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Temporal Trends of Risk Factors Associated With Low Birthweight - National, State and Local: 1992 - 1996

Gloria Lyons Borders

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TEMPORAL TRENDS OF RISK FACTORS
ASSOCIATED WITH LOW BIRTHWEIGHT –
NATIONAL, STATE AND LOCAL: 1992 – 1996

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Master of Public Health Thesis

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Presented by

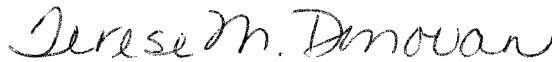
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I. INTRODUCTION – STATEMENT OF PROBLEM

Low birthweight (LBW) is an identified public health problem. [1];[2] Annually, about 1% of the approximately four million women in the United States who deliver a baby will experience the loss of their child soon after birth. [2] One of the major causes of these infant deaths is low birthweight. [1]; [2]; [4]

Defined by the World Health Organization as weight less than 2500 grams (5 pounds 8 ounces) at birth, [3] low birthweight may be the result of premature birth or intrauterine growth restriction [5]; [2]; [6]; [7]; [8]

Premature or preterm birth, defined as delivery at less than thirty-seven completed weeks of gestation, is one of the major causes of low birthweight. The etiology of premature or preterm birth is largely unknown [2] but the results are that the immature organ system development of the preterm infant often necessitates intensive care after birth. Gestational age is considered to be more important than birthweight in determining outcome, but the two are highly correlated. [9] Birthweight is a more objective, reliable and readily available measure and is more often referred to in the literature. [2]; [7]

Intrauterine growth restriction accounts for approximately one third of the low birthweight infants. [10] Suboptimal growth, as determined by growth charts of weight and gestational age may be a result of genetic factors, infection, cardiovascular anomalies, multiple gestation, and inadequate maternal nutrition. Other associated factors are decreased uteroplacental perfusion and environmental toxins such as maternal smoking, ingestion of alcohol or other drugs or medications. [10]

In 1996, approximately 288,000 infants were born at low birthweight in the United States, a weight that puts them at risk. Low birthweight is a major determinant of infant morbidity and mortality and is a critical health status indicator. [1]

LBW and mortality: The rate of low birthweight is a strong predictor of the infant mortality rate [3]; [4]; [1]; [12]; [13] and compared with infants of normal birthweight, LBW infants are five to ten times more likely to die within the first year. [11] Infant mortality is recognized as a proxy for the health of a population. [7]; [13]; [2]; [14] Disorders related to short gestation and unspecified low birthweight were second only to congenital anomalies as the leading cause of infant death in 1996, followed by Sudden Infant Death Syndrome (SIDS) and Respiratory Distress Syndrome, another condition usually associated with shortened gestation or prematurity. These four causes accounted for over one half of the infant deaths in the United States in 1996. [4]

In international comparisons of infant mortality, the United States ranks poorly, especially among developed countries. The infant mortality ranking of the United States fell from thirteenth internationally in 1968 to twenty first in 1989. [8] By 1992, the United States rate dropped further to the rank of twenty-second. [2] It is suggested that while differences in defining and reporting of live births may play a role, the high infant mortality rate is significantly influenced by mortality associated with low birthweight. [4]

LBW and morbidity: Not only is there higher mortality, but the overall risk of abnormal sequelae and morbidity associated with low birthweight is substantial and the risk increases as birthweight decreases. [15] Some of the early and long-term risks associated with low birthweight include blindness, deafness, cerebral palsy, cognitive

deficits, chronic lung disease and functional changes in the gastrointestinal system. [9]; [2]; [8]

Cost of LBW: The problem of low birthweight is both financially and emotionally costly. There is a financial burden to the society because there is frequently a need for high cost, specialized care in the immediate newborn period. Additional costs as a result of associated morbidity may include the need for long-term health care and education beyond the acute phase of illness. Researchers have documented the associated long-term health care and educational costs. [16]; [17]; [18]; [15]; [9] In 1988, initial intensive care costs incurred for low birthweight infants constituted 35% of the \$11.4 billion spent on infant health care. In that year, 6.9% of the 3,909,510 total births were low birthweight infants (269,756). [9]; [4] The low birthweight rate has since increased to 7.4% (287,230 infants) in 1996 among 3,891,494 total births. [11] (See table 1.) The financial costs of neonatal intensive care in the United States are estimated from \$2.8 to \$4 billion annually. A decrease of 1% in the low birthweight rate could save over \$40 million in costs for intensive care alone. Potentially greater savings could be achieved by diminishing the need for special education and those costs associated with chronic illness. [15] Emotional costs for parents who struggle with large healthcare expenditures as well as concerns for an acutely ill newborn have also been identified. Lost wages and loss of productive work and family time compound the stress experienced by those close to the ill child and family. [8]

LBW trends: Reduction of the incidence of low birthweight (LBW) to less than 5% of live births was identified by the United States Department of Health and Human Services as part of the national health promotion and disease prevention objectives for

Year 2000. [19] In the period from 1970 to 1984, the number of low birthweight infants as a percent of total births declined to a low of 6.7% but, since that time, there has been a steady increase to 7.4% in 1996. [11] While there has been documented success in birthweight specific survival and the lowering of the infant mortality rate, there has been little success in preventing the incidence of low birthweight. [7]; [4]; [8] Kliegman notes in discussion of the “Perinatal Paradox” that a “goal should be to reduce the risk of being born at a low birthweight rather than having to treat the consequences.” [15]

To search for trends in the increasing incidence of low birthweight, researchers need to collect and analyze data on identified risk factors and associated conditions. Identification of trends is vital in order to make more informed decisions in treatment, meet the specific needs of the population served, effectively plan and evaluate programs, execute strategic planning at the institutional level, and give direction to continued research for the problem of low birthweight. [8]; [14]; [14]; [2]; [1]; [7]; [9]; [20]

Conditions associated with LBW: Maternal conditions and behaviors and pregnancy-related risk factors shown to have an association with low birthweight include maternal age, parity, previous preterm delivery, prior infertility and access to and consistent use of prenatal care. Conditions and behaviors also include maternal smoking, alcohol consumption and/or drug use, multiple gestation, maternal height and weight and pregnancy weight gain. Other associated factors are infection and chronic disorders such as cardiovascular disease, diabetes, and asthma. [8]. Sociodemographic factors associated with low birthweight risk are race and ethnicity, marital status, socioeconomic status, stress, support systems, and maternal employment. [7]; [8]; [12]

Summary: As there has been no success in decreasing the rates of low birthweight to the Year 2000 goal, a greater understanding of possible contributing factors continues to be necessary. A current description of the problem of low birthweight will provide a baseline for this evaluation. Temporal trends of risk factors associated with low birthweight, and their relationship to birth rate, lend potential predictive value to this description of the population.

II. OBJECTIVES

Problem: This paper will describe the magnitude of the problem of low birthweight at the state and national level. Additionally, evaluation of the temporal trends of a group of risk factors associated with the problem at a national, state and local level over a five-year period will be presented.

Risk factors: The maternal and infant characteristics that have been shown to be risk factors associated with low birthweight which were evaluated include shortened length of gestation, maternal age, marital status, race, utilization of prenatal care, and plurality of birth. Similarities or differences of populations were assessed at the local, state and national level for the year 1994.

Temporal trends - risk factors and total births: Trends in risk factors for total births that may contribute to the increased risk for LBW (e.g., married versus unmarried) were analyzed for significance over the five-year period individually at the national, state and local level.

III. RATIONALE

A. Rationale for the study: The continued increase in percentage of low birthweight infants over time is a problem that is complex and multifaceted. A greater understanding of the incidence of low birthweight and trends of associated risk factors enables those involved in maternal and child health to plan and deliver care more effectively to at risk populations. For example, a study by Kessel, et al. identified the changing pattern of low birthweight, term and preterm, over the ten-year period of 1970-1980. At the time of the study, the low birthweight rate was decreasing (from 7.39 to 6.31). The authors noted that the improved infant survival seen in that study period could be attributed to reduced birthweight specific mortality resulting from advances in perinatal care with little evidence to support the contribution of preventive efforts. [13]

As the characteristics of the low birthweight population continue to evolve, current information that accurately reflects the population being served is essential in program planning and allocation of funds for prevention and treatment, appropriate interventions after birth, and continued research. The information highlighted in this study will be useful for clinicians, administrators and policy makers and will provide a clear picture from which to make plans for effective use of scarce resources.

B. Rationale for choosing the sociodemographic risk factors:

Period of gestation: Preterm or premature birth, one of the major causes of low birthweight, [2] is that which occurs at less than 37 completed weeks of gestation, determined from the last menstrual period. [7] If this information is unavailable or considered inaccurate, the gestational age of the fetus is estimated by obstetric

examination and ultrasound results. Gestational age can be estimated after birth using the Dubowitz [21] or Ballard [22] exam to evaluate a list of newborn attributes and behaviors known to be associated with specific maturity levels. These evaluations are not always reliable assessments of gestational age, particularly in the preterm population. [7]

Principal causes of preterm birth are spontaneous labor, premature rupture of membranes and medical intervention for maternal or infant conditions. [7] Some associations have been identified with infection, dehydration and trauma in premature rupture of membranes and spontaneous labor. There is no readily identifiable cause in a portion of preterm births. [7]

Medical management of the preterm infant is required as a result of interrupted growth and maturation of the vital organs and body systems, which occurs in the latter part of a pregnancy. Infants require stabilization and support of the immature systems during initial adaptation to the extrauterine environment. This includes thermal regulation, assisted ventilation and respiratory and cardiovascular support. Additional needs of preterm infants include management of infection and fluid, electrolyte and gastrointestinal support. [23] Much of weight gain achieved in utero occurs during the third trimester of the pregnancy. Interruption of the pregnancy during this critical period often produces a low birthweight infant with immature physiologic function. Continued support is required until such a time that system maturation occurs and the infant is able to regulate body temperature, maintain respiratory and cardiac function, breast or bottle feed, and gain weight. The timing of this maturation has historically approximated expected due date. [2]; [24]

Marital status: Marital status has been found to have a relationship with preterm birth and incidence of low birthweight. [7] Marital status is viewed as a surrogate for a variety of biological, environmental, and medical care factors which are related to a positive pregnancy outcome [8]. The association of this risk factor to low birthweight has been shown to vary when examined in combination with other maternal factors, such as age and race. [25]; [11] While unmarried status has been cited in the literature as the risk factor most associated with low birthweight, Bennet found married status put the younger mothers (those ages 17 and under) at greater risk. The association of marital status with low birthweight may be more related to whether the pregnancy was a planned versus unplanned pregnancy, economic status of the mother, and social supports available to the mother and her pregnancy. [25] High levels of stress and fatigue as well as negative behaviors which may coexist with unmarried status such as smoking, drinking and drug use can all negatively impact the pregnancy. [26]. Unmarried status is also a consistent marker for late entry into prenatal care. [25]

Prenatal care: Access to and use of prenatal care has long been identified as a predictor of a positive birth outcome. Medical, nutritional and educational assessments and interventions are provided in a variety of settings to assess and monitor the status of the mother and fetus. Prenatal care is known to promote and support healthful behaviors, provide information about needed resources and offer emotional support and general knowledge about the pregnancy. [8]; [11] The low birthweight rate is identified by Fiscella as the most common measure with which to evaluate the effectiveness of prenatal care because LBW is easily quantifiable from birth certificates and is the single largest

contributor to infant mortality. [27] Prenatal care is widely supported as having overall benefit and potential cost effectiveness. Gorsky and Colby reported on the possible savings for each dollar spent on prenatal care in preventing the need for high cost neonatal intensive care. These savings range from \$1.70 to \$3.38 for each dollar spent on prenatal care. [1]

The support in the medical community as well as in health policy planners stressing the effectiveness of prenatal care in improving birth outcomes remains strong. The areas seen as most likely to be targeted in preventing low birthweight are modifiable behaviors such as smoking and nutrition as well as increased awareness of the need for routine medical care. [28] A more detailed evaluation of low birthweight infants and the risk factors associated with them will allow for targeted programs and interventions for the greater proportion of high-risk pregnancies.

While support for prenatal care remains strong, Fiscella states that a review of the literature to identify studies of effectiveness of prenatal care on birth outcomes fails to empirically support the need for prenatal care as it is presently defined. However, he noted that, since prenatal care is widely assumed to be effective in reducing infant mortality and morbidity, a randomized controlled trial of prenatal care versus no care would be considered unethical. [27]

Tracking of the use of prenatal care reveals that the access to and use of care is rising throughout the population although recognized ethnic differences in use of care exist. [8]

Race: Differences in fertility rates, birth rates, low birthweight rates and infant mortality rates are documented phenomena related to maternal race and ethnicity. Particularly striking are the low birthweight rates for African Americans compared to other races. [11] This difference has been explained in a variety of ways including socioeconomic differences, access to prenatal care, lifestyle differences and racism. [26] Black infants have a higher low birthweight rate than do white infants as well as a higher infant mortality rate. While these rates are decreasing, there remains a marked racial disparity. [4] The complex relationship between race and incidence of low birthweight is illustrated by the observation that even low risk black women with high educational attainment and socioeconomic status continue to have higher low birthweight rates than high risk white women. [7] McCormick notes that while the infant mortality rate of blacks is decreasing, the low birthweight rate is not decreasing. One hypothesis for some of the increased incidence of low birthweight infants in this population is genetic or inherited differences in birthweight distributions. When analyses are done with the range of birthweight distribution of races and ethnic groups, a trend is noted towards lower weights for black infants. [29] It may well be that the standard definition of low birthweight does not connote the same degree of risk for black infants as for non-black infants. [12] A study done by Roberts, et al. [29], supported this theory, which explains some of the increase in low birthweight infants in Connecticut. Connecticut birth certificates for 1988 through 1993 were examined for the relationship among birthweight and gestational age and race. For singleton births, the median birth weight of black infants was lower than that of white infants at nearly every gestational age. This is seen as important data for health care providers to use when evaluating newborns. [29]

McCormick identified three sociodemographic characteristics associated with low birthweight which occur in higher proportions in the black population. These characteristics are young maternal age, low maternal educational attainment and unmarried status. These characteristics are often associated with poverty and increased risk of a negative pregnancy outcome. [12]

The incidence of low birthweight births as related to ethnicity and race is dependent on the population from which the data are drawn. Baruffi et al. looked at temporal trends of race and ethnicity as well as other risk factors in Hawaii from 1979 to 1994 to identify population groups that may require special attention. [30] Changes identified during that time period in that population were increases in proportion of births to women >35 years and in proportion of births to unmarried mothers. The changes were seen across all ethnic groups to various degrees. Races and ethnic groups evaluated in this study were Caucasian, Hawaiian, Filipino, Japanese, Samoan, Black and other Asian.

Groupings of Hispanic populations could be evaluated in a similar way to identify differences in risk factors and outcomes. For purposes of this study, the disparity associated with low birthweight among the black population was evaluated.

An understanding of the ethnic and cultural differences in the population is essential in providing effective health care. The health care provider's understanding must take into account the beliefs, actions, customs and unique health care needs of distinct population groups. [31]

Maternal age: There exists a significant amount of data documenting maternal age and it's relationship to birth outcome. A study by Reichman and Pagnini showed a

U-shaped relationship found to exist, with the youngest (≤ 15 years) and oldest (≥ 40 years) at greater risk of delivering a low birthweight infant in study of New Jersey infants. [32] While the outcome of low birthweight is the same, the etiology, risk factors, rates and trends vary between the age groups (≤ 17 years and ≥ 35 years).

Factors identified in the teen population which increase the risk of a low birthweight delivery may be: a young, growing body which competes with the fetus for nutrients; biologic immaturity; unintended pregnancy; poor nutrition; delayed or inadequate prenatal care; poverty and inadequate social supports. [32] The Committee on Adolescence noted that the incidence of low birthweight for adolescents is more than double that for adults and the subsequent neonatal death rate is almost three times higher. Young adolescent mothers, aged fourteen and younger, are more likely than any other age group to give birth to low birthweight infants, especially in the African American population. [33] An early intervention program for adolescent mothers reported improved outcomes for teen mothers involved in an intensive supportive program aimed at reducing the behavioral risk factors including poor nutritional habits, substance abuse and unsafe sex. [34] Fraser et al. reported in their study of mothers aged 13 through 24 years that young age conferred an increased risk of adverse pregnancy outcomes, independent of confounding sociodemographic factors. [35]

The risk factors among older mothers that contribute to increased incidence of low birthweight include chronic medical disorders such as diabetes and cardiovascular disease, history of infertility, unintended pregnancy, and multifetal pregnancy. [32] Dollberg et al studied the risk of low birthweight with advanced maternal age and its relationship to adequacy of prenatal care. They concluded that maternal age greater than

35 carried a higher risk even with adequate prenatal care. [36] Cnattingius reviewed published studies of older maternal age and potential increased risk and reported that delayed childbearing was associated with increased risk of poor pregnancy outcomes of fetal death, low birthweight and growth restriction. [37]

Delayed childbearing, resulting in increased maternal age, may result in some couples utilizing fertility enhancing therapies to improve their chances of pregnancy. These therapies also substantially increase the possibilities of a multiple gestation pregnancy. [37] Additionally, older mothers, even without assisted reproductive techniques, have an increased chance of releasing multiple eggs, which may go on to be fertilized. [8]

Multiple birth: A dramatic shift has occurred over the last several years in the rates of multiple births. Twin birth rates increased 42% between 1980 and 1994 nationally. There is a marked variation in the rate of twin births among the states, with the Northeast and Mid-Atlantic States having the highest rate of twin births. [38] The numbers of triplet and other high order multiple births have increased greater than four-fold from 1,034 in 1971 to 4,973 in 1995, many a result of enhanced fertility or assisted reproduction. In many of the states, insurance policies are now required to cover assisted reproduction and infertility treatments, which were cost prohibitive to couples in the past. [38]; [39]

A multiple pregnancy is considered high risk. Intrauterine growth restriction contributes to the high incidence of low birthweight in multiple gestation pregnancies. For twins, the average birthweight of the first twin is 2390 grams and of the second twin

2310 grams. [40] The increased incidence of complications of a multiple gestation pregnancy include preeclampsia, polyhydramnios, gestational diabetes, anemia, fetal anomaly, fetal death, intrauterine growth retardation and premature delivery. [23] Perinatal mortality is four to eleven times greater for twins than singletons. High rates of prematurity and intrauterine growth restriction are associated with increased neonatal morbidity and mortality. [40]

A study done in Massachusetts and reported in MMWR investigating the increasing low birthweight rate reported the increase associated with changes in the rate of multiple births. This was especially apparent in the population of older, better-educated women. [39] This is in agreement with Ventura et al. in reporting Final Natality Statistics for 1996. Most of the increase in LBW for 1996 was attributable to a rise in LBW among births to non-Hispanic white women and an increase in the multiple birth rate among these women. [11]

Summary: The problem of low birthweight is multifaceted and complex. While the goal of this descriptive study is not to explain causation of low birthweight, the aim is to describe risk factors in the population and trends which will provide a better understanding of the problem at the local, state, and national level. Information pertinent to these risk factors associated with low birthweight will be vital to those involved in health care, education, policy making, and program planning.

IV. METHODS

This retrospective descriptive study utilized data collected on the national, state and local level.

Data sources

National data: The Reports of Natality Statistics have been utilized for the national data. These reports include detailed data on births, birth and fertility rates, maternal lifestyle and health characteristics, medical service utilization by pregnant women and infant health characteristics. They also provide maternal demographic characteristics including age, marital status, educational attainment, weight gain, race and Hispanic origin. The data are calculated from 100% of birth certificates registered in all states and the District of Columbia. The National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC) publishes the data annually and maintains the data on the Internet at CDC Wonder. [11]; [41-44]

State data: The Annual Registration Reports of Vital Statistics for the State of Connecticut were the sources for state data used in this study. These reports provide a statistical summary of births, deaths, marriages and divorces. Birth data is obtained from birth certificates for 100% of state births and maintained by the Connecticut Department of Public Health, Office of Policy Planning and Evaluation. Summary reports are available in annual Connecticut Registration Reports from which information for this study was drawn. [45-49]

Local data: The source of the local data was the John Dempsey Hospital Neonatal Intensive Care Unit (NICU), a tertiary care level nursery associated with a

university hospital and medical school in central Connecticut. High-risk obstetric patients are referred from the associated attending physicians in the local area, as well as from the outlying community hospitals in the state. Because it is a regional referral center, a disproportionate amount of low birthweight infants have been seen in this facility. The neonatal unit consists of a thirty-bed intensive care nursery, a ten-bed step-down special care nursery and twelve-bed newborn nursery. Maternal and infant information is gathered and maintained for this institution using the National Neonatal Information System (NIS2). Complete data are extracted from the medical record forms within the maternal and infant charts and entered into the database on a daily basis by two individuals with neonatal intensive care nursing experience. Data that is entered into this system for 100% of admissions include information from the following five sources in the chart: Admission Form, Perinatal Form, Admission Exam, Hospital Summary and Discharge/Transfer Form. Information gathered includes maternal history, demographics, and obstetric information as well as infant status, consults, medical interventions, and referrals. (See Appendix A). The low birthweight infants in this local population represented 9% of total state of Connecticut low birthweight infants for the five-year study period.

Of the variables collected on patients in this facility, seven were identified for evaluation in this study. The variables include pregnancy and infant characteristics of birthweight, gestational age, plurality of pregnancy and prenatal care, as well as maternal characteristics of age, marital status and race. These variables were identified in the literature as consistent risk factors for low birthweight and continue to be available on the local, state and national levels.

Measures and definitions:

Low Birthweight - Births are reported as low birthweight in this study if they meet the World Health Organization criterion (less than 2500 grams or 5 pounds 8 ounces).

Period of gestation – A preterm or premature birth is defined as one which occurs at less than 37 completed weeks of gestation from the date of last menstrual period. A limitation to this measure is that it is subject to error due to faulty maternal recall and misidentification of postconception bleeding or history of amenorrhea. [28]

Marital Status - Marital status for this study is defined as legally married at the time of birth of the infant. In the local data, marital status was further classified for separated and divorced. For purposes of this study, separated was combined with married and divorced was combined with unmarried. A limitation is lack of consistency in reporting of this variable throughout the United States. Connecticut remains one of the five states that prohibit by law inclusion of a direct question about marital status on the birth certificate. Marital status is inferred in Connecticut by a match of maternal, paternal and infant surnames according to a set of criteria. [46] California and New York City changed their reporting of marital status for 1997 to include it as a separate reporting item.

Prenatal Care - Prenatal care is referred to in this study as the stage of pregnancy at which visits to a clinician to monitor the pregnancy are begun. The stage of pregnancy at which the patient began prenatal care was reported as a) first trimester, b) second trimester, c) third trimester, and d) other, which includes no care and unknown care. A

limitation related to this variable is missing data. Data were missing in 379 (17%) of the 2176 cases identified in the five-year study period in the local dataset. A second limitation is lack of a clear and consistent definition of the variable, its scope, and its measurement. Prenatal care has been defined as the number of visits, the stage of pregnancy at which care was initiated, the source of care (private versus clinic), the spacing of visits, and the content of care. [28]

Maternal Race - Race is reported in this study as a) white (Caucasian), b) black (African American), c) other (Hispanic, Asian, Middle Eastern etc.). As it is a self-reported or inferred variable by the health care provider, it may be inconsistently measured and classified.

Maternal Age – Maternal age is defined as the age in years of the mother at the time of delivery of the child. Five-year periods are used for mothers from age 20 through 50 and data is reported in smaller increments in the teenage population. Categories are age a) less than and including 17 years, b) 18-19 years, c) 20-24 years, d) 25-29 years, e) 30-34 years, f) 35-39 years, g) 40-44 years, h) 45 years and above.

Plurality - Plurality is defined in this study as a) singleton, b) multiple according to whether the pregnancy is of a single infant or multiple. Higher order multiple pregnancies will not be differentiated.

Study Period:

Data evaluated for this study were gathered from statistics for the calendar years 1992 through 1996.

Cases:

The population studied consisted of all live born infants weighing less than 2500 grams at birth as well as total births at the state and national level and total admissions at the local level. Local cases over the five-year period totaled 2,176, of which 1,427 were low birthweight (66%). State births over the study period totaled 228,870, of which 15,928 were low birthweight (7%). National births totaled 19,809,104, of which 1,435,964 were low birthweight (7.3%). Table 1 reports statistics by year.

Statistical Analysis:

A comparison of the population of low birthweight infants in 1994 at the national and state level for identified risk factors was done. Results were also evaluated in relationship to the local population. Risk factors evaluated were period of gestation, marital status, prenatal care, race, maternal age, and plurality. The Student t-test or chi-square tests using 2 x 2 tables were employed for comparison as appropriate. Significance was identified at <0.05 for all analyses.

Temporal trends of identified risk factors as a percentage of total births at the state and national level and total admissions at the local level were evaluated for the period 1992-1996. The birth rate per one thousand women over the five-year period was presented. The percent of low birthweight births (infants weighing less than 2500 grams at birth) to total births, is presented graphically. Temporal trends of identified risk factors (including period of gestation, marital status, prenatal care, race, age less than or equal to 17 years and greater than or equal to 35 years and multiple birth) are presented in the form of graphs. These characteristics were further evaluated for trend using simple

regression analysis. Analysis via 2 x 2 tables, chi-square and Student t-test were employed as appropriate.

V. RESULTS

A. Birth rate and Percent Low Birthweight

The national birth rate fell during the period from 1992 through 1996 from 15.9 to 14.7 births per thousand women, an 8% decrease ($R^2 = 0.9727$, $p = 0.0019$). The state birth rate also decreased from 14.5 in 1992 to 13.6 births per thousand women in 1996, a 6% decrease ($R^2 = 0.9474$, $p = 0.0052$). (See Figure 1.) During the same time period the percentage of low birthweight infants increased nationally from 7.1 to 7.4, a 4% increase ($R^2 = 0.9423$, $p = 0.006$). On the state level, low birthweight increased 6%, from 6.9 to 7.3 ($R^2 = 0.7812$, $p = 0.0467$) (See Figure 2.) Although there was an increase in low birthweight over the study period on both the national and state level, a significant increase was not seen at the local level (i.e. the high-risk environment of the NICU). There was a significant difference between the national and state birth rates at all time points studied ($p = 0.0003$) as well as in the percent low birthweight ($p = 0.01162$).

B. Temporal trends of risk factors in total births at the national and state levels and total admissions at the local level

The temporal trends of LBW-associated risk factors as a percentage of total births or admissions are graphically presented in Figures 3-9 for the period from 1992 through 1996.

Preterm: Figure 3 presents the linear regression analysis of preterm births at the national, state and local level. Results were $R^2 = 0.5$, $p = 0.1817$ (national); $R^2 = 0.3645$, $p = 0.281$ (state); $R^2 = 0.5453$, $p = 0.1541$ (local). There were no significant trends within

any of the three data sets.

Marital Status: The trend of marital status (unmarried) is presented in Figure 4. Results are $R^2 = 0.7169$, $p = 0.0704$ (national); $R^2 = 0.9453$, $p = 0.0055$ (state); and $R^2 = 0.0115$, $p = 0.8635$ (local). In the state population there was a significant increasing trend in percent of low infants born to married women ($p = 0.0055$). No significant trend was noted in the national or local data.

Prenatal Care: Level of prenatal care as a risk factor was analyzed for all care begun any time other than the first trimester of pregnancy (Figure 5). Regression plots showed no significant trend, within any of the data sets. National results were $R^2 = 0.0126$, $p = 0.8571$; state results, $R^2 = 0.0243$, $p = 0.8024$; and local results $R^2 = 0.0734$, $p = 0.6593$. At the local level, data collection and entry changed as a designated individual was hired to oversee the Neonatal Information System. More complete information was collected and entered into the database. The dramatic change in information between 1992 and 1993 appears to have been a function of more complete evaluation and tracking and completion of previously missing data for prenatal care.

Race: Black race, which has been consistently identified as a risk factor in low birthweight, was analyzed. Figure 6 presents regression analysis for the risk factor of race for blacks. The results were $R^2 = 0.9475$, $p = 0.0052$ (national); $R^2 = 0.167$, $p = 0.4939$ (state); and $R^2 = 0.2303$, $p = 0.4133$ (local). There was a significant negative trend at the national level in that percent of total births who were black decreased significantly (0.0052). No such difference was identified in the state or local population.

Maternal Age: Maternal age was evaluated for a trend stratified by two high risk age groups. When the regression analysis focused on a maternal age of less than or equal

to 17 years (Figure 7), the results were $R^2 = 0.2584$, $p = 0.3818$ (national); $R^2 = 0.1635$, $p = 0.4995$ (state); and $R^2 = 0.6295$, $p = 0.1092$ (local), showing no significant trend. For the group consisting of a maternal age greater than or equal to 35 years (Figure 8) the results were $R^2 = 0.9997$, $p = <0.0001$ (national); $R^2 = 0.9985$, $p = <0.0001$ (state); and $R^2 = 0.678$, $p = 0.0867$ (local). This showed a significantly increasing trend for births in this age group at the national and state level.

Multiple Births/Plurality: Plurality was evaluated with multiple birth as the risk factor (Figure 9). Regression analysis for the national data set was $R^2 = 0.9576$, $p = 0.0038$; for the state data set, $R^2 = 0.6904$, $p = 0.0813$; and for the local, $R^2 = 0.5038$, $p = 0.1793$. There was a significant increasing trend at the national level. The percentage of low birthweight births in the State of Connecticut for a singleton ranged from 5.6% to 5.8% for 1992-1996. The percentage of low birthweight births for multiples in the state for the same time frame was 48.4% to 52%. [49]; [11]

Many women at each level of the analysis, national, state and local, may have had multiple risk factors. For this study, each risk factor was evaluated as a single risk factor and not undertaken as part of a multivariate analysis.

C. Comparison of LBW Populations, National, State and Local

To identify possible relationships of identified risk factors in the three sets studied, a one-year period (1994) was chosen. The LBW population was evaluated by risk factor.

The study variables associated with low birthweight were compared in the low birthweight population at the national, state and local level in Table 2 for 1994.

Unmarried: The percent of unmarried women in the low birthweight population was unavailable at the national level. There was a greater percentage of unmarried women in the low birthweight population at the local level (62%) than at the state level (54%), but the difference did not achieve statistical significance.

Prenatal Care: On the national, state and local level, the risk factor of late or no entry into prenatal care, identified as anything other than first trimester care, was evaluated in the low birthweight population. Early prenatal care was more prevalent than late or no prenatal care, ranging from 72% nationally to 77% in the state. Nationally, 28% received late or no prenatal care compared to 23% at the state and 24% at the local level. There was no statistical difference in this variable between national and state low birthweight populations ($p = 0.417$) or between the state and local populations ($p = 0.8676$) in 1994.

Race: Race was examined in the low birthweight population in the three databases. The race identified in much of the literature as a risk factor in low birthweight, i.e. black, was evaluated for purposes of this study. Black women delivered 29% of the national and 19% of the state low birthweight infants. There was not a significant statistical difference between these two sets ($p = 0.0968$). The local NICU population of low birthweight infants consisted of 8% blacks, a statistically significant decrease from the state data ($p = 0.0228$).

Maternal Age: A distribution of the low birthweight population by maternal age at the national, state and local level is presented in Figure 10. The local population had consistently higher percentages of births than did the national and state populations in the age ranges of 25-29, 30-34, and 35-39 years. The maternal age of the local low

birthweight population clustered in the older age groups. The percentages of mothers in the age groups of 25-29 years, 30-34 years, and 35-39 years exceeded that of the state and national data. In the 40-45 year age group the local data were similar to the state data and both exceeded the national (Figure 10). The age group with the highest percentage of mothers in the local and state groups was 30-34 years while that with the highest percentage in the national group was 20-24 years. The mothers at the state and local level were of a more advanced age. While the percentage of low birthweight is greatest at the extremes of age, more absolute number of low birthweight infants are born to women of “ideal” childbearing age because of the distribution of live births. For this study the two identified risk factors in maternal age were further evaluated at all three levels.

Maternal Age \leq 17 years: Age of mother less than and equal to age 17 was found to be 7% at the national level and 5% at the state level in 1994. The difference between the national and state levels was $p = 0.5515$, not significant. At the local level, the percentage of 17 year old and younger mothers delivering low birthweight infants was 6%. The difference between the state and local levels was $p = 0.7564$, also not significantly different for this risk factor

Maternal Age \geq 35 years: Maternal age equal to and greater than age 35 years was evaluated in the three datasets for 1994. The percentage of mothers in this category delivering low birthweight infants was 17.2% at the national level, compared to 16.7% at the state level. There was no significant statistical difference between the two populations ($p = 0.4866$). Similarly, mothers in this age group made up 16.6% of the low birthweight population at the local level. There was also no significant difference between the state and local sets for this parameter ($p = 0.9245$).

Multiple Births: The percentage of low birthweight infants who were multiples was greatest at the local level (25%), followed by 20% at the state level and 19% at the national level. Differences were not, however, statistically significant between the databases.

Period of gestation: Figure 11 demonstrates the contribution of prematurity in low birthweight infants at the national, state and local level. In 1994, 63% and 64% of the low birthweight infants were preterm in the national and state statistics respectively. A comparison between data sets showed no significant difference for preterm infants in the low birthweight population ($p = 0.8832$). The local low birthweight population was comprised of 94% preterm infants. The difference between the state and local low birthweight population of preterm or premature infants was identified as $p < 0.0001$.

V. DISCUSSION

Temporal trends and relationship by dataset

National trends: A decrease in the birth rate, an increase in low birthweight, a decrease in percentages of black women giving birth, and an increase in births to mothers greater than and equal to 35 years were statistically significant findings at the national level. Multiple births were also a significant trend over the study period ($p=0.0038$) at the national level while at the state level the trend was not as dramatic. Multiple births and births to women greater than and equal to age 35 were seen as key in analyzing the increase in the low birthweight rate at the national level by the National Center for Health Statistics in 1996.[11] These same risk factors were identified as key indicators in the changing low birthweight rate in Massachusetts.[39]

State trends: At the state level the statistically significant trends identified were a decrease in the birth rate, an increase in low birthweight, an increased percent of births to unmarried women, and, the most significant trend, an increase in percent of births to women greater than or equal to thirty-five years ($p\text{-value} < 0.0001$). However, a chi-square analysis via 2x2 table of the variables between state and national low birthweight populations identifies no statistically significant.

Local trends: At the local level, the risk factors of low birthweight, preterm birth, young and older maternal age and plurality changed over the five-year period with r -values greater than 0.5 but did not reach statistical significance. The population remained relatively stable over the study period. Patients with increased risk factors are more likely to be over represented in this neonatal unit by virtue of it being part of a high risk, tertiary care program. A temporal study of longer duration would be required to identify

changes over time in this stable high-risk environment as a result of potential changes at the national and state level. In the comparison between the local NICU low birthweight population and state population in the year 1994 we see statistically significant differences in two risk factors, i.e. increased percentage of premature infants and less blacks in the local NICU population.

Therefore, mothers of the low birthweight infants at the local level were older and more likely to be white than at the state and national level in 1994. This type of demographic information is important to share with health care policy and resource planners, administrators and clinicians. Attention to temporal trends may assist in supplying the information with which to make decisions in planning resources.

Discussion by risk factor

Preterm birth: While the majority (63% & 64%) of low birthweight infants in the nation and state were also preterm, an increased percentage (94%) of preterm infants made up the low birthweight population at the local data level. Preterm low birthweight infants, frequently require specialized care available in the neonatal intensive care unit and are more likely to be seen in this high risk environment. At the national and state level, while the change in the percentage of low birthweight infants was supported statistically, concomitant changes in preterm deliveries have not occurred. This could impact the NICU if the increased numbers of low birthweight infants are able to be cared for in a less high tech, labor and cost intensive environment than the tertiary care level of a neonatal intensive care unit. The population of low birthweight infants in this environment may remain stable or could decrease. While this is important information from a public health cost perspective, it may require those involved in projections and

planning at the local level to consider potential changes in census. Expansion of other services for critically ill newborns such as transports, surgical intervention, or advanced therapies may need to be considered. Also, expansion of other maternal child health services, which provide for a level of care appropriate to a less critically ill infant, such as special care nursery services may be expanded. Costs can be managed by ensuring that infants would be cared for in the least technologically sophisticated environment required.

Race: The local population had a greater percentage of whites with low birthweight than either the state or national populations as well as a greater percentage of “other” races, which may include, but are not limited to, Hispanics and Asians. The population from which the local patients are drawn influences this composition. Neonatal units based in an inner city hospital or a different region would be expected to have a different racial make-up of patients. An increase in births to Caucasian women, particularly in the age range of 35 and older identified in the temporal trends at the state and national level, could have a significant impact on local data. Many of the references have discussed the issue of low birthweight and race, in large part a result of historically higher rates of low birthweight among blacks. [5]; [13]; [26]; [50]; [51]. However, a recent trend of an increase in low birthweight infants among white women is now also being reported. [6]; [11]

Marital status: At the local level, married women delivering low birthweight infants were represented in larger percentages than at the state level, again a reflection of the population from which the patient base is drawn. Many of the patients at the institution are high-risk infertility patients in a higher socioeconomic group or those

referred by obstetricians in private practice. Nationally, the birth rate to unmarried women was at its highest level of 46.9% in 1994. [11] In the state of Connecticut in 1994, the percent of LBW births to unmarried women was 10.5% while LBW births to married women was 5.3%. [47]

Prenatal care: First trimester prenatal care was seen in most low birthweight infants at all levels, with state and local rates slightly higher than national rates. At the local level, the category of “other” exceeded that found at the state and national level but this may be a function of missing data. The achievements identified over the last several years in increased early prenatal care at all levels are promising. However, since the percent low birthweight has continued to increase in spite of this, continued funding for programs, especially for those at high risk such as teens, minorities, and the economically disadvantaged, must be reevaluated. Only by continued analysis of the costs and benefits can costs associated with health care resource allocation be optimized. While early entry into prenatal care is reported, it would be important to evaluate the appropriateness of the care since wide variations in the level and comprehensiveness of care received have been reported. [27]; [28] Adequacy of prenatal care and attention to the larger social issues of racial and socioeconomic inequities are important areas of research and interventions in the continued attempts to reduce the low birthweight rate. One limitation of the present study is that there is no possible way to identify the degree of prenatal care the women received or level of patient compliance with recommendations during the prenatal care visit, which may have a great impact on the outcome of the pregnancy.

Maternal age: Analysis of the temporal trend revealed that at the national and state level, a significant change was noted with increasing numbers of women in the at

risk age group of age 35 and older giving birth. While some increase was noted at the local level, it was not statistically significant in this a priori high-risk population. In the comparison of the three low birthweight populations, maternal age was found to be higher in the local study group than in the state and national groups. Temporal trends are now revealing increases in births to older mothers. These trends have been reported and discussed at the national level [11] by CDC and the local level by the Connecticut Department of Public Health [49]. It is interesting, however, that this has not impacted the local NICU population.

Plurality: Most of the low birthweight infants were singleton at all three levels. This is expected, as singletons comprise the largest proportion of births. However, plurality has significantly increased at the national level over the five-year study period. It has also increased at the state level, but not at the same rate as at the national. Although the local NICU did not experience a significant increase in multiple births over the study period, the comparison of the LBW populations for 1994 revealed that the percentage of multiple births in the low birthweight population at the local level far exceeded that at the state and national levels.

The state of Connecticut has one of the highest levels of multiple birth [38] and many of these infants are low birthweight. This is also to be expected, since the likelihood of being at low birthweight is much greater for multiples than singletons. Multiple births are, therefore, a growing area of risk to newborns. For higher order multiples, triplets and greater, the risk to the developing fetus increases dramatically. Risks include delivery at a low birthweight as well as an increased potential for morbidity and mortality. [40] The popular press has glamorized the pregnancy and births of higher

order multiples and downplayed the risks to the developing fetuses and mother. Options and decisions for patients and medical staff during the process of infertility treatment have not been adequately presented. These may include number of embryos to implant and potential ethical issues such as extent of treatment attempted and the option of selective reduction for a higher order multiple pregnancy.

Multiple birth is an emerging health problem, largely a result of assisted reproduction. Accurate and timely information about the risks must be shared with the prospective couple seeking medical intervention for reproduction.

Conclusion

An emerging trend is that older women are giving birth to more multiples and they are smaller but not necessarily born earlier. Many may require supportive treatment. The high cost of medical care associated with the treatment of low birthweight infants as well as the increased risk of morbidity and mortality to the infant should caution us regarding this alarming trend. It is unclear as to the actual factor causing this change. This report highlights some of the variables that require more thorough investigation.

Unanswered questions

Questions remain unanswered from this study regarding low birthweight and associated morbidity and mortality. At what weight or gestational age do the risks increase? With improvements in neonatal intensive care, do smaller infants still face the same risks as previously established? Is the weight cutoff of 2500 grams still appropriate in identifying risk for specific populations i.e. African Americans or near term multiples?

How have birthweight and gestational age specific issues in the problem of low birthweight changed? How will the ethical issues be resolved re: infertility treatments as well as extraordinary care for the smallest and most premature infants.

Continued research

Continued research into all areas of the complex problem of low birthweight and its associated risk factors is imperative. The general information about the low birthweight populations as well as that of temporal trends in each of the three databases, national, state and local, is one piece in identifying the problem of low birthweight and in predicting future needs. Information about the population presently served and those at risk who may benefit from targeted interventions is vital to be made available to policy makers, program planners, health educators, and clinicians. Health teaching and interventions must be planned with the specific audience in mind. A clear understanding of those we serve as clinicians in maternal and child health is critical in delivering care in the most culturally sensitive, focused manner.

TABLE 1: CASES - NATIONAL, STATE AND LOCAL = TOTAL BIRTHS/ADMISSIONS AND LOW BIRTHWEIGHT
AND PERCENT LOW BIRTHWEIGHT

	NATIONAL			STATE TOTAL BIRTHS				LOCAL TOTAL ADMISSIONS		
	TOTAL BIRTHS	LBW	%		LBW	%			LBW	%
1992	4,065,014	287,493	7.1%	47,574	3,269	6.9%		450	289	64%
1993	4,000,240	288,482	7.2%	46,658	3,191	6.9%		434	273	63%
1994	3,952,767	287,607	7.3%	45,795	3,140	6.9%		399	253	63%
1995	3,899,589	285,152	7.3%	44,388	3,129	7.1%		426	295	69%
1996	3,891,494	287,230	7.4%	44,455	3,199	7.3%		467	317	68%
	19,809,104	1,435,964		228,870	15,928			2176	1427	

National data NCHC Natality Statistics Tables 43, 44, 45.
State data Connecticut Registration Report Tables 2B, 3.

TABLE 2: A COMPARISON OF CHARACTERISTICS IN THE LOW BIRTHWEIGHT
POPULATION: NATIONAL, STATE AND LOCAL LEVEL: 1994

Comparison National/State

	National	State	p-value
Preterm	63.0%	64.0%	0.8832
Unmarried	Missing	54.0%	***
Prenatal Care (all but 1st trimester)	28.0%	23.0%	0.417
Black	29.0%	19.0%	0.0968
Age (≤ 17 years)	7.0%	5.0%	0.5515
Age (≥ 35 years)	17.2%	16.7%	0.4866
Multiple	19.0%	20.0%	0.8584

Comparison State/Local

	State	Local	p-value
Preterm	64.0%	94.0%	<0.0001
Unmarried	54.0%	62.0%	0.2517
Prenatal Care (all but 1st trimester)	23.0%	24.0%	0.8676
Black	19.0%	8.0%	0.0228
Age (≤ 17 years)	5.0%	6.0%	0.7564
Age (≥ 35 years)	16.7%	16.6%	0.9245
Multiple	20.0%	25.0%	0.3972

FIGURE 1. BIRTH RATE - STATE AND NATIONAL: 1992-1996

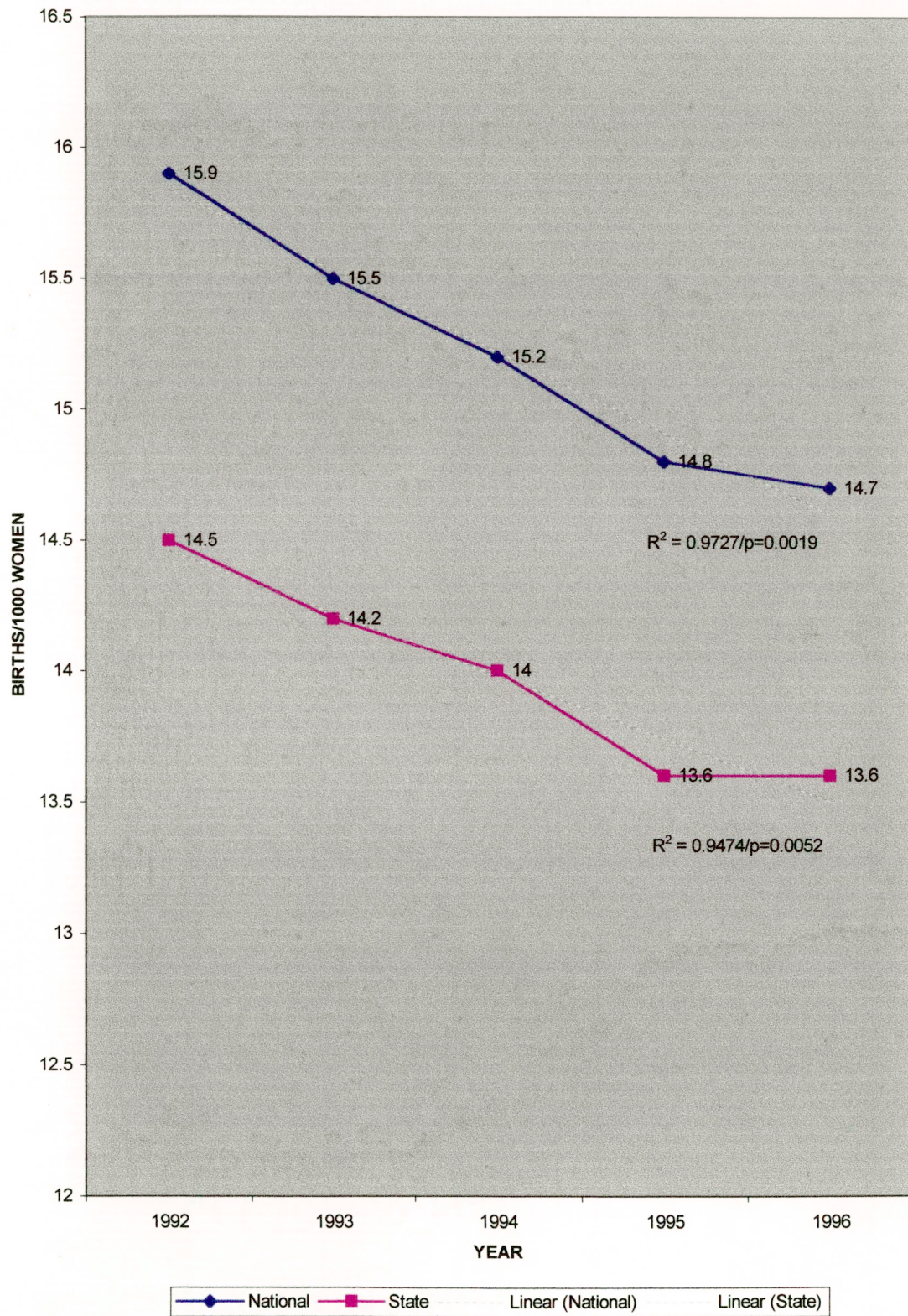


FIGURE 2. PERCENT LOW BIRTHWEIGHT - STATE AND NATIONAL:1992-1996 AND HEALTHY PEOPLE 2000 GOAL

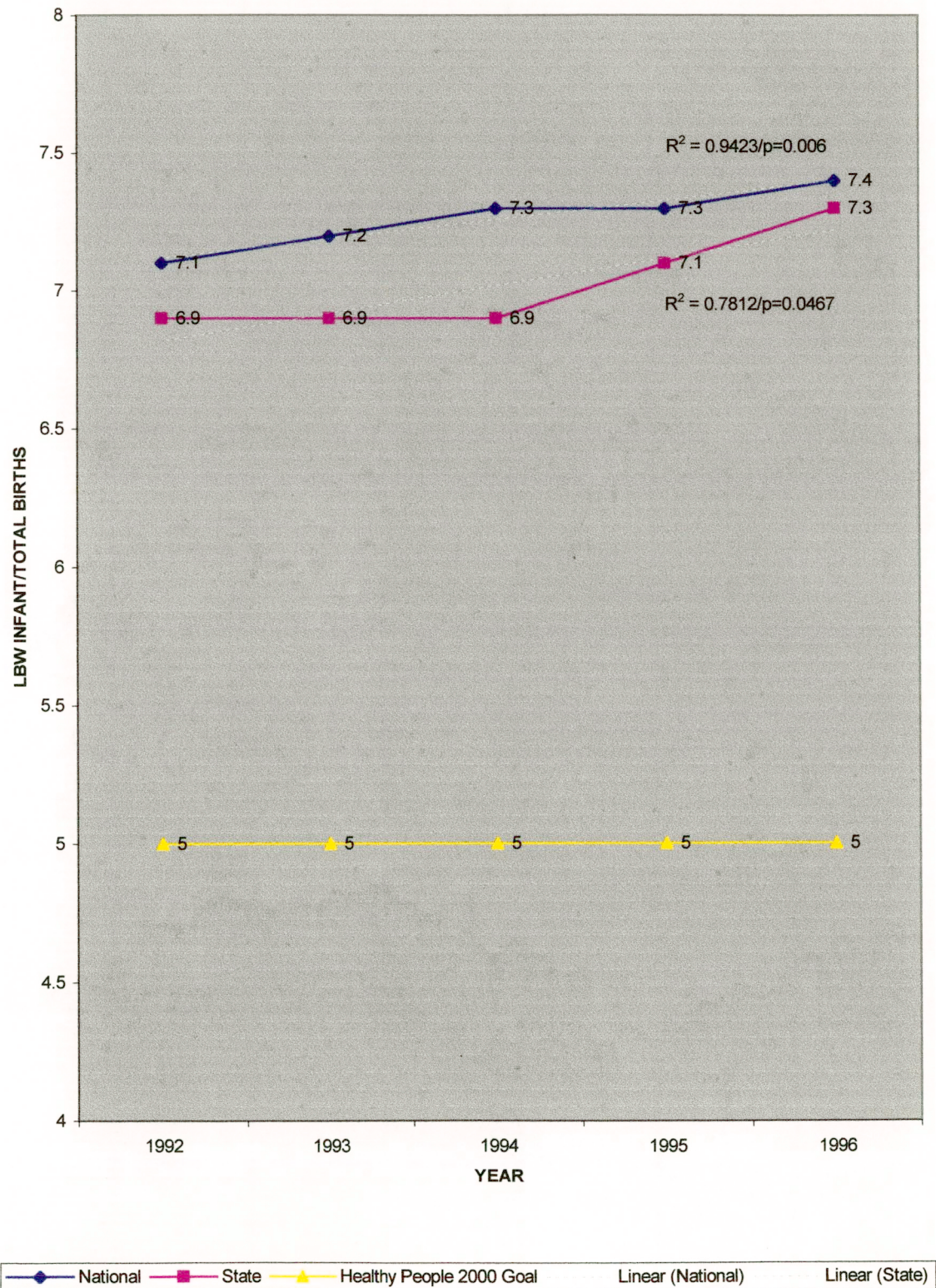


FIGURE 3: TEMPORAL TREND OF PERIOD OF GESTATION - PRETERM

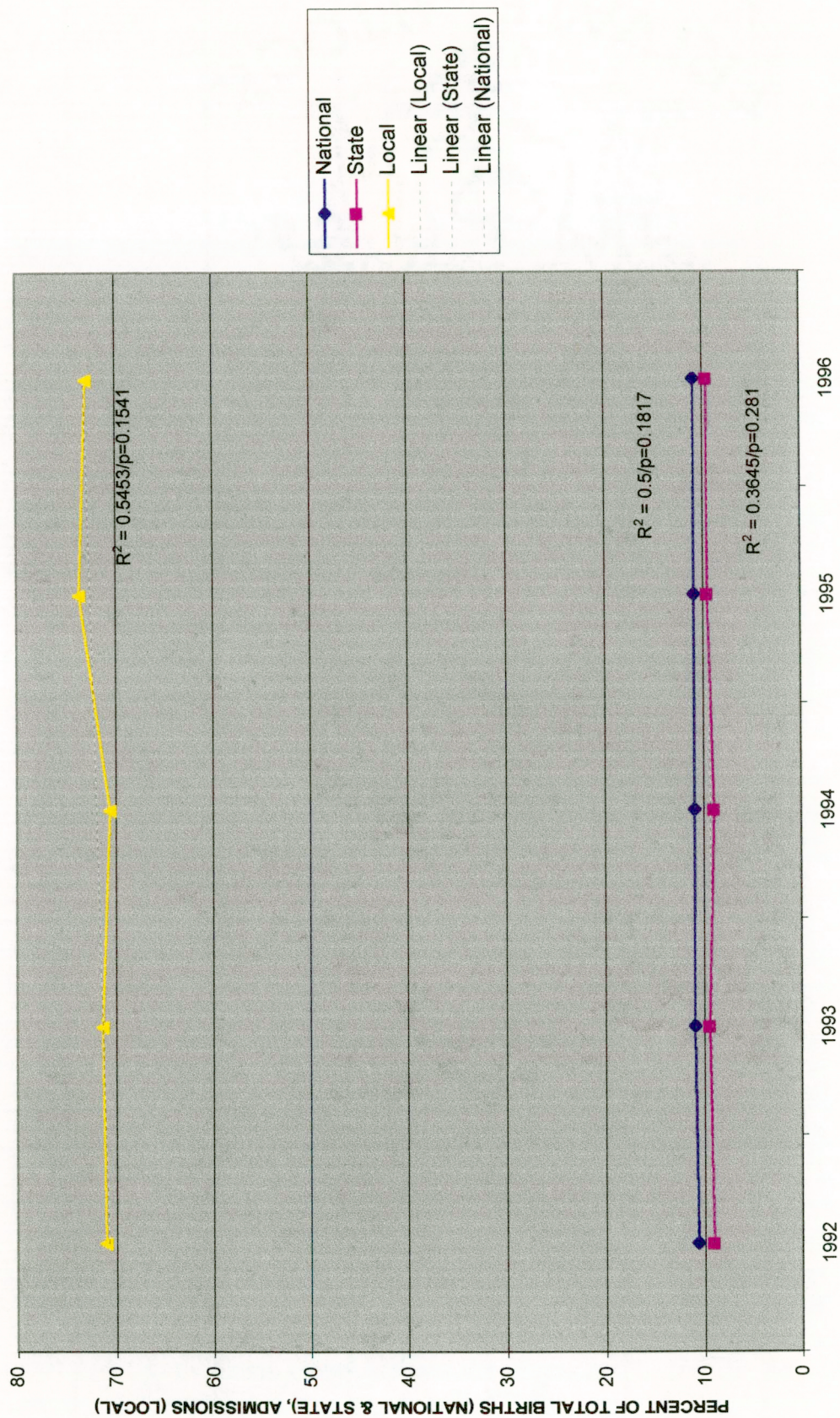


FIGURE 4: TEMPORAL TREND OF MARITAL STATUS - UNMARRIED

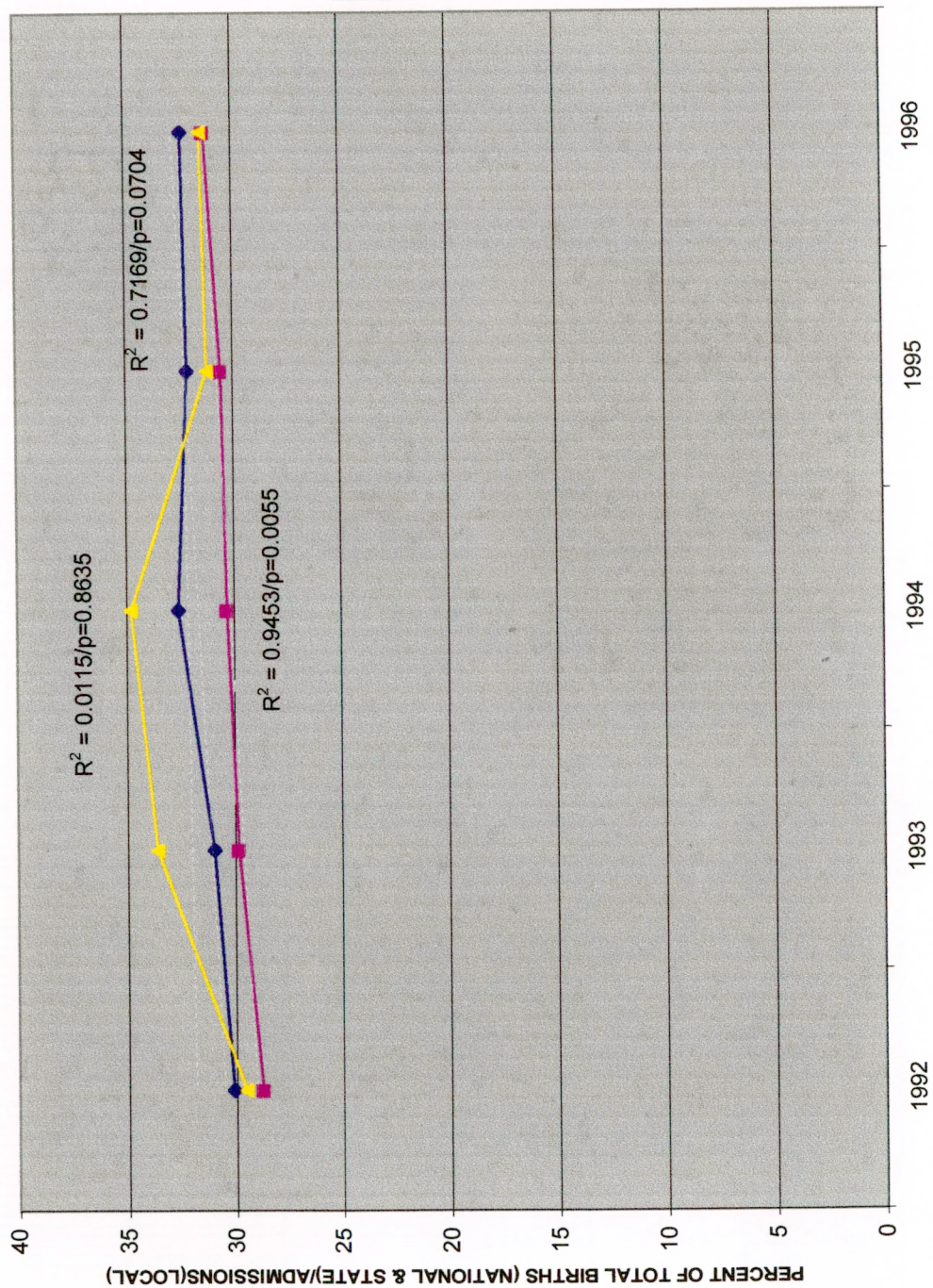


FIGURE 5: TEMPORAL TREND OF PRENATAL CARE: ALL EXCEPT FIRST TRIMESTER

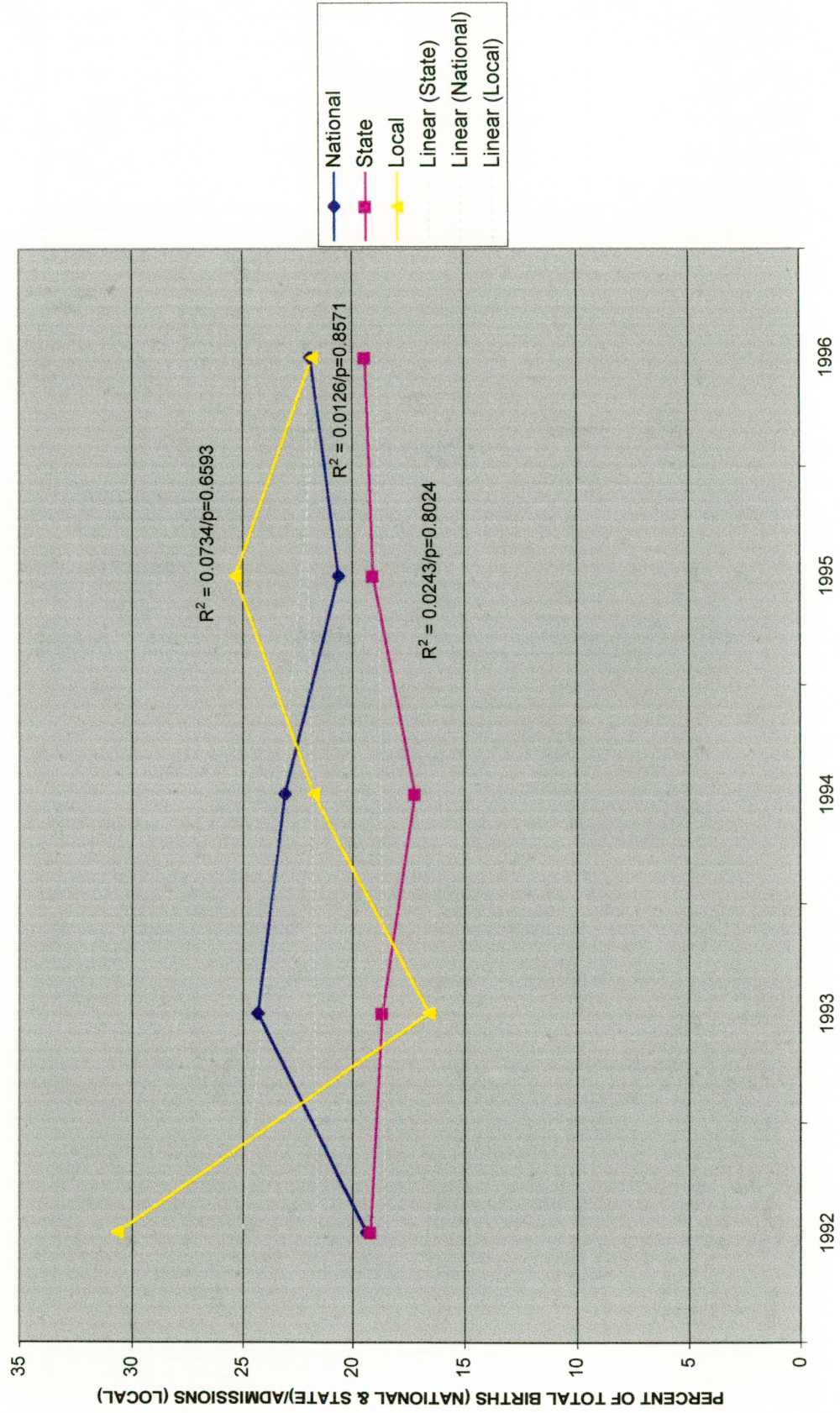


FIGURE 6: TEMPORAL TREND OF RACE - BLACK

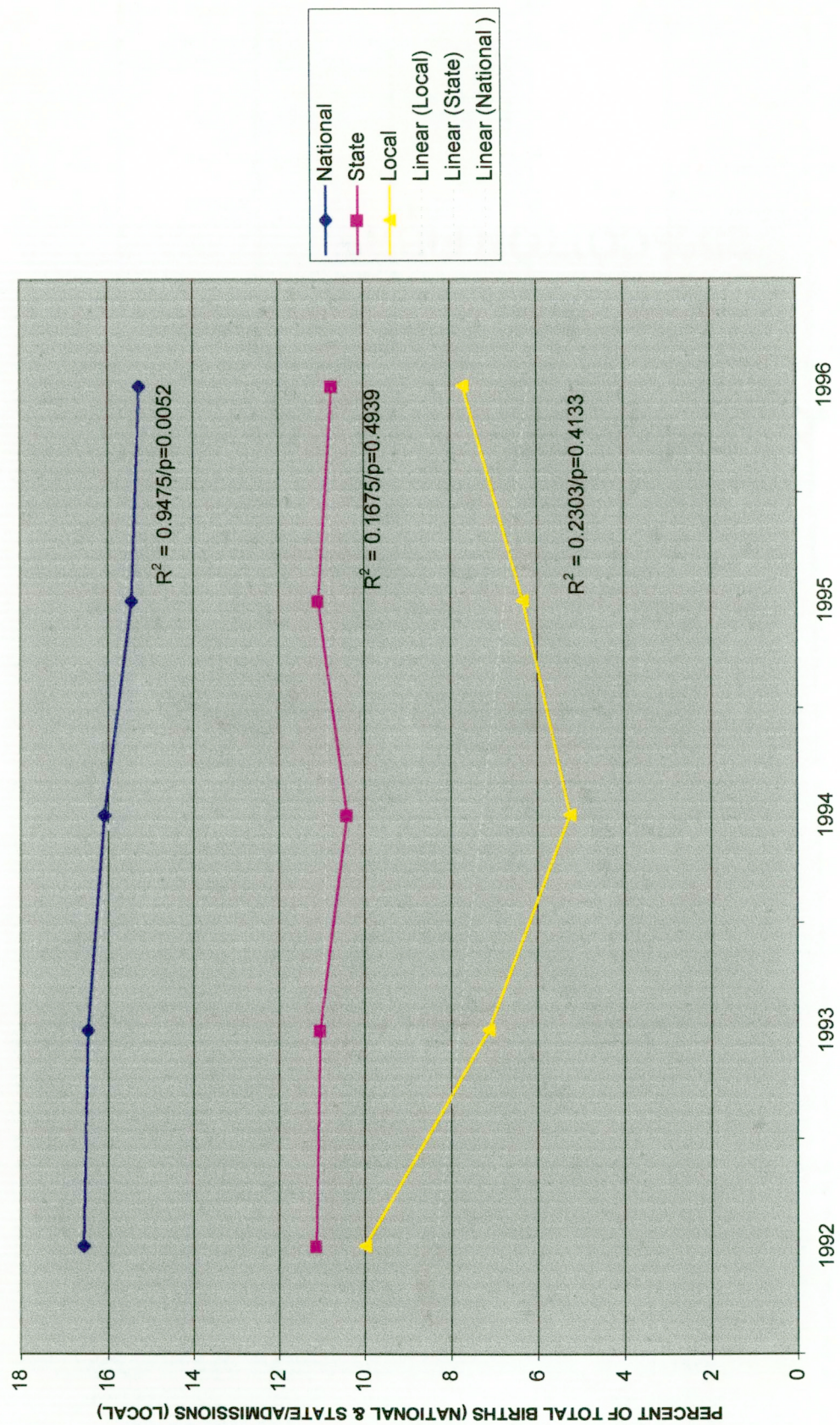


FIGURE 7: TEMPORAL TREND OF MATERNAL AGE - LESS THAN AND EQUAL TO 17 YEARS

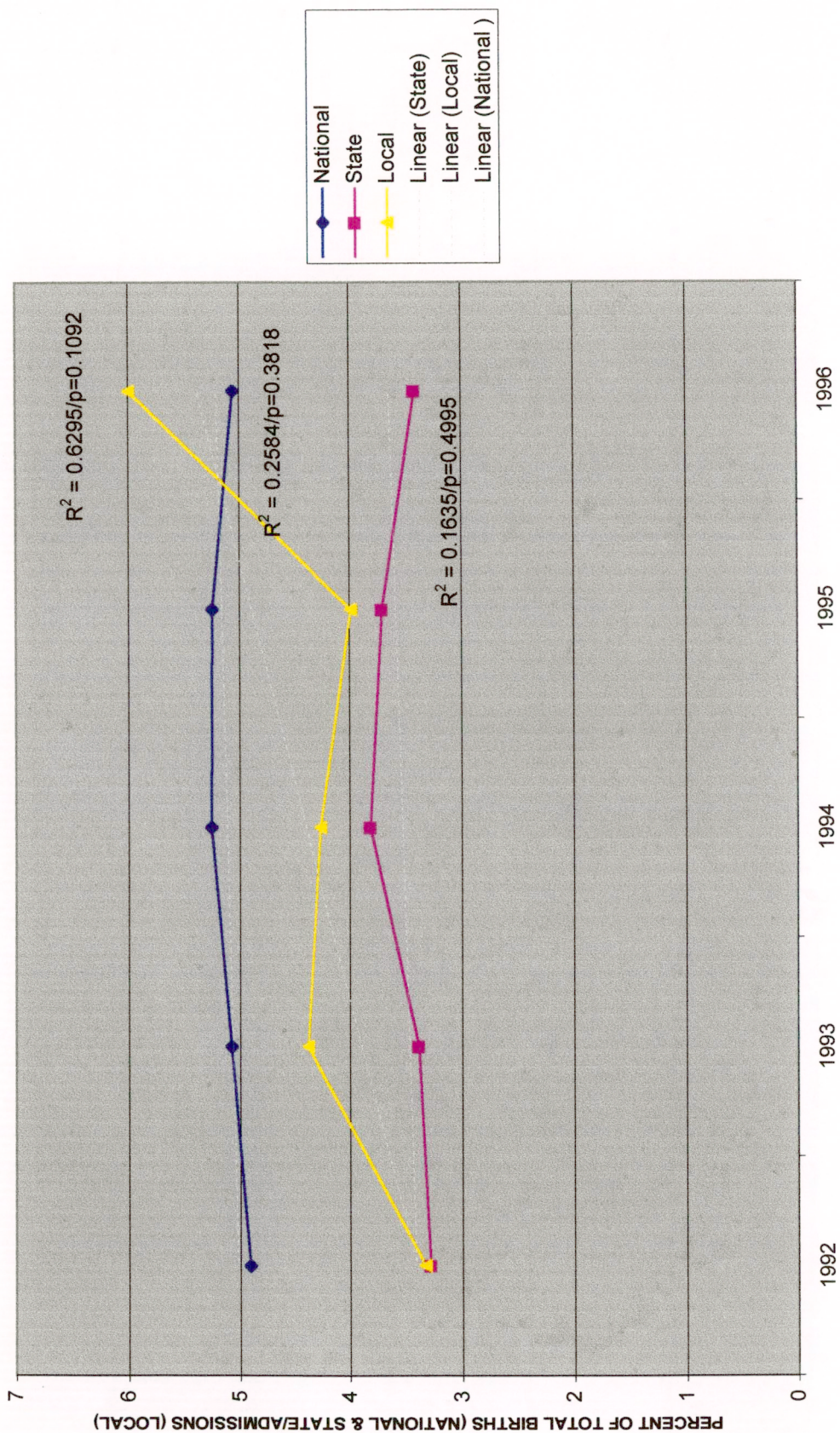


FIGURE 8: TEMPORAL TREND OF MATERNAL AGE - GREATER THAN AND EQUAL TO 35 YEARS

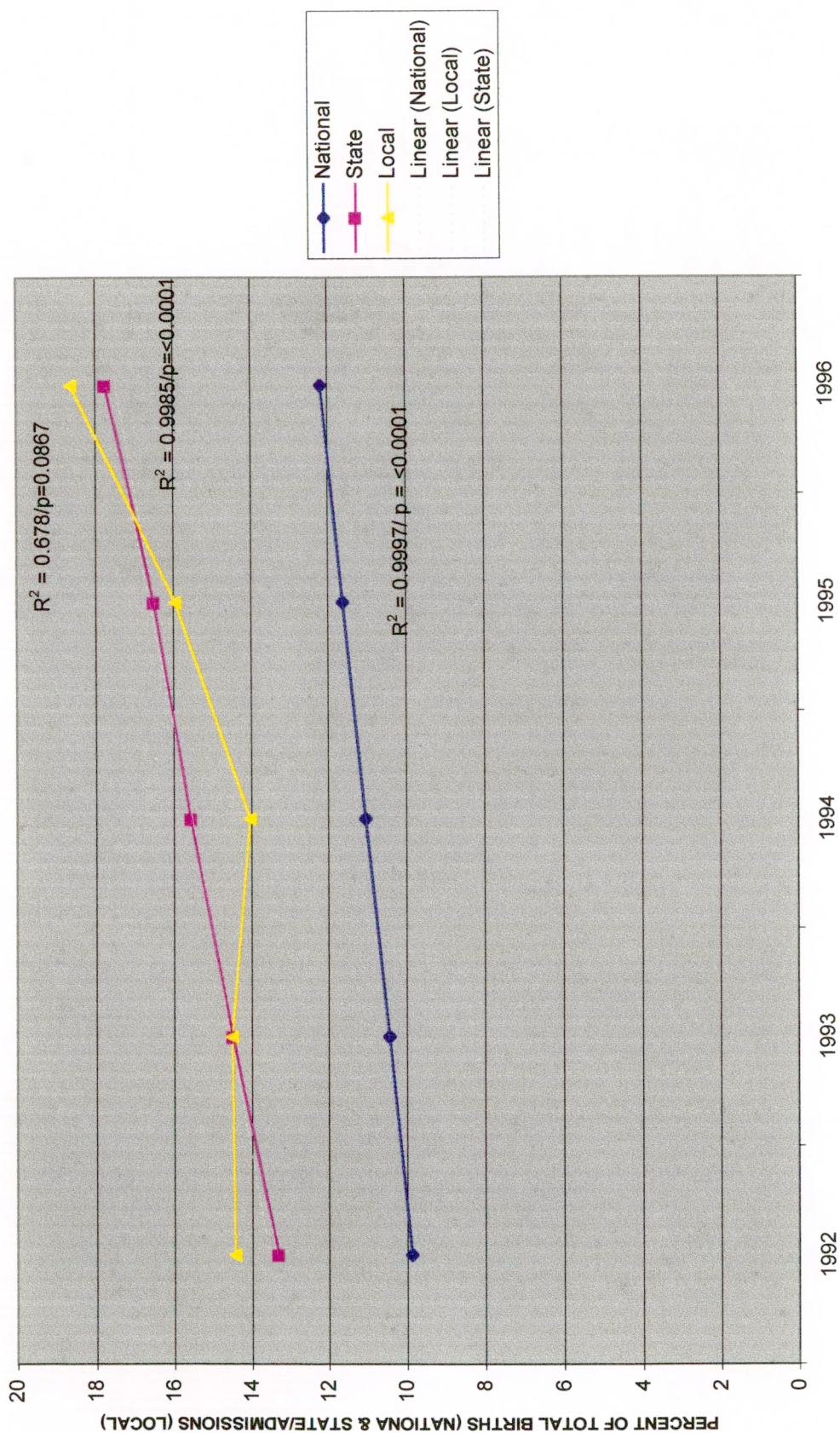


FIGURE 9: TEMPORAL TREND OF PLURALITY - MULTIPLE BIRTH

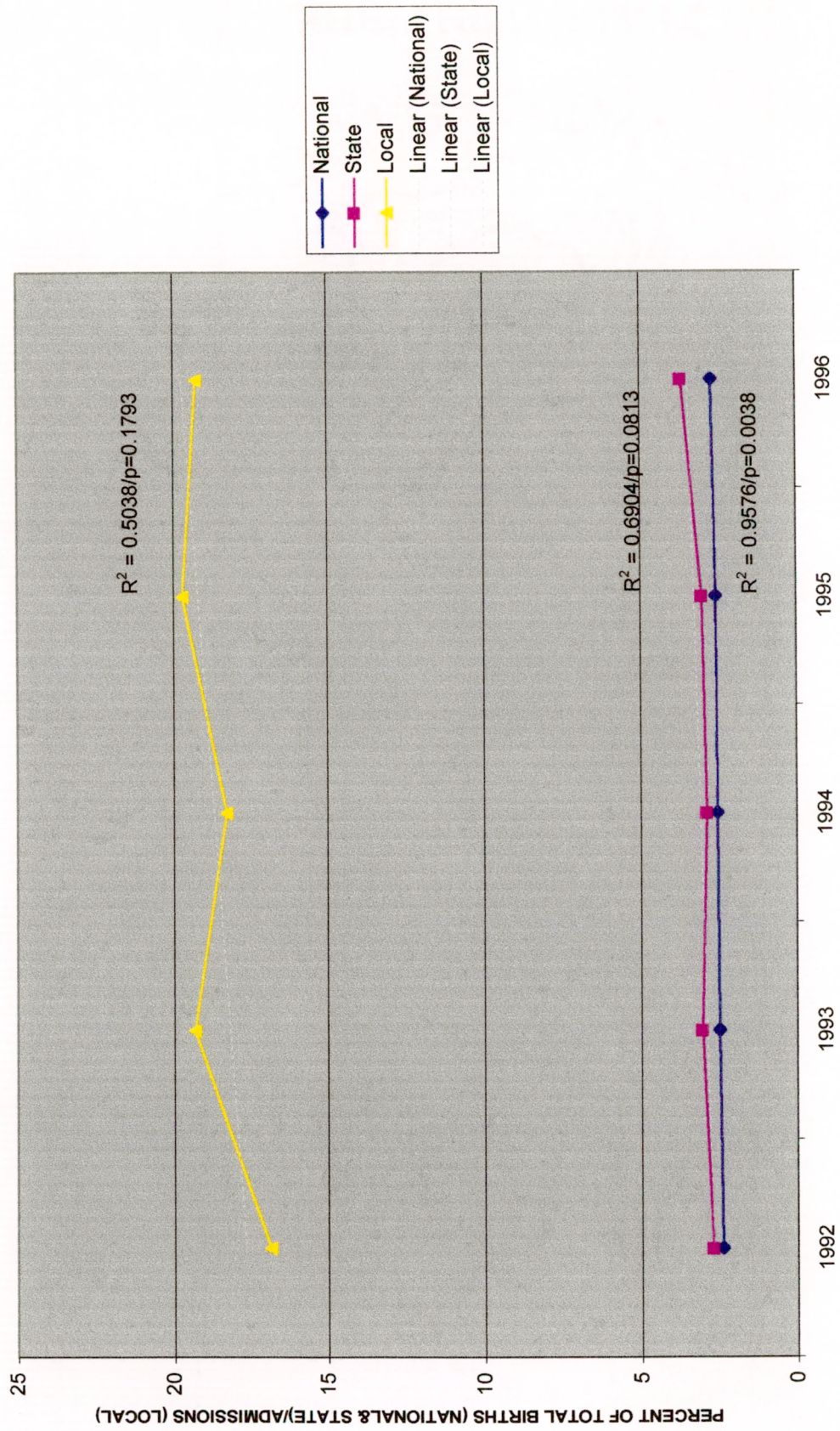


FIGURE 10: DISTRIBUTION OF LOW BIRTHWEIGHT POPULATION BY MATERNAL AGE - NATIONAL, STATE AND LOCAL: 1994

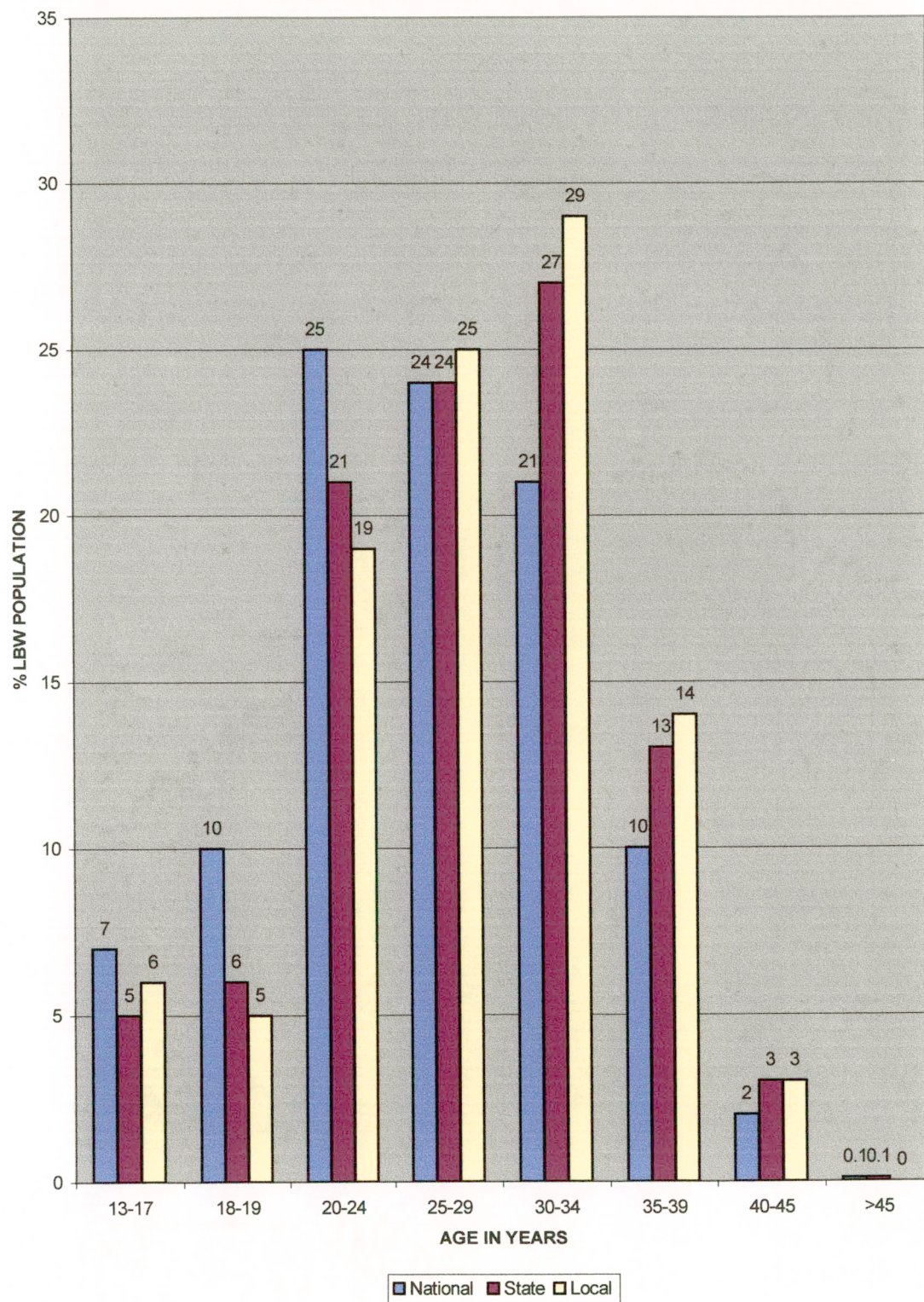
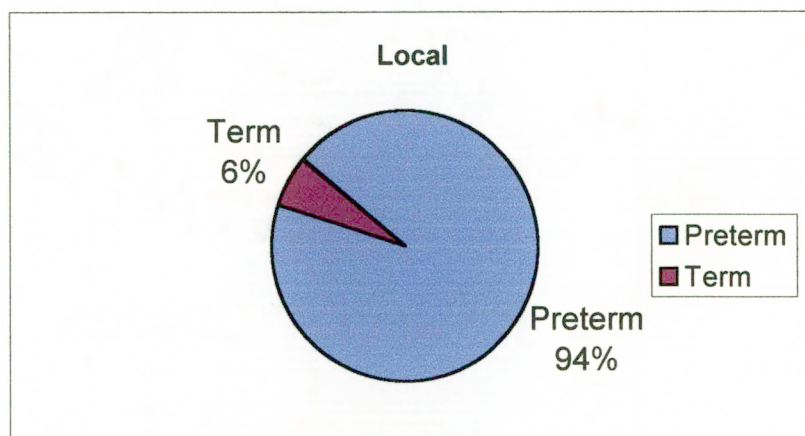
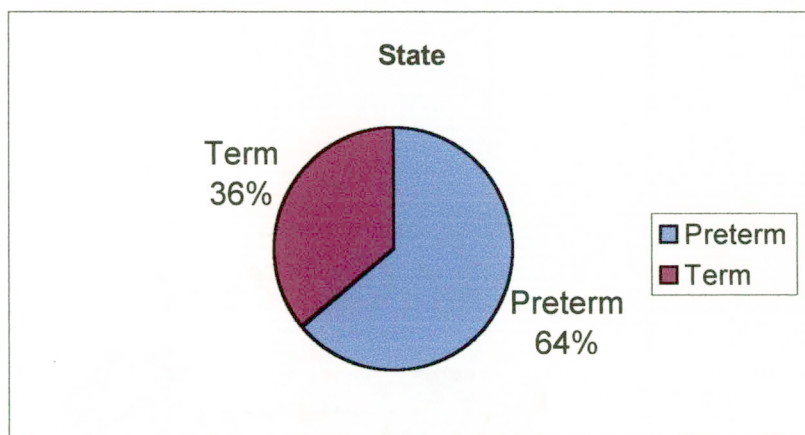
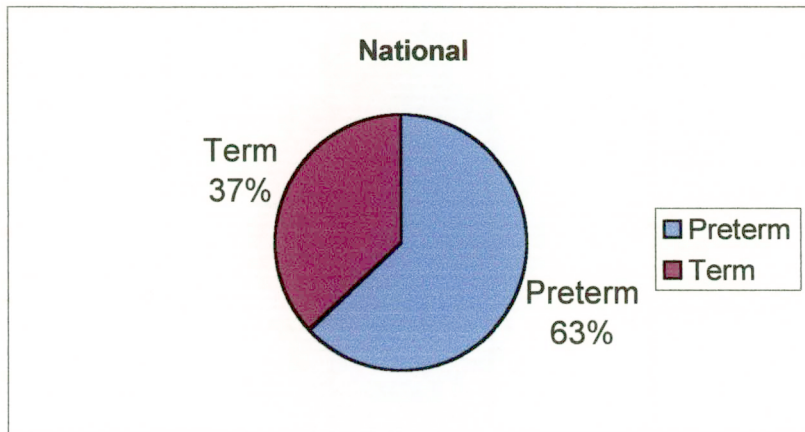


Figure 11: Period of Gestation in Low Birthweight Infants
National, State and Local: 1994



APPENDIX A. NEONATAL INFORMATION SYSTEM

NEONATAL INFORMATION SYSTEM	
MEDICAL RECORD FORM	VARIABLES INCLUDED
1. Admission Form	Patient #, Name, Date and time of admission, Parental demographics, Extended family/support demographics, Primary care physician, Origination of referral, Billing information.
2. Perinatal Form	Patient #, Name, Date and time of birth, Adoption information, Birthweight, Apgar scores at 1,5,10 minutes, Sex, Gestational age by dates and exam, Race, Blood type and Rh, Birth sequence and total, Marital status, Maternal race, Maternal weight gain, Maternal obstetric history, Prenatal care, Street drug use, Alcohol use, Tobacco use, Maternal/fetal conditions, Amniocentesis results, Ultrasound results, Prenatal drugs and medications, Delivery type and complications, Resuscitation.
3. Admission Exam	Patient #, Name, Admission date, Weight, Length, Head circumference, Vital signs, Physical exam by system, Admitting impressions and diagnosis.
4. Hospital Summary	Patient #, Name, Date of admission, Growth parameters, Respiratory support, Procedures, Consults, Medications, Nutrition, Diagnoses.
5. Discharge/Transfer Form	Patient #, Name, Admission date, Discharge date, Disposition, Primary caretaker, Active diagnosis at discharge, Cumulative diagnoses, Discharge physical exam, Recent laboratory tests, Recent procedures, Discharge medications and requirements, Nutrition at home, Screenings and exams, Referrals, Primary care physician, Follow-up appointments.

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