Effect of Hurricane Katrina on Low Birth Weight and Preterm Deliveries in African American Women in Louisiana, Mississippi, and Alabama

Chau-Kuang Chen, Ed.D.
Office of Institutional Research, Meharry Medical College
Nashville, Tennessee, 37208, U.S.A

Patricia Matthews-Juarez, Ph.D.
Principal Investigator/National Center on Minority Health and Health Disparities (NCMHD)/ARRA Gulf Coast Region Transdisciplinary Research Recovery Center for Community Health Project and 5P20MD000516-07 NCMHD/Health Disparity Research of Excellence at Meharry

Meharry Medical College
Nashville, Tennessee, 37208, U.S.A

and

Aiping Yang, Ph.D.
Department of Industrial Engineering, Beijing Union University
Beijing, China 100020

ABSTRACT

Using three modeling techniques (GLR, GEP, and GM), the effect of Hurricane Katrina on low birth weight and preterm delivery babies for African American women is examined in Louisiana, Mississippi and Alabama. The study results indicate that risk factors associated with low birth weight and preterm delivery for American African women include unemployment and percent of mothers between the ages of 15-19. Among White women, ages 15-19, risk factors included poverty rate, median household income, and total birth rate. The GMs performed accurate predictions with increasing low birth weight and preterm delivery trends for African American women in the Gulf Coast states and other U.S. states, and decreasing low birth weight and preterm delivery trends for their White counterparts in the same state locations. Data presented between 2007-2010 show low birth weight and preterm delivery for White women as a decreasing tendency while adverse birth outcomes for African American women exhibited a monotonically increasing trend. The empirical findings suggest that health disparities will continue to exist in the foreseeable future, if no effective intervention is taken. The models identify risk factors that contribute to adverse birth outcomes and offer some insight into strategies and programs to address and ameliorate these effects.

Keywords: Health Disparity, Low Birth Weight, Preterm Delivery, GLR, GEP, and GM.

INTRODUCTION

Adverse birth outcomes for African American women in Louisiana, Mississippi, and Alabama reflect a major health disparity before and after Hurricane Katrina. Using three modeling approaches (generalized linear regression model (GLR); gene expression programming (GEP); and grey model (GM)), the effect of Hurricane Katrina on low birth weight and preterm delivery babies for African American women are examined before and after Hurricane Katrina. The study population includes a comparison of African American and White women between the ages of 15-19 living in Louisiana, Mississippi, and Alabama and their counterparts across the United States before and after Hurricane Katrina.

Recent studies show that disasters such as Hurricane Katrina and their aftermath may lead to factors that disrupt healthy pregnancies. These disruptions can be characterized as limited or no access to prenatal care, lack of social support, and the inaccessibility to physical resources such as food, pharmacy, housing, etc. [1]. Historically, natural disasters lead to adverse pregnancy outcomes; the frequency of low birth weight infants increases immediately following a disaster [1]. Despite large declines in the U. S. infant mortality in recent years, low birth weight infants born to African American women continue to increase. However, the improvement in birth outcomes is faster among White women, resulting in a wider gap between the two racial groups.

Hurricane Katrina, a deadly storm that struck the Gulf Coast in August of 2005, continues to have a major health effects on the Gulf Coast Region in the United States. Many of the effects have been studied by other researchers including economic devastation, displaced populations, and increased levels of health problems in survivors, ranging from mental health issues to child health issues. In 2009, the National Vital Statistics Report indicated that there were fewer births in the Gulf Coast region following Hurricane Katrina when compared to births outcomes prior to the Hurricane, 27 and 33, respectively [2].

This retrospective study offers some insight and is critically important as potential risk factors may contribute to infant mortality, which is one of the measures that predict nation's health. This article examines the effect of Hurricane Katrina on low birth weight and pre-term delivery of infants born to African American women living in the geographical target states of Louisiana, Mississippi, and Alabama. Examining the root cause of adverse birth outcomes for African American women before and after the Hurricane Katrina may help explain the dramatic increase of these cases in these target states. By identifying the risk factors that may contribute to adverse birth

outcomes, appropriate health care strategies and programs can be put into place to address and ameliorate these effects.

LITERATURE REVIEW

Data shows that among all factors that could lead to infant mortality, low birth weight and preterm delivery are most prevalent in the African American community [3]. Despite indications that more African American women are receiving prenatal care, African American infants die more often of low birth weight than any other leading causes. Many studies have concluded that socioeconomic status leads to this alarming trend. However, it alone cannot describe or explain the health disparity gap. Research has actually proven that race and socioeconomic status have separate, independent effects on low birth weight [4]. Given that teenage mothers have a high prevalence of giving birth to a low birth weight infant; the race-specific relative risk for babies born to mothers less than 16 years of age were at an 11% to 40% increase compared to babies born to mothers 25-29 years of age [5]. It has been indicated that while the risk for poor pregnancy outcomes is high among young adolescents, young African American mothers appear to be particularly vulnerable. African American women are two times more likely to give birth to an infant with a weight of less than 2500 grams than their White counterparts. They are also more likely to have a preterm delivery, which is defined as the birth of a baby before 37 weeks of pregnancy

The adverse effects of childbearing by African American teenagers on the outcome of pregnancy among African American women appear to have been overemphasized. African American infants in the U. S. are more than twice as likely as White infants to die in the first year of life. African Americans aged 10-14 have a birth rate of 4.29 per 1,000 live births, which is seven times more than their counterparts (0.59 per 1,000 live births). African American mothers also had higher proportions of very low (3.7 grams) and low birth weight (2.6 grams) infants than non-Hispanic Whites, 15.0 and 10.5 respectively [6].

Rates of infant mortality are substantially higher for less than 15 year olds (8.1 per 1,000 live births) than 16-17 year olds (6.3 per 1,000 live births) and 18-19 year olds (5.4 per 1,000 live births). In a study on the effect of gross domestic product (GDP) and infant mortality, the distribution of income suggests that in rich countries, reduction of income inequality was likely to be more effective in lowering infant mortality rates [7]. Health system variables, particularly the method of healthcare financing and the supply of physicians significantly attenuated the effect of wage inequality on infant mortality. Disruption of health care provisions due to the hurricane is likely to have an impact on the overall quality of healthcare, and ultimately, increase health disparities among African American women [8].

The study objectives are (a) to identify risk factors associated with the adverse birth outcomes before and after Hurricane Katrina, (b) to compare mean difference of the adverse birth outcomes before and after Hurricane Katrina, (c) to compare mean difference of the adverse birth outcomes before and after Hurricane Katrina within the Gulf Coast states and other U.S. states, respectively, and (d) to perform data analysis to determine future predictions for the adverse birth outcomes of African American women in this target geographical area.

STUDY METHOD

To explore the study objectives as proposed, secondary data from the Center for Disease Control and Prevention (CDC) Wonder [9], and the U.S. Census Bureau are used retrospectively to show important risk factors leading to an increase in low birth weight and preterm deliveries in this comparison study. The outcome variables are (1) the number of low birth weight babies per 10,000 live births (defined as the weight of infants less than 2,500 grams) and (2) the number of preterm delivery babies (defined as the birth of an infant before 37 weeks of pregnancy) for each county/perish from years 2003-2004 (before Katrina) to 2006 (after Katrina). The ten (10) explanatory variables used in this study include the number of total primary care physicians, unemployment rate, poverty rate for all ages, median household income, total birth rate, percent of African American mothers aged 15-19, and percent of White mothers aged 15-19, state group (Gulf Coast states vs. other U.S. states), timeline (2003-2004 before Katrina vs. 2006 after Katrina), and interaction of state group by timeline for the same county/parish in the study period.

To identify a subset of significant risk factors associated with low birth weight and preterm delivery and compare marginal mean difference of low birth weight and preterm delivery before and after Katrina for the study group, the generalized linear regression (GLR) model in the SPSS package is used for the data analysis. In the GLR model, multiple linear regression analysis and 2 x 2 factorial designs with a two-way analysis of variance (ANOVA) are combined. In this study, the numbers of low birth weight and preterm delivery babies are postulated to be larger after the timeline of Katrina than before the timeline of Hurricane Katrina, regardless of the state group.

To rank risk factors affect low birth weight and preterm delivery in African American and White mother aged 15-19, the gene expression programming (GEP) approach is performed. The GEP model offers new possibilities for solving complex scientific problems. As the world constantly changes, the population within it is suspected to change accordingly, so that it has a chance of surviving. The GEP algorithm simulates this occurrence by creating models that consist of populations that are derived from previous generations that were best fit to survive the model under previous conditions [10]. In the GEP model, the outcome variables of interest are low birth weight and preterm delivery at the county/parish, respectively, and the genotypes (chromosomes) placed into the system that are executed include all independent variables. These chromosomes are placed into the system and each chromosome is expressed through a mathematical equation, phenotype (expression tree).

To predict a mid-range of 4-year low birth weight and preterm delivery for African American and White groups, grey models (GMs) are constructed. The main strength of the GM is to use a short-term time series (a minimum of four data points) to perform reliable and accurate predictions [11]. The GM model can be used to determine health disparity in terms of low birth weight and preterm deliveries between African American and White women and to predict the 2007 – 2010 low birth weight and preterm delivery babies for African American and White women who reside in Gulf Coast states vs. other U.S. states, respectively. The traditional time series methods (simple, Holt's, and Brown's exponential smoothing models) are used to compare the prediction accuracy of the GMs based on the small value of mean absolute percentage error (MAPE).

STUDY RESULTS

Low birth weight and preterm deliveries were analyzed using the GLR and GEP models at the county/parish level. The sample size (1,467 counties/parishes) with low birth weight infants and preterm deliveries in the Gulf Coast states were 81 counties/parishes and 1,386 other counties/parishes in the U.S. This number was equal to the total number of counties with preterm deliveries and low infant birth weight before Hurricane Katrina (978) in Years 2003-2004 and after Hurricane Katrina (489) in year 2006.

The GLR model was also used to determine trends for risk factors affecting low birth weight and preterm deliveries over the three year study period. Risk factors were further examined for low birth weight and preterm deliveries separately. The separate analysis of low birth weight, the significant variables found by the GLR model (R squared value of 0.884), and the important variables ranked in GEP order for African Americans were the percentage of African American mother's ages 15-19 (b1=0.692, p<0.001, GEP rank no. 1), percentage of White mothers ages 15-19 (b2=-.068, p<0.001, GEP rank no. 2), state group (b3=87.096, p< 0.001, GEP rank no. 3), and timeline concerning Katrina (b4=59.178, p<0.001, GEP rank no. 4), unemployment rate (b5=-2.959, p<0.01, no GEP rank), and state group by timeline interaction (b6=60.328, p <0.001, no GEP rank). For Whites model (R squared value of 0.709), the most important risk factors were the percentage of White mothers ages 15-19 (b1=4.40, p <0.001, GEP rank no. 1), poverty rate (b2=-8.843, p <0.001, GEP rank no. 2), and the total number of primary care physicians (b3=.141, p<0.001 GEP rank no. 3), median household income (b4=.002, p <0.001, no GEP rank), total birth rate (b5=-.088, p <0.001, no GEP rank), and state group (b6=59.747, p <0.001, no GEP rank).

The mean difference in low birth weight babies was significantly higher in the Gulf Coast states than in other U.S. states. For African American women the marginal mean difference of low birth weight babies in target geographical area and other U.S. states was 56.932 with p<0.001. The marginal mean difference for White women was 48.195 with p<0.001. White women had increased the marginal means for low birth weight babies in the Gulf Coast states in comparison to other U.S. states; however, African American women had a larger marginal mean difference of low birth weight babies between Gulf Coast states and other U.S. states. The marginal mean of low birth weight babies was higher after Hurricane Katrina for both African American and White women. However, the marginal mean difference (29.014) in pre and post Hurricane Katrina was only significant (p <0.001) for African American women.

When comparing marginal means by timeline within state groups, Gulf Coast states had a higher number of low birth weight babies for African American women and Whites before and after Katrina. There was a larger marginal mean difference in low birth weight babies before and after Katrina in the Gulf Coast states. The marginal mean of African American low birth weight babies decreased in other U.S. states while this number increased for that in the Gulf Coast states after Katrina. For Whites, this number increased in both Gulf Coast states and other U.S. states after Katrina.

The individual analysis of preterm deliveries, the significant variables found by the GLR model (R squared value of 0.889) and the most important variables ranked in GEP order for African American were percentage of African American mothers aged 15-19 (b1=.95, p<0.001, GEP rank no. 1), percentage of White mothers aged 15-19 (b2=-.088, p<0.001, GEP rank no. 2), state group (b3=57.746, p<0.001, GEP rank no. 3), unemployment rate (b4=-7.554, p<0.001, GEP rank no. 4), timeline (b5=32.746, p<0.05, GEP rank no. 5), and state group by timeline interaction (b6=34.371, p<0.05, no GEP rank). For White Americans, the significant variables found by the GLR model (R squared value of 0.712) and the important variables ranked in GEP order were percentage of White mothers ages 15-19 (b1=.729, p<0.001, GEP rank no. 1), poverty rate (b2=-14.892, p<0.001, GEP rank no. 2), median household income (b3=.003, p<0.001, GEP rank no. 3), unemployment rate (b4=-5.584, p<0.05, GEP rank no. 4), state group (b5=128.470, p<0.001, GEP rank no. 5), number of total primary care physicians (b6=.184, p<0.001, no GEP rank), and total birth rate (b7=-.103, p<0.001, no GEP rank). Preterm delivery was significantly higher in the Gulf Coast states than other U.S. states for both Whites and African Americans. For African American women, there was a marginal mean difference of 40.083 with the .01 significance level and for White women the marginal mean difference of 36.946 was significant at the .01 significance level.

Overall preterm deliveries were higher for African American and White women in the Gulf Coast. African American women living in the Gulf Coast had a higher increase in preterm deliveries than did their White counterparts in the Gulf Coast before and after Katrina. After analyzing low birth weight and preterm delivery data both separately and collectively, there seems to be an emerging trend for African American women and adverse birth outcomes. Low birth weight babies and preterm deliveries disproportionately affect African American women more than White women. African American women had consistently greater mean differences in low birth weight and preterm deliveries before and after Katrina as well as when comparing state location. Another overall trend observed was the consistently higher levels of low birth weight and preterm deliveries in the Gulf Coast states when compared to other U.S. states. These marginal means also increased after Hurricane Katrina, while these numbers for other U.S. states increased minimally or decreased. These trends in results suggest that African American women and their infants in the Gulf Coast states were more affected by Hurricane Katrina than their counterparts in the geographical area and their counterparts in other U. S. states.

The grey prediction models outperformed all exponential smoothing models. The GMs for African American women and their White groups had the smallest MAPEs compared to the most accurate simple, Holt's, and Brown's exponential smoothing models in the areas of low birth weight and preterm delivery for both Gulf Coast states and other U.S. states.

The minimal value for MAPE of the GMs for low birth weight rates in the Gulf Coast states among African American groups was 34%, compared to the most accurate and simple, Holt's, and Brown's exponential smoothing models (2.87%, 0.65%, and 1.26%, respectively). Among the non-Hispanic White groups, the minimal value was 0.27%, compared to the most accurate and simple, Holt's, and Browns exponential smoothing models (1.35%, 1.14%, and 1.80%, respectively).

When viewing the MAPE value among the other U.S. states by race, the results differed. The minimal value for MAPE of the GMs for low birth weight among African American groups was 0.97%, compared to the most accurate and simple, Holt's, and Brown's exponential smoothing models (2.15%, 2.15%, and 2.68%, respectively). Among the non-Hispanic White groups, the minimal value for MAPE was 0.21%, compared to the most accurate and smallest, Holt's, and Browns exponential smoothing models (0.66%, 0.57%, and 0.55%, respectively).

A similar test was run to determine the smallest MAPE of the GMs for preterm delivery among the Gulf Coast States compared to other U.S. states. Among African Americans residing in the Gulf Coast, the minimal MAPE was 0.64%, compared to the most accurate and simple, Holt's, and Brown's exponential smoothing models (2.58%, 1.42%, and 2.48%, respectively). Among the non-Hispanic White Gulf Coast residents, the smallest MAPE was 0.89%, compared to the most accurate and simple, Holt's, and Brown's exponential smoothing models (1.98%, 2.01%, and 2.55%, respectively).

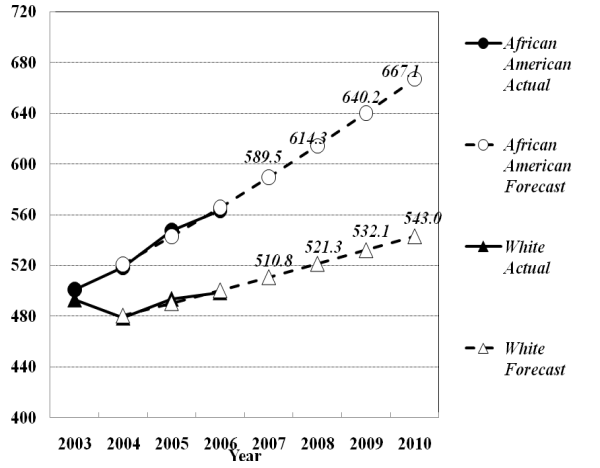
In regards to other U.S. states, the smallest MAPE of the GMs for preterm delivery among African American women was 0.07% in comparison to the most accurate and simple, Holt's, and Brown's exponential smoothing models (1.41%, 0.44%, and 0.51%, respectively). Among the non-Hispanic Whites, the smallest MAPE was 0.24%, compared to the most accurate and simple, Holt's, and Browns exponential smoothing models (0.73%, 0.52%, and 0.52%, respectively).

LOW BIRTH WEIGHT AND PRETERM DELIVERY PREDICTIONS IN 2007-2010

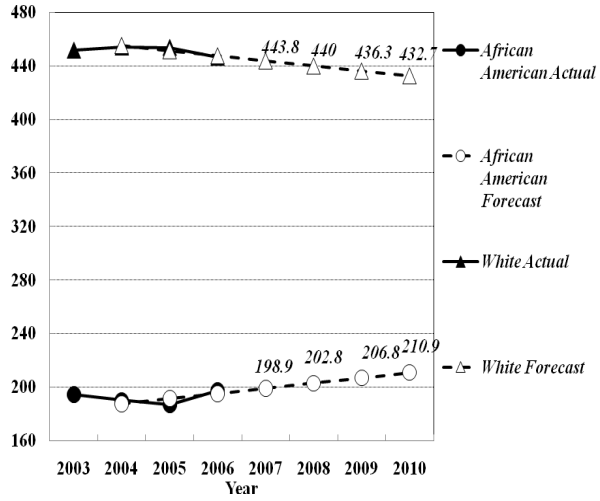
The magnitude of change in low birth weight or preterm deliveries between two consecutive years is called the average annual rate of change which equals to $(e^{-a} - 1)$ 100% for time period (t) being greater than or equal to two.

Graph #1 indicates that the African American women have the sharpest increase prediction for low birth weight, with an average annual rate of 4.18%, compared to 2.02% among non-Hispanic Whites in the Gulf Coast. Among the other states in the U.S (Graph #2), African Americans have an average annual rate increase of 1.92% while non-Hispanic Whites experience an average annual rate decrease of 0.85%.

Graph #1:
Low Birth Weight Prediction Results for Gulf Coast States, 2003 - 2010

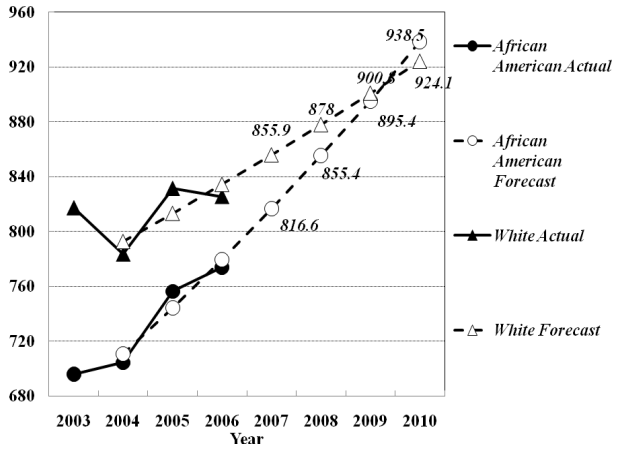


Graph# 2:
Low Birth Weight Prediction Results for Other U.S. States, 2003 - 2010

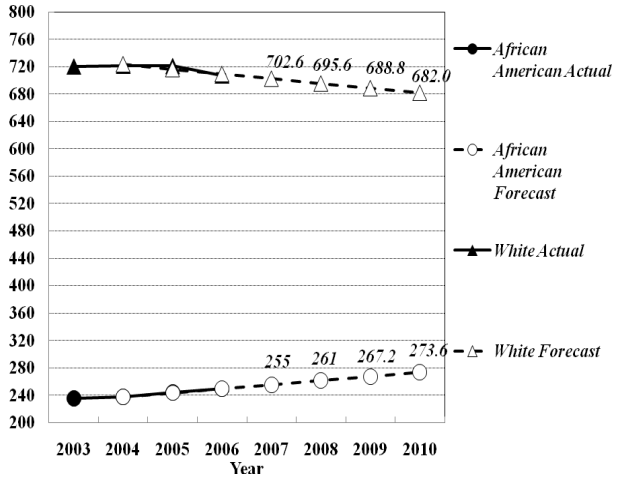


Graph #3 indicates that African American women had the sharpest prediction of an increase in preterm delivery, with an annual average rate increase of 4.71%, compared to a rate increase of 2.63% for non-Hispanic Whites in the Gulf Coast Region. Among the other U.S. states (Graph #4), African American women had an annual average rate increase of 2.43% while non-Hispanic Whites experienced an annual average rate decrease of 0.99%.

Graph #3:
Preterm Delivery Prediction Results for Gulf Coast States, 2003 - 2010



Graph #4:
Preterm Delivery Prediction Results for Other U.S. States, 2003 - 2010



CONCLUSIONS

This study indicates that when compared the Gulf Coast Religion to other U.S. states, African American women had more adverse birth outcomes. The outcome included more infants that were born preterm and low birth weight within the first year of life. Risk factors associated with low birth weight and preterm delivery among this target group included unemployment, and the percent of African American mothers aged 15-19. Among White women, factors included the poverty rate, median household income, total birth rate, and the percent of White mothers aged 15-19.

The GMs were viable tools used to predict the 2007-2010 low birth weight and preterm delivery of African American and White women who reside in the Gulf Coast and other U.S. states. Not surprisingly, the GMs performed accurate predictions with increasing low birth weight and preterm delivery trends for African American women in both the Gulf Coast and other U.S. states, and decreasing low birth weight and preterm delivery trends for their White counterparts in the same state locations. In years 2007-2010, low birth weight and preterm delivery for White women presented a decreasing tendency while the same birth outcomes for African American women exhibited a monotonically increasing trend. The empirical findings suggested that the health disparities will continue to exist in the foreseeable future, if no effective intervention is taken.

Although there were different factors that contributed to the race-specific low birth weight and preterm deliveries, birth outcome by both races were affected by the presence of Hurricane Katrina. Due to this increase in the Gulf Coast states, existing prevention programs should seek to incorporate an educational strategy into community-based program, focusing on those teens that are not pregnant, finding ways to avoid teen pregnancy, and reduce the percentage of low birth weight and preterm delivery infants in the Gulf Coast Region. Intervention programs may focus on teenage pregnancy to increase educational attainment, career options, and the probability of better health outcomes for both mother and child.

This study illustrates the effect that Hurricane Katrina has on the Gulf Coast Region with regard to low birth weight and preterm delivery and the necessity for policy implementation and program development in Louisiana, Mississippi, and Alabama. The field of public health and its practitioners should be enlisted to assist in bringing action to eliminate low birth weight and preterm deliveries among African American women living in Louisiana, Mississippi, and Alabama.

DISCLAIMER

Funding for this activity was made possible (in part) by 5RC2MD004783-02/National Center on Minority Health and Health Disparities (NCMHD)/ARRA Gulf Coast Region Transdisciplinary Research Recovery Center for Community Health Project and 5P20MD000516-07 NCMHD/Health Disparity Research of Excellence at Meharry. The views expressed in written materials or publications and by authors do not necessarily reflect the official policies of the Office on Minority Health and Health Disparities nor does mention by trade names, commercial practices, or organizations imply endorsement by the US Government.

REFERENCES

[1] X. Xiong, D.R. Mattison, K. Elkind-Hirsch, G. Pridjuan, and P. Buekens, Exposure to Hurricane Katrina, Post-Traumatic Stress Disorder and Birth Outcomes, **American Journal of Medical Science**, 2009, 336(2):4.

[2] B.E. Hamilton, T.J. Matthews, J.A. Martin, and S.J. Ventura, The Effect of Hurricane Katrina: Births in the U.S. Gulf Coast Region, Before and After the Storm, **National Vital Statistics Reports**, 2009, 58(2):32.

[3] S.C. Chang, K.O. O'Brien, M.S. Nathanson, J. Mancini, and F.R. Witter, Characteristics and Risk Factors for Adverse Birth Outcomes in Pregnant Black Adolescents, **Journal of Pediatrics**, 2003, 143:250-7.

[4] C.G. Colen, A.T. Geronimus, J. Bound, and S.A. James, Maternal Upward Socioeconomic Mobility and Black–White Disparities in Infant Birthweight, **American Journal of Public Health,** 2006, 96(11): 2032-2039.

[5] A. Friede, W. Baldwin, P.H. Rhodes, J.W. Buehler, L.T Strauss, J.C. Smith, and C.J. Hogue, Young maternal age and infant mortality: the role of low birth weight, **Public Health Rep.,** 1987, 102(2), 192–199.

[6] N.L Leland, D.J. Petersen, M. Braddock, and G.R. Alexander, Variations in pregnancy outcomes by race among 10-14-year-old mothers in the United States. **Public Health Rep,** 1995, 110(1), 53–58.

[7] S. Hales, P. Howden-Chapman, C. Salmond, A, Woodward and J. Mackenbach. National infant mortality rates in relation to gross national product and distribution of income, **The Lancet**, 1999, 354:2047.

[8] M. Phipps, M. Sowers, and S. Demonner, The Risk for Infant Mortality among Adolescent Childbearing Groups, **J Women's Health,** 2002, 11(10):889-897.

[9] CDC, Infant Mortality Statistics from the 2005 Period Linked Birth/Infant Death Data Set, **National Vital Statistics Reports,** 2008, 57(2), Table 2.

[10] C. Ferreira, **Gene Expression Programming: Mathematical Modeling by an Artificial Intelligence**, 2nd Ed., Springer, 2006, pp: 3-116.

[11] J.L. Deng, Control Problem and Grey System, **Systems and Control Letters**, (1982) 1:288-94.