KITAGAWA ANALYSIS, 2003-2012 Period
Kalamazoo County Healthy Babies-Healthy Start

PROJECT NAME: Kalamazoo County Healthy Babies-Healthy Start

TITLE OF REPORT: Kitagawa Analysis: Partitioning Infant Mortality Risk

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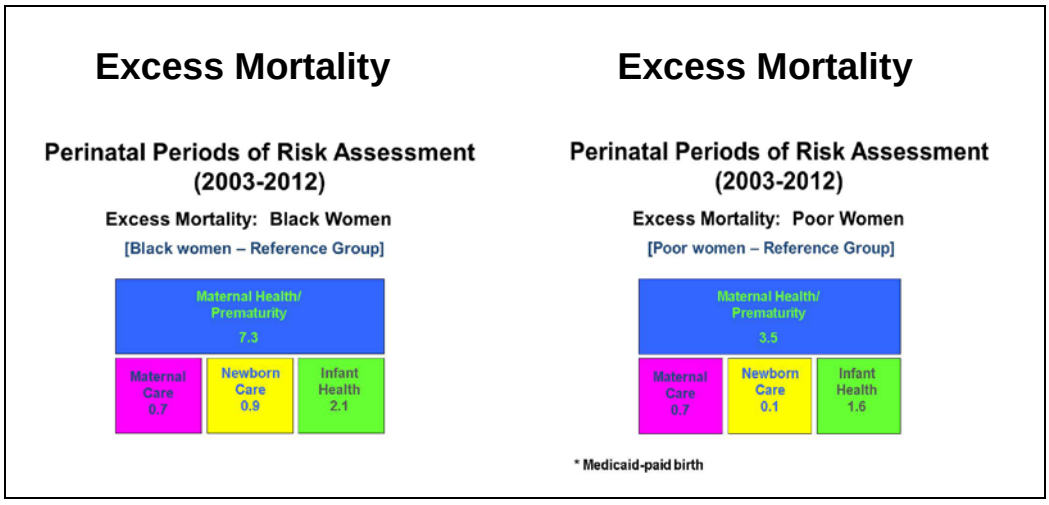
Section I: Introduction

Measuring health disparities, their magnitude and their source, is a challenging task. Difficulties arise for several reasons: First, you are trying to track the difference between populations rather than just the problem itself; leading to the second difficulty, which is that measuring this difference is best done at the population level, and most of our analytical tools, and even our approach to health itself, tend to operate at the individual level. To address this problem, the public health field has developed methods for broadly assessing risk. The first method, Perinatal Periods of Risk (PPOR) Analysis, was developed by the World Health Organization, and later adopted by the Centers for Disease Control and Prevention, for evaluating broad categories of infant mortality risk and focusing public health efforts. A second method, the focus of this report, takes the PPOR to the next step by parsing the risk within the "Maternal Health / Prematurity" category even further.

A recent PPOR analysis identified the "Maternal Health / Prematurity" category as the primary problem area for excess infant mortality for poor women and, even more markedly, for Black women in Kalamazoo County, Michigan (see figure below). Taken together, nearly two-thirds of infant mortality risk is lodged here. Within the United States, and within Michigan specifically, this is the most common problem area for excess risk.



Unfortunately, it is also the broadest category, encompassing contributors spanning preconceptional, prenatal and infant health. These factors include:

- Stress (chronic, traumatic)

- Physical health conditions (reproductive, infection, disease, injury)
- Mental health (depression, anxiety, psychiatric)
- Health care (education, diagnostics, referrals, treatment)
- Behaviors (smoking, drug use)
- Social, living conditions (housing, safety, social support, food access)

Section II: Process

Applying a statistical formula originally developed by Evelyn Kitgawa[1] in 1955, to the "Maternal Health / Prematurity" category serves to further partition this excess risk into two sub-categories: VLBW Risk and Birthweight-specific Mortality Risk. The first mortality pathway is due to being born too early or too small (at a birthweight less than 1,500 grams (e.g., a little over three pounds)), and links risk more solidly to maternal health-related factors. The second mortality pathway is actually more tied to infant-related health and perinatal care to mother and infant, and considers the excess death among infants *who have similar birthweights*.

Key Questions:

1) How much of the excess "Maternal Health / Prematurity" category risk among Black women in Kalamazoo County is due to VLBW-risk and how much is due to Birthweight-specific Mortality risk?
2) Does this vary for poor families?

Methodology:

Summary counts of infant birth and deaths within Kalamazoo County, Michigan occurring during the period 2003 through 2012 formed the basis for this analysis. These counts were generated by the Michigan Department of Community Health, Division of Vital Records and Health Data Development**.** We adopted the traditional option, where all live births of 500 or more grams constituted the denominator, for the following formula:

$$MR_1 - MR_2 = \sum_1^n \left(\left(\frac{(P_{1n} + P_{2n})}{2} \times (M_{1n} - M_{2n}) \right) + \left(\frac{(M_{1n} + M_{2n})}{2} \times (P_{1n} - P_{2n}) \right) \right),$$

{Overall difference} ={Birthweight-specific mortality} + {Frequency of lower birthweights}

where: n= Number of birthweight categories (birthweight "strata")

MR_1=Overall feto-infant mortality rate for high (target) mortality group
MR_2=Overall feto-infant mortality rate for the reference group

P_{1n}=Proportion of births for a specific birthweight category for the high mortality group
P_{2n}=Proportion of births for a specific birthweight category for the reference group

M_{1n}=Birthweight specific mortality rate for high mortality group
M_{2n}=Birthweight specific mortality rate for the reference group

[1] Kitagawa, E.M. (1955) Components of a Difference Between Two Rates. *Journal of the American Statistical Association*, vol. 50, no. 272, pp 1168-1194.

This formula directly estimates the amount of excess mortality due to VLBW versus the amount due to birthweight specific mortality rates. The contributions can be added up across birthweight categories.

An explanation for the reasoning behind the formula will be provided in the example below. There are four points that need to be considered before applying the formula:

1. Live births of less than 500 grams birthweight are excluded in order to decrease the effect of reporting biases.
2. The estimates of the two contributing pathways can be affected by the number of birthweight categories (*n*). The birthweight-specific mortality rapidly decreases with the increase in birthweight. In the current analysis, seven birthweight categories were calculated.
3. If the overall difference in mortality rates between the study group and reference group, ($MR_1 - MR_2$), is very small (say, less than 2 per 1,000), the proportions attributed to each of the contributing pathways become unstable and provide extreme results. When this difference is small, your target population has similar outcomes to the reference population. In addition, since the Kitagawa formula is applied mainly to partition the excess in Maternal Health/ Prematurity mortality, the most stable results are achieved when the Maternal Health/ Prematurity excess is at least 2 per 1,000, as is the case for both populations of excess risk in our analysis: 7.3 for Blacks and 3.5 for Poor.
4. Also, results will be unstable if either of the two groups have less than 60 deaths overall. That requirement usually puts more restrictions on the reference population. In order to make the formula's application feasible for medium-sized communities, a longer period of time is needed; thus, the time span we selected was for the 2003-2012 period.
5. In Kitagawa analysis for Maternal Health/ Prematurity, we are mainly interested in the contribution of the two pathways to the excess of VLBW deaths. These contributions could be found by summing up all numbers contributing to each pathway for only the birthweight categories between 500 and 1,500 grams. Note that the sum of all contributions to cells corresponding to birthweights between 500 and 1,500 grams (both for birthweight frequency and birthweight-specific mortality) is exactly the excess rate for Maternal Health/ Prematurity.

Section III: Findings

Excess Mortality among Blacks:

Table 1. below, with the summary counts, the birthweight distributions and the mortality rates stratified by birthweight category, shows the relatively higher percentages of Black births in the lower birthweight categories. It also shows the relatively higher mortality rates within five of the seven categories. The only two categories with relatively lower deaths appears in the middle, the 1250 g-1499 g and 1,500 g-1,999 g categories.

Table 1. Birthweight Distribution & Birthweight-Specific Mortality for Black & Reference Populations

	Target Population: Black Infants				**Reference Population***			
	Col (1)	**Col (2)**	**Calc (3)**	**Calc (4)**	**Col (1)**	**Col (2)**	**Calc (3)**	**Calc (4)**
	# Live Births	**# Infant**	**Birthweight**	**Infant Mortality**	**# Live Births**	**# Infant**	**Birthweight**	**Infant Mortality**

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Birthweight		Deaths	Distribution	Rates		Deaths	Distribution	Rates
500-749	42	19	0.8%	452.4	21	6	0.1%	285.7
750-999	44	3	0.8%	68.2	27	0	0.2%	0.0
1,000-1,249	33	3	0.6%	90.9	34	2	0.2%	58.8
1,250-1,499	46	1	0.8%	21.7	48	2	0.3%	41.7
1,500-1,999	149	2	2.7%	13.4	174	3	1.2%	17.2
2,000-2,499	443	5	8.1%	11.3	579	4	3.8%	6.9
2,500-6,499	4735	13	86.2%	2.7	14158	16	94.1%	1.1
Total	5492	46	100.0%	8.4	15041	33	100.0%	2.2

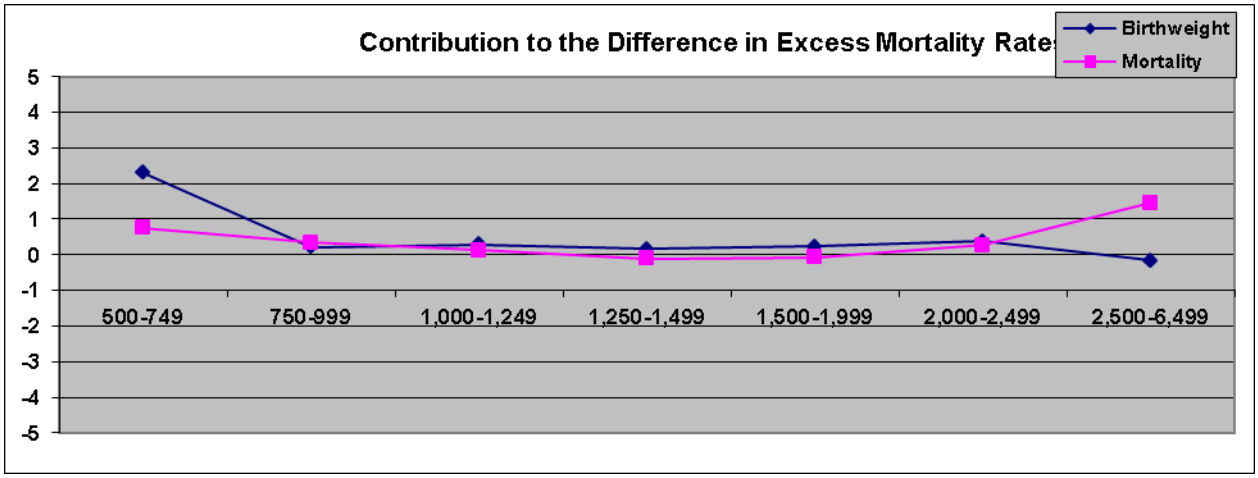
* Births to White, non-Hispanic women, age 20+, with 13+ years of education

Table 2 and Chart 1, together, summarize the relationship between Black and Reference populations, illustrating two patterns: (1) A downward, linear trend within the Birthweight Distribution sub-category, pointing to the substantially greater proportion of Black infants born small, and (2) A mild U-shaped curve within the Birthweight-Specific Mortality rates showing excess deaths among Blacks at the low end of the birthweight spectrum (500-749), and at the high end (2,500-6,499).

Table 2. Excess Mortality – Effects of the Birthweight Distribution & the Birthweight-Specific Mortality

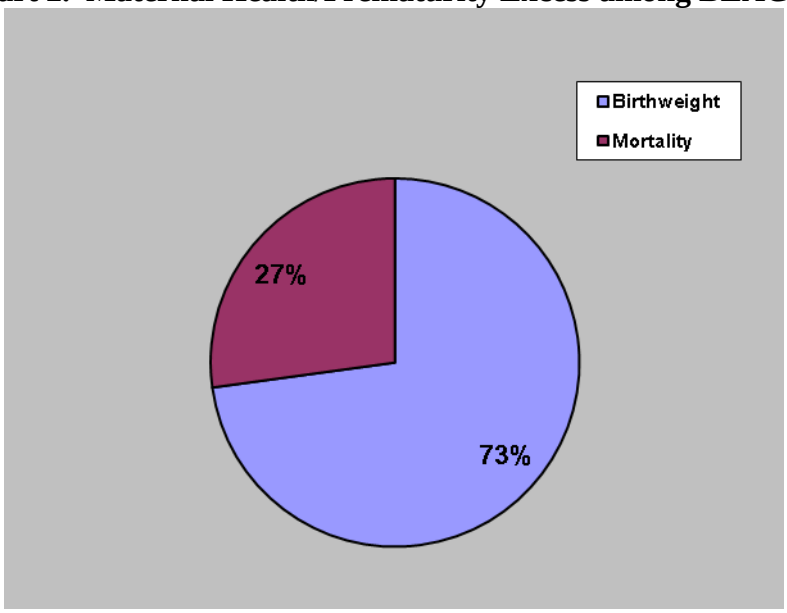
	Actual Contribution to the Difference in Excess Mortality Rates			Percentage Contribution to the Difference in Excess Mortality Rates		
	Column (1)	Column (2)	Calculated (3)	Calculated (4)	Column (5)	Column (6)
Birthweight	Birthweight Distribution	Infant Mortality Rates	Total	Birthweight Distribution	Infant Mortality Rates	Total
500-749	2.3	0.8	3.1	37.3%	12.2%	49.5%
750-999	0.2	0.3	0.5	3.4%	5.4%	8.8%
1,000-1,249	0.3	0.1	0.4	4.5%	2.1%	6.7%
1,250-1,499	0.2	-0.1	0.0	2.7%	-1.9%	0.8%
1,500-1,999	0.2	-0.1	0.2	3.9%	-1.2%	2.7%
2,000-2,499	0.4	0.3	0.6	6.2%	4.2%	10.4%
2,500-6,499	-0.2	1.5	1.3	-2.5%	23.6%	21.1%
Total	3.4	2.7	6.2	55.5%	44.5%	100.0%
MH / Prem.	3.0	1.1	4.1	47.9%	17.9%	65.8%

Chart 1. Excess Mortality – Effects of the Birthweight Distribution & the Birthweight-Specific Mortality



In sum, Kitagawa analysis revealed that Black excess infant mortality is due to both maternal health factors and infant health factors: Black women are more likely than White women to delivery early. ALSO, Black infants born early are more likely to die than White infants born early, especially at the very low end of the birthweight spectrum and into the normal end of the spectrum. As demonstrated in the chart below, within the "Maternal Health / Prematurity" category, the relative contribution of maternal- and infant- health related factors to Black excess mortality is heavily weighted towards maternal factors; a ratio of three to one (73% and 27%). Although not shown, when these figures are distributed across all four PPOR categories of excess risk, the relative distribution is split more evenly between the maternal- (Birthweight) and infant- (Mortality) factors, at 56% maternal and 44% infant.

Chart 2. Maternal Health/Prematurity Excess among BLACKS



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Excess Mortality among Poor:

Table 3. below, with the summary counts, the birthweight distributions and the mortality rates stratified by birthweight category, shows that, similar to Black births, births among Poor families are more likely to fall into the lower birthweight categories. It also shows the relatively higher mortality rates within four of the seven categories. Similar to Blacks, the categories with relatively lower deaths appears in the middle.

Table 3. Birthweight Distribution & Birthweight-Specific Mortality for Poor & Reference Populations

	Target Population: Poor Infants				Reference Population*			
	Col (1)	Col (2)	Calc (3)	Calc (4)	Col (1)	Col (2)	Calc (3)	Calc (4)
Birthweight	# Live Births	# Infant Deaths	Birthweight Distribution	Infant Mortality Rates	# Live Births	# Infant Deaths	Birthweight Distribution	Infant Mortality Rates
500-749	61	28	0.4%	459.0	21	6	0.1%	285.7
750-999	66	5	0.5%	75.8	27	**0**	0.2%	0.0
1,000-1,249	63	**3**	0.4%	47.6	34	**2**	0.2%	58.8
1,250-1,499	75	5	0.5%	66.7	48	**2**	0.3%	41.7
1,500-1,999	270	**3**	1.9%	11.1	174	**3**	1.2%	17.2
2,000-2,499	911	6	6.5%	6.6	579	**4**	3.8%	6.9
2,500-6,499	12653	35	89.7%	2.8	14158	16	94.1%	1.1
Total	14099	85	100.0%	**6.0**	15041	33	100.0%	**2.2**

* Births to White, non-Hispanic women, age 20+, with 13+ years of education

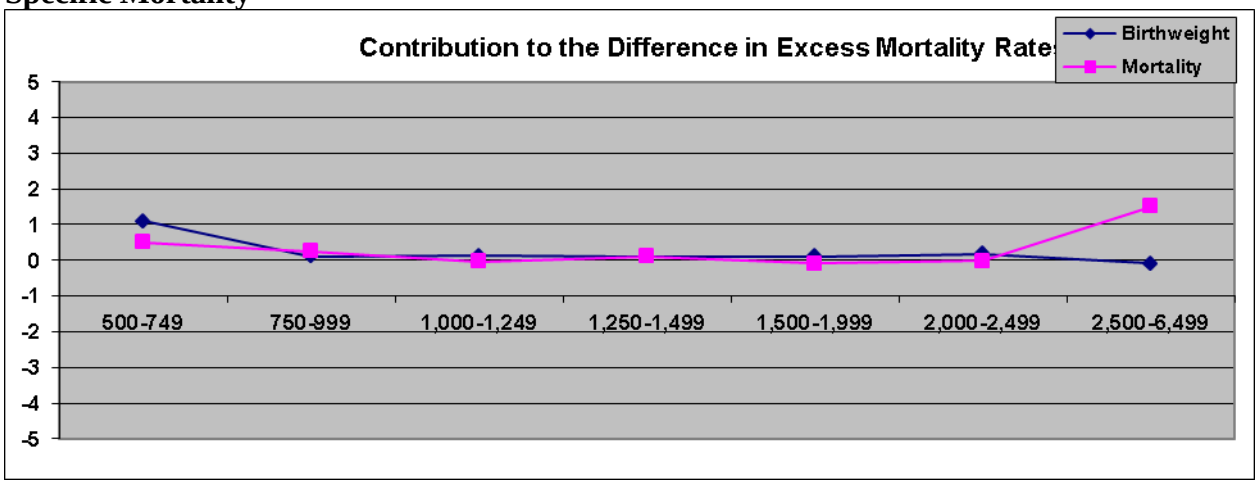
Table 4 and Chart 3, together, summarize the relationship between Poor and Reference populations, and illustrate the same general patterns seen in the Black-Reference populations: (1) A somewhat flattened downward trend within the Birthweight Distribution sub-category, pointing to the greater proportion of Poor infants born small, and (2) An even milder U-shaped curve within the Birthweight-Specific Mortality rates showing excess deaths among Poor infants at the low end of the birthweight spectrum (500-749) and, more markedly for Poor infants, at the high end (2,500-6,499).

Table 4. Excess Mortality – Effects of the Birthweight Distribution & the Birthweight-Specific Mortality

	Actual Contribution to the Difference in Excess Mortality Rates			Percentage Contribution to the Difference in Excess Mortality Rates		
	Column (1)	Column (2)	Calculated (3)	Calculated (4)	Column (5)	Column (6)
Birthweight	Birthweight Distribution	Infant Mortality Rates	Total	Birthweight Distribution	Infant Mortality Rates	Total
500-749	1.1	0.5	1.6	28.5%	12.9%	41.4%
750-999	0.1	0.2	0.4	2.9%	6.4%	9.2%
1,000-1,249	0.1	0.0	0.1	3.1%	-1.0%	2.1%
1,250-1,499	0.1	0.1	0.2	3.0%	2.8%	5.8%
1,500-1,999	0.1	-0.1	0.0	2.8%	-2.5%	0.3%
2,000-2,499	0.2	0.0	0.2	4.6%	-0.4%	4.2%
2,500-6,499	-0.1	1.5	1.4	-2.2%	39.2%	37.0%

Total	1.6	2.2	3.8	42.5%	57.5%	100.0%
MH / Prem.	1.4	0.8	2.2	37.4%	21.1%	58.5%

Chart 3. Excess Mortality – Effects of the Birthweight Distribution & the Birthweight-Specific Mortality



The Kitgawa findings for Poor infants produced very similar results to those for Black infants, not surprising given the substantial overlap between Black race and poverty in Kalamazoo. Similar to the Black-related results, Kitagawa analysis showed that excess mortality among Poor infants is due to both maternal health factors and infant health factors: Poor women are more likely than higher-income women to delivery early. In addition, Poor infants born early are more likely to die than higher-income infants born early. The effect of poverty appears to weigh more heavily upon infant health than the effect of race: Compared to 27% of excess within the "Maternal Health / Prematurity" category attributed to infant factors among Black individuals, 36% of excess among Poor individuals is due to infant-health factors. Although not shown, when these figures are distributed across all four PPOR categories of excess risk, the amount attributed to infant-health (Mortality) factors is even more marked, accounting for over half, 57%, of all excess mortality among poor families.

Chart 4. Maternal Health/Prematurity Excess among POOR

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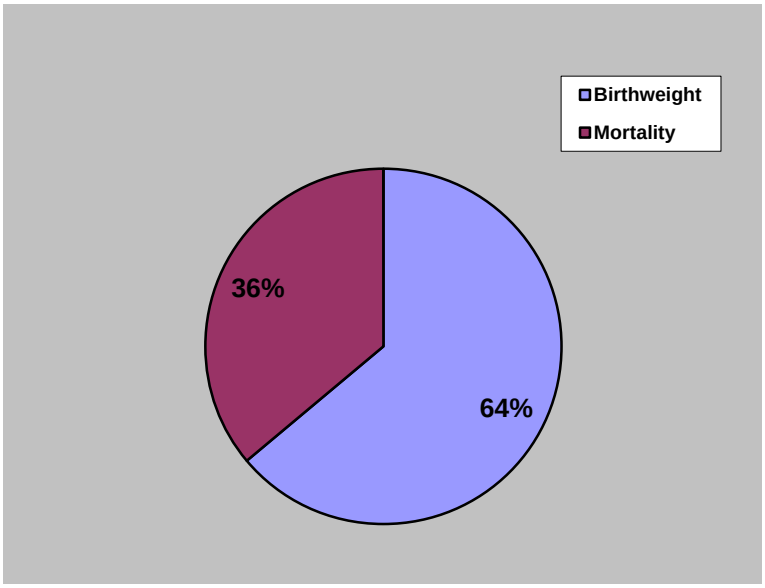

Section IV: Conclusions & Recommendations

Conclusions

The risk conditions that lead to extreme prematurity (<28 weeks) or very low birthweight (<1,500 grams) infants are known to contribute to maternal ill health that, subsequently leads to these birth outcomes. As such, they are largely considered in the context of maternal risk. What results from the Kitagawa analysis reveal is the extent to which these risks extend to the infant as well. Apart from the natural disadvantage of being born too early or too small, both being Black and being poor confers added risk to infant survival. In other words, not only is a Black mother more likely to deliver early but her infant is more likely to die than a White, higher-income infant born under the same conditions.

Similar to the PPOR findings, this added risk to infant is more pronounced for Poor families than it is for Black families.

Recommendations

1. Examine the strength of various health and behavioral predictors of VLBW births, and of Perinatal Care:
    a. Analyze population-based birth and death records for trends associated with race and with poverty that predict VLBW (prematurity and birth weight), and that predict death among VLBW births.
    b. Conduct a FIMR summary study that focuses upon the fetal deaths and infant births weighing in between 500 and 1500 grams (the "Maternal Health" PPOR cells). Stratify this analysis by race (Black women versus White women and other races), and by poverty (poor women versus higher-income women). Note the social, behavioral and medical risk factors identified as well as the interventions (public health and medical) delivered, especially those not included in the vital records analysis above.

2. Disseminate Healthy-Babies/Healthy-Start Evaluation Findings to local, state and national audiences
3. Develop a strategic plan for reducing identified risk factors, with specific and proportional attention paid to those factors affecting Black women and poor women.