Perinatal Periods of Risk: An Analysis of Fetal-Infant Mortality in Clark County, Ohio

Anna Jean Petroff

Wright State University
ABSTRACT

Phase 1 of the Perinatal Periods of Risk (PPOR) analysis was used to assess fetal-infant mortality in Clark County, Ohio over a five-year period from 2012 to 2016. The overall Fetal-infant Mortality Rate (FIMR) for Clark County (7.06) was greater than overall FIMR for the Reference Population (5.43). The highest FIMR for Clark County residents belonged to the Maternal Health/Prematurity (MH/P) period of risk (3.03 deaths per 1,000 live births + fetal deaths). Among the Reference Population, the highest FIMR was also found in the MH/P period of risk (1.98 deaths per live births + fetal deaths). Excess FIMR was highest in MH/P (1.05), followed by Maternal Care (MC) (0.53). MH/P accounted for 64.2% of excess mortality in Clark County, while MC accounted for 32.4% of excess mortality. In Clark County, the MH/P period had the highest rate of excess mortality among all periods of risk. Broad prevention strategies should focus on improving Preconception Health, Health Behaviors, and Perinatal Care. In order to narrow the focus of prevention strategies, Phase 2 PPOR analysis must be done for Clark County in the near future to discover which risk factors contribute the most to excess FIMR.

Keywords: fetal-infant mortality, perinatal periods of risk (PPOR)
Perinatal Periods of Risk: An Analysis of Fetal-Infant Mortality in Clark County, Ohio

Introduction and Literature Review

Infant mortality is defined by the Ohio Department of Health as “the death of a live-born baby before his or her first birthday” (Ohio Department of Health [ODH], 2017). There are several causes of infant death. In 2015, the five leading causes of infant death in the United States were: 1) birth defects, 2) preterm birth and low birthweight, 3) sudden infant death syndrome (SIDS), 4) maternal pregnancy complications, and 5) injuries (Centers for Disease Control and Prevention [CDC], 2018).

In 2016, Ohio’s infant mortality rate (IMR) was 7.4, a slight increase from 7.2 in 2015 and much higher than the state’s goal of 6.0 infant deaths per 1,000 live births (ODH, 2017). Of all counties in Ohio, Clark County had the highest rate in 2016, with an IMR of 13.0, a 251% increase from the previous year (ODH, 2017). In order to determine how to reduce this mortality disparity, this paper examines fetal-infant mortality in Clark County over a five-year period (2012-2016) using Phase 1 of the Perinatal Periods of Risk (PPOR) analysis.

The PPOR approach was developed between 2000 and 2004 by CityMatCH, a national public health organization whose mission is to promote health equity among women, children, and families by supporting public health leaders and organizations in improving the services they offer (CityMatCH, 2018). PPOR provides a research-based framework for investigating and identifying
specific causes of local fetal-infant mortality. In PPOR analysis, fetal and infant deaths are sorted into four “periods of risk,” defined by age at death and birthweight (Peck, Sappenfield, and Skala, 2010) (Figure 1). Each period is associated with a set of potential areas for intervention that are likely to reduce infant or fetal death (Figure 2).

There are two analytical phases of PPOR. In Phase 1, local data is compared with a reference population of “near-optimal” outcomes to determine excess mortality, which is interpreted as an opportunity gap that identifies where the community has the most potential to make improvements (Sappenfield, Peck, Gilbert, Haynatzka, and Bryant, 2010a). Phase 2, which was not completed in this study, further investigates opportunity gaps and suggests appropriate actions (Sappenfield et al., 2010). Most communities in the U.S. discover the highest excess mortality belongs to the Maternal Health/Prematurity (MH/P) period and therefore perform the Kitagawa Protocol to investigate this gap (CityMatCH, n.d.). Several studies have used PPOR to assess and identify plans to reduce fetal-infant mortality rates (FIMR) in the study community, but no follow-up studies were found that revisited the community after implementation of programs or policies developed as a result of the PPOR conducted.
One example of a local PPOR analysis is Burns’ (2005) study in Tulsa County, Oklahoma. In this study, PPOR was conducted for Tulsa County and FIMRs were compared with traditional calculation methods (Burns, 2005). PPOR methods returned higher overall FIMRs than traditional calculation methods (Burns, 2005). In this case, MH/P was the risk period with the highest mortality (Burns, 2005). After completing PPOR, the organization leading this research study targeted health promotion strategies to improve maternal health with a focus on inter-conceptive care (Burns, 2005). One limitation of this study is that the CDC Wonder database that was used to obtain fetal death data does not offer a gestational age category of 24 weeks (as recommended by CityMatCH for use in PPOR), and instead 20 weeks gestation was used for these analyses (Burns, 2005; Peck et al., 2010). This would limit any comparisons that may be made between this study’s findings and other published research.

Another example of PPOR analysis is a study by Cai, Hoff, Dew, Guillory, and Manning (2005) in Kansas City, Missouri. This study describes a full PPOR analysis conducted for the period 1998-2002, which discovered that the black FIMR was 2.8 times higher than the white non-Hispanic FIMR (Cai et al., 2005). Cai et al. (2005) also found that the majority of excess mortalities occurred in the MH/P and Infant Health (IH) periods. Results of Phase 2 analysis showed that within MH/P, nearly all excess deaths belonged to the very-low birthweight category. Within IH, Phase 2 analyses showed that over half of post-neonatal deaths were due to SIDS. Additionally, SIDS deaths among black infants were associated with mothers under 20 years of age, insufficient prenatal care, previous births, and being a recipient of Medicaid (Cai et al., 2005).

To further strengthen this relationship, insufficient prenatal care was related to an increased risk of a black infant dying from SIDS, a finding supported by other research on the
issue (Cai et al., 2005). Through this study, Cai et al. (2005) concluded that certain resources must be allocated towards preventing teen pregnancy and improving access to proper medical care and prenatal care (Cai et al., 2005).

A separate study was done in Jackson County, Missouri, which encompasses Kansas City, Missouri (Cai, et al., 2007). In this study, researchers restricted analysis to the first phase of PPOR, and showed geographic and racial differences in FIMR in Jackson County, which mirrored racial disparities found in Cai et al. (2005) (Cai et al., 2007). Cai et al. (2007) determined that the majority of fetal-infant deaths occurred in Kansas City. Congruent with the 2005 study, excess mortality was found to be highest in the MH/P period for Kansas City (Cai et al., 2005; Cai et al., 2007). Excess mortality in Jackson County overall was highest in the IH period (Cai et al., 2007). The majority of excess deaths in Jackson County were contributed by birth-weight-specific mortality (showing a need for perinatal care), while excess deaths in Kansas City were contributed by very low birthweight (Cai et al., 2007).

These apparent spatial differences suggest that different intervention/prevention tactics be used in each area. Cai et al. (2007) suggests that efforts in Kansas City be focused on decreasing the rate of very low birthweight infants, specifically blank infants, while efforts in Jackson County overall should be focused on decreasing mortality among very low birthweight births, particularly white infants (Cai et al., 2007).

Montgomery County, Ohio, a neighboring county of Clark, conducted its own PPOR analysis in 2017 (Seybold, 2018). Congruent with the majority of other urban communities in the U.S., Seybold (2018) identified the highest excess mortality in the MH/P period of risk. Since Montgomery County is a nearby county with a similar community to Clark, it is expected that Clark County will also have the highest excess mortality in the MH/P period of risk.
In summary, PPOR is an effective, easy-to-use tool that is utilized by urban communities to establish a framework to assess fetal-infant mortalities. PPOR has been used to monitor progress, aid public health planning, and guide communities to prioritize prevention. Further research is necessary to investigate the effectiveness of programs or policies implemented based on PPOR recommendations.

**Methodology**

For this study, infant birth-death linked data and fetal death data for the state of Ohio was obtained from the Ohio Department of Health (ODH) Bureau of Vital Statistics for the years 2012 to 2016. Due to inconsistent reporting between hospitals, the study population was restricted by birthweight and gestational age to exclude extremely premature cases. Infant deaths less than 500 grams were excluded from analysis, as well as fetal deaths less than 24 weeks gestation and less than 500 grams. Since over 5% of births, deaths, and fetal deaths were missing birthweight, age at death, or gestational age, some missing data elements were imputed (Table 1). Racial and ethnic analyses were not conducted due to inadequate sample size (<60 fetal and infant deaths). IMR and Fetal mortality rate (FMR) were calculated for both Clark County and the state of Ohio for years 2012-2016.

An external reference population was selected for comparison in this study. This reference group was chosen based on the following maternal characteristics: 1) Ohio resident at the time of the child’s birth; 2) White, Non-Hispanic; 3) At least 20 years of age; and 4) At least 13 years of education.

Fetal and infant deaths for both Clark County and the Reference Population were then sorted into periods of risk based on age at death and birthweight (Figure 1). The FIMR was calculated for each period and overall for each group using the following formula:
\[ \text{FIMR} = \frac{\text{# of Fetal Deaths} + \text{# of Infant Deaths}}{\text{Total # of Fetal Deaths} + \text{Live Births}} \times 1,000 \]

The excess mortality rates were then calculated for each period using the following formula:

\[ \text{Excess FIMR} = (\text{Clark FIMR}) - (\text{Reference FIMR}) \]

Percent excess mortality was calculated to identify the period of risk with the highest excess mortality.

\textit{Table 1: Perinatal Periods of Risk (PPOR) Data Preparation and Imputation Algorithms}

<table>
<thead>
<tr>
<th>Fetal Deaths</th>
<th>1. Birthweight unknown:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a. If gestational age was greater than 32, then the birthweight was imputed as 1500g</td>
</tr>
<tr>
<td></td>
<td>b. If gestational age was greater than 24, then birthweight was imputed as 500g</td>
</tr>
<tr>
<td></td>
<td>c. If gestational age was less than 24, then the case was excluded from analyses</td>
</tr>
<tr>
<td>2. Gestational age unknown:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. If birthweight was greater than 500g, then gestational age was imputed as 24 weeks</td>
</tr>
<tr>
<td></td>
<td>b. If birthweight was less than 500g, then the case was excluded from analyses</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Infant Deaths</th>
<th>1. Birthweight unknown:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a. If the gestational age was greater than 31 weeks, the birthweight was imputed as 1500g</td>
</tr>
<tr>
<td></td>
<td>b. If the gestational age was greater than 22 weeks, the birthweight was imputed as 500g</td>
</tr>
<tr>
<td></td>
<td>c. If the gestational age was less than 22 weeks, then the case was excluded from analyses</td>
</tr>
<tr>
<td>2. Gestational age unknown:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. If the gestational age was unknown, then the case was excluded from analyses</td>
</tr>
</tbody>
</table>

\textit{Results}

There were 7,968 fetal deaths and live births in Clark County between 2012 and 2016. Of those, 24 fetal deaths and 32 infant deaths fit the criteria for PPOR analysis. In 2016, the overall IMR for Clark County was 7.2 deaths per 1,000 live births (Figure 3). In comparison, Ohio’s IMR was 5.0 deaths per 1,000 live births (Figure 3). From 2012-2016, Clark County’s IMR increased by 278.9% (from 1.9 to 7.2). During this time period, Ohio’s IMR increased slightly from 4.6 to 5.0 (an increase of 6.8%). Clark County’s IMR 5-year average was 4.1
deaths per 1,000 live births, compared to Ohio’s 5-year average of 4.7 deaths per 1,000 live births.

Clark County’s fetal mortality rate (FMR) in 2016 was 2.6 deaths per 1,000 live births + fetal deaths, while Ohio’s FMR was 3.5 deaths per 1,000 live births + fetal deaths (Figure 4). From 2012-2016, however, Clark County’s FMR increased by 100% (from 1.3 to 2.6). During this same time period, Ohio’s FMR remained relatively the same, decreasing by 2.8% (from 3.6 to 3.5). Clark County’s FMR 5-year average was 3.0 deaths per 1,000 live births + fetal deaths, compared to Ohio’s 5-year average of 3.7 deaths per 1,000 live births + fetal deaths.

Figure 3: Infant mortality rate (IMR) for Clark County and Ohio, 2012-2016
Note: All infant deaths with a birthweight of at least 500g were included in this calculation
Perinatal Periods of Risk Analysis

Overall FIMR for Clark County was 7.06, as compared to the overall FIMR for the Reference Population (5.43). The FIMR for Clark County for each period were 3.03 deaths per 1,000 live births + fetal deaths in MH/P period of risk, 1.89 deaths per 1,000 live births + fetal deaths in Maternal Care (MC), 1.13 deaths per 1,000 live births + fetal deaths in Newborn Care (NC), and 1.01 deaths per 1,000 live births + fetal deaths in IH (Table 2).

Among the Reference Population, the FIMR for each period were 1.97 deaths per live births + fetal deaths in MH/P, 1.36 deaths per live births + fetal deaths in MC, 1.10 deaths per live births + fetal deaths in NC, and 0.99 deaths per live births + fetal deaths in IH (Table 3). Assuming a constant reference rate, the Clark County MH/P rate was 1.5 times higher than the
Reference Population MH/P rate, and the Clark County MC rate was 1.4 times higher than the Reference Population MC rate.

Table 2: Clark County Perinatal Periods of Risk (PPOR) Map, Fetal-Infant Mortality Rates with 95% Confidence Intervals, 2012-2016

<table>
<thead>
<tr>
<th>Category</th>
<th>Maternal Health/Prematurity</th>
<th>Maternal Care</th>
<th>Newborn Care</th>
<th>Infant Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate (95% CI)</td>
<td>3.03 (1.94, 4.50)</td>
<td>1.89 (1.06, 3.12)</td>
<td>1.13 (0.52, 2.15)</td>
<td>1.01 (0.44, 1.99)</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Category</th>
<th>Maternal Health/Prematurity</th>
<th>Maternal Care</th>
<th>Newborn Care</th>
<th>Infant Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate (95% CI)</td>
<td>1.98</td>
<td>1.36</td>
<td>1.10</td>
<td>0.99</td>
</tr>
</tbody>
</table>
Excess FIMR was greatest in the MH/P period of risk (1.05), followed by MC (0.53) (Figure 5). MH/P accounted for 64.2% of excess mortalities in Clark County, MC accounted for 32.4%, NC accounted for 2.4%, and IH accounted for 1.0% (Figure 6).

*Figure 5: Excess fetal-infant mortality rates (FIMR), Clark County, 2012-2016*

*Figure 6: Percent excess fetal-infant mortality, Clark County, 2012-2016*
Discussion

On average, IMR in Clark County was higher than in Ohio between 2012 and 2016. Alternatively, average FMR for Clark County was lower than Ohio from 2012-2016. In Clark County, both IMR and FMR increased over the five-year period, as compared to IMR and FMR in Ohio, which remained relatively the stable.

Overall FIMR for Clark County was higher than overall FIMR for the Reference Population. The highest FIMR for Clark County residents was identified as the MC/P period of risk, followed by MC. Among the Reference Population, the highest FIMR also found in the MH/P period of risk. The second highest period in the Reference Population was also MC.

As expected based on the results of previous studies (Cai et al., 2005; Cai et al., 2007; CityMatCH, n.d.; Seybold, 2018), this Phase 1 PPOR analysis identified that MH/P accounted for the greatest percent of excess deaths in Clark County, followed by MC. These excess deaths are considered preventable and signify an opportunity gap that could benefit from prevention efforts. Further investigation into the causes and other factors that may have contributed to this gap is necessary.

A Phase 2 PPOR analysis should be done for Clark County to determine which causes and risk factors are most likely to have the greatest effect on the community’s FIMR. Phase 2 is a process that identifies specific pathways and mechanisms for excess FIMR by exploring previously identified opportunity gaps (Sappenfield, Peck, Gilbert, Haynatzka, and Bryant, 2012b). Because Clark County’s largest opportunity gap falls within the MH/P period of risk, the Kitagawa Protocol is recommended (Sappenfield et al., 2010b). The Kitagawa protocol will help determine whether the predominant mechanism for MH/P is birthweight distribution (Prematurity) or birthweight-specific mortality (Perinatal Care) (Sappenfield et al., 2010b). The
results of this analysis will lead to more specific areas of focus and will provide better direction for planning prevention activities and programs.

Limitations

There are two limitations involved in conducting this PPOR analysis. First, this study excludes infant deaths under 500 grams birthweight and fetal deaths under 500 grams or earlier than 24 weeks gestation. While this restriction is recommended by CityMatCH to ensure data quality and consistency of reporting, it may result in an underestimation of fetal-infant mortality and excess mortality calculations. Second, this study included less than the recommended sample size of 60 fetal and infant deaths (n=56), which may affect the accuracy of the PPOR analysis.

Conclusion

Across all periods of risk, Clark County had the highest rate of excess, preventable mortality in the Maternal Health/Prematurity period. This means that prevention strategies should focus on improving Preconception Health, Health Behaviors, and Perinatal Care. Since Maternal Care was the second largest opportunity gap, some efforts should also be focused on improving Prenatal Care, High-risk Referral, and Obstetric Care. In order to narrow the focus of prevention strategies, Phase 2 PPOR analysis must be done for Clark County in the near future to discover which risk factors contribute the most to excess FIMR.
References


CityMatCH. (n.d.) PPOR National data tables: Table 7A. Retrieved April 6, 2018, from http://webmedia.unmc.edu/Community/CityMatch/PPOR/NationalDataTables98-00/Table7A.pdf


