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Perinatal Periods of Risk Analysis: Disentangling Race and Socioeconomic Status to Inform a Black Infant Mortality Community Action Initiative

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Abstract *Objectives* The goal of this study is to use Perinatal Periods of Risk (PPOR) analysis to differentiate broad areas of risk (Maternal-Health/Prematurity, Maternal Care, Newborn Care, and Infant Health) associated with being Black from those associated with being poor. *Methods* Phase I PPOR compared two target populations (Black women/infants and poor women/infants) against a gold standard reference group (White, non-Hispanic women, aged 20+ years with 13+ years of education), then against each other. Phase II PPOR further partitioned excess risk into (1) Very-low-birthweight-risk and (2) Birthweight-specific-mortality-risk and identified individual-level risk factors. *Results* Phase I PPOR revealed Black excess mortality within the Maternal-Health/Prematurity category (67% of total excess mortality). Phase II PPOR revealed that Black excess mortality within this category was primarily due to premature deliveries of very-low-birthweight infants. In a unique extension of the PPOR methodology, a poverty-excess-PPOR was subtracted from the Black-excess-PPOR, and showed that Black women have substantial excess mortality above and beyond that associated with poverty. Subsequent analyses to identify Black-specific risks, controlling for poverty, found that vaginal bleeding, premature rupture of membranes, history of preterm delivery, and having no prenatal care significantly predicted preterm delivery. *Conclusions* This study demonstrated the utility of PPOR, a standardized risk assessment approach for focusing health promotion efforts. In the study community, PPOR identified that maternal preconception and prenatal factors contributed the greatest risk for Black infants due to prematurity and low birthweight. Higher socioeconomic status did little to mitigate this risk. These findings informed a community-wide plan that integrated evidence-based strategies for addressing systematic racial inequity with strategies for addressing systematic socioeconomic disadvantage.

Keywords Perinatal Periods of Risk · Kitagawa analysis · Racial disparities · Socioeconomic disparities

Significance

What is already known on this subject Racial disparity in infant mortality persists despite overall population improvement. The contribution of poverty to racial disparity varies by community. Perinatal Periods of Risk Analysis is a population-health tool that identifies broad categories of excess risk. *What this study adds* Extends the use of PPOR to compare two at risk populations within a community to identify categories of excess risk specific to each population. In a community with high Black infant mortality, the Black population exhibits excess risk above and beyond socioeconomic status, primarily associated with maternal preconception/prenatal health factors. The poor population

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has disproportionate excess risk associated with infant health factors, primarily related to unsafe-sleep.

Introduction

Over the last century in the United States, infant mortality has dropped more than 90%, from 100 infants dying within their first year in 1915 to a historic low of 6.0 infants dying in 2014 (per 1000 births) (CDC 1999; U.S.DHHS 2015). This decline has been attributed to improvements in sanitation, living conditions, medical advancements, public health programming and, most recently, putting infants to sleep on their backs, which prevents sudden infant death syndrome (Kinney and Thach 2009). Within the U.S., infant mortality can vary dramatically by geography. At the state level, rates range from a low of 4.1 IMR (Infant Mortality Rate per 1000 infants) in Iowa to a high of 9.6 in Mississippi. However, within states, there is additional geographic variability between counties (Xu 2016). In addition there are regional variations in the causal reason for death; including inadequate medical care, pollution, injury, maternal health or preterm birth (Lawn et al. 2006; Rosano et al. 2000; Waller et al. 1989). Mortality causation can further vary between groups within the same community, such as low and high-income groups or different racial groups (Eudy 2009; Kramer and Hogue 2008).Focusing prevention efforts and identifying the most appropriate evidence-based maternal-infant interventions is complicated by the complex interaction of individual and community factors that contribute to infant mortality within a community (Avellar et al. 2016).

The Perinatal Periods of Risk (PPOR) analysis is a structured appraisal that captures the dynamic, multifactorial contributors to infant mortality and translates these into broad risk categories (CityMatch 2016; Peck et al. 2010). Developed by the World Health Organization, the Centers for Disease Control and Prevention and CityMatch, PPOR is a multi-stage approach combining vital statistics data with community engagement in an iterative process of surveillance and collective intervention (CityMatch 2016; McCarthy 1992). PPOR maps infant birthweight by age at death to produce four categories of risk, each tied to specific problem areas (Sappenfield et al. 2010a, b):

1. Maternal Health/Prematurity category (preconception health, health behaviors, perinatal care, etc.)
2. Maternal Care category (prenatal care, referral system, high-risk obstetric care, etc.)
3. Newborn Care category (perinatal management, perinatal system, pediatric surgery, etc.)
4. Infant Health category (sleep-related, injury prevention, breast-feeding, etc.)

PPOR has been particularly useful as a standardized approach for assessing perinatal health disparities, enabling communities to develop policies and programs to reduce the identified disparities (Stampfel et al. 2012; Sappenfield 2010a). The state of Michigan, where the study county is located, utilized PPOR to frame statewide infant mortality reduction efforts (State of Michigan 2016). Similar to PPORs across the United States, Michigan's PPOR identified excess mortality among the Black population that was concentrated within the Maternal Health/Prematurity category (Griffith et al. 2012; Besculides et al. 2005; Cai et al. 2005, 2007; Hoff et al. 2009; Sappenfield et al. 2010a). The resulting State of Michigan Infant Mortality Reduction Plan included elimination of racial disparities as an overarching goal, proposing to integrate the life course approach to address preconception maternal health, and to adopt strategies that focus upon the social determinants of health, particularly those related to poverty (State of Michigan 2016).

A broad body of maternal-infant health literature underscores the strong connection between being Black, having low income and experiencing poor infant outcomes (prematurity, low birthweight, infant mortality, sudden infant death syndrome) (Cooper et al. 2013; Eudy 2009; Kinney et al. 2009; Krieger 2014). No studies, to date, however, have utilized PPOR to parse high Black infant mortality into (a) mortality associated with being Black and (b) mortality associated with being low income (Cai et al. 2005, 2007; Sappenfield et al. 2010b). Given the importance this distinction has for public action, this is a critical gap in the current literature.

Kalamazoo County, MI, offers an ideal setting for such an inquiry. Kalamazoo County has a history of high Black infant mortality rates (IMR) (17.4 per 1000 live births among Black women, 2010–2012 period) and high racial disparity (Black to White IMR disparity ratio of 4.5, 2010–2012 period). The IMR disparity ratio of 4.5 is markedly higher than the state's ratio of 2.6 and the nation's ratio of 2.2 during the same period (Michigan Department of Community Health 2014; Xu et al. 2016). The PPOR analysis presented here was conducted by Kalamazoo Healthy Babies-Healthy Start as a standardized approach to identify broad areas of risk in a Healthy Start community with high Black infant mortality, and to isolate risk patterns that are associated with race compared to those associated with income status.

Methods

PPOR Samples

The PPOR sample consisted all fetal and infant deaths that occurred to women residing in Kalamazoo County MI at the time of delivery. PPOR birth counts were based upon the

combined total of all infant births and all stillbirths (fetal deaths at 24 or more weeks gestation) from the years 1997 to 2012. PPOR death counts were based upon the combined total of all infants who died in the years 1997 to 2012 and all stillbirths. Infant deaths were defined as deliveries of live infants who died within 365 days after delivery. Stillbirths were defined as deliveries of infants who were dead at birth. Inclusion criterion for infant and stillbirths was birthweight of 500 g or more. Infant deaths were Infant study sample variables were obtained from linked birth and infant death certificates. Stillbirth study sample variables were derived from the fetal death certificate. Cases with missing PPOR-criterion data were excluded from the study sample. Less than 3% of the linked birth–death certificate cases had to be excluded from the infant study sample due to missing data. All stillbirths reported to the Michigan Department of Community Health, Vital Records Division were included; although it is suspected that these records under-report fetal deaths. State definitions for reporting infant and fetal deaths remained the same over the study period, 1997–2012. A quality check of infant birthweight counts from the linked birth–death certificate data for birthweights $\geq$ 500 g showed the same counts as those calculated for the PPOR analysis.

Based upon recommendations from Sappenfield et al. (2010a, b), the reference group for each of the analyses was: Non-Hispanic, white women, aged $\geq$ 20 years, with $\geq$ 13 years of education. To maintain the integrity of the study, an internal reference group was selected: woman from the same community, Kalamazoo County, as the comparison populations. This reference group represented over 15% of the study population and with at least 60 feto-infant deaths during the study periods (Sappenfield et al. 2010a). There were two comparison populations, women of Black race and women with Medicaid-paid birth, a measure of poverty. Race was based upon maternal race, as recorded in the birth certificate records. To maintain consistency with state-level racial categorization, infants with either "Black" or "multi-race Black" were included in the Black counts, those with either "White" or "multi-race White" were included in the White counts. The "multi-race" designation is the result of mother completing the birth certificate race item and indicating multiple races. In these instances, a federal algorithm combines the reported races into one group (White, White Multi-Racial, Black, Black Multi-Racial, etc). A sub-analysis by study investigators confirmed that multi-race White infants were more similar to White infants, and multi-race Black infants were more similar to Black infants regarding Medicaid status, paternal education and birth outcomes.

Vital Statistics

Birth and infant death rates for the county and the state were calculated for the study period 1997–2012 by the Kalamazoo county epidemiologist for the purposes of this study. These counts were generated from birth certificate datasets provided by the Michigan Department of Community Health, Division of Vital Records and Health Data Development. Comparable national statistics were generated using CDC Wonder database (http://wonder.cdc.gov/). Race for birth-rate calculations was defined by maternal race, and race for death-rate calculations were defined by infant race.

Phase 1

Data for the Kalamazoo County Michigan PPOR was provided by the Michigan Department of Community Health, Division of Vital Records and Health Data Development, who generated counts of infant births, fetal deaths, neonatal deaths (occurring within 28 days of delivery) and post-neonatal deaths (occurring between 28 and 365 days after delivery). Annual counts during the 1997 through 2012 period were produced for the total population and the following sub-groups: the Black population, the Medicaid (i.e., poor) population, and the reference population (Kalamazoo County non-Hispanic White women, age 20+, with 13 or more years of education).

For reliable PPOR mapping, mortality of 60 individuals or more are needed. Because Kalamazoo County is a mid-sized community (with an average of 15 infant deaths per year), and the analytical focus of the study further divided this into sub-populations, the PPOR was calculated using 10-year increments.

Applying the PPOR algorithm, maps were produced for Black infants, poor infants, and the reference-group infants. Then, "excess" deaths were calculated by subtracting these PPOR maps from each other in the following manner:

- Excess Black map = [Black PPOR] minus [Reference PPOR]
- Excess Poor map = [Poor PPOR] minus [Reference PPOR]
- Trend analysis = [2003–2012 PPOR] minus [1997–2006 PPOR]

To isolate the relative contribution of being Black from being poor on infant mortality, a final excess map was calculated by subtracting the poor-excess PPOR map from the Black-excess PPOR map. This final step is unique to the current study, and extends the application of PPOR methodology to identify excess deaths between two related sub-populations (Black and Poor); groups that, historically, display a substantial degree of overlap. Producing a Net-Black-Excess map uses PPOR Phase I Analytical methods to simplify the complex interrelationship of race and socioeconomic status and identify the opportunity gaps that are specific to being Black; opportunity gaps that exist independent of those

associated with being poor, given that poverty has, literally, been deducted from the equation (Sappenfield et al. 2010a).

Phase 2

In Phase 2, a Kitagawa analysis was conducted to further partition risk within the "Maternal Health/Prematurity" category. Applying a statistical formula originally developed by Evelyn Kitagawa in 1955 (Kitagawa 1955), excess risk within this category is divided into VLBW (very low birth weight) Risk and Birthweight-specific risk. The first mortality pathway is generally attributed to being born too early or too small (at a birthweight less than 1500 grams), and points to maternal health-related factors. The second mortality pathway considers excess death among infants who have similar birthweights, and directs attention to issues related to infant health or perinatal care of either the mother or infant.

Similar to Phase 1 data collection methods, data counts for Phase 2 were provided by the Michigan Department of Community Health, Division of Vital Records and Health Data Development. Summary counts of infant birth and deaths within Kalamazoo County, Michigan occurring during the most recent period, 2003–2012, formed the basis for the Kitagawa analysis. Linked birth and death records contained cause of death codes, which were categorized into natural, non-natural (accidents, homicide, unsafe sleep-related) and undetermined. Again, separate calculations were conducted for Black infant deaths compared to the reference population, and for poor infant deaths compared to the reference population. Kitagawa results were derived using the formula below:

$$MR_1 - MR_2 = \sum_{1}^{n} \left(\left(\frac{(P_{1n} + P_{2n})}{2} \times (M_{1n} + M_{2n}) \right) + \left(\frac{(M_{1n} + M_{2n})}{2} \times (P_{1n} + P_{2n}) \right) \right)$$

where n is the number of birthweight categories (seven categories were used in this analysis), MR_1 is the overall feto-infant mortality rate for high (target) mortality group, MR_2 is the overall feto-infant mortality rate for the reference group, P_{1n} is the proportion of births for a specific birthweight category for the high mortality group, P_{2n} is the proportion of births for a specific birthweight category for the reference group, M_{1n} is the Birthweight specific mortality rate for high mortality group, M_{2n} is the Birthweight specific mortality rate for the reference group.

Additional analyses were conducted to identify the primary risk factors for prematurity (delivery < 37 weeks gestation) among Black women with singleton deliveries. These analyses were conducted using Kalamazoo County birth records for 2008–2012, the years for which detailed data was available to study investigators. To isolate the risk factors specific to Black race, logistic multivariable regression was used, adjusting for income (Medicaid-paid delivery or not). Statistical significance was two-sided and set at $p < .05$.

Institutional review board oversight for this study was provided by the Western Michigan University Human Subjects Institutional Review Board.

Results

Infant Mortality Rates

Over a 15-year period, infant mortality rates decreased 29% in the study county, from 8.6 deaths per 1000 births in 1997 to 6.1 in 2012. At the same time, racial and socioeconomic disparities grew, Black:White relative risk increased from 1.3 (1997) to 4.5 (2012), and the Medicaid:non-Medicaid relative risk increased from 1.6 (1997) to 2.6 (2012). This is different from the trends seen at the state and national levels, where overall infant mortality declined (by 14 and 15% respectively), and where racial and socioeconomic disparities were higher to begin with, but subsequently declined. At the state level, racial disparities dropped from 2.9 (1997) to 2.5 (2012) Black:White relative risk, and from 1.9 (1997) to 1.5 (2012) Medicaid:non-Medicaid relative risk. At the national level racial disparities remained fairly constant, from 2.3 Black:White relative risk in 1997 to 2.1 relative risk in 2012.

As demonstrated in Table 1, Kalamazoo is comparable to the state and the nation regarding racial and socioeconomic distribution of infant births, and of overall infant death rates. However, as described above and shown in Table 1, the racial and socioeconomic disparities seen in the study county are markedly higher than that at the state and national levels. Further, race and socioeconomic status interact, such that Black populations see less health gain with improvements in socioeconomic status compared to White populations. During 2010–2012, Kalamazoo County infants with Medicaid were nearly three times more likely to die than infants whose births were self-paid or covered by private insurance (10:3, Medicaid-paid:non-Medicaid infant deaths per 1000 live births). However, this income disparity did not hold when examining infant death by race. Black infants regardless of income, died at higher rates than their White counterparts (Medicaid paid infant deaths 17: 6, Black: White, per 1000 live births, and for non-Medicaid 19: 2, Black: White infant deaths per 1000 live births, data not shown). A similar trend was observed for the state of Michigan. Suggesting that there

Table 1 Comparison of the study county to state and national birth and infant death rates, 2010–2012

	Kalamazoo County	State of Michigan	Nation
Birth population (Total Births, 2010–2012)	9305	341,584	11,905,817
Race (annual average % of births)			
White births	77.5	74.6	76.3
Black births	17.7	19.2	16.0
Other race births	4.8	7.1	7.7
Hispanic ethnicity (annual average % of births)	6.1	6.7	23.3
Socioeconomic status (annual average % of births)			
Non-medicaid paid delivery	53.3	54.0	NA
Medicaid paid delivery	46.5	44.8	NA
Unknown or other	0.1	1.2	NA
Infant deaths (rate per 1000, 2010–2012)*	6.43	7.76	6.06
Race (rate per 1000)*			
White deaths	3.88	5.28	5.14
Black deaths	17.40	13.76	11.08
Other race deaths	12.47	4.87	4.85
Hispanic ethnicity (rate per 1000)*	7.05	7.45	5.17
Socioeconomic status (rate per 1000)*			
Non-Medicaid paid delivery	3.4	5.6	NA
Medicaid paid delivery	9.7	8.1	NA

NA not available

*Moving average for 2010–2012

are factors that contribute to Black infant mortality that are unrelated to poverty.

Perinatal Periods of Risk Analysis, Stage 1

Excess Mortality among Black and Poor Populations

Overall, the data in Table 2 show that total Black excess mortality increased by 8%, from 10.1 to 10.9 (per 1000 births) for the periods 1997–2006 and 2003–2012, while total poverty excess mortality decreased by 25% between the two time periods assessed. The majority of the excess mortality among the Black population was attributed to the Maternal Health/Prematurity category and increased over time, from 50% in 1997–2006 to 67% in 2003–2012. The Infant Health category was the next largest category contributing to mortality, with Black mortality in excess of White mortality at 29 and 20% in the 1997–2006 and 2003–2012 periods, respectively.

Compared to the Reference group, poor infants had excess mortality of 8.0 and 5.9 per 1000 births compared to the reference group for the time periods 1997–2006 and 2003–2012, respectively. Among the poor population, the Maternal Health/Prematurity category accounted for 40 and 59% of excess mortalities for the two periods of time. Again, the Infant Health category was the next largest, with excess rates that stayed level across the time periods, 28 and 27% for 1997–2006 and 2003–2012, respectively.

Comparing Excess Mortality Among Black and Poor Populations

The net (Black minus poor) excess mortality PPOR from 1997 to 2006 was 2.3 per 1000 births (data not shown); a rate that more than doubled to 5.1 per 1000 births in the 2003–2012 period (3.8 + 0 + 0.8 + 0.5, see Fig. 1 below). Risk within this net excess PPOR was predominantly within the Maternal Health/Prematurity category (75% in 2003–2012). The second largest category of risk, Infant Health, had more to do with being poor than with being Black. Only a fraction of net excess (0.5 per 1000 births) remained in the Infant Health category after subtracting the poverty PPOR (1.6) from the Black PPOR (2.1).

Perinatal Periods of Risk Analysis, Stage 2 (Maternal Health/Prematurity)

The Kitagawa analysis, conducted for the 2003–2012 time period, further partitioned excess mortality in the Maternal Health/Prematurity category, showing that for both the Black and the poor populations, risk was most heavily weighted toward maternal health factors (birth weight distribution): 73% of Black excess and 64% of poor excess

Table 2 Fetal–Infant death rates within the perinatal periods of risk categories—Kalamazoo County, MI

	Maternal Health/ Prematurity	Maternal care	Newborn care	Infant health	Total*
Race (1997–2006)					
Black	7.4	2.9	1.0	3.5	14.7
Reference	2.3	0.9	0.8	0.6	4.6
Excess	5.1	2.0	0.2	2.9	10.1
Race (2003–2012)					
Black	8.7	2.0	1.6	2.9	15.2
Reference	1.4	1.3	0.7	0.8	4.3
Excess	7.3	0.7	0.9	2.1	10.9
Poverty (1997–2006)					
Medicaid	5.5	2.6	1.6	2.8	12.6
Reference	2.3	0.9	0.8	0.6	4.6
Excess	3.2	1.7	0.8	2.2	8.0
Poverty (2003–2012)					
Medicaid	4.9	2.0	0.8	2.4	10.2
Reference	1.4	1.3	0.7	0.8	4.3
Excess	3.5	0.7	0.1	1.6	5.9

Reference Kalamazoo County non-Hispanic, White women, age 20+ years, 13+ years of education

*Categories may not sum to total due to rounding

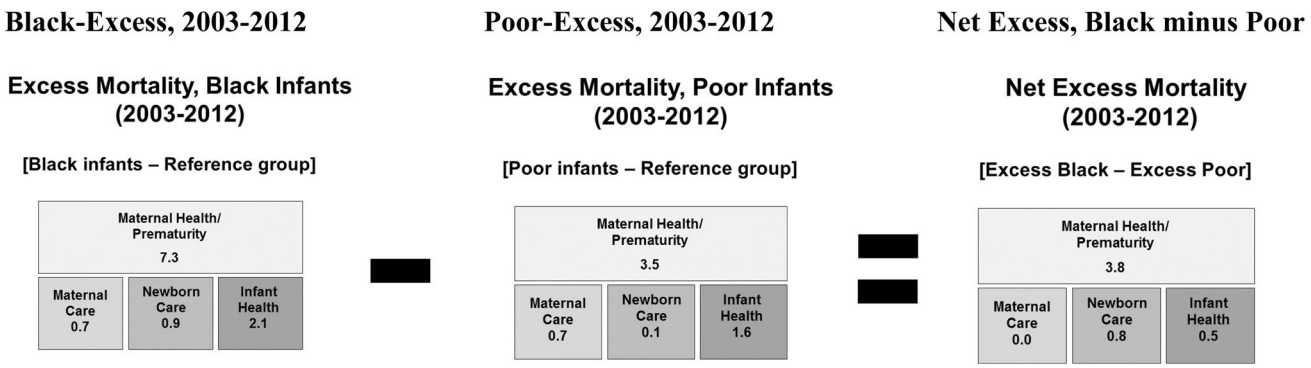

Fig. 1 Perinatal periods of risk analysis: black excess minus poverty excess

mortality was due to infants being born too early or too small (VLBW very low birthweight). The first mortality pathway is generally attributed to being born too early or too small (at a birthweight less than 1500 g), and points to maternal health-related factors. The second mortality pathway considers excess death among infants who have similar birthweights, and directs attention to issues related to infant health or perinatal care of either the mother or infant.

The Kitagawa analysis apportioned the remaining excess risk, 27% for the Black population and 36% for the poor population, into to birthweight specific mortality Deaths within this category are linked to infant health and medical care. Apart from the natural disadvantage of being born too early or too small, being Black and being poor conferred added risk to infant survival. In sum, not only were Black and poor mothers more likely to deliver early than their White higher-income counterparts, but their infants with the same birthweights were more likely to die.

As shown in Table 3, subsequent analyses of maternal risk factors, controlling for socioeconomic status, identified vaginal bleeding (a relatively rare event) as the leading risk for premature delivery among Black women. Other critical risks included lacking any prenatal care, having a history of prior preterm delivery, and premature rupture of membranes.

Discussion

In a community where racial and socioeconomic disparities have grown steadily over the last 15 years, PPOR analysis

Table 3 Predictors of Premature Delivery (< 37 weeks gestation) among Black Women, Kalamazoo County, 2008–2012

	Prevalence % (#)	Odds of premature delivery aOR*	*p*
Maternal demographics			
Adolescent	22.8 (620)	1.15	0.292
< High school education	25.1 (683)	1.52	0.001
Single	82.1 (2232)	1.04	0.803
Maternal Health			
Sexually transmitted disease (non-GBS)	19.8 (538)	1.13	0.397
Chronic disease (diabetes, hypertension)	16.1 (439)	1.54	0.002
Obese BMI	33.9 (921)	0.72	0.009
Prior preterm delivery	6.4 (174)	4.44	< 0.001
prenatal care			
No prenatal care	2.4 (66)	4.60	< 0.001
Late to prenatal care (initiated past first trimester)	38.3 (1041)	0.87	0.247
Prenatal smoking (tobacco)	26.7 (727)	1.12	0.362
Delivery complications			
Premature rupture of membranes	10.1 (276)	4.16	< 0.001
Chorioamnionitis	1.1 (29)	1.81	0.203
Vaginal bleeding	0.7 (18)	8.13	< 0.001

*Each predictor adjusted for income (Medicaid-paid delivery or not)

offered a standardized approach for examining the differential contributions of race and poverty. Study results identified excess health burdens for Black individuals in the area of preconception and prenatal health (Maternal Health/Prematurity); a burden that has increased in recent years and that remains substantial even after poverty is taken into account. PPOR maps revealed that, regardless of income level, the health of Black women before and during pregnancy was the largest source of health inequity within the study county. Risks that were most detrimental to full-term deliveries among Black women included having a prior preterm delivery, lacking prenatal care, vaginal bleeding and premature rupture of membranes. The next biggest PPOR risk category, Infant Health, was largely accounted for by poverty, with the majority of post neonatal deaths resulting from unsafe-sleep conditions. This unique application of PPOR, which separated the contributions of race and poverty, identified important differences that were useful in directing public health action.

Excess mortality related to maternal health is a common finding among PPORs conducted within the U.S., whether they compare an entire community against a gold-standard reference, one geographic area against another, or one racial group against another (Besculides et al. 2005; Cai et al. 2005; Chao et al. 2010; Guillory et al. 2008; Hoff et al. 2009). Subsequent analyses have often identified low socioeconomic status (typically defined by Medicaid insurance) as a dominant risk factor distinguishing the PPOR target population from the reference population (Cai et al. 2005, 2007; Guillory et al. 2008). Both of these trends were reflected in current study findings which, by highlighting the degree and nature of risk associated with race and isolating it from that associated with poverty, spurred the development of a community-level strategic plan, Cradle-Kalamazoo, to address both. This plan was developed using the collective impact approach, which formally organizes community residents and service agencies to address a common goal through shared operational structures and processes (Healthy Start Epic Center 2016; Kania and Kramer 2011; Minkler et al. 2001). Led by the YWCA-Kalamazoo in partnership with Western Michigan University Homer Stryker M.D. School of Medicine and Kalamazoo Health and Community Services and Healthy Start, Cradle Kalamazoo's goal was to reduce Black infant mortality to 6.0 deaths per 1000 births, the Healthy People 2020's infant mortality goal. Multiple strategies were implemented to tighten the safety net under the community's most vulnerable families: street outreach, coordinated resource-linkage and home visitation support. As a result of these analyses, the Cradle-Kalamazoo Initiative intentionally focused efforts on three populations: (1) Black women at all income levels, (2) poor women and (3) women who had experienced a prior poor birth outcome (preterm delivery, low birth weight or infant death).

This community action plan was designed by a leadership steering team focused by the underlying social causes of racial inequities, e.g., differential access to knowledge and resources, and disproportionate stress because of lower social status, impoverished environments and limited control over daily living conditions (Aneshensel 2015; Krieger 2014; Link and Phelan 1995). With demonstrated

effectiveness engaging socially disenfranchised populations, accessing community resources, and improving health practices, Kalamazoo Healthy Start program, along with other community health worker and home visitation programs, comprised the working elements of the planned system (Avellar et al. 2016; Lewin et al. 2010). A sub-group was formed to organize culturally-competent safe-sleep-related trainings for medical, public health and social service providers. Following guideposts laid down by nationally-funded care coordination initiatives (Hanlon 2013; McDonald et al. 2007), the plan integrated program elements into a streamlined delivery process using a dedicated hotline within the local 2-1-1 system, and creating a care coordination registry of all prenatal home visitation referrals and weekly community case-review meetings. Outreach capacity and co-location was expanded from prenatal clinics to include WIC, Medicaid benefit sites, and community association sites. In a partnership between the public health department and the new medical school within Kalamazoo, Fetal Infant Mortality Review was strengthened, by incorporating medical students, residents and faculty and expanding case data collection to include maternal and paternal interviews. To embed these efforts within important social institutions in the hardest hit neighborhoods, formal partnerships with faith based institutions were established. Finally, local anti-racism expertsprovided anti-racism trainings, health equity workshops and ongoing project oversight. Public education presentations were delivered to community and professional audiences using the PPOR maps generated, as an effective method for describing how race and socioeconomic status were interacting to produce excess risk for Black families in Kalamazoo County.

In addition to the collaborative activities described above, results from the PPOR analysis led the Kalamazoo Healthy Start program to: (1) initiate a social media campaign with local radio, talk show and print publications celebrating being Black (Rodriguez et al. 2012), (2) develop fatherhood programming for enhanced family engagement, and (3) expand stress-reduction activities within the community, including yoga, maternal massage, infant massage, breathing exercises, and swimming classes(Ingoldsby 2010).

Limitations

These findings should be viewed in light of the following study limitations. The number of unreported fetal death cases is unknown, introducing potential bias into study results. As dichotomized measures, the two key study indicators, race and income, may not have captured important dimensions of these concepts, particularly as only White and Black race infants had sufficient numbers to be included in the analysis, and multi-racial infants were forced into White or Black racial categories, which can mask important differences from single-race infants. Additionally, as is common practice, infant race for birth vital statistics and the PPOR calculations was drawn from the recorded maternal race, without consideration of paternal race, and thus may not have accurately categorized multi-racial infants. A final caution is that PPOR presents a greatly simplified view of a very complex dynamic. While this is useful in narrowing the lens for preventive action, PPOR should not be used as a stand-alone analysis, but rather, as part of a series of epidemiological analyses that may include matched comparisons of infants with similar demographics but different outcomes, and ongoing monitoring to assess the impact of community interventions on contributors as well as outcomes.

Conclusions

Perinatal Periods of Risk, a standardized approach for identifying population-specific risk, highlighted that maternal preconception and prenatal factors conferred the greatest risk for Black infants, leading to prematurity and low birthweight. Furthermore, Black infants with the same birthweight as White infants died at higher rates, pointing to additional risk associated with infant health and healthcare factors. Higher socioeconomic risk did little to reduce mortality risk among Black infants. These findings informed a community-wide plan that integrated evidence-based strategies for addtableressing systematic racial inequity with those for addressing systematic socioeconomic disadvantage.

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Compliance with Ethical Standards

Conflict of interest This study was sponsored by the Kalamazoo Healthy Babies Healthy Start program, but the program itself has no financial interest regarding the direction of study findings.

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