also Black-White disparities for all COD groups.

Table 24. Cause-Specific Mortality Rate by PPOR Group: 2014-2018

	Reference		Allegheny County		White		Black	
	Count	CSMR*	Count	CSMR*	Count	CSMR*	Count	CSMR*
Congenital Anomaly	23	0.540	38	0.605	26	0.589	12	0.952
Perinatal Conditions	17	0.399	37	0.589	18	0.406	18	1.428
Sleep-Related	31	0.728	58	0.924	33	0.745	24	1.903
Infection	-	ND**	-	ND	-	ND	-	ND
Injury	-	ND	12	0.191	-	ND	-	ND
All Other	-	ND	19	0.302	-	ND	-	ND
Total	85	1.995	167	2.660	95	2.144	67	5.314

Table 25. Excess Cause-Specific Mortality Rate by PPOR Group:

	Reference	Allegheny County	White	Black
Congenital Anomaly	0.540	0.065	0.047	0.412
Perinatal Conditions	0.399	0.190	0.007	1.029
Sleep-Related	0.728	0.196	0.017	1.176
Infection	-	-	-	-
Injury	-	0.073	-	-
All Other	-	0.138	-	-
Total	1.995	0.665	0.149	3.319

Excess CSMR = (Target Group CSMR) – (Reference Group CSMR)

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