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ABSTRACT

This report examines the determinants of the high level of infant mortality in Washington, D.C. Data were analyzed for 36,872 black resident single-delivery births occurring in the years 1980 through 1984, and 762 infant deaths occurring to these birth cohorts from 1980 to 1985. Findings were the following: (1) poor birthweight distribution among black residents, rather than high birthweight-specific mortality rates, was found to be mainly responsible for the high infant mortality rate; (2) low birthweight was found to be significantly associated with maternal age, marital status, educational attainment, socioeconomic status, prenatal care, complications during pregnancy, illness during the pregnancy, prior fetal loss, previous child death, total birth order, and interval between deliveries; (3) contrary to expectations, teenage mothers had the best pregnancy outcomes; (4) inadequate prenatal care and complications during pregnancy posed the greatest risk to black mothers; and (5) normal birthweight babies accounted for one-fourth of all black infant deaths. Statistical data are included on nine tables. The appendices comprise the following: (1) definitions and computations; (2) five supplemental tables of statistical data; and (3) a note on the quality of the statistical data. A list of 58 references is also appended. (FMW)

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ABSTRACT

With a view to examine the determinants of the high level of infant mortality in Washington, D.C, official vital registration data were analysed. These data consisted of 36,872 Black resident single-delivery births taking place in calendar years 1980 through 1984, and 762 infant deaths occurring to these birth cohorts from 1980 to 1985.

Poor birthweight distribution among Black residents, rather than high birthweight-specific mortality rates, was found to be mainly responsible for the high infant mortality rate. If Blacks in the District of Columbia had the same birthweight distribution as Blacks in the United States as a whole, the city's infant mortality rate would be 13 percent lower than the national rate for Blacks, rather than 19 percent higher. Similarly, if Black babies in the city had the same birthweight distribution as their White counterparts, the difference between Black and White infant mortality rates would be reduced from 240.7% to only 11.1%.

Low birthweight was found to be significantly associated with maternal age, marital status, educational attainment, socio-economic status, prenatal care, complications during the pregnancy, illnesses during the pregnancy, prior fetal loss, previous child death, total birth order and interval between deliveries. Of these, all except socio-economic status, illnesses during the pregnancy and total birth order remained independently significant after multivariate analysis. Prenatal care, complications during the pregnancy and interval between deliveries were also found to have significant association with both neonatal

and post-neonatal mortality. Maternal age, marital status, socio-economic status, illnesses during the pregnancy, prior fetal loss and previous child death had a significant association with neonatal mortality, while education and birth order had a significant association with post-neonatal mortality.

Contrary to the expectation, teenage mothers, far from having the worst pregnancy outcomes, in fact, had the best outcomes. Even the infants born to the mothers under 17 years of age were at the same risk for low birthweight and a 13% lower risk for neonatal mortality than infants born to women aged 20-34.

Inadequate prenatal care and complications during the pregnancy posed the greatest risk to Black mothers. However, high-risk cases, did not show any great degree of demographic or georgraphic concentration. This relative homogeneity makes the task of profiling and targetting high-risk groups and selecting geographic areas for delivering special health services exceedingly difficult.

One-fourth of all Black resident infant deaths are accounted for by normal weight babies. Congenitial anomalies are the major cause of death among these normal weight infants. Plural births comprise only 2.5% of all Black births, but are responsible for 10% of the infant deaths -- most of these being low birthweight infants.

Abbreviations

AR	Attributable risk
BWD	Birthweight distribution
BWSMR	Birthweight-specific mortality rate
BWSNMR	Birthweight-specific neonatal mortality rate
BWSPNMR	Birthweight-specific post-neonatal mortality rate
IMR	Infant mortality rate
LBW	Low birthweight
NIMS	National Infant Mortality Surveillance
NMR	Neonatal mortality rate
PNMR	Post-neonatal mortality rate
PNSMR	Post-neonatal survivors' mortality rate
RR	Relative risk
SGA	Short gestational age
VLBW	Very low birthweight

I. INTRODUCTION

High infant mortality rates (IMR) in Washington, D.C., have been a matter of great concern to the community and the government alike. Published vital statistics have shown that the IMR in the District of Columbia is not only higher than that of the 50 states of the union, but it is the highest among the U.S. cities with a population of 500,000 or more. Given the persistent 2:1 ratio of Black IMR to White IMR in the U.S. (NCHS, 1986), it is not surprising that the nation's capital, with a 70 percent Black population, has a higher IMR than the 50 states and most of the larger cities, none of which has as high a proportion of Blacks as Washington, D.C. But the District's high IMR level acquires real significance when it is shown that even when the rates for Blacks alone are examined, Washington, D.C., has an IMR lower only than that of Indianapolis among cities with a population of 500,000 or more (CDF, 1987). The concern about this high level of infant mortality in D.C. has led to a number of intervention programs, both by the government and voluntary organizations. It has also produced a spate of newspaper articles and television reports. Some of these popular reports have dubbed the District's performance in curbing high infant death rate as worse than that of some of the third world countries, and have even advised the D.C. government to learn from Mississippi (Washington Post, Feb. 3, 1987). The controversy generated on the question of high IMR in D.C., it appears, has produced more heat than it has shed light on the causes, determinants or correlates of high IMR in the nation's capital. Scientific studies, based on empirical data, are certainly needed for a better understanding of the problem,

Table 1
Infant Mortality Rates: United States and Washington, D.C., by Race, 1984

Rate	United States		Washington, D.C.	
	Black	White	Black	White
Infant Mortality Rate (IMR)	18.4	9.4	24.0	7.8
Neonatal Mortality Rate (NMR)	11.8	6.2	18.4	5.4
Post-Neonatal Mortality Rate (PNMR)	6.5	3.3	5.6	2.4

Sources: Monthly Vital Statistics Report, Vol. 34 No. 13, DHHS Pub. No. (PHS) 86-1120, September 19, 1986; DCDHS, Infant Mortality: District of Columbia, 1984, Statistical Note 72, April 1986.

and for designing more effective intervention strategies to lower these excessively high rates.

Infant mortality rate is considered to be an index of economic and social well-being of a population. It is measured in terms of the number of infant deaths per thousand live births in a given period. Because of the temporal difference in the relative role of the so-called endogenous and exogenous causes of infant death, the infant period is usually divided into: a) neonatal period, i.e., up to 27 days, and b) post-neonatal period, i.e., 28 days to the day before the first birthday (Bourgeois-Pichat, 1981).

With the improvement in the living conditions and advancement of medical care, the traditional major causes of post-neonatal mortality tend to be controlled relatively easily. Thus, in the industrialized countries of the world, the share of PNMR declines and the share of NMR in IMR increases correspondingly. A high degree of positive correlation is found between the level of infant mortality and the ratio of PNMR to IMR. In industrialized countries this ratio, as well as the level of PNMR, tends to be very low. Recent efforts to bring down IMR in these countries are, therefore, largely focussed on lowering NMR, and neonatology has emerged as an important specialized branch of health care. Since the causes of fetal and neonatal death are quite similar, common strategies of prevention are applied, and a common nomenclature is used to denote this group of deaths and to the science pertaining to the study and prevention of this category of deaths. The respective terms for the two are perinatal mortality and perinatology.

Greater control of the so-called exogenous causes of infant mortality has also resulted in lowering the share of deaths among normal weight neonates to total neonatal mortality. As a result, the role of low birthweight in neonatal mortality has been highlighted. Infants born with a weight under 2500 grams are regarded as having low birthweight (LBW), while those having a birthweight under 1500 grams are considered as very low birthweight (VLBW) infants. As the incidence of intermediate low birthweight (ILBW), i.e., between 1500 and 2500g, declines, the focus tends to shift to the VLBW as the principal predictor of neonatal mortality.

The relationship between low birthweight (LBW) and IMR, especially neonatal mortality rate (NMR), is well established (Shapiro, _et al_., 1968, Shah & Abbey, 1971; Rooth, 1979; Lumley, 1980; Bross & Shapiro, 1982). Very low birthweight (VLBW) has been found to be the principal predictor of NMR in the industrialized countries (Lee, _et al_., 1980b). Even though, LBW and short gestational age (SGA) usually appear as joint pregnancy outcomes, it is known that infants with similar birthweights could be of dif erent gestational ages (Fitzhardinge, 1976), and that when the effect of SGA on NMR is controlled, LBW not only remains important (Koops, _et al_., 1982), but it appears as more important than SGA as the proximate determinant of NMR (Hoffman, _et al_., 1974; Williams, _et al_., 1982). Of the two components of relationship between birthweight and IMR, i.e., birthweight distribution (BWD) and birthweight specific mortality rates (BWSMR), reductions in the latter, rather than improvements in the former, have been the major reason for the recent decline in NMR (and thus, IMR) in the United States (Lee et al., 1980a).

Given the fact that 90 percent of the infant deaths in Washington, D.C., are Black, attempts to analyze high infant mortality in the city must take cognizance of the specific features of Black infant mortality in the United States, in addition to drawing upon the pool of knowledge available about infant mortality in general.

Statistics on low birthweight and infant mortality in the United States have consistently shown a substantially higher incidence of LBW and a higher IMR for Blacks than for Whites (National Center for Health Statistics, 1973, 1976, 1986). Greater incidence of LBW, higher mortality rates among normal weight infants and higher levels of post-neonatal mortality are generally recognized as the reasons for high infant mortality among Black Americans (U.S. DHHS, 1986). Studies attempting to analyze inter-racial differences in LBW or infant mortality have shown that while a good part of the excess infant mortality or greater incidence of LBW among Blacks is due to their greater exposure to the major risk factors, such as low SES, low educational attainment, out-of-wedlock birth, young maternal age, high parity, closely-spaced deliveries and poor prenatal care (Shah & Abbey, 1971; Bross & Shapiro, 1982), "race" remained significant even after controlling for a number of risk factors (Bross & Shapiro, 1982; Geronimus, 1986). Detailed analyses of the bi-variate construct of birthweight and gestational age have consistently shown that Black babies, on the average, are lighter in weight and born earlier than white babies, but they survive better in lower birthweight-gestational age categories. This trend, however, is reversed in higher categories (Binkin, et al., 1985; Alexander, et al., 1985, Sappenfield, et al., 1987). There is as yet no consensus as to what "racial" differences mean in the context of LBW and infant mortality.

Studies focussing on high IMR among Black Americans, even when applying different research techniques, have tended to adopt the method of studying ethnic differentials (Eberstein, 1984; Binkin, 1985; Sappenfield, et al., 1987). A large number of other studies have included race as one of the many variables in their multivariate analyses seeking to explain the determinants of or risk factors associated with LBW or infant mortality (Shah & Abbey, 1971; Bross & Shapiro, 1982; Paneth, et al., 1982).

This study, however, will focus on examining intra-Black differentials in exposure to risk factors and co-variation between those risk factors and adverse pregnancy outcomes. The reason for adopting this strategem is not only the practical constraint imposed by too few White infant deaths in Washington, D.C., but because such an approach allows us to:

a) keep constant the so-called racial effects (biological or cultural or both, as well as socio-economic where there is no other mark for SES) while delineating the role of various risk factors. The residual "racial" differences are substantial, as mentioned previously;

b) explore intra-Black variations, per se, which remain masked in the racial differentials models;

c) identify Black sub-groups with favorable pregnancy outcomes which can be set up more realistically as models to emulate than White standards, whose preconditions may be unrealistic for the Blacks to meet.

Given the mounting evidence concerning racial differences in the patterns of BWSMR'S (Alexander, et al., 1985; Binkin, et al., 1985, Erhardt, et al., 1964) and possible non-socioeconomic reasons for the racial differentials in BWD (North & MacDonald, 1977; Alexander, et al., 1985), standardization of Black IMR or NMR by applying the BWD or BWSMR schedule of another Black population, avoids the argument against using a White standard on the grounds of scientific validity (Kleinman, 1984) or practical realism, even though the heuristic value of the latter approach cannot be denied.

Black-white differentials will be examined only to the extent that such comparison helps illuminate the role of a given risk factor for or determinant of Black infant mortality. For the reasons already mentioned, LBW will be chosen as the principal path through which risk factors affect infant mortality, and neonatal mortality will be the principal component to be emphasized as the ultimate adverse pregnancy outcome.

There have been a limited number of published studies on the aspects of high infant mortality in Washington, D.C. Of these, one deals specifically with inter-hospital differences in caring for the LBW neonates (Madans, et al., 1981). The two papers by Rahbar, et al. (1982; 1985) are based on data collected from one particular hospital, i.e., Howard University Hospital, where 95% of the patients are Black and mostly indigent. Rahbar, et al. found a significant difference in perinatal mortality rates by level of prenatal care and by levels of low birthweight, i.e., under 1500g and 1500g-2500g. They also state that chances of survival are better when maternal age is greater than 17. However, this is not supported by their data (Chi-Square = 2.62, df=1, $p > .10$ after Yates correction). Boone (1982) collected her data mainly from one public hospital. This quasi-anthropological study, with a questionable design, found no statistically significant differences between normal weight (2500g and above) and very low birthweight (emphasis added), i.e., 1500g and below, proportions by marital status, maternal age, education, and drug abuse. However, the differences were found to be significant for migrant status, prenatal care, number of previous infant deaths, number of previous terminations, smoking and history of hypertension in the bi-variate analysis.

Since the setting-up of the mayor's blue-ribbon committee on infant mortality and teenage pregnancies, a number of internal studies have been reportedly carried out. However, attempts to secure these from the D.C. officials and contracting agencies were unsuccessful.

The present study was initially undertaken to provide a comprehensive understanding of the factors associated with high infant mortality in Washington, D.C. However, in view of the limitations imposed by the available data, as well as by time and resources, the scope of this research had to be restricted. Therefore, the specific objectives of this study are:

a) to delineate the role of birthweight distribution and birthweight-specific mortality rates in producing high infant mortality in Washington, D.C.;

b) to measure the extent to which various demographic, medical, and health care risk factors explain the variation in the incidence of low birthweight, neonatal mortality and post-neonatal mortality;

c) to develop a multivariate analytical model to measure the independent or net effects of risk factors on low birthweight;

d) to relate the findings to the existing body of knowledge concerning low birthweight and infant mortality;

e) draw policy implications from the results of the study.

II. MATERIALS AND METHODS

In view of the relatively small number of infant deaths in a given year, it was decided to obtain birth and infant death data for the latest five years, and subject them to analysis in a consolidated form. The data available from the D.C. Department of Human Services consisted of two tapes each of birth and infant death records. The first tape in each case contained the data for the years 1980, 1981 and 1982, while the second tape had the records for the years 1983 and 1984. The birth files contained all live births taking place in the District of Columbia, whether occurring to a D.C. resident or to a non-resident. The infant death files, on the other hand, contained records only of D.C. residents who were born in the calendar years 1980 through 1984 and who died within the first year. Information from birth and death certificates was linked for such infants in the infant death files. Because of the change in the birth certificate in 1983, as well as in the coding instructions, the data for the two periods not only contained dissimilar variables, but also different coding schemes for some of the variables in the two different time periods. These were given a consistent form before being analyzed.

The consolidated birth file contained 102,787 births, of which 47,119, or 45.8%, were D.C. resident births. The consolidated infant death file contained 950 resident infant deaths. For the four of the five years in which infant deaths for complete calendar years were used, i.e. 1981 through 1984, the linked dataset, due to non-matching, contained 31 (or 4%) fewer infant deaths than the published figures for the same years.

The present study excludes multiple births, and, unless explicitly mentioned, it excludes data on non-resident vital events and events occurring to non-Blacks. Thus, it focuses on single delivery births and infant deaths among such births occurring to Black residents of Washington, D.C. Thus, a total of 36,872 live births and 762 infant deaths have been included in this study for all analyses, except where comparisons have been made with white or non-resident populations.

The criterion used for separating the data for the Blacks, was the race of the child, because this variable was present in both the data files; race of the mother, which would have been a more appropriate variable, was missing from the linked death file for 1983-84. By definition, a Black infant can have one non-Black parent. Thus, all mothers of Black infants are not necessarily Black. In our consolidated birth file 0.8 percent of mothers of Black infants were non-Black. Cross-tabulations between birthweight and all the major risk factors for infants of Black mothers showed almost no difference with the results obtained for Black infants (not shown here).

In order to examine the relative role of BWD and BWSMR in producing a high IMR, and especially a high NMR, in Washington, D.C., the BWD and BWSMR'S of D.C. Blacks were compared with corresponding 1980 national rates for Blacks, obtained from the National Infant Mortality Surveillance (NIMS) data. Since D.C. Blacks had lower BWSMR'S but poorer BWD than the NIMS figures, the D.C. BWSMR'S were applied to the NIMS BWD in order to directly standardize the rates for D.C. Adjusted rates for both neonatal and post-neonatal periods were computed. Of the 88 live births in weight group under 501 grams, 10 were recorded as having survived the first year. To adjust for this unlikely event, of the 13 neonatal deaths with unspecified birthweights, the 10 with gestational ages of less than 37 weeks were assumed to be under 501 gms, and were added to the 77 recorded neonatal deaths in that weight category. To underscore the effect of poor BWD for the D.C. resident Blacks, direct standardization was also made to the BWD of the D.C. resident Whites.

In order to examine the risk factors associated with low birthweight, the following variables were selected for contingency table and logit analyses: maternal age, marital status, maternal education, socio-economic status, total birth order, interval between the last two deliveries, prenatal care, prior fetal loss, prior child death, complications during the pregnancy, and concurrent illnesses and associated conditions during the pregnancy. Selection of these variables was based on prior knowledge concerning risk factors associated with LBW (NCHS, 1980; IOM, 1985) and on the availability of information in the D.C. data tapes.

The variables used in this study were grouped as shown in the tables. A few of these warrant comment. Birthweight was coded as: VLBW (under 1501g), intermediate low birthweight, or ILBW (1501-2500g), and normal weight (2501g and over) for contingency table analysis. For maternal age, although under 20 years was taken as the standard lowest age group in the contingency table analysis, as well as in the logit analysis, mothers under 17 or under 19 were also subjected to comparative analysis where warranted. There was no information on income or occupation of the mothers. Therefore, in addition to taking educational attainment as a rough approximation of the mother's socio-economic status (SES), an attempt was made to utilize the census tract data for socio-economic ranking. This method has been used, among others, by Shah & Abbey (1971) and Horon, et al. (1983) in similar analyses. Of the four sets of data from the 1980 census examined, i.e., percentage Black, Black median family income, median rental value for Blacks, and percentage of families under 125% of the poverty line, the last showed the highest degree of concordance with the remaining variables (Bureau of the Census, 1983). Census tracts were, therefore, divided into: (1) Low - 30 or higher percentage of families under 125% poverty line, (2) Medium - 10-29% of the families under 125% poverty line, and (3) High - less than 10% of the families under that line. This classification puts about 45% of the births in the low category, 48% in the middle category and the remaining 7% in the high category. It must be kept in mind that not only is any single-measure approximation of SES less than satisfactory, but in this instance individuals have been assigned to a category not on the basis of their individual attributes but on the basis of the ranking of their addresses. This should be taken only as a very rough indicator of SES.

Adequacy of prenatal care can be judged on the basis of the onset of the care obtained, and on the frequency of and interval between visits for a given gestational age. Although our dataset contained information on gestational age, number of prenatal visits and the week of pregnancy in which prenatal care began, it suffered from two serious drawbacks: (a) for each of these variables, there were too many cases with missing or out-of-expected range data, (b) for number of visits and the week the first prenatal visit was made, instead of specific values, the tape contained data grouped into the following categories: For visits, (a) No visit, (b) 1-4, (c) 5-9, (d) 10-14, (e) 15-19 and (f) 20 or more; For number of weeks, (a) no visits, (b) less than 15 weeks, (c) 15-21, (d) 22-28, (e) 29-35, (f) 36 or more, (g) weeks not known but number of visits given. Information available in this form was not found suitable to compute the composite health care index, similar to the one used by Kessner, et al. (1973). Therefore, a modified index of adequacy of prenatal care was computed in the following manner:

(a) Inadequate: (i) no prenatal visits (3.1% of the cases); or (ii) care started after 28 weeks; or (iii) week care was started not known, but the number of visits less than 10.

(b) Adequate: (i) care started within 14 weeks, and the number of visits 5 or more; or (ii) care started in 15 to 28 weeks, and the number of visits 10 or more; or (iii) week care started not known, but the number of visits 20 or more.

(c) Intermediate: (i) care started within 14 weeks, but the number of visits less than 5; or (ii) care started in 15 to 28 weeks, but the number of visits less than 10; or (iii) week care started not known, but the number of visits 10 to 19.

For logit analysis birthweight and interval between the last two deliveries were dichotomized: LBW (2500gms or less) and normal weight (over 2500gms); high risk and non-high risk delivery interval.

The logit modelling procedure in SPSSX was used to analyze the relationship between the dependent variable, i.e., birthweight, and each of the independent variables, while controlling for the effects of the remaining variables in the model. The process adopted to arrive at the final model was as follows: as the first step, with birthweight as dependent variable, the maximum of nine independent variables permitted by SPSSX, were listed, and a model with main effects only was run. In the next step, the variable with the lowest lamda coefficient, which also happened to be statistically not significant, was substituted by a new variable which was also found not significant. The model was re-run with the non-significant variable being substituted by yet another variable. The three variables whose Z-values were less than 1.5 were removed from the model and an eight factor main effec[illegible] was run. All eight factors remained statistically significant and, from iteration to iteration, their lamda coefficients varied only slightly. In the next step, a saturated model consisting of birthweight and the eight significant independent variables was run to examine all possible interactions between independent variables in affecting the dependent variable. Interaction terms with high Z-values were added to the main effects one at a time. No statistically significant interaction was found. Odds ratios were computed for the eight statistically significant variables from the lamda coefficients obtained in the eight-variable main effects model. Similarly, after converting the natural logs of standard errors into standard errors, confidence intervals were computed. Logit analysis was not extended to infant mortality because of the peculiar manner in which births and infant deaths had been linked by the D.C. Department of Human Services.

Relative risks (RR) of low birthweight and of neonatal and post-neonatal mortality were computed for all the significant demographic and medical factors. Association between the two sets of factors was also examined, and the frequency rate and RR were computed for the associations found statistically significant. Attributable risks (AR) for LBW and NMR were computed for demographic categories having high RR. Missing cases were prorated according to a category's proportion in the valid cases, while computing NMR and PNMR.

To identify high risk areas of the city, IMR, LBW ratio and incidence rates for the major risk factors were computed for the census tracts at birth. The census tracts, in which a minimum average of 50 births per year occurred and for which IMR was higher than the city average were ranked according to the level of IMR and presented in **Table 8**, along with related data. Since infant death data for the earlier years was available only for the old census tracts, five-year consolidated figures were computed for all the variables on the basis of old boundaries. New census numbers are given in parentheses. In this way, the actual number of current tracts listed in **Table 8** are 12 rather than 10. It is not necessary that both new parts of each partitioned census tract should meet the criteria of ranking in this table.

Given the fact that infant deaths in our dataset represent the deaths ' curring within the first year to infants born in the years 1980 through 1984, and are not corresponding calendar-year deaths, the rates computed in our study are cohort rates which may differ slightly from the calendar-year rates. It is now becoming fashionable to call them infant mortality risk or neonatal mortality risk, and to reserve the term rate only for the calendar year rates (see all the papers published from NIMS in Public Health Reports, Vol. 101, No. 2, March - April 1987). However, we see no real advantage in adopting this nomenclature, particularly when there are already "risk factors," "relative risk" and "attributable risk" to contend with in studies on infant mortality. It should suffice to note that these are cohort rates rather than calendar-year rates.

As with any vital registration data, there are some problems of completeness and accuracy in the datasets used in this study. These deficiencies and errors have the potential of biasing the results. This question is addressed in some detail in Appendix C. While the quality of the vital statistics of Washington, D.C., leaves much to be desired, the analyses based on these data are probably no more biased than the results of most studies of infant mortality based on official vital records.

III. RESULTS

Figures in **Table 2** through **Table 4** represent the comparison between Washinton, D.C. Black residents and U.S. Blacks in terms of the relative importance of birthweight distribution and birth weight-specific mortality. In **Table 2**, columns 3 and 4 show that D.C. has a poorer birthweight distribution than the U.S. Blacks as a whole. This difference is markedly pronounced in the weight group 501-1000 gms which accounts for 54% of its neonatal deaths (col. 8), as compared to 39% for the U.S. (col. 9). Washington, D.C., however, has lower birthweight specific neonatal mortality rates (BWSNMR) than the U.S. for all weight groups, except one. This clearly indicates that the excess of D.C. NMR over the national Black NMR is entirely due to its poorer birthweight distribution.

As a result of direct standardization, i.e., by applying the D.C. BWSNMR'S to the birthweight distribution of the U.S., the NMR of D.C. declines to 10.9 per 1000 live births, as shown in Col. 10 of **Table 2**. The post-neonatal mortality rate (PNMR) of D.C, which is already lower than the corresponding U.S. rate, declines even further as a result of direct standardization **(Table 3, col. 6)**. The post-neonatal survivors mortality rate (PNSMR), in which the live births surviving neonatal mortality, rather than all live births, are taken as the denominator, shows a similar decline.

The figures in **Table 4** sum up the results of the standardization procedures shown in details in **Tables 2** and **3**. It shows that if the D.C. Blacks had the same birthweight distribution as the U.S. Blacks, the city's infant mortality rate (IMR) would have been 15.9 instead of 20.7; i.e., 3 percentage

Table 2
Crude and Adjusted Neonatal Mortality Rates: Black Single-delivery Births, Washington, D.C. Residents, 1980-84 and U.S. 1980

Weight Group (gms)	Live Births (No.) D.C.	Birth Wt. Distribution (%) D.C.	Birth Wt. Distribution (%) NIMS	Neonatal Deaths (No.) D.C.	BWSNMR (5)/(2) D.C.	BWSNMR (5)/(2) NIMS	Neonatal Deaths (%) D.C.	Neonatal Deaths (%) NIMS	Expected NN Deaths (4) x (6) x 10 D.C.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
≤ 500	88	0.2	0.2	87*	988.6	1000.0	15.4	15.6	2.00
501 - 1000	523	1.4	0.8	306	585.1	615.6	54.1	39.1	4.68
1001 - 1500	493	1.3	1.1	46	93.3	131.3	8.1	10.5	1.03
1501 - 2000	923	2.5	2.1	26	28.2	36.1	4.6	5.8	0.59
2001 - 2500	2,908	7.9	7.1	31	10.7	10.6	5.5	5.7	0.76
2501 - 3000	9,015	24.4	24.1	25	2.8	3.6	4.4	6.5	0.68
3001 - 3500	13,851	37.6	39.0	30	2.2	2.4	5.3	7.2	0.86
3501 - 4000	7,279	19.7	20.2	9	1.2	2.5	1.6	3.8	0.24
4001 - 4500	1,531	4.2	4.4	2	1.3	2.8	0.4	0.9	0.06
>4500	262	0.7	0.8	1	3.8	8.7	0.2	0.5	0.03
N.S.	-	-	-	3	-	-	0.6	4.3	-
Total	36,873	100.0	100.0	566	15.4	12.4	100.0	100.0	10.93

Source: D.C. data: data tapes, D.C. Department of Human Services; NIMS data: Public Health Reports, Vol. 102, No.2 (March - April 1987).

* 10 neonatal deaths with unspecified weights and under 37 weeks gestational age added to the entered number.

Table 3
Crude and Adjusted PNMR and PNSMR: Black, Single Delivery Births, Washington, D.C. Residents, 1980-84 and U.S. 1980

Weight Group (gms)	PN Deaths (NO.) D.C.	BWSPNMR D.C.	PN Survivors (No.) D.C.	BWSPNSMR	Expected PN Deaths
(1)	(2)	(3)	(4)	(5)	(6)
≤ 500	1	11.4	1	1000.0	0
501 - 1000	28	53.6	217	129.0	0.43
1001 - 1500	22	44.7	447	49.2	0.49
1501 - 2000	11	11.9	897	12.3	0.25
2001 - 2500	16	5.5	2,897	5.6	0.39
2501 - 3000	48	5.3	8,990	5.3	1.27
3001 - 3500	41	3.0	13,821	3.0	1.17
3501 - 4000	23	3.2	7,270	3.2	0.65
4001 - 4500	5	3.3	1,529	3.3	0.14
> 4500	1	3.8	261	3.8	0.03
Total	196	5.3	36,310	5.4	4.8

Table 4
Summary of Crude and Adjusted Rates:
Black, Single Delivery Birth Cohorts, D.C. 1980-84
and U.S. 1980

Rates (Per 1000)	U.S. (NIMS)	D.C. Crude	D.C. Adjusted
IMR	18.9	20.7	15.9
NMR	12.5	15.4	10.9
PNMR	6.4	5.3	5.0
PNSMR	6.5	5.4	4.8
Percent of Births			
Under 2500g	11.3	13.4	
Under 1500g	2.1	2.9	

Source: Table 4

points lower than the national rate of 18.9, rather than 1.8 percentage points higher than it. It also shows that the contribution of poor birthweight to D.C.'s high IMR is affected largely through the neonatal component of infant mortality. After standardization, the adjusted NMR declines by almost 30%, i.e., from 15.4 to 10.9, and becomes 13% lower, rather than 19% higher, than the national NMR.

Similar standardization of resident Black NMR to resident White BWD, brings down the Black NMR to 6 per thousand, i.e, from a 240.7% difference to an 11.1% difference. While this underscores the contribution of poor BWD to the Black NMR, it also shows a slight White advantage due to lower BWSMR.

The next stage of our analysis consisted of investigating the determinants of or risk factors for low birthweight among Black residents of Washington, D.C. The results of our bi-variate contingency table analysis are presented in **Table 5**, along with category-specific NMR, PNMR and the relative risk (RR) of the two rates for different categories. The results of the final model of multivariate logit analysis are presented in **Table 6**. Only statistically significant results are shown in these Tables. The main findi .s of these analyses are summarized below.

Table 5
Relative Risk for Low Birthweight, and Neonatal and Post-neonatal Mortality by Risk Factors

Risk factor	% Total	VLBW	LBW		NMR		PNMR	
		%	%	RR	Rate	RR	Rate	RR
Maternal age								
Under 20	23.4	2.5	12.6***	1.00	12.3***	1.00	6.1*	1.00
20 - 34	71.8	3.1	13.5	1.07	16.4	1.33	5.3	0.87
35 & over	4.8	3.1	14.1	1.12	15.3	1.24	2.3	0.38
Marital Status								
Married	32.6	2.2	10.8	1.00	12.4**	1.00	4.3*	1.00
Unmarried	67.4	3.4	14.6	1.35	16.8	1.35	5.8	1.35
Education								
Less than High School	31.6	2.8	15.1	1.47	16.1*	1.21	7.5**	2.34
High School	44.9	2.9	13.1	1.27	15.9	1.20	4.8	1.50
Some College	23.5	2.4	10.3	1.00	13.3	1.00	3.2	1.00
Socio-economic Status (125% poverty line)								
Under 10%	6.9	2.9	10.5	1.00	9.0**	1.00	5.5*	1.00
10 - 29%	48.1	2.8	12.9	1.23	16.7	1.85	5.6	1.02
30% & over	45.0	3.2	14.3	1.36	14.9	1.65	5.0	0.91
Prenatal Care								
Inadequate	11.8	4.6	18.2	1.72	28.2	3.36	7.6**	1.77
Intermediate	22.5	4.6	16.4	1.55	29.0	3.45	7.0	1.63
Adequate	65.8	1.8	10.6	1.00	8.4	1.00	4.3	1.00
Complications during pregnancy								
Complications	19.9	8.4	26.9	2.66	37.9	3.87	7.1	1.45
No complications	80.1	1.7	10.1	1.00	9.8	1.00	4.9	1.00
Concurrent illnesses								
Illnesses	14.2	4.8	18.9	1.51	29.0	1.53	7.1*	1.42
No illness	85.8	2.7	12.5	1.00	18.9	1.00	5.0	1.00

Table 5 (Continued)
Relative Risk for Low Birthweight, and Neonatal and Post-neonatal Mortality by Risk Factors

Risk factor	% Total	VLBW	LBW		NMR		PNMR	
		%	%	RR	Rate	RR	Rate	RR
Prior Fetal Loss								
Fetal loss	15.2	4.6	16.2	1.27	20.0**	1.38	5.0*	0.92
No fetal loss	84.8	2.7	12.8	1.00	14.5	1.00	5.4	1.00
Prior Child Death								
Child death	3.2	6.8	21.1	1.61	41.7	2.88	7.6*	1.46
No child death	96.8	2.8	13.1	1.00	14.5	1.00	5.2	1.00
Total birth order								
1st	41.3	2.8	12.6	1.00	15.4*	1.00	3.9	1.00
2nd	42.8	2.9	13.2	1.05	14.8	0.96	5.7	1.46
3rd or higher	15.8	3.8	15.8	1.25	16.6	1.08	8.1	2.08
Interval between deliveries								
Not high risk	66.0	2.7	12.4	1.00	14.4***	1.00	3.2	1.00
Live birth 23 mos.	12.6	2.8	14.6	1.18				
Fetal death 23 mos.	4.6	4.6	15.6	1.26				
Live birth 5 years	15.2	2.9	13.9	1.12				
Fetal death 5 years	1.5	4.0	17.7	1.43				
All high risks	-	-	-	-	17.2	1.19	9.5	2.97

Table 5 (Continued)
Relative Risk for Low Birthweight, and Neonatal and Post-neonatal Mortality by Risk Factors

Risk factor	% Total	VLBW	LBW		NMR		PNMR	
		%	%	RR	Rate	RR	Rate	RR
Multiple medical risks								
0	42.0	1.6	9.2	1.00	10.0	1.00	3.5**	1.00
1	30.6	3.0	13.8	1.50	14.3	1.43	6.9	1.97
2	17.0	4.3	17.6	1.91	21.4	2.14	6.2	1.77
3	7.2	5.6	20.8	2.26	27.2	2.72	4.9	1.40
4-6	3.2	8.9	25.7	2.79	36.1	3.61	10.1	2.89

*Not Significant.
**Significant at .01 level.
***Significant at .05 level. All other associations significant at .001 level.

Table 6
Odds Ratios of Having Low Birthweight:
Logit Analysis

Risk Factor	Z-Value	Odds Ratio	95% Confidence Interval
Maternal age			
Under 20 Years	-5.02, $p < .001$	0.80	0.74 - 0.88
20-34 years	2.33, $p < .05$	1.08	1.01 - 1.16
Out-of-wedlock birth	5.87, $p < .001$	1.14	1.09 - 1.19
Education			
Less Than High School	5.55, $p<.001$	1.18	1.11 - 1.25
Prenatal Care			
Inadequate	5.88, $p<.001$	1.23	1.15 - 1.31
Intermediate	2.97, $p<.01$	1.09	1.03 - 1.16
Complications during pregnancy	29.32, $p<.001$	1.78	1.71 - 1.85
Prior fetal loss	2.05, $p<.05$	1.05	1.00 - 1.11
Prior child death	4.81, $p<.001$	1.25	1.14 - 1.36
High risk birth interval	2.83, $p<.01$	1.06	1.02 - 1.10

Likelihood Ratio Chi Square = 577.67, df=556, p=.254
Pearson Chi Square = 536.54, df= 556, p=.716

A. **SOCIO-DEMOGRAPHIC RISK FACTORS**:

1. **Maternal age**: The age group 20-34 years, which accounted for 72% of all mothers, had a 7% higher risk of having a LBW baby than the mothers under 20 years of age. However, it had a 5% lower risk than mothers 35 years and over. Infants of mothers 20-34 also had a considerably larger risk of dying during the neonatal period than the infants of younger mothers. The relative risk (RR) of neonatal death to the infants born to mothers 35 and over was somewhat lower than that for infants born to mothers 20-34 years of age. When the age group under 20 is broken down into under 17 and 17-19, the risk for neither of these age groups exceeds that for the 20-34 age group -- whether it is for LBW, IMR or NMR. In fact, the RR of neonatal death for infants born to 17-19 mothers is only 68% of the risk for babies of 20-34-year-old mothers. For the 16 years and under group, the RR is 1.00 for LBW, 0.98 for IMR and 0.87 for NMR, with 20-34 being the reference group.

After controlling for the effect of other variables, the effect of maternal age on LBW remains significant, with 20-34-year group having an odds ratio of 1.08 for LBW, the 35 years and over group having a ratio of 1.15 and the age group under 20 an odds ratio of only 0.80.

2. **Marital status**: More than two-thirds of the Black resident births occurred to currently unmarried women. Infants of these mothers had a one-third higher NMR than the infants of married mothers. The role of LBW in their NMR differentials is indicated by the fact that while 10.8% of the infants of married mothers had a LBW, the corresponding figure for the infants of

unmarried mothers was 14.6%, i.e., an RR of 1.35. The percentage VLBW for the two groups was 2.2 and 3.4, respectively. After controlling for the effects of the other significant variables, the unmarried mothers had a 14% higher odds of delivering a low weight infant than a married mother.

3. Education: Less than one-fourth of the mothers had some college education. This group had the lowest risk for LBW as well as for neonatal or post-neonatal mortality. Neonatal mortality differentials, however, were not statistically significant. Compared to the infants of the college-educated group, babies born to mothers who had less than high school education or who had a high school diploma, the RR for LBW was 1.47 and 1.27, respectively, and for post-neonatal mortality, 2.34 and 1.50, respectively. After controlling other factors, the less than high school educated mothers had an odds ratio of 1.18 for delivering a LBW baby. From our analysis of quality of data (Appendix C), it appears that the infants born to women in the less than the high school education category should have had a higher incidence of LBW, and more neonatal deaths during cross-tabulation than obtained either by unadjusted figures or by proportionate reallocation of missing cases. The Chi-square test, which, in Table 5, is not significant for educational differences in NMR, may, actually, have been significant.

4. Socio-economic status: Seven percent of the babies were born to mothers in high SES groups, i.e., those living in census tracts where less than 10% of the Black families were under 125% of the official poverty line; 48% of the babies belonged in this manner to the middle level census tracts (10-29% families under

125% of poverty line); and 45% to the lower level (30% or more families under 125% of poverty line). Compared to the high SES, the middle and low levels had an RR of 1.23 and 1.36 respectively for LBW. The NMR'S for the different levels were significantly different, but PNMR'S were not. While the high SES group had the lowest RR for both LBW and NMR, and the lowest group had the highest RR for LBW, it had a lower RR for NMR than the middle group. This could possibly be due to the inadequacy of this indicator as a measure of SES. In the multivariate analysis SES was not found to be significant.

B. **HEALTH CARE AND MEDICAL RISK FACTORS**

1. **Complications during the pregnancy:** Complications developed by the mother during the pregnancy, as distinct from complications of labor or pre-existing illnesses or adverse conditions, emerged as the most important single variable in our study. Mothers with one or more complications had more than 2 and 1/2 times higher proportion of LBW and four times higher proportion of VLBW babies than the mothers who had no complications. The NMR for the former group of babies was almost four times the rate for the latter group, and the RR for PNMR was 1.45. When seven other significant risk factors were controlled for (Table 6), complications during the pregnancy still remained the factor most strongly associated with low birthweight. The odds of having a LBW baby were still 80% higher for mothers with compared to than for those without complications.

Information on specific complications was not adequate to examine it in any greater detail. Not only was the data collected in an inconsistent manner during the time periods for which we have data tapes, but there were too many entries in the blanks for the residual "other" categories. According to the available data, which are most probably under-reported, 5.1 percent of the mothers had premature rupture of membrane, 4.1 percent had pre-eclampsia. For the 1983-84 period, 4 percent of the mothers were reported to have had acute uterine infection, 1.9 percent had hypermesia, 1 percent had fever over 101 degrees, and only 0.9 percent were reported as having developed gestational diabetes.

The significance of high risks associated with pregnancy complications is underscored by the fact that 20% of all babies were born to mothers who had had one or more complications during the pregnancy. This gives an attributable risk of 12.4% for LBW, and 14.8% for neonatal mortality.

2. Concurrent illnesses or conditions affecting pregnancy: In this group of conditions, pre-existing illnesses, such as hypertension, heart disease, and kidney disease, and other conditions, such as sexually transmitted infections, were included. For the 1980-82 period, information on narcotic addiction was also included. About fourteen percent of the mothers were reported to have had one or more of these illnesses or conditions. Those with illnesses had a 51% higher risk of delivering a LBW baby than those who did not have any illness or condition. Infants born to mothers with these illnesses or conditions had a 53% higher risk of dying during the neonatal period than other babies.

This variable was not statistically significanct when adjusted for other risk factors. This may be due to the strong inter-correlation between this variable and some of the statistically significant risk factors. For example, of the mothers who had illnesses (14.2% of the total) one-half had complications, and the other one-half did not. A large proportion of those who did not have any illnesses (85.8% of the total), did not have complications of pregnancy either (85.1%).

3. <u>Prior fetal loss</u>: A little over 15% of the mothers had experienced one or more spontaneous or induced terminations. Due to the form in which data were available, it was not possible to distinguish between these terminations according to the length of gestation. The mothers who had had a fetal loss, had a 27% higher risk of delivering an LBW baby than the mothers who did not. Babies born to the former group of mothers had a 38% higher risk of dying during the neonatal period.

After controlling for the other significant risk factors, the odds ratio of having an LBW baby remained only 5% higher for the mothers who had experienced fetal loss than those who had not.

4. <u>Prior child death</u>: About three percent of the mothers had a previous live infant which had died before the current live birth. Such mothers had a 61% higher risk of having an LBW baby than other mothers. Babies of such mothers had almost three times as high a risk of neonatal death than babies born to the other women. Even after controlling for other variables, the odds ratio for having an LBW baby remained 25% higher for mothers with prior child death.

The ages of the dead children are not specified. It is possible that most of these are deaths of infants who were also born with LBW. Women with a history of LBW deliveries are known to have a two to five times higher than average risk of having a subsequent LBW baby (Bakketeig, et al., 1979).

5. **Total birth order**: Total birth order includes all births to a woman, whether live or not. The current live birth was the first delivery for 41.3% of the mothers; for 42.8%, this was their second delivery, while for the remaining 15.8%, this was their third or later birth. Compared to the first births, the second births had a 5% higher risk of having LBW, and third and higher order births had 25% higher risk. Differences in NMR were not statistically significant. However, the risk of PNM increased with birth order. For third and higher order of births the relative risk of PNM was twice that of first order births.

When other risk factors were controlled for, total birth order did not remain statistically significant as a factor associated with LBW. This may be due to the fact that this variable overlaps with prior fetal loss and the interval between deliveries to some extent.

6. **Interval between deliveries**: In terms of the interval between the current live birth and the previous delivery, 66% of the births were not considered to be high risk. The remaining 34% were born either within 23 months of a live birth or fetal loss, or more than five years after a live birth or fetal loss. All the high risk categories had a higher proportion of LBW and a higher IMR than for the low risk babies. The risk of having LBW or infant death was generally higher if the previous delivery was in less than 23 months rather than after more than five years. It was generally higher if the previous delivery was a fetal death rather than a live birth.

This variable remained significant even after controlling for the seven other risk factors shown in **Table 6**. However, its effect was considerably reduced, with high risk intervals having only 6% higher odds of LBW than other births. The odds ratio remains unchanged even if previous fetal loss is taken out of the model.

7. **Multiple medical risks**: Over one-fourth of mothers had more than one medical risk. **Table 5** shows the frequency distribution of multiple risks. It also shows the RR for LBW, NMR, and PNMR by number of risks. The higher the number of risks, the higher the percentage of VLBW and LBW, and the higher the NMR. There is no linear pattern for PNMR, even though the differences are statistically significant.

The fact that different medical risks are not equally important can be gauged from **Table 5**. Complications during the pregnancy, as a single factor, appear to be as important as the six factors combined. While percent VLBW is only slightly lower for complications than for six factors, percent LBW and NMR are higher for complications alone. However, if factors with maximum net effects are combined, the RR for adverse pregnancy outcomes exceeds the risks associated with complications alone.

The LBW differentials by number of medical risks remained statistically significant ($p < .001$) for each level of prenatal care, revealing the joint effect of medical risks and prenatal care. For example, infants whose mothers had four to six medical risk factors and received inadequate care had a 5.35 times higher risk of LBW than infants whose mothers had no medical risk factors and received adequate prenatal care.

8. **Prenatal care**: Nearly two-thirds of the mothers had adequate prenatal care by the definition used in this study, while one-third had inadequate or intermediate care. Compared to the mothers with adequate care, mothers with inadequate and intermediate care had a risk of having an LBW baby which was 72% and 55% higher, respectively. Differences in birthweight by level of prenatal care remained statistically significant ($p < .001$) for each value of the combined medical risk factor and complications during the pregnancy when these variables were controlled. When seven risk factors were controlled, prenatal care remained independently significant **(Table 6)**. Mothers with inadequate care had an odds ratio of 1.23 for LBW and mothers with intermediate care had an odds ratio of 1.09, while mothers with adequate care had an odds ratio of only 0.75.

NMR for the babies born to women with inadequate or intermediate care was more than three times higher than that for the babies born to women with adequate prenatal care. However, NMR was slightly higher for infants born to mothers with intermediate care than for those born to mothers with inadequate care. PNMR was highest for the infants whose mothers received inadequate prenatal care: RR of 1.77, as compared to the infants whose mothers received adequate care. The difference between inadequate and intermediate care in not very large with respect to any of the pregnancy outcomes.

C. **Association between Socio-demographic and health care-medical risk factors.**

As would be expected, the health care and medical risk factors which are significantly associated with LBW, also tend to be associated with the socio-demographic risk factors significantly associated with LBW. Analysis of inter-correlation of these two sets of risk factors, however, allows us to see how the various socio-demographic categories relate to the different medical risk factors.

Table 7 shows that while teenage mothers are much more likely to not have adequate prenatal care and to have a higher risk of developing complications during the pregnancy than the older women, they have a substantially lower relative risk of having prior fetal loss, prior child death or high risk birth interval, and a moderately lower RR for concurrent illnesses. Similarly, unmarried women, who are at a higher overall risk for LBW, have a greater incidence of inadequate care and somewhat higher risk of complications and concurrent illnesses, but have considerably lower risk for prior fetal loss, prior child death, and high-risk birth interval than married women.

While the frequency of inadequate prenatal care and RR for complications and prior child death vary inversely with educational attainment of the mother, the RR for prior fetal loss varies directly with education. For concurrent illnesses, mothers with high school education have a lower risk than mothers having a college education or less than high school education. For high-risk birth intervals, mothers with less than high school education have the same risk as mothers with college education,

Table 7
Association Between Medical and Socio-Demographic Risk Factors: Incidence Rate (%) and Relative Risk (RR)

Medical risk factors	Socio-demographic factors: Maternal age					
	LT 20		20-34		35 +	
	%	RR	%	RR	%	RR
Inadequate prenatal care	16.4	1.56	10.5	1.00	10.4	0.99
Complications during pregnancy	21.5	1.12	19.2	1.00	23.4	1.22
Current illnesses	12.6	0.87	14.5	1.00	18.1	1.25
Prior fetal loss	8.1	0.47	17.2	1.00	20.6	1.20
Prior child death	0.9	0.24	3.7	1.00	7.9	2.14
High-risk birth interval	14.3	0.37	38.7	1.00	59.9	1.55

Medical risk factors	Marital Status			
	Married		Unmarried	
	%	RR	%	RR
Inadequate prenatal care	8.3	1.00	13.6	1.64
Complications during pregnancy	18.6	1.00	20.5	1.10
Current illnesses**	13.6	1.00	14.4	1.05
Prior fetal loss	17.4	1.00	14.1	0.81
Prior child death	4.4	1.00	2.7	0.61
High-risk birth interval	42.9	1.00	29.6	0.69

Table 7 (Continued)
Association Between Medical and Socio-Demographic Risk Factors: Incidence Rate (%) and Relative Risk (RR)

	Maternal education					
	LT High		High School		Some College	
	%	RR	%	RR	%	RR
Inadequate pre-natal care	17.2	2.69	10.7	1.67	6.4	1.00
Complications during pregnancy	21.3	1.16	19.6	1.06	18.4	1.00
Current illnesses	15.7	1.14	13.2	0.96	13.7	1.00
Prior fetal loss	12.6	0.67	15.6	0.82	18.9	1.00
Prior child death**	3.6	1.20	3.1	1.03	3.0	1.00
High-risk birth interval	32.9	1.00	35.3	1.07	33.0	1.00

	Socio-economic status (% families under 125% of poverty line in birth census tract)					
	30% & over		10 - 29%		Under 10%	
	%	RR	%	RR	%	RR
Inadequate pre-natal care	13.2	1.57	11.0	1.31	8.4	1.00
Prior fetal loss*	14.5	0.90	15.7	0.97	16.2	1.00
High-risk birth interval**	34.7	1.08	33.6	1.05	32.0	1.00

*Significant at .01 level.
**Significant at .05 level. All other associations significant at .001 level.

while mothers with high school education have a slightly higher risk than the other two groups. In relation to SES, as measured by census tract of residence, prenatal care and the RR for high-birth interval were inversely correlated, but prior fetal loss was directly associated.

D. High-risk census tracts

Table 8 shows the ten census tracts with the highest levels of infant mortality. Only the tracts with a minimum of 50 births per year and an IMR above the city average were ranked. These census tracts, together, account for 15.8% of all infant deaths, and only one of these individually accounts for less than one percent of the deaths. With few exceptions, all values for LBW ratio and proportion of unmarried, non-college and receiving inadequate prenatal care are substantially higher than the corresponding city average. Except for census tract 46, all high-risk tracts are located in the Northeast and Southeast.

E. Mortality among normal birthweight infants

Nearly one-fourth of all resident Black infant deaths occurred to normal weight infants. Congenital anomalies accounted for the major share of deaths among normal weight infants. Twenty-three percent of normal weight infant deaths and 5.8% of all infant deaths were caused by congenital anomalies among normal weight infants.

F. Plural births and infant mortality

Although multiple births have been excluded from this analysis in order to avoid possilbe bias in our results, a separate accounting of the contribution of such births to adverse pregnancy outcomes in Washington, D.C., may be in order. Mortality among

Table 8
Ten High Risk Census Tracts by IMR and
Incidence of Major Risk Factors

Census Tract	Births (%)	Infant deaths (%)	IMR (000)	LBW (%)	Unmarried (%)	Inad. Care (%)	Non-college (%)
46.0	1.1	2.2	41.6	24.8	73.5	16.7	83.3
71.0	0.7	1.2	35.2	18.7	80.9	14.8	85.8
77.6 (99.6-99.7)	1.3	2.0	34.3	16.3	71.4	11.9	84.1
89.2 (89.4)	0.9	1.7	33.7	16.4	76.4	14.0	86.0
73.2	1.2	1.6	32.7	15.9	66.0	8.8	79.6
74.1	1.2	1.7	28.9	16.7	83.0	16.1	90.0
79.1	1.0	1.3	26.8	15.6	77.0	13.7	81.2
72.0	0.8	0.9	25.2	13.0	87.1	13.0	92.9
77.7	1.0	1.2	25.0	16.6	71.1	13.7	78.8
78.1 (96.1-96.2)	2.0	2.0	24.7	12.7	79.6	17.7	88.0
All	100	100	20.7	13.4	67.4	11.8	76.5

plural births is excessively high. While these births comprised only 2.5 percent of all Black resident births, infant deaths occurring among them accounted for 10.1% of all Black resident infant deaths. Sixty-six point three percent of all plural births had LBW, and 94.2 percent of all plural deaths had LBW.

IV. DISCUSSION

The results of this study indicate that poor birthweight distribution is the principal proximate reason for a high neonatal -- and, thus, overall infant -- mortality rate among Black residents of Washington, D.C. While direct standardization to white resident birthweight distribution shows the enormous extent to which BWD is responsible for the extremely high Black infant mortality, standardization to the national Black BWD shows the substantial reduction in neonatal mortality rates that can be achieved only if the BWD of the Washington, D.C., Blacks were to equal that of U.S. Black babies as a whole. This would lift Washington from the seventeenth position to fifth from the top in the ranking of 18 U.S. cities with a population of 500,000 or more on the basis of Black IMR.

This adjusted level of infant mortality rate (15.9) or of neonatal mortality rate (10.9) for single-delivery births is still very high, associated with a high ratio of low birthweight (11.3%). The results of our risk factors analyses show sub-groups with an LBW ratio from 4.4% to 10.6% lower than the National Black average, and an NMR 10.1% to 19.3% lower than the adjusted neonatal mortality rate. However, even the lowest sub-group levels of LBW and NMR are not very low, aside from being very difficult to generalize.

Our findings concerning the risk factors are, in broad terms, consistent with the existing knowledge. Three factors, i.e., prenatal care, complications during the pregnancy and birth interval were found to be significantly associated with all three pregnancy outcomes, i.e., birthweight, NMR and PNMR. Maternal age, marital status, socio-economic status, concurrent illnesses, prior fetal loss, and previous child death, i.e., a total of six factors, were significantly associated with birthweight and neonatal mortality. Two factors, i.e., education and total birth order were found to have a significant statistical association with birthweight and post-neonatal mortality. Although lack of statistical significance in relationship between education and neonatal mortality is consistent with the findings of Bross and Shapiro (1982), we have a strong suspicion that this result in our study is an artifact of defects in our dataset.

It is interesting to note that there is no risk factor which is significantly associated with either neonatal mortality or post-neonatal mortality which is, at the same time, not significantly associated with low birthweight. This means that any variable that directly affects infant mortality, also affects it indirectly through low birthweight. This result justifies the extra effort made to carry out multi-variate analysis of risk factors associated with low birthweight. Of the eleven factors found significant in the bivariate analysis, eight remained significant after controlling for all other variables. However, of these factors, only three showed substantial net effects: prenatal care, complications during the pregnancy, and prior child death -- a possible proxy of history of past successive low birthweight births and infant deaths. The critical role of prenatal care is already well established (IOM, 1985) and has even been established for Washington, D.C. (Rahbar, et al., 1985). Role of specific complications, such as pre-eclempsia, in intrauterine growth retardation has been previously demonstrated

(Low & Galbraith, 1974). Vital registration data may not afford the possibility of studying individual complications. However, data on complications, combined as in this study, do help underline the role of maternal health, other than pre-natal care, in pregancy outcomes. History of child death is, similarly, a crude and disaggregated measure of possible adverse obstetrical history, specific parts of which have been linked to low birthweight (Bakketeig, et al., 1979).

Because of the ease of identification that age provides, as well as for possible biological, social, financial and emotional implications of maternal age -- particularly very young age, teenage pregnancies, as well as LBW and IMR for such births, have been the focus of attention on the part of the professionals, community and the government. In Washington, D.C., public discussion of infant mortality has focussed almost exclusively on teenage pregnancies. Accumulated knowledge in the field also tends to point toward teenage motherhood as a major risk factor for LBW and infant mortality (IOM, 1985; DHHS, 1986; CDF, 1987; Friede, et al., 1987).

Results of this study contradict the common belief that teenage motherhood is a major risk factor for LBW and infant mortality in general, and that it is the main reason for high IMR in Washington, D.C. Our results show that infants of Black teenage mothers in D.C. have the best birthweight distribution and the lowest relative risk for neonatal and overall infant mortality. Even when teenage mothers aged 16 and under are separated from the rest, their babies have no higher risk of having LBW or of dying during the neonatal period than infants born to women 20-34 years and 35 years and above. Infants born to mothers 17-19 years have a better BWD and lower risk of neonatal death than infants born to any other age group in the study, including 16 and under.

The results of this study are by no means the first to fail to conform to the widely-held view about the relationship between teenage motherhood and adverse pregnancy outcomes. Geronimus (1986), who analyzed data from Louisiana, Tennessee and Washington states, noted that although among Whites, NMR were higher for all ages under 20 than for the age group 24-26, among Blacks this was true only for infants born to women under 17 years. Infants of Black mothers 35 years and over, also had a lower NMR than those born to 24-34 year olds. From her logit analysis, she concluded that association of race and prenatal care with LBW, SGA and neonatal mortality confound the association between teenage motherhood and poor pregnancy outcomes.

Zukerman, et al. (1983), in their clinical study of primiparous women, found that infants born to mothers 13-18 years were, on an average, 94 grams lighter than the infants of older mothers. However, when several health care and social factors were controlled, the association between adolescent status and LBW was statistically not significant. In a separate regression analysis, the independent effect of maternal age of 16 and under on LBW was not found significant. Sixty-seven point six percent of the mothers were Black. Even the recent national study on infant mortality, which seems to establish a negative correlation between birthweight and IMR on one hand, and maternal age up to 25-29 years on the other, fails to present a clear linear relationsh-- between age of Black mothers and these outcomes (Friede, et al., 1987).

While it seems that the general question of relationship between maternal age and pregnancy outcomes needs more definitive answers from further research, the relationship between teenage motherhood and infant mortality found in this study can be explained by looking more closely at the relationship between maternal age on one hand, and other risk factors and pregnancy outcomes on the other hand.

As discussed in Section III-C, for the risk factor having the strongest independent association, i.e., complications developed during the pregnancy, teenage mothers have a higher risk than mothers 20-34, but lower than that of mothers aged 35 and over. Mothers 16 and under have the highest RR of complications. In terms of prenatal care, which affects the birthweight outcome in many ways other than being associated with complications, the teenage mothers have a substantially higher proportion receiving inadequate care than the percentage among older women. Yet a substantially lower RR for the other medical risks more than offsets the adverse effect of poor prenatal care and of complications.

Almost all of the teenage mothers (94.1% under 20 and 98.5% under 17) are unmarried, and unmarried mothers, in general, have a 35% higher risk of delivering an LBW baby than do married mothers. Yet when the effect of age is controlled, there is no statistically significant difference between married and ummarried women under 20 in terms of the risk of delivering an LBW baby. When marital status is controlled, there are significant maternal age differentials in LBW for unmarried women: infants born to teenage mothers have a 19% lower risk and those born to women 35 and over a 17% higher risk, as compared to infants born to unmarried women 20-34 years (Chi square = 53.5, df=4, $p < .001$). Among infants of married women, there are no statistically significant maternal age differentials in birthweight. When education is held constant, there are significant maternal age differentials in birthweight only for the infants born to women with less than high school education (Chi square = 52.7, df=4, $p < .001$). There too, the women under 20 have the lowest (12.4) percentage of LBW babies; the percentage of LBW infants for mothers 20-34 and 35 and over being 17.1 and 19.1, respectively. Thus, the high RR which mothers with less than high school education have in relation to most of the health care-medical risk factors and the high RR of delivering an LBW infant, is due to the mothers being 20 years and older.

From the discussion above, it emerges that the better pregnancy outcomes of young mothers, particularly at ages 17-19, seem to overshadow the high risks these mothers carry in terms of low educational attainment, out-of-wedlock births, inadequate prenatal care and complications during the pregnancy. Even when prenatal care is controlled, RR for delivering a VLBW or LBW baby remains lowest for the mothers under 20 for inadequate or intermediate levels of care ($p < .01$). If the teenage group is further broken down, 17-19-year-olds have a lower percentage of LBW infants at the inadequate level and the under 17 group has a slightly lower percentage at the intermediate level ($p < .05$). Birthweight differentials by maternal age were found statistically non-significant for those receiving adequate prenatal care. Whatever biological advantages young age may bestow in overcoming a large number of medical risks, it is clear that the element of time, reflected by age, is, in itself, a very important factor in not allowing significant medical risk factors, associated with pregnancy history, such as prior fetal loss, prior child death, too long a birth interval, and many of the deleterious diseases (heart, kidney, chronic hypertension, etc.) to develop to the extent that they do among the older women.

From the standpoint of prevention of LBW and infant mortality, therefore, it is not easy to identify a target age group in the District of Columbia. Incidence of LBW is high among all groups, but highest among women 35 and over. However, the latter group constitutes just under 5% of all mothers, and, therefore, carries an attributable risk (AR) of no more than 0.5% for LBW and 1.2% for neonatal mortality. The largest segment of the mothers, i.e., age 20-34, comprises about 72% of all mothers. The infants born to these mothers already have a higher risk of LBW than infants born to younger women, and they have the highest NMR of all groups. Although, the AR for this age group for LBW is less than 5%, for neonatal mortality it is almost 20% (Table 9).

What remains of the socio-demographic variables in this study may largely be the proxy of socio-economic status. Census tract, itself, is an indicator of SES, although an inadequate one. Education, particularly when educational level differentials in birthweight are statistically not significant for mothers under 20, may reflect, to a large extent, SES differences. Indeed, there is a statistically significant association between

Table 9
Relative and Attributable Risks for LBW and NMR by Demographic Factors

Factor	LBW RR	LBW AR	NMR RR	NMR AR
Age (LT 20=1)				
20 - 34	1.07	0.047	1.33	0.178
35 & over	1.12	0.005	1.24	0.009
Marital status				
Unmarried (Married = 1)	1.35	0.175	1.35	0.174
Unmarried 20-34 (Married 20-34=1)	1.46	0.138	1.63	0.169
Education (College=1)				
LT High School	1.47	0.101		
High School	1.27	0.095		
LT High School 20-34 (College 20-34=1)	1.66	0.064	1.46	0.051
High School 20-34	1.28	0.077	1.30	0.081
SES (LT 10%=1)				
30% & over	1.36	0.119	1.65	0.177
10-29%	1.23	0.090	1.85	0.221

educational attainment and census tracts ranked by Black families under 125% of the poverty line (Chi square= 1600.7, df=4, p <.001). With marital status differentials in birthweight being statistically not significant for infants born to mothers under 20, marital status differentials for the older women may also reflect SES differentials in birthweight.

However, this is not to deny the non-economic effects of adequate education and married status which may provide attitudes and emotional support conducive to good ante-natal and post-partum care, including adequate nutrition and other sound health practices.

A number of other risk factors known to affect pregnancy outcomes such as nutrition, weight gained during the pregnancy, smoking, alcohol consumption, drug addiction and stress (IOM, 1985) could not be analyzed because we have little or no data on these risk factors. According to information on narcotic addiction, available only for the years 1980 through 1982, 278 (1.3%) mothers reported addiction to narcotics. Of these, 93 (33.5%) had LBW babies; eight (8.6%) died within a year. This amounts to an RR of 1.39 for infant mortality among babies of addicted mothers compared to the overall rate.

Congenital malformations are known to be associated with LBW (Christianson, et al., 1981), and account for a significant proportion of infant deaths (Johnson & Dubin, 1980; Kaltrieder & Kohl, 1980). In our dataset, 11.7% of neonatal deaths, 12.8% of post-neonatal deaths and 11.9% of all infant deaths were diagnosed as having been caused by congenital malformations. Yet only 5% of all infant deaths were identified at the time of birth as possessing congenital anomalies. This means 38.5% of the infants dying of congenital malformations. For the infant deaths whose cause of death was listed as congenital anomalies, 52% had LBW.

Data on sexually transmitted diseases in our dataset, which show only 1% of the mothers to be affected, are probably under-reported. With the growing spread of AIDS, the risks of pediatric AIDS and infant death are also likely to increase. It is not possible to determine from the data used in this study if AIDS had played any role in infant mortality during the period under study.

Given these limitations of this study, it is not unlikely that one or more of the major determinants of LBW and infant mortality among Black residents of Washington, D.C., may have been left out of the analysis.

In terms of readily identifiable demographic characteristics, infants born to mothers 20 years and older, especially if they are unmarried or have never been to college, pose the highest relative and attributable risk for LBW and neonatal mortality. Despite a lack of an adequate measurement of socio-economic status, there are indications that high incidence of LBW and infant mortality are related to low SES. Census tracts identified as having the highest risk of infant mortality also happened to be among the poorest, with a heavy concentration of public housing. Infants born to women aged 20-34 years, married, with some college education and living in the areas of the city where less than 10% of the Black families are under 125% of poverty line, have the best pregnancy outcomes.

It appears from the above discussion that the roots of high infant mortality among D.C. Blacks lie deeply embedded in the conditions of socio-economic disadvantage, and will require long-term social and economic solutions. To the extent short-term interventions at the health care level can help mitigate the conditions, adequate pre-natal check-up and effective remedial measures for complications and illnesses developed during the pregnancy and for illnesses predating the pregnancy should be the areas demanding maximum attention. However, these should be extended equally to women of all reproductive ages. Singling out teenage mothers for special attention could lead to ignoring the age group which has the highest attributable risk. If there is any basis for singling out, it is the socio-economic disadvantage. Unfortunately, this places a very large segment of the city's reproducing female population in the category of those needing special attention. As Boone (1982) has observed, this is a more or less homogeneously disadvantaged urban population in which women cannot be easily profiled as high risk. There are no small, clearly demarcated demographic sub-groups, with lopsidedly high IMR, which can be isolated, defined as "target groups" and subjected to quick-fix intervention measures for reducing infant mortality rates.

In contrast to socio-demographic sub-groups, identification of high-risk residential areas appears relatively easy. Census tracts with the highest levels of IMR and the largest percentage of all infant deaths are mostly concentrated in the Northeast and Southeast sections of the city, many overlapping with public housing locations. A number of service/intervention programs are predicated on this approach of geographic concentration. However, our analysis of infant deaths by census tracts, while confirming this pattern of concentration, shows that 12 census tracts with highest levels of IMR and a minimum average of 50 births per year, together, account for no more than 15.8% of the city's total infant deaths. This suggests that the geographic area for concentrated outreach service needs to be expanded vastly.

Clearly, the absence of lopsidedly high-risk, small-sized demographic groups or geographic areas, makes the task of city officials in lowering IMR much more difficult than it may initally appear from the statistics showing high levels of IMR in Washington. Even if the problem of outreach can be solved satisfactorily to a considerable degree, it should be noted that the results of the health service programs in terms of lowering IMR may not be proportional to the reduction brought about in the exposure to an associated risk factor. For example, the role of adequate prenatal care in bringing down the incidence of low birthweight and infant deaths has been well-established. Our analyses have also shown that inadequate prenatal care and complications during the pregnancy are the two proximate factors with the highest independent effect on birthweight and IMR. Our data show that Black mothers who receive adequate prenatal care by our standards, and who comprise two-thirds of all Black mothers, have an infant mortality rate for their babies which is not only lower than the lowest 1984 Black rate among 18 cities with a population of 500,000 or more, i.e., that of Columbus, Ohio, but it is lower than the White IMR in Detroit and Baltimore. Would providing adequate prenatal care to the remaining one-third of the mothers bring Washington's IMR down to a level close to that of Columbus, Ohio? Probably not. Pregnancy outcomes of mothers receiving inadequate prenatal care, show that while the relative risk of delivering an LBW infant for such mothers is about 60% higher than that for mothers receiving adequate care, the relative risk of their babies dying within four weeks is about 340% higher. This could be interpreted to mean that not getting adequate prenatal care is only one manifestation of a deeper malaise -- possibly involving poverty, alienation, apathy and lack of pertinent knowledge -- which results in unhealthy child care practices. Post-partum health programs directed towards infants may be able to address part of this problem. But it seems that the basic problem would still remain outside the realm of health. This is also indicated by the differentials in the IMR for married and unmarried mothers.

From the point of view of health service measures to lower the IMR in Washington, our data justify support for family planning. Mothers delivering a third or later baby have a 25% higher risk as compared to those delivering their first baby, and a 20% higher risk than those delivering their second baby to have that baby weigh under 2500 grams. The data also show that mothers whose last two deliveries were less than 23 months apart have approximately 20% higher risk of delivering an LBW infant than those who have a longer birth interval. Approximately one-fifth of the mothers fall into the high-risk category on the basis of these two factors.

Although this study was not undertaken basically with a view to providing benchmark data for health service programs, and many detailed analyses possible within the limits of our dataset were not carried out, it is hoped that our analyses of risk factors associated with high infant mortality among Black residents of Washington, D.C., will be of help in understanding the problem of infant mortality not only from the standpoint of devising strategies for health care services, but also from the point of view of education, social services and employment.

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APPENDICES

Appendix A

DEFINITIONS AND COMPUTATIONS

APPENDIX A
Definitions and Computations

Attributable risk (AR): Also known as "attributable proportion" or "etiological fraction," it is a measure which takes into consideration the relative risk (RR) for a disease or event for a particular category of cases as well as the proportion of that category in the study population (f).

$$AR = \frac{RR - 1}{RR} \times f$$

Birthweight-specific mortality rate (BWSMR): Mortality rate computed for each specific birthweight category.

$$BWSMR = \frac{\text{Number of infant deaths in a specific birthweight group}}{\text{Number of live births in the same birthweight group}}$$

Birthweight-specific mortality rates may be computed for neonatal deaths only or for post-neonatal deaths only. In that case, they are called birthweight-specific neonatal mortality rates (BWSNMR) and birthweight-specific post-neonatal mortaltiy rates (BWSPNMR) respectively.

Infant mortality rate (IMR): A child under one year of age is defined as an infant in demographic and medical literature. The IMR is computed as follows:

$$IMR = \frac{\text{Number of infant deaths in a given period}}{\text{Number of live births in the same period}} \times 1000$$

Usually, IMR and other vital rates are computed for calendar years, and, therefore, calendar-year events are used in both the numerator as well as the denominator. However, in certain cases, the numerator may consist of the infant deaths which actually occurred to the birth cohort in the denominator. In such a case, a portion of infant deaths takes place in the year following the birth year. Such rates are cohort rates, as distinct from calendar-year deaths. Some researchers have begun to call them "risks" rather than rates.

Low birthweight (LBW): Birthweight is a continuous variable. By convention, all births weighing less than 2500 or 2501 grams are considered to be LBW. Even though Black American infants are known to have a higher survival rate at birthweights lower than 2500 grams, for a number of reasons, including the need for a standard measurement, the definition of LBW has not been changed or modified.

Neonatal mortality rate (NMR): All infant deaths which occur in less than four weeks, or 28 days, are defined as neonatal deaths. NMR is computed in the same way as IMR, with all live births in the denominator, and neonatal deaths in the numerator.

$$NMR = \frac{\text{Neonatal deaths}}{\text{All live births}} \times 1000$$

Perinatal mortality: Because of common etiology, i.e., "endogenous" causes, fetal and neonatal deaths are combined and called perinatal deaths. Perinatal mortality rate (PMR) is calculated as follows:

$$\frac{\text{Fetal deaths of over 20 weeks gestation + neonatal deaths}}{\text{Live births + fetal deaths}} \times 1000$$

Post-neonatal mortality rate (PNMR): All infant deaths which take place after the first 27 days of life are defined as post-neonatal deaths. Thus,

$$PNMR = IMR - NMR, \text{ or}$$

$$= \frac{\text{Post-neonatal deaths}}{\text{all live births}} \times 1000$$

Post-neonatal survivors' mortality rate (PNSMR): This is a post-neonatal rate which applies to cohort deaths and in which the births surviving neonatal mortality, rather than all live births, are taken as the denominator.

$$PNSMR = \frac{\text{Post-neonatal deaths}}{\text{all live births - neonatal deaths}} \times 1000$$

The PNSMR is usually higher than the PNMR.

Relative risk (RR): This is a ratio of two rates, usually the incidence rate of a disease or event occurring to one (or exposed) category of cases as compared to the incidence rate for the reference (or unexposed) category.

$$RR = \frac{\text{Incidence rate for exposed category}}{\text{Incidence rate for unexposed category}}$$

Relative risk provides a handy measurement of comparison between several categories of a variable with regard to the frequency of a disease or vital event. However, if the proportion of a category with a very high RR is extremely low in the population, the role of that category of cases to the total incidence of the disease or event will be quite small. That is why its frequency in the population is taken into account and attributable risk (AR) is computed. RR is expressed in relation to 1, where 1 represents the incidence rate for the reference group.

Short gestational age (SGA): Like birthweight, gestational age is also a continuous variable. By convention, all births which take place before 37 weeks of gestation are considered as pre-term, or of short gestational age. SGA may be defined differently to suit the needs of a particular study. The abbreviation SGA, unfortunately, is also used to denote small-for-gestational age.

Very low birthweight (VLBW): A birthweight of under 1500 or 1501 grams is defined as very low birthweight.

APPENDIX B

SUPPLEMENTAL TABLES

Table B-1
Infant and Neonatal Mortality Rates by Race:
Washington, D.C., 1970-1985

Year	IMR		NMR		NMR-IMR Ratio	
	Black	White	Black	White	Black	White
1970	29.7	23.0	23.2	19.3	77.9	83.7
1971	30.3	15.7	22.5	11.8	74.2	75.0
1972	28.1	19.7	20.3	16.1	72.0	81.5
1973	26.0	21.8	19.7	16.2	75.5	74.2
1974	29.2	16.9	22.4	15.4	76.9	90.9
1975	30.0	19.5	23.4	17.1	77.9	88.0
1976	27.7	7.5	22.7	3.7	81.7	50.0
1977	29.5	13.9	22.2	10.2	75.3	73.7
1978	28.6	9.5	21.0	8.0	73.4	84.6
1979	24.7	5.9	18.9	5.2	76.4	87.5
1980	26.6	13.1	19.8	8.7	74.3	66.7
1981	25.3	9.5	19.0	9.5	75.0	100.0
1982	23.4	6.0	17.4	1.8	74.4	30.0
1983	20.1	8.6	14.3	8.0	71.1	92.7
1984	24.0	7.8	18.4	5.4	76.7	69.2
1985	22.9	10.6	17.6	8.2	76.3	77.8

Sources: Department of Human Services, District of Columbia, _Vital Statistics of the District of Columbia_ 1983, Washington, D.C., 1986; DHS, Unpublished tables, 1984 and 1985.

Table B-2
Birtnweight Distribution of Single Delivery
Birth Cohorts: Washington, D.C., 1980-84 and U.S. Blacks 1980

Weight group (grams)	Percentage Distribution of Births				
	U.S.A.	Washington, D.C.			
	Black	Resident Black	Resident White	N.R. Black	N.R. White
Under 501	0.2	0.2	0.0	0.3	0.0
501-1000	0.8	1.4	0.5	1.3	0.6
1001-1500	1.1	1.3	0.4	1.2	0.7
1501-2000	2.1	2.5	1.0	2.3	1.2
2001-2500	7.1	7.9	3.1	5.5	2.9
2501-3000	24.1	24.4	13.6	19.5	12.1
3001-3500	39.0	37.6	38.2	39.0	35.4
3501-4000	20.2	19.7	31.7	23.8	33.7
4001-4500	4.4	4.2	9.6	5.8	11.2
4501 & over	0.8	0.7	1.7	1.1	2.2
Total	100.0	100.0	100.0	100.0	100.0

Table B-3
Number of Live Births, Infant Deaths and Neonatal Deaths, Black Residents, Calender Years 1970-1985

Year	Live Births	Infant deaths	Neonatal deaths
1970	13,091	389	303
1971	12,131	368	273
1972	10,518	296	213
1973	9,413	245	185
1974	8,737	255	196
1975	8,462	254	198
1976	8,293	230	188
1977	8,515	251	189
1978	8,004	229	168
1979	8,053	199	152
1980	7,884	210	156
1981	7,749	196	147
1982	7,710	180	134
1983	7,896	159	113
1984	7,888	189	145
1985	8,136	186	143

Sources: DHS, Vital Statistics of the District of Columbia, 1983; Unpublished tables.

Table B-4
Selected Data in Absolute Numbers from Data Tapes, Black Resident Single-delivery Birth Cohort, 1980-84

1.	Live births	36,872
2.	Infant deaths	762
3.	Neonatal deaths	566
4.	Post-neonatal deaths	196
5.	Births under 2501 grams	4,921
6.	Births under 1501 grams	1,101
7.	Births to unmarried mothers	24,751
8.	Births to women under 17 years	2,025
9.	Births to women under 20 years	8,639
10.	Births to women 20-34 years	26,415
11.	Births to women 35 years and over	1,760
12.	Mothers with less than high school education	11,277
13.	Mothers with high school education	16,007
14.	Mothers with some college education	8,378
15.	Mothers with complications during the pregnancy	7,337
16.	Mothers with concurrent illnesses	5,236
17.	Mothers with prior fetal loss	5,463
18.	Mothers with prior child death	1,176
19.	Mothers receiving inadequate prenatal care	3,734
20.	Mothers receiving intermediate prenatal care	7,094
21.	Mothers receiving adequate prenatal care	20,756
22.	Mothers with high risk birth intervals	11,680

Table B-5
Number and Percentage of Neonatal and Post-neonatal Deaths by Leading Causes of Death: Black Resident, Single-delivery Birth Cohort 1980-1984

Cause of Death	Neonatal No.	Neonatal %	Post-neonatal No.	Post-neonatal %
Diseases of perinatal origin	481	85.0	27	13.8
Short gestation and low birthweight	195	34.5		
Trauma & Asphyxia	30	5.3		
Respiratory distress syndrome	85	15.0		
Other respiratory diseases of perinatal origin	77	13.6		
Complications of pregnancy	13	2.3		
Other perinatal diseases	81	14.3		
Congenital anomalies	66	11.7	25	12.8
Sudden infant death syndrome	9	1.6	72	36.7
All other causes	19	1.7	72	36.7
Total	566	100.0	196	100.0

Appendix C

A NOTE ON THE QUALITY OF DATA

APPENDIX C

A Note On the Quality of Data

1. **Completeness**

The births and deaths occurring to the residents of Washington, D.C. are registered to the extent of nearly 100% (DHS, 1986). However, while linking birth certificate information to the death records, a small number of cases could not be matched. For the years 1981 through 1984, for which we have full calendar year infant deaths in our data tape, we have 32 (4.1%) fewer infant deaths in our data tape than in the published vital statistics (DHS, 1986). Birth data are difficult to compare, because in the data tape, resident and non-resident births were available together. We used census tract information to separate them. There were 79 (1.7%) more resident births in our dataset than in the published report. This may be due to possible coding or entry errors during the preparation of the data tape.

The subset used for analysis in this study consisted of 36,872 Black, resident, single-delivery births. Recording, coding or entry errors in any of these variables could have led to adding wrong cases or excluding valid cases from the subset.

2. **Missing information**

Blanks and out-of-range codes were treated as missing values. **Table C-1** shows that the percentage of cases with missing values was high for maternal education, estimated gestational age, birth interval and variables relating to prenatal care. Gestational age information tends to be notorious for missing cases as well as for implausible values (David, 1980). The extent of missing information for gestational age was found to be 18.3% of the cases

Table C-1

Percentage of Cases in Single Variables with Missing Information:

Birth and Infant Death Data Tapes

Variable	Percent of Cases Birth tape	 Infant death tape
Age at death	-	0.0
Cause of death	-	0.0
Maternal age	0.2	0.5
Birthweight	0.3	1.7
Gestational age	8.4	7.9
Maternal education	3.3	15.6
Marital status	0.4	0.5
Prior child death	[a]	4.2
Number of deliveries	0.1	0.0
Total birth order	0.1	0.0
Live birth order	0.1	0.4
Week prenatal care began	11.9	20.6
No. of prenatal visits	14.5	20.6
Prenatal care (computed)	14.3	24.8
Apgar score - 5 minute	2.3	9.0
Interval between deliveries	6.7	12.2
Birth census tract	0.0	0.0

in North Carolina (David, 1980) and up to 20% in the national study (Sappenfield, et al., 1987). Gestational age information, which is missing for 8.4 percent of the cases in our birth file, has hardly been utilized in our analysis. However, the remaining variables with a high percentage of cases with missing information are among the key variables of this study. **Table C-2** shows that when the independent variables are cross-tabulated with the principal dependent variable, i.e., birthweight, the percentage of missing information increases with an additive effect. Thus, the extent of missing information for birthweight, which appears tolerable at first glance, becomes extremely high for certain independent variables.

If the missing information were randomly distributed across variable categories, the result of the study would not be biased because of the missing information, except for the level of any rates, such as IMR or NMR, computed from the figures which exclude certain deaths or other events. However, evidence suggests that usually there is a socio-demographic bias in non-reporting or misreporting (David, 1980; Frost & Shy, 1980).

Tables C-1 and **C-2** show a clear bias in the extent of missing information for different variables. For almost all the variables, the extent of missing information is higher in the death file than in the birth file. Since the source of birth information in the linked death file is the birth file itself, this difference reflects the degree of selection bias in the missing information. Infants who are likely to die within the first year--most of whom are LBW -- are more likely to have blanks or incomplete information in their birth certificates and

Table C-2

Percentage of Cases in Cross-tabulations with Missing Information: Birth and Infant Death Data Tapes

Variables	Percent of Cases Birth tape	Infant death tape
Birthweight by:		
Maternal age	4.1	2.2
Gestational age	8.6	9.3
Maternal education	3.5	17.2
Marital status	0.6	1.7
Prior child death	2.1	5.9
Total birth order	0.4	1.7
Live birth order	0.3	2.1
Week prenatal care began	12.0	21.5
No. of prenatal visits	14.6	25.7
Prenatal care (computed)	14.5	25.6
Interval between deliveries	6.9	13.8
Prior fetal loss	2.2	6.2

supplemental information forms than the infants who are likely to survive the first year of life. The greater the difference between the percent missing in the two files, the greater the selection bias. Thus, when cases with missing information are dropped from the analysis based on the birth file alone, a far larger percentage of those with an LBW than those with a normal weight would be excluded; i.e., the extent of low birthweight would be underestimated. Fortunately, the extent of missing information for birthweight itself is very low (0.3%). Even if all of these cases are assumed to have LBW, the overall extent of LBW would be 13.7% instead of 13.4%.

As already pointed out, a good proportion of birthweight information is lost while cross-tabulating this variable with those having a large amount of missing information. Given an LBW bias in the missing information, this loss of information in cross-t bulation would affect the results in two ways: (a) for all categories of the independent or explanatory variable, the percentage of cases with LBW would be understimated; (b) if the different categories of the independent variable lose cases disproportionately to their numbers in the population, i.e., birth population or infant death population, the relative extent of LBW for the different categories would also be biased.

To show the effect of inter-category differentials in missing information, relative frequency distribution of each category in the population, as well as in the missing information, is tabulated for selected variables in **Table C-3**. The first set of figures for each of the birth and death files represents the populati n proportion, while the second column of figures for each

Table C-3

Extent of Missing Information: Type of Information by Variable Categories

Variable-Category	Type of Missing Information			
	Birth File		Death File	
	% in Pop.	% of missing	% in Pop	% of missing
		Education		
Birthweight				
Under 1501	2.9	10.3	62.9	79.8
1501 - 2500	10.4	12.9	11.3	7.6
2501 +	86.4	64.0	24.3	11.8
Missing	0.3	12.8	1.7	0.8
Age				
Under 20	23.3	23.8	20.6	16.9
20-24	71.7	70.3	75.2	78.2
35+	5.0	5.9	4.2	4.9
Marital Status				
Married	32.5	25.9	26.2	23.5
Unmarried	67.1	71.2	73.2	74.8
Missing	0.4	2.9	0.5	1.7
Prenatal care				
Inadequate	10.1	12.7	15.4	10.1
Intermediate	19.2	20.5	29.1	25.2
Adequate	56.3	36.3	30.7	15.1
Missing	14.3	30.5	24.8	49.6

Table C-3 (Continued)

Extent of Missing Information: Type of Information by

Variable Categories

Variable-Category	Birth File % in Pop.	Birth File % of missing	Death File % in Pop	Death File % of missing
<u>Complications</u>				
Complications	19.9	21.0	43.2	36.1
No complications	80.1	79.0	56.8	63.9
<u>SES</u>				
30% +	45.0	46.6	43.0	42.9
10 - 29%	48.1	47.2	52.0	54.6
Under 10%	5.9	6.2	5.0	2.5
		<u>Prenatal care</u>		
<u>Birthweight</u>				
Under 1501	2.9	4.5	62.9	70.4
1501 - 2500	10.4	12.5	11.1	11.1
2501 +	86.4	82.9	24.3	14.8
Missing	0.3	0.1	1.7	3.7
<u>Age</u>				
Under 20	23.3	28.9	20.6	19.6
20- 34	71.7	67.3	75.2	76.2
35 +	5.0	3.8	4.2	4.2

Table C-3 (Continued)

Ext nt of Missing Information: Type of Information by

Variable Categories

Variable-Category	Birth File % in Pop.	Birth File % of missing	Death File % in Pop	Death File % of missing
Marital status				
Married	32.5	26.4	26.2	24.9
Unmarried	67.1	73.3	73.2	75.1
Missing	0.4	0.2	0.5	0.0
Complications				
Complications	19.9	19.9	43.2	43.4
No complications	80.1	80.1	56.8	56.4
SES				
30% +	45.0	47.2	43.0	41.8
10 - 29%	48.1	47.0	52.0	52.4
Under 10%	6.9	5.7	5.0	5.8
Education				
Less than H.S.	30.6	35.9	30.8	25.4
High School	43.4	41.4	37.9	33.3
Some college	22.7	15.7	15.6	10.1
Missing	3.3	7.0	15.6	31.2

Table C-3 (Continued)

Extent of Missing Information: Type of Information by

Variable Categories

Variable-Category	Birth File % in Pop.	Birth File % of missing	Death File % in Pop	Death File % of missing
		Gestational age		
Birthweight				
Under 1501	2.9	3.1	62.9	66.7
1501 - 2500	10.4	9.0	11.3	5.0
2501 +	86.4	87.0	24.3	25.0
Missing	0.3	0.9	1.7	3.3
Age				
Under 20	23.3	18.4	20.6	18.3
20- 34	71.7	76.0	75.2	78.4
35 +	5.0	5.6	4.2	3.3
Marital status				
Married	32.5	22.2	26.2	31.7
Unmarried	67.1	75.0	73.2	66.7
Missing	0.4	2.8	0.5	1.6
Prenatal care				
Inadequate	10.1	8.9	15.4	16.7
Intermediate	19.2	12.8	29.1	31.7
Adequate	56.3	62.1	30.7	28.3
Missing	14.3	16.1	24.8	23.3

Table C-3 (Continued)

Extent of Missing Information: Type of Information by Variable Categories

Variable-Category	Type of Missing Information			
	Birth File		Death File	
	% in Pop.	% of missing	% in Pop	% of missing
Complications				
Complications	19.9	32.7	43.2	43.3
No complications	80.1	67.3	56.8	56.7
SES				
30% +	45.0	37.6	43.0	43.3
10 - 29%	48.1	53.8	52.0	51.7
Under 10%	6.9	8.6	5.0	5.0
Education				
Less than H.S.	30.6	22.0	30.8	23.3
High School	43.4	42.6	37.9	36.7
Some college	22.7	31.6	15.6	20.0
Missing	3.3	3.8	15.6	20.0
		Interval between deliveries		
Birthweight				
Under 1501	2.9	4.8	62.9	69.9
1501 - 2500	10.4	11.5	11.3	7.5
2501 +	86.4	83.2	24.3	21.5
Missing	0.3	0.5	1.7	1.1

Table C-3 (Continued)

Extent of Missing Information: Type of Information by Variable Categories

Variable-Category	Type of Missing Information			
	Birth File		Death File	
	% in Pop.	% of missing	% in Pop	% of missing
Age				
Under 20	23.3	21.7	20.6	14.1
20- 34	71.7	73.0	75.2	79.4
35 +	4.8	4.7	4.2	6.5
Missing	0.2	0.6	0.0	0.0
Marital status				
Married	32.5	27.9	26.2	23.7
Unmarried	67.1	70.9	73.2	74.2
Missing	0.4	1.2	0.5	2.2
Prenatal care				
Inadequate	10.1	7.9	15.6	10.8
Intermediate	19.2	20.4	29.1	32.3
Adequate	56.3	58.6	30.7	30.1
Missing	14.3	13.1	24.8	26.9
Complications				
Complications	19.9	23.7	43.2	39.8
No complications	80.1	76.1	56.8	60.2

Table C-3 (Continued)

Extent of Missing Information: Type of Information by Variable Categories

Variable-Category	Birth File % in Pop.	Birth File % of missing	Death File % in Pop	Death File % of missing
SES				
30% +	45.0	44.3	43.0	41.9
10 - 29%	48.1	49.2	52.0	52.7
Under 10%	6.9	5.5	5.0	5.4
Education				
Less than H.S.	30.6	28.6	30.8	19.4
High School	43.4	40.9	37.9	26.9
Some college	22.7	19.8	15.6	9.7
Missing	3.3	10.7	15.6	44.1

file comprises the percentage distribution of missing cases by variable category. Missing information for maternal education, prenatal care, gestational age and birth interval, i.e., the variables with the highest extent of missing information, is tabulated by categories of the major variables of this study, i.e., birthweight, maternal age, marital status, prenatal care, complications of the pregnancy, socio-economic status and education. A ratio of proportion in the population to the proportion in the missing cases was computed for each category, but not shown in **Table C-3**. This ratio -- which may be referred to as ratio of population proportion to missing information proportion (RPMP) -- shows the relative degree of bias in the distribution of cases with missing information among different categories of a variable. A ratio of 1:1 means complete correspondence between population proportion and the proportion in the missing information. Values higher than one represent the excess, and lower than one represent the shortfall in the missing information over the population proportion. A rough idea about the extent of discrepancy between the population proportion and the proportion of missing cases can be had by looking simultaneously at the two sets of figures in **Table C-3**. However, we will use the RPMP in our discussion to underscore this difference.

From the data in **Table C-3**, it can be shown that certain variables are affected more than others by inter-category differentials in the bias entered by cases with missing information. Among the categories of birthweight, the very low birthweight category has, in general, high PMP ratios for different kinds of missing information: for education, 3.55 in birth file and 1.27 in death file; for prenatal care, 1.55 in birth file and 1.12 in death file; for birth interval, 1.65 in birth file and 1.11 in death file. For the gestational age missing information, the RPMP for VLBW is close to one in both the files. Normal birthweight category tends to have quite low ratios for education and prenatal care.

The above analysis shows that any cases dropped from the analysis, because of missing information about education, prenatal care or birth interval, will cause a far greater attrition in the cases with VLBW than cases with other birthweights.

Among the categories of educational attainment, less than high school has a higher relative proportion of missing information for prenatal care in the birth file, and a very low RPMP for gestational age in both the files, and for birth interval in the death file. The missing information category for education accounts for such a high percentage of missing cases for prenatal care and birth interval that all the real categories, except less than high school for prenatal care in birth file, have a RPMP substantially lower than one.

Categories of age, marital status, prenatal care and complications, with a few exceptions, have RPMP values close to one for missing information in all of the variables examined.

3. **Within range misreporting, miscoding and misentry**

Some errors in reporting, recording, coding or computer data entry can be such that they fall within the valid range of values. Many of these are impossible to detect. Some, because of impossible or implausible values for a certain variable in relation to another variable can be detected by simple cross-tabulation. Only a few examples of such implausible values, as they appear in our datasets, are give below:

- ten cases in which the mother's race was given as Black, but the child's race was recorded as White. D.C. vital registration defines a child as Black, if either of his parents is Black;
- among mothers 13-16 years of age, 95 were recorded as having completed high school and 2 were reported as having received some college education;
- among 17 year-old mothers, 360 were reported as having completed high school, while 9 were recorded as having received some college education;
- fifteen 18-19 year-olds were reported as having completed 16 or 17 years of education;
- twelve cases in which the estimated gestational age was recorded as 17-27 weeks, but the birthweight was given as above 2501 grams;
- with estimated gestational age recorded as 28 weeks, one case was reported as having a birthweight in 3501-4000g category, three in 3001-3500g category, and one in 2751-3000g category;
- two cases in which the number of prenatal visits was given as none, yet a valid period was recorded for the week of pregnancy in which prenatal care began;
- three 15 year-olds were reported as having had their third delivery; for three 16 year-olds, it was their fourth delivery and for one, it was her fifth delivery; while

for one 18 year-old, the current delivery was reported as her sixth.

From the nature of missing information and erroneous values, it appears that errors were committed at all three stages: recording, coding and entry. Probably the larger part of the responsibility for missing information lies with the attendants at birth who do not care to fill out the birth certificate and the supplemental information form fully. Nonsensical codes, such as open parenthesis, closed parenthesis, exclamation mark, question mark, plus sign, equal-to sign, etc., are a clear indication of carelessness during data entry. Frequencies of a third sex or for four additional race categories may reflect problems either during coding or at the time of data entry.

4. Errors due to the choice of coding and recoding criteria

Marital Status: The marital status categories were coded differently in two time periods. In 1980-82 data tapes, the two categories were: (a) never married, and (b) currently married, divorced, separated, or widowed (ever married). However, in the 1983-84 data, distinction was made between "legitimate" and "illegitimate" births by including the divorced/separated and widowed women in the same category as never married women if they had conceived the child after the dissolution of their marriage. In combining the data for the two periods, births to ever married women in 1980-82 were added to the "legitimate" births in 1983-84, while births to never married women in 1980-82 were added to the "illegitimate" births in 1983-1984. A small degree of error is possible due to such consolidation.

Complications during the pregnancy: Complications developing during the pregnancy and illness or conditions predating the pregnancy and existing concurrently with the pregnancy were grouped and coded differently in the two time periods. In the 1983-84 period, there were four groups of complications which clearly developed during the pregnancy. In the 1980-82 period, there were three groups of "direct" conditions, most of which, such as eclampsia, pre-eclampsia and premature rupture of membrane, were the same as complications defined in 1983-84. However, data for the earlier period possibly included cases with pre-existing hypertension. Because of the method applied to combine the data for the two periods, the latter type of cases could not be excluded. This method, which took the code for "none" in the first group of complications/direct conditions in each time period as the basis for defining the cases with no complications, automatically assigned the complement of it as the cases with one or more complications. It is possible that some of the cases for which neither a specific complication nor the "none" box was checked, i.e., they were left blank, actually had no complications. Thus, the effect of this method of recoding would be to overestimate the percentage of mothers with one or more complications.

Concurrent illnesses: The percentage of cases with concurrent illnesses was obtained from three groups of "concurrent illnesses" in the 1983-84 data and three groups of "indirect conditions" in the 1980-82 data in the same manner as the extent of complications during the pregnancy. This estimate is subject to the same kind of error.

Child/fetal loss: An error of underestimation, may have been committed while recoding the variables concerning prior child death and prior fetal loss. In these cases, if the boxes for fetal loss or child death were not checked, it was assumed that no fetal loss or child death took place. Keeping in view the nature of biases in non-reporting, it is our opinion that the extent of fetal loss and child death has actually been underestimated on a net basis.

Birthweight: According to the DHS code books, there were the following coding differences between the 1980-82 and 1983-84 birth data with regard to the birthweight:

Code	Weight interval 1980-82	Weight interval 1983-84
A	Too small to weigh	500g or less
B	500g or less	501-750g
C	501 - 1000g	751 - 1000g
S	-	too small to weigh

However, when frequencies were run, not only the code S was obtained for 1980-82, but the frequency for the code A was too large to mean "too small to weigh," but much smaller than the percentage in category A for 1983-84. If categories B and C were combined for 1983-84, the relative frequency exceeded the percentage in category C for 1980-82 by a wide margin. Thus, it was not possible to take the coding instructions at their face value. In response to our query, the DHS informed us that the birthweight codes used in the data tape for 1980-82 given to us were the same as the codes in the 1983-84 dataset, i.e., the new 1983 codes. We, therefore, combined the figures for the two periods on the basis of the above assumption. However, there remains a degree of suspicion about the fact that the percentage of cases in category A was much smaller and the percentage in category B was much larger for 1980-82 than for 1983-84. It is not unlikely that this difference may have been due to random periodic fluctuations.