Parametric Graduation of Male fertility rates

Introduction

Female fertility has always attracted the interest of demographers in contrast to male fertility. Fertility rates are almost always calculated for females and hardly ever for males.

In the field of graduation techniques, various parametric and non parametric techniques have been proposed for estimating age-specific female fertility patterns e.g. the Coale-Trussell function (Coale and Trussell, 1974; 1978), the Beta, the Gamma and the Hadwiger distributions (Hoem et al., 1981; Hadwiger, 1940; Gilje, 1969; Yntema, 1969), cubic splines (Hoem and Rennermalm, 1978; Gilks, 1986) the parametric models proposed by Peristera and Kostaki (P-K models) in 2007. In contrast to the attention paid to female fertility patterns little work has been done on modeling the male ones. Paget and Timaeus (1994) proposed an extension of Brass relational model in order to estimate male fertility patterns. According to the authors this model seems sufficiently flexible to estimate a variety of male fertility distributions. Kamper-Jorgensen et al (2004) presented the classical age-period-cohort model for describing male first-child fertility patterns in Denmark.

In the literature trends in female fertility are well documented, while trends in male fertility have typically not been examined. Morris (1993) studied male fertility in 12 Latin American countries taking into account factors like the premarital intercourse of males and the use of contraception methods. Low (1994) provided a longitudinal analysis of male fertility patterns during the demographic transition. Bostofte et al. (1983) and Miret-Gimundi (2000) presented the declining fertility of males since the 1950s. Gray (2002) studied men's fertility levels in Australia. His main result is that the median age of fathers is increasing over time however the peak age at birth differs between married and unmarried fathers.

Another topic presented in the literature concerns comparisons between male and female fertility patterns. Dinkel and Milenovic (1993) examined age-specific and cohort fertility rates for males and females. The main conclusions are that before 1930 male fertility was higher than female fertility but the age fertility gap between the two sexes narrowed over time among males aged over 40 years. Ventura et al. (2000) examined the TFR for both females and males in the US. Their basic results are lower fertility for men compared to females for the year 1998. However as they notice a reverse situation characterized the US population twenty years ago. Toulemon and Lapierre-Adamcyk (2000) analysed differences between male and female fertility in France. They found that there are substantial differences between the parenthood experience for men and women in France. Men declare fewer "biological" children on average than women. The main reason for this is the proportionately higher number of men among immigrants and the number of children not recognised by their father. More men than women remain childless, but men have large families more often than women. Zhang (2006) compared female and male fertility rates in 43 countries. He found that for most the countries male and female fertility rates are very close while the countries for which appear the largest differences between male and female fertility are those with higher fertility rates. Alich (2007) studied sex -specific differences in fertility behavior in Russia. He focused on four sex-specific differences, concerning the length of a fertile time span, the age and timing pattern of fertility, the completed fertility and parity distributions, and finally the underreporting behavior.

Several biological, methodological and sociological reasons justify the exclusion of males from fertility studies. The biological reasons are related to the well defined and narrower limits in the reproductive span for women (ages 15 to 49), in contrast to the rather vague temporal boundaries of male reproduction (ages 15 to 79) (Shryock and Siegeletal, 1976, Keyfitz, 1977). In addition there is big variation regarding the number of children and the age interval of

childbearing between males and females compared to men (Keyfitz, 1977). The methodological reasons that may contribute to the exclusion of males from fertility studies concern the lack of such data in a systematic manner and more specifically data about the parental age the birth of a child. Such data are more frequently collected on registration certificates for mothers rather than for fathers while there are a greater number of cases with unreported age data for fathers rather than for mothers especially for births outside marriage (Keyfitz, 1977). Men tend to underreport the number of their biological children, either intentionally or due to a lack of information (Duberstein Lindberg et al, 1998). Despite changes in labor force participation throughout the industrialized countries, women are easier to interview because they are more often at home (Goldscheider and Kaufman, 1996). Another methodological problem according to several authors is that male and female fertility rates are rather incompatible (Coleman, 2000, Smith, 1992). Sociological reasons refer to the different gender role, e.g. the breadwinner's model according to which men have no involvement in the fertility apart from impregnating women (Greene and Biddlecom, 2000).

However recent socio-demographic changes, such as high divorce and cohabitation rates, increased participation of women in the labour force and the shift from family to individual wage rates, which affect gender division of labour and place more responsibility on men for children rearing, make necessary the study of male fertility.

In this work data from the 2002 National Survey of Family Growth about male and female fertility are used. In order to estimate the age specific fertility pattern of males two versions of the parametric model presented by Peristera and Kostaki (2007), are used. The above models have proved accurate in the case of female fertility curves. Based on the parameter estimates of the models the shape and the evolution of the age specific male fertility through time is examined. Furthermore male fertility differentiated according to, race, ethnicity and parity order is studied. Finally by fitting the same models to the female fertility rates, we also compare the fertility patterns of males and females for the total populations but also according to the race, ethnicity of the parents as well as by birth order.

Fertility pattern of female and male populations

Although fertility schedules of males and females are similarly shaped, fertility is distributed over different age ranges for each sex. In addition, fertility schedules for both males and females are usually unimodal and right skewed but the female reproductive period ranges from approximately 15 to 49 years. In contrast the male reproductive age interval is open to the right. Moreover, in most populations, males become parents at a greater age than females, exhibiting an age gap of two to three years at the average (Gray, 2002; Alich, 2007; Hynes et al., 2008).

In recent years a distortion of the female fertility pattern has been observed in data of several populations of developed countries in Europe and the USA (Chandola et al., 1999; Peristera and Kostaki, 2007). This variation is related to the form of the fertility curve. While the standard fertility pattern is a bell shaped one, roughly symmetrical around its peak placed in an age around 25, in recent years, in data of modern developed populations, a second peak becomes obvious. This is placed in a much younger age than the first one. This has been initially identified for fertility data of some English-speaking countries, e.g., United Kingdom, Ireland and the United States where a marked hump in early ages is displayed (Chandola et al., 1999; 2002). The pattern of early age fertility nowadays characterizes more European countries, such as Spain, Denmark, Sweden, Norway and Italy (Peristera and Kostaki, 2007). An interesting finding is that the pattern of first births also exhibits a strongly intense hump in

younger ages, stronger than the pattern of total fertility. This fact provides a strong evidence of heterogeneity in the female populations.

Regarding males, there is not much information in the literature about the age pattern of their fertility in recent populations. Dinkel and Milenovic (1993) compared age specific fertility patterns of men and women in Germany over 1902-04 to 1959-61. Their main conclusion is that prior to 1930 the gap between male and female fertility was wider while male fertility was higher. Through time this gap narrowed especially for males above age 40. Vince Salazar (1996) studied the age-specific fertility pattern of males for first birth occurrence in US for race-stratified groups. According to the author there are clearly marked differences between racial subpopulations but also the new distorted fertility pattern exists for some of the racial groups. Anderson (1997) compares male and female fertility rates in the case of France. His main conclusion is that since marriage is a dominant link between male and female fertility, the fertility rates of the two sexes tent to be more similar in populations where monogamy is most strictly observed. In contrast, in societies where large proportions of births take place out of wedlock, there should be more differences in the age fertility curves between the two sexes. He also notices that in recent years due to the rise of divorce and remarriage rates in the US and Western Europe more important differences are observed between male and female fertility rates. Ravanera and and Rajulton (2003) examined fertility of Canadian men. Based on existing literature there is no evidence of distorted fertility pattern in the case of males.

The data

This work relies on data from the National Survey of Family Growth (NSFG). Data correspond to two different cycles of the survey, i.e. cycle 6 and cycle 7 for the years 2002 and 2006-2008 respectively. This database provides information on men's fertility behavior from cross-sectional sample of women and men aged 15–44 who reside in households. In addition, the data sets provide information on male fertility across various years, allowing for an examination of fertility behavior over time. The main variable of this study is based on the respondent's age at first birth. Due to well-documented differences in family formation behavior by race, results are presented for three race/ethnic groups: Hispanics, non-Hispanic African-Americans, and non-Hispanic whites

There is a huge discussion in the literature about the quality of male fertility data. It is often stated that male fertility data are less reliable than the female fertility data and this is due to under-reporting of fathering in the national datasets (Rendall et al, 1999; Cherlin and Griffith, 1998). Various studies have found serious problems when analyzing male fertility behaviour stemming from the various methodological difficulties mentioned above (Bledsoe et al., 2000; Coleman, 2000; Rendall et al., 1999; Cherlin and Griffith, 1998). Most of the studies about male fertility stress than men underreport their fertility, even if they are interviewed directly (Goldscheider, and Kaufman, 1996; Rendall et al., 1999; Toulemon, 2001). However, other studies conclude that it is possible to obtain correct fertility data from men (Duberstein Lindberg et al., 1998b; Mott and Gryn, 2002; Alich, 2007).

Male data from the NSFG database are considered less problematic due to various reasons. Due to a general lack of available data on male fertility, improved practices for collecting male fertility were incorporated into data collection efforts. In several studies in order to assess the quality of male fertility data, they compare the age-specific fertility rates to estimates on men's fertility from vital statistics. In the case of the NSFG database, it was found that the estimated rates fall within the confidence intervals surrounding the observed age-specific fertility rates of

the NSFG database. The only exception was for younger ages of the previous NSFG database where underreporting births were found (Rendall et al, 2006; Peters et al, 2006).

Methodology

The parametric model presented by Peristera and Kostaki (2007) is used in order to estimate the male and female fertility patterns of the various populations. Three versions of this model have been proposed in order to estimate the typical or the distorted fertility pattern of modern populations. In this work the following two versions are used.

The Simple Model

$$f(x) = c_1 * \exp\left[-\left(\frac{x-\mu}{\sigma\ (x)} \right)^2 \right]$$

where *f(x)* is the age-specific fertility rate at age x, while c_1, μ, σ are parameters to be estimated and $\sigma(x) = \sigma_{11}$ *if* $x < \mu$, *while* $\sigma(x) = \sigma_{12}$ *if* $x > \mu$. The parameter c_1 describes the base level of the fertility curve and is associated with the total fertility rate, μ reflects the location of the fertility curve, i.e. the age corresponding to the peak of the curve, while σ_{11}, σ_{12} reflect the spread of the distribution before and after its peak, respectively.

The Mixture Model

$$f(x) = c_1 * \exp\left[-\left(\frac{x-\mu_1}{\sigma_1} \right)^2 \right] + c_2 * \exp\left[-\left(\frac{x-\mu_2}{\sigma_2} \right)^2 \right]$$

where f(x) is the age-specific fertility rate at age x, while c_i, μ_i σ_i, are the parameters to be estimated and $\sigma_1(x) = \sigma_{11}$ *if* $x <= \mu_1$, *while* $\sigma_1(x) = \sigma_{12}$ *if* $x > \mu_1$.

The parameters c_1, c_2 express the severity i.e. the total fertility rates of the first and the second hump respectively, μ_1, μ_2 are related to the mean ages of the two subpopulations the one with earlier fertility and the other with fertility at later ages, while σ_1, σ_2 reflect the variances of the two humps.

For the estimation of the parameters of the alternative versions a non-linear least-squares procedure was used by minimising the following sum of squares,

$$\sum_x \left(\hat{f}_x - f_x \right)^2$$

where $\hat{f}_x$ is the estimated fertility rate at age x and f_x is the empirical one.

Results

The main aim of this work is to investigate the differences between male and female fertility patterns in terms of age, timing and parity. In addition, a cross timing study of the fertility trends is provided.. A second part of the analysis consists in examining how racial or ethnic differences contribute to different fertility patterns both for females and males.

Figures 1 to 10 illustrate observed and expected age-specific fertility rates of the US male and female populations for the years 2002 and 2006-2008. The estimated parameters of the models are given in Tables 1 to 3.

Comparing total male and female fertility, important differences at the pattern, the level and the evolution of fertility through time are observed. Considering the fertility pattern of the total populations, as illustrated in Figure 1, the female pattern is characterized by a two-hump distribution for all the years examined, while the male fertility pattern tends to be a flat topped distribution, especially for the years 2006-2008. Concerning the years 2006-2008, the average difference for the peak age between females and males is 1.2 years for early ages fertility and 0.18 years for later ages (Table 1). These differences get smaller for the year 2006-2008. This indicates a tendency of convergence between males and females. As regards to the age at which males have children, it is observed a shift to younger ages. The opposite is however observed for the female population.

Given that usually significant differences exist in the basic demographic characteristics between race and ethnic groups, male and female fertility by ethnicity and race of the mother and father are also examined. Regarding the white population (Figure 2), the female fertility pattern in 2002 is characterized by a two hump distribution, one a lower ages and a second one at higher ages. The same fertility pattern of two humps is also apparent in 2006-2008. However there is a shift of the two humps at higher ages, while the level of fertility is significantly lower (Table 1). A different pattern occurs for males. Concerning 2002, a slight second hump at higher ages, around 35 starts to appear at a modest level, while in 2006-2008 the male fertility pattern is very different and described by a flat-topped distribution. Through time, males obtain children at younger ages. Comparing the female and male fertility patterns, even for the white population, the general differences are similar to those of the total population. Females have higher levels of fertility than males over the total age span for the year 2002, while in 2006 the fertility level is higher for males than females after the age of 25. The average age difference in the peak fertility is diminishing between males and females over time. Thus, this average was 6.2 years for early age fertility and 9.32 for years for later age fertility at 2002, while it declined to 1.4 years and 2.02 years respectively in the period 2006-2008. Regarding the white population, the age of peak fertility between males and females is converging the recent years.

Regarding the black population of females (Figure 3), a distorted fertility pattern appears only for the years 2006-2008. In contrast a distorted fertility distribution characterizes male fertility both in 2002 and 2006-2008, indicating higher heterogeneity in the fertility behavior of these populations. Females exhibit higher fertility levels in 2002, opposite to 2006-2008, where higher fertility levels are observed for males above age 25 (table 1). Black males obtain children at higher ages over time,. On the contrary, in recent years women are distinguished in two groups regarding their fertility behavior. It appears a group of women with early age fertility, before age 20 and a second group of women with fertility at later ages, close to their 30s. In recent years a convergence in the difference in the age of peak fertility between the two sexes is observed. In fact the fertility gap for the period 2006-2008 have diminished to 1.48 and 1.16 years for early age and late age fertility respectively, compared to a proxy of 2 years in 2002.

In the sequence the race of the mother/father is taken into account. Populations with Hispanic origin, do not exhibit distortions in their patterns (Figure 4). Female populations experience fertility at lower ages, with higher fertility levels over the total age span compared to men. Fertility is shifted to higher ages over time for both the male and female populations. The age gap is 3.3 years for 2002 while it widens in 2006-2008 reaching the 6.6 years (Table 1). A very different picture emerges for the non-Hispanic populations (Figure 5). The fertility distributions of women are very heterogeneous, comprising of two humps while no heterogeneity characterizes the male fertility curve. This heterogeneity for females is related to the fact that there exist two groups of women regarding the ages they give birth. The first concerns women that have children at younger ages, below age 20 and the second consists of those having children at higher ages, around 30 years old. The mean age of fertility increases over time for women, in contrast to men (Table 1). The mean age of fertility for men coincides with the late age fertility of women for both 2002 and 2006-2008 while the age gap between males and females is increasing over time.

The next step of analysis consists in studying fertility differentiated by order of birth. Male and female fertility differentiated by birth order is studied. In addition differences in the male and female fertility according to the ethnicity and race are taken into consideration. Figures 6 to 10 illustrate the results of first births while the corresponding graphs for second births are depicted in Figures 11 to 15.

Initially the results referring to the first births are presented. For the total population, it is obvious that in recent years the female fertility distribution shows a distorted pattern (Figure 6). Males also exhibit a distortion though less intense. As regards to the mean ages of fertility, they are higher for males compared to those of females. In 2006-2008, in contrast to previous years, men with fertility at later ages exhibit higher levels of fertility in comparison to women No significant deviations through time are shown in the age gap fertility between men and women.

A similar picture emerges in the case of the white population (Figure 7). The female fertility pattern is characterized by a two hump distribution for all years considered. In the case of males, this appears at a modest level for 2006-2008. Women experience earlier first births than men. Through time the mean age of fertility for women moves to higher ages. However in 2006-2008, the peak age fertility for men belonging to group with early age fertility is at younger ages compared to the mean age of fertility in 2002. The gap of fertility differences between the two sexes is declining over time (Table 2).

Regarding black population we observe that the male fertility distribution is more sharply right skewed compared to female fertility (Figure 8). Black men experience later first births than black women. However a shift of males' first births at earlier ages is observed through time. The age gap in fertility differences between males and females is also declining over time (Table 2).

Similar trends characterize the male and female fertility distributions of people with Hispanic origin (Figure 9), although in 2006-2008 the male distribution is not as skewed. Females exhibit higher fertility levels than males. The age gap in fertility differences between males and females is increasing over time (Table 2). For both males and females the mean age of fertility is shifted to higher ages over time.

Considering the non-Hispanic population (Figure 10), we observe that the fertility distributions between men and women are quite heterogeneous. The fertility curve of women consist of two humps, at earlier and later ages, while the male fertility distribution, especially in 2006-2008, is sharply skewed to the right. The age at which males have their peak fertility is shifted to

younger ages over time. On the contrary, women experience fertility at higher ages through time. Comparing male and female fertility curves in 2002, the mean age of male fertility is very close to the mean age of fertility for the group of women with older age fertility. This changes in 2006-2008, since then the mean age of male fertility is closer to the mean age of fertility for the group of females with early age fertility.

The differences between male and female fertility for second births are presented in Figures 11 to 15. Considering the total population (Figure 11), the female fertility distributions consist of two humps. For females, even though the shape of the age distribution of second births is similar over time, there are important differences at the level of fertility and at the mean ages of birth. The fertility distribution is shifted to higher ages over time (Table 3), while the peak fertility for both the women with early age fertility as well as for those with fertility at later ages, is quite lower in 2006-2008. As regards to males, their fertility is described by a bell-shaped curve in 2002, which turns to a flat-topped distribution in 2006-2008. Males obtain their second child at higher ages through time, while the age gap between females and males in 2006-2008 is approximately one year (Table 3).

A similar behavior is exhibited by the white populations (Figure 12). As before, the female fertility distributions are quite heterogeneous. There exist two groups of females regarding their fertility behavior. The first includes women with fertility around the age of 20 and the second group women with fertility around age 30. This pattern is consistent over time. In contrast, for males this pattern makes its appearance later in time. Regarding the age of second birth, it tends to be very close for men and for the group of women with older age fertility. Both males and females experience postponed second child fertility through time.

Black populations exhibit a different behavior regarding their second birth distribution (Figure 13). For males this distribution is sharply right skewed, with peak fertility at a lower level than for females. Regarding females, a distorted fertility pattern with two humps appears in 2006-2008. For both males and females the age of having a second child moves to higher ages over time (Table 3).

Considering the Hispanic population (Figure 14), the fertility pattern is much more intense. Both males and females tend to obtain their second child at later ages through time. It is remarkable that the age gap between males and females is declining over time. It varies from 5 years in 2002 to 2 years in 2006-2008.

On the other hand, a different situation is observed for the non-Hispanic population (Figure 15). There exist two groups of women regarding fertility behavior, while non-Hispanic men do not show differences in their fertility behavior. For both males and females there is a shift of fertility at older ages. The peak age fertility of men is close to the age of women with old age fertility (Table 3).

Based on the results for the various population subgroups, similarities are observed in the shape of the age distribution of total births between total, white, black and non-Hispanic female populations. The shape of the age distribution of total births differs between males and females. For males, two different groups exist, the first consisting of the total, white and black populations and the second including the Hispanic and non-Hispanic populations. All the female population subgroups, except for the Hispanic women, are characterized by a two hump fertility distribution, which is an indication of heterogeneity in the fertility behavior. Male populations also show a heterogeneous fertility behavior, especially in recent years, since their fertility distribution has the shape of a flat-topped distribution. This type of fertility curve has been firstly described for the US female population by Chandola et al.(2002). This heterogeneity has been attributed to racial differences and differences in the timing of births

between these groups as well as to the growing proportion of births outside marriage. Peristera and Kostaki (2007) mentioned that that religion, as well as the educational and the social status of parents is also a source of heterogeneity.

In terms of timing of births, mostly in previous years women experience earlier births than males. However in recent years, this trend is reversed for some populations and the age gap in fertility differences has been declined. In addition, for many populations women give birth at later ages than in the past, while men become fathers at earlier ages, while there is a percentage of males with early age fertility. It is documented that the age gap in fertility varies from 2 to 3 years (Landry and Forrest, 1995). However, A new finding is that in male populations with distorted fertility patterns, a convergence of the timing of births is observed. Referring to the total number of births, a declining age gap in fertility differences between sexes is observed for the both, white, and black populations.

It has also been documented that men with fewer opportunities are more likely to experience early fertility than their counterparts from more advantaged backgrounds (Glick et al., 2006; Pears et al., 2005). In fact men from more advantaged backgrounds are more likely to have a birth at older ages, around late 20's or early 30's. Based on our analyses, we find out that these differences tend to assimilate between the various populations' subgroups. White and black males show very similar fertility behaviour. They are distinguished in two different groups regarding fertility one at earlier ages and a second at older ages. The age gap in fertility differences between sexes has also being diminished over the years. Hispanic males in recent years obtain their children at later ages compared to the white and black with early age fertility.

A different picture emerges regarding to the shape of the age distribution of fist births between the total, the white, the black and the non-Hispanic male and female populations. For females, the fertility curves of the total, white and non Hispanic populations are quite similar, characterized by two humps, indicating great heterogeneity in the fertility behavior of these population groups. On the contrary, Black and Hispanic females are characterized by similar uniform fertility distributions. Regarding males, the fertility distributions of the total and white populations have similar shapes, with the appearance of a slight second hump at older ages. On the other hand for the Black, Hispanic and Non-Hispanic groups, the first births distribution has a common shape, with only one peak fertility year and a rather skewed to the right distribution. Differences are therefore observed in the shape of fertility distributions between males and females. White males and females have more common features in their fertility behavior compared to the other population groups. Differences are also observed in the timing of births between the various subgroups. Previous research has shown that African-American and Hispanic women and men experience earlier first births than white women and men. This was also verified from our analysis. Comparing the timing of birth for the various subgroups, fertility of women takes place at younger ages than male fertility.

Regarding second births, the age shape of fertility is characterized by a skewed distribution with one peak for the black, Hispanic and non-Hispanic males. The same occurs for black and Hispanic females. For the other population subgroups a distorted fertility distribution has arisen. Regarding the timing of births, between males and females black and Hispanic males have children at older ages than females. In the case of white and non-Hispanic groups it is observed a convergence of the age males have peak fertility with the age of peak fertility corresponding to women belonging to the group with old age fertility.

Summarizing the results, a general finding is that not only the timing of births differs for women and men, as already documented in the literature, but also the shape of the age distribution of births is different. As prior research has shown women experience earlier first births than men. In fact men start their family and fertility career two to three years later than

women. The gap applies to males' start into fatherhood as well as to their marriage and partnership formation (Coleman, 2000; Hogan and Goldescheider, 2000). As it comes out from our analysis this applies to the cases of non distorted fertility patterns, usually describing the Black and Hispanic fertility. The above is verified for all parity orders. However, in distorted fertility patterns a declining in the age gap in the fertility differences is observed and a tendency of convergence in some cases.

Childbearing and childrearing interfere with educational and labour market experiences that are important for career attainment and financial well-being because of both the time and financial costs involved. High educational aspirations and variables that are proxies for anticipated higher education and wages are negatively associated with early female fertility (Harris, et al., 2002). Men with fewer opportunities are simirarly more likely to experience early fertility than their counterparts from more advantaged backgrounds (Glikc et al 2006, Pears et al 2005). The typical role for men is that of an economic provider not a caregiver. For men after their early 20s or for those who do not intend to attend college, becoming a father may not alter the timing of labor market participation. Therefore individuals who perceive fewer long-term opportunities for higher education or professional careers are more likely to have early births because the opportunity costs of these births are lower, whereas those who expect greater opportunities are likely to delay fertility. As men's family roles are changing, however, defining opportunity costs for men is arguably less straightforward than it is for women and will likely depend on whether the birth occurs within marriage, which is justified by these results.

Conclusions

Many existing fertility studies focus on women. However the role of fathers in family and society is changing through time given that new types of families are dominating in a society with continuous evolving structure. Therefore studies focusing also on male fertility are necessary despite the lack of sufficient and robust data.

In this work male and female fertility patterns for the US population for the period 2002 to 2006-2008, are studied, using data of the NSFG survey. Fertility trends differentiated by order of birth, and by ethnic and racial characteristics of mother and father, are also studied.
In order to estimate the age-specific fertility patterns of the various populations we used the parametric P-K models. Two different versions of the models have been used, depending on the shape of the fertility curve. Model 1 was used in cases of populations that do no show early age fertility. Model 2 was used in cases of a distorted fertility pattern.

A general finding is that in recent years, male fertility is also described by a distorted fertility pattern, either a flat-topped distribution or a distribution with two humps. Until recently, this distorted fertility pattern has been identified only in female fertility rates. The shape of male age specific fertility differs between ethnic/racial groups and by order of birth. The fertility curves of the total population and those of white males exhibit two humps. A slight distorted curve appears also in the case of black males. A different picture emerges when differentiating by order of birth. In the case of first births the most heterogeneous populations described by a distorted fertility pattern are the total and white populations. Differences occur between male and female fertility patterns. For the majority of female subgroups, except for Hispanic females the fertility distribution is a two-hump curve, indicating heterogeneity in the fertility behavior of these groups. This heterogeneity also characterizes the fertility distributions of first and second births. The fertility curve of Hispanic females is not characterized by a distorted pattern.

Differences also exist in the timing of births between males and females. In general, females have children earlier compared to men. A new finding is that in cases of distorted fertility, i.e. in populations that consist of two different groups in terms of fertility behavior, there is a convergence between males and females in the age of peak fertility. Hispanic and black males and females experience earlier births than white persons.

As expected the shape of the age fertility pattern differs between males and females. In addition males are also exhibiting a distorted fertility pattern. In terms of the timing of births women generally experience earlier fertility, especially in previous years and in populations with non distorted fertility patterns. This is reversed in recent years where distorted patterns characterize the fertility distributions of the populations. The age gap in fertility between sexes is declining over time. Racial differences seem to play an important role in the timing of births. However, dissimilarities between the various ethnic groups, regarding the timing of births seem to be diminishing over time. Heterogeneity is apparent in fertility of first or second births to the various ethnic groups but not for Hispanic populations.

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Appendix

Figure 1: Observed and estimated age-specific fertility rates (total births) for the total population

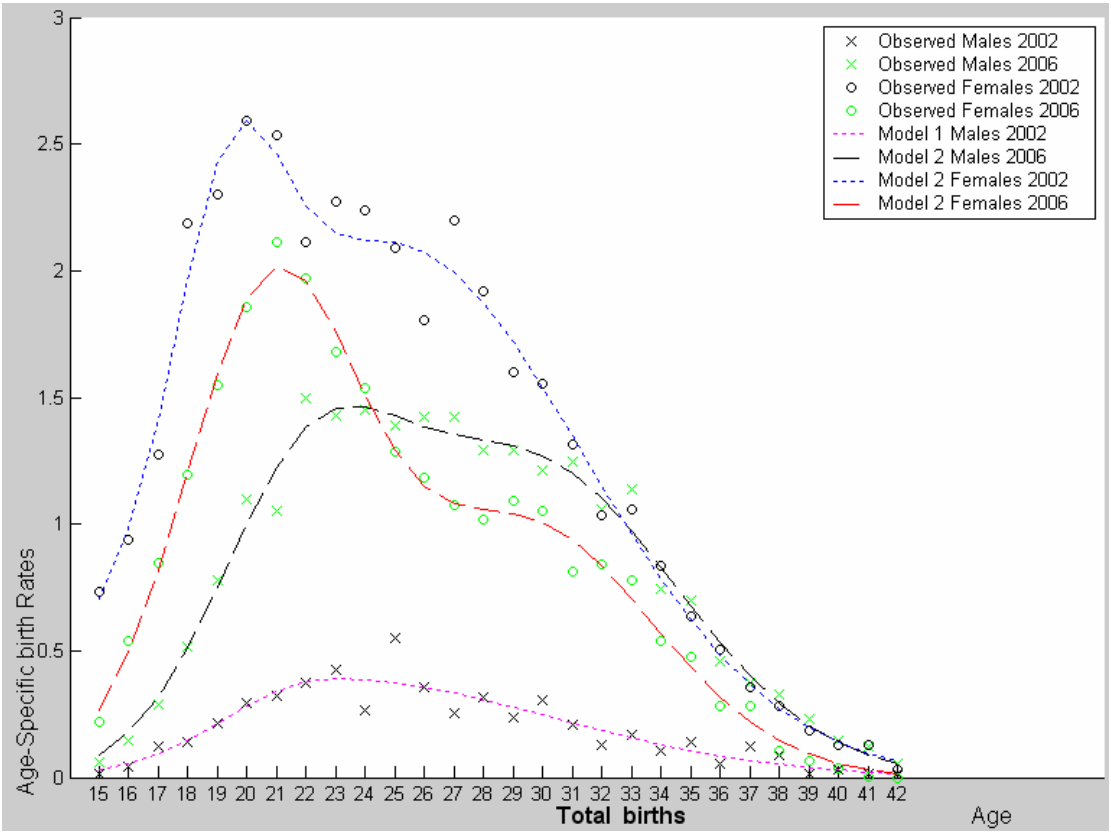

Figure 2: Observed and estimated age-specific fertility rates (total births) for the white population

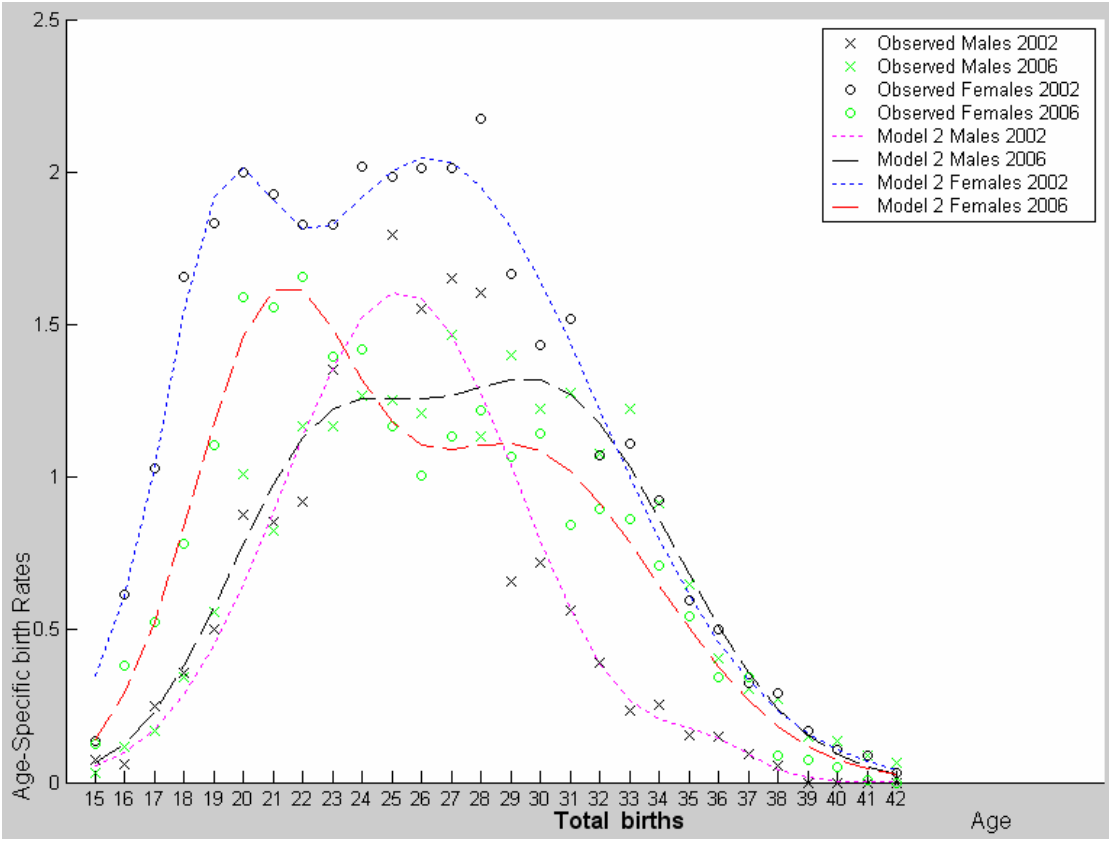

Figure 3: Observed and estimated age-specific fertility rates (total births) for the black population

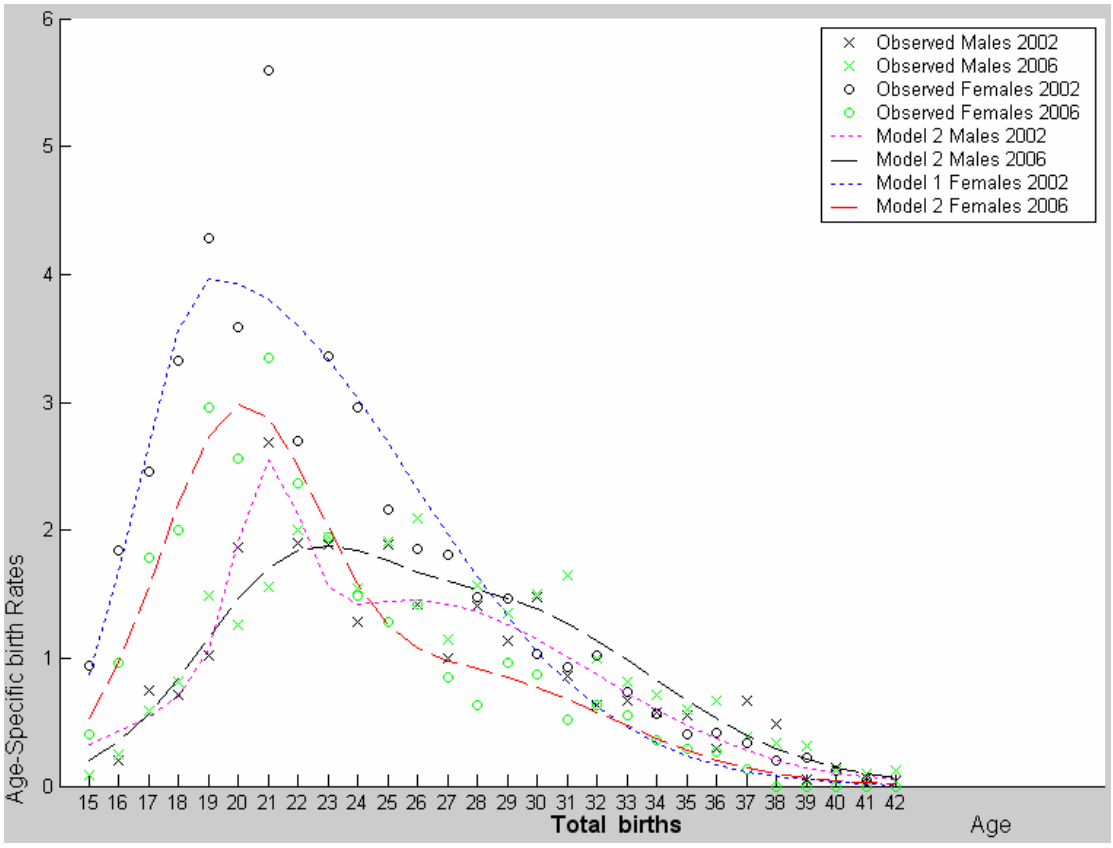

Figure 4: Observed and estimated age-specific fertility rates (total births) for the Hispanic population

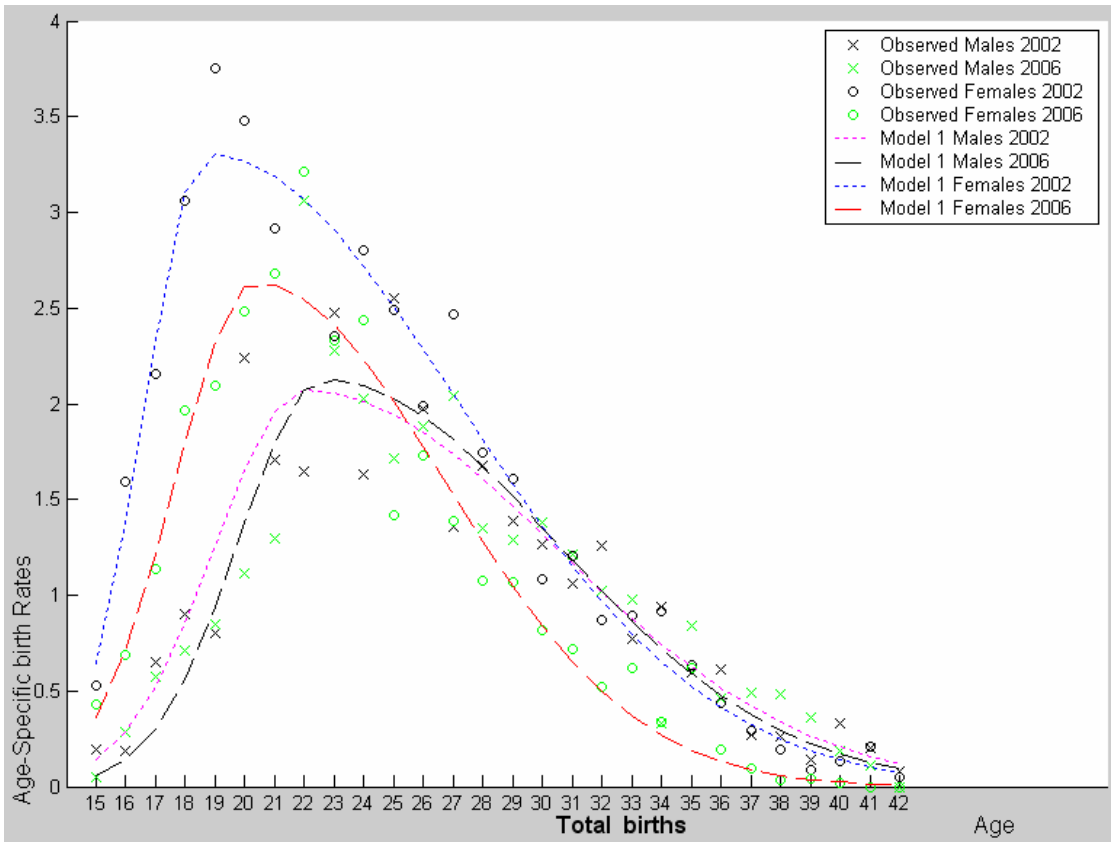

Figure 5: Observed and estimated age-specific fertility rates (total births) for the non-Hispanic population

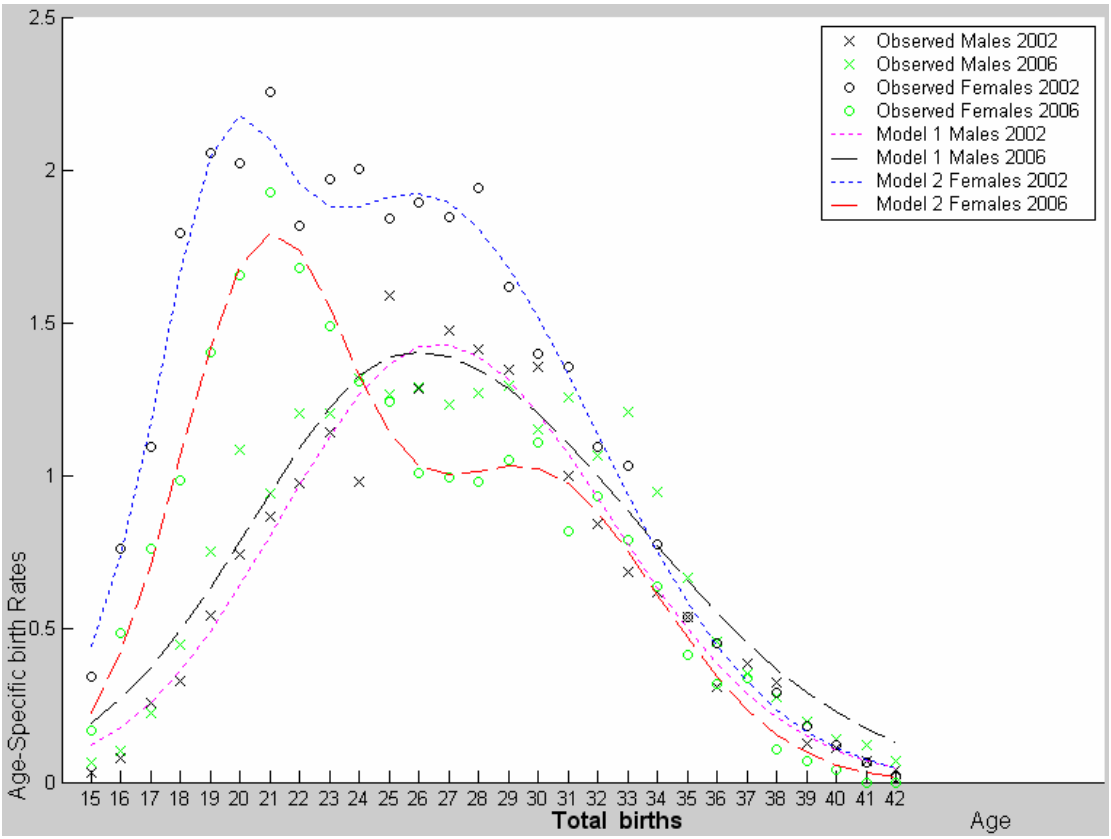

Figure 6: Observed and estimated age-specific fertility rates (first births) for the total population

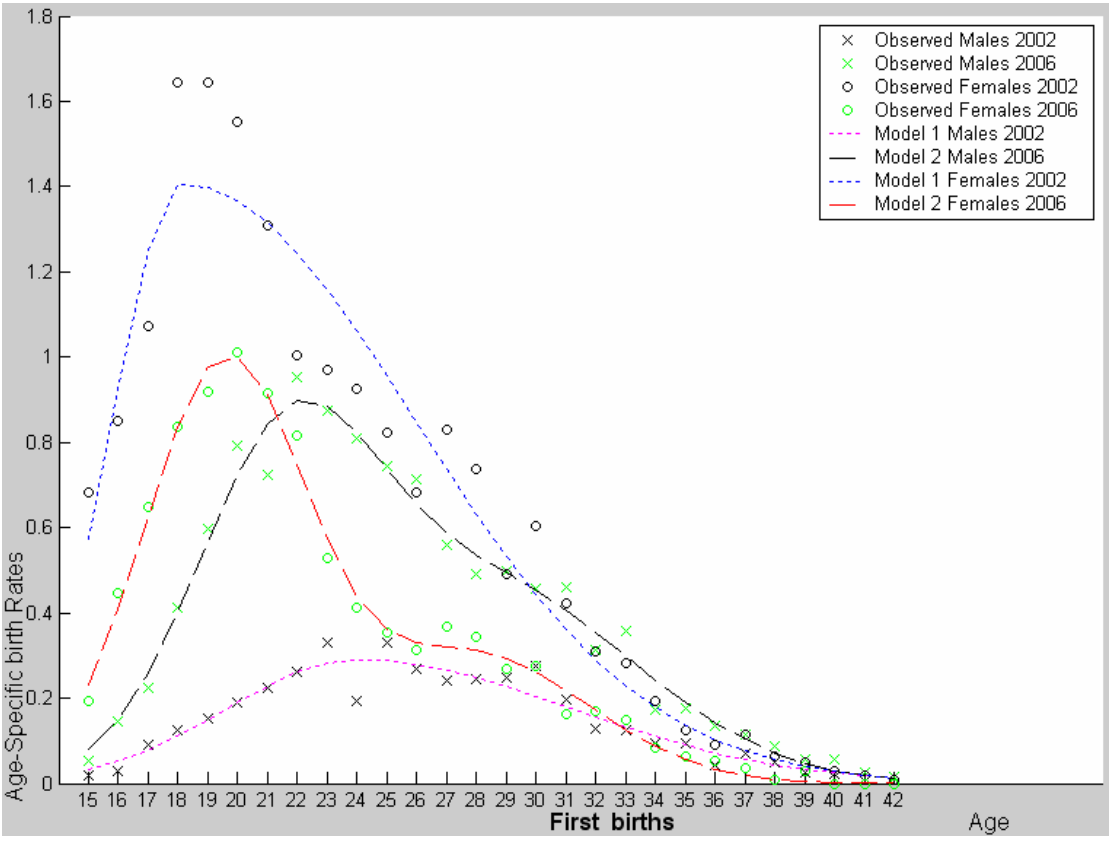

Figure 7: Observed and estimated age-specific fertility rates (first births) for the white population

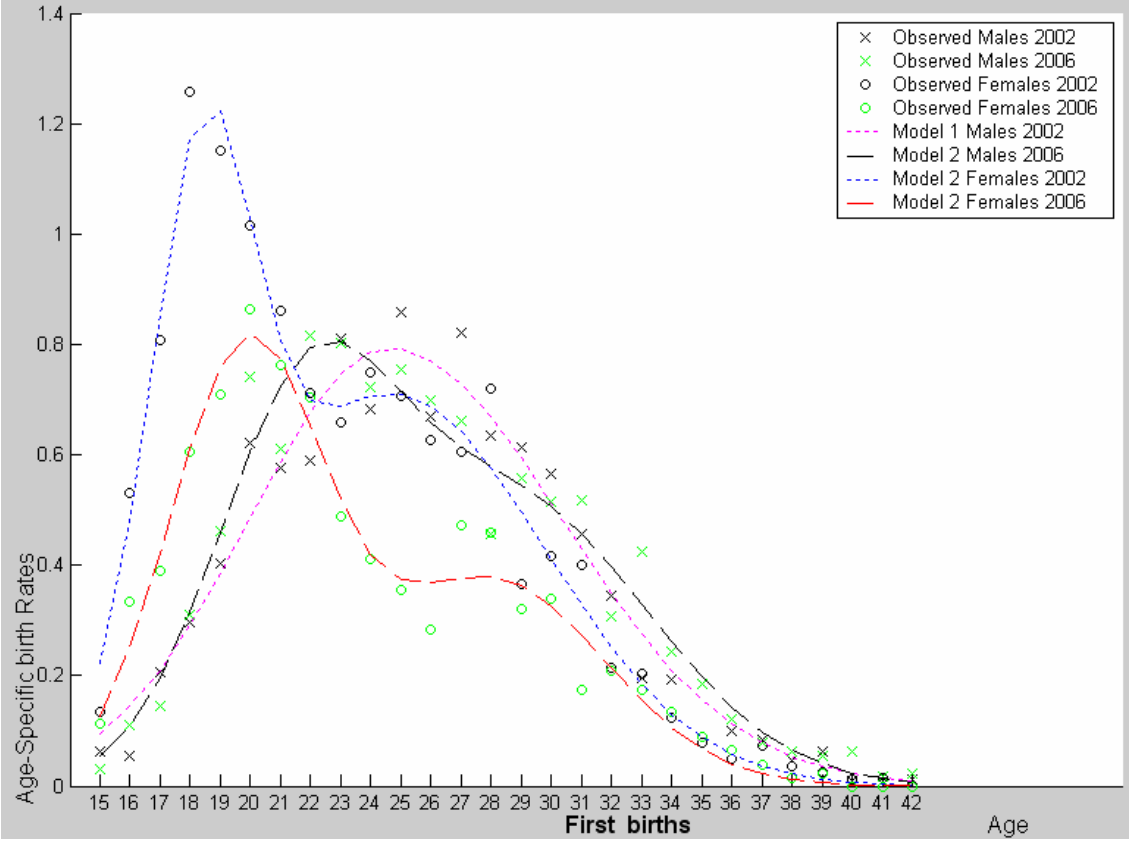

Figure 8: Observed and estimated age-specific fertility rates (first births) for the black population

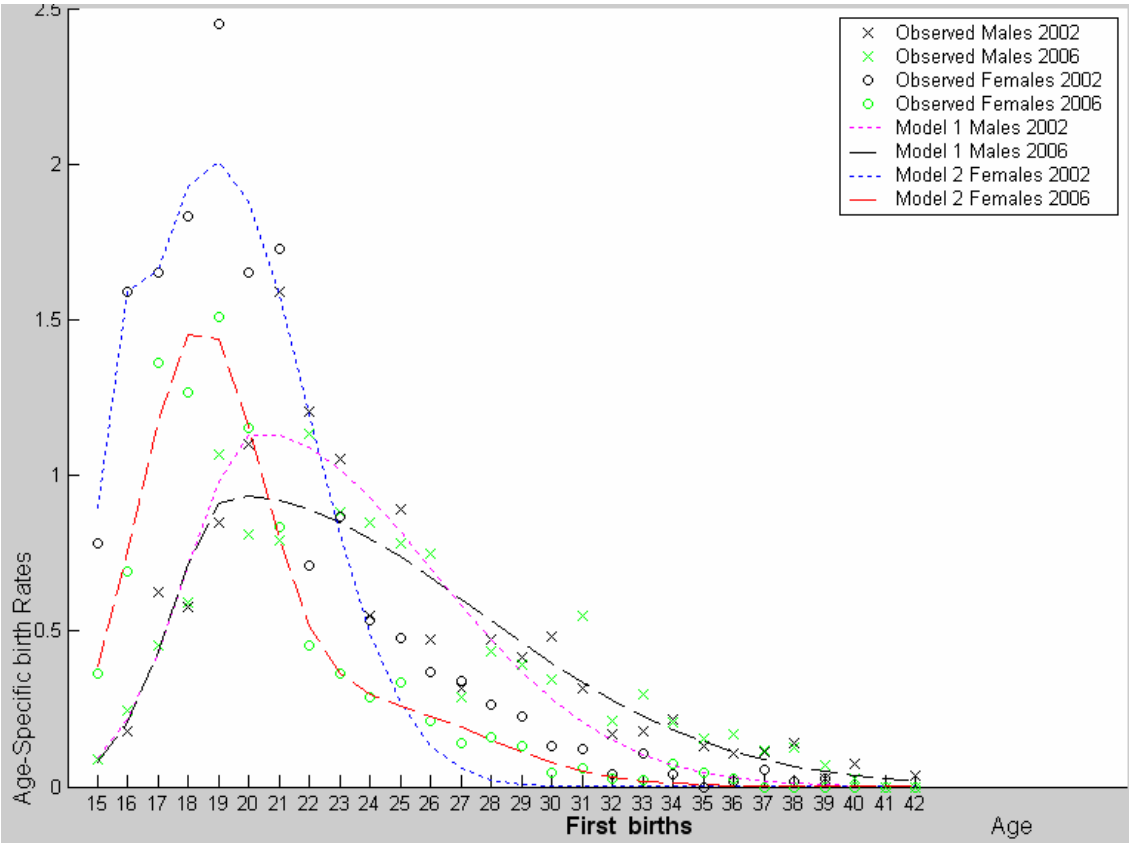

Figure 9: Observed and estimated age-specific fertility rates (first births) for the Hispanic population

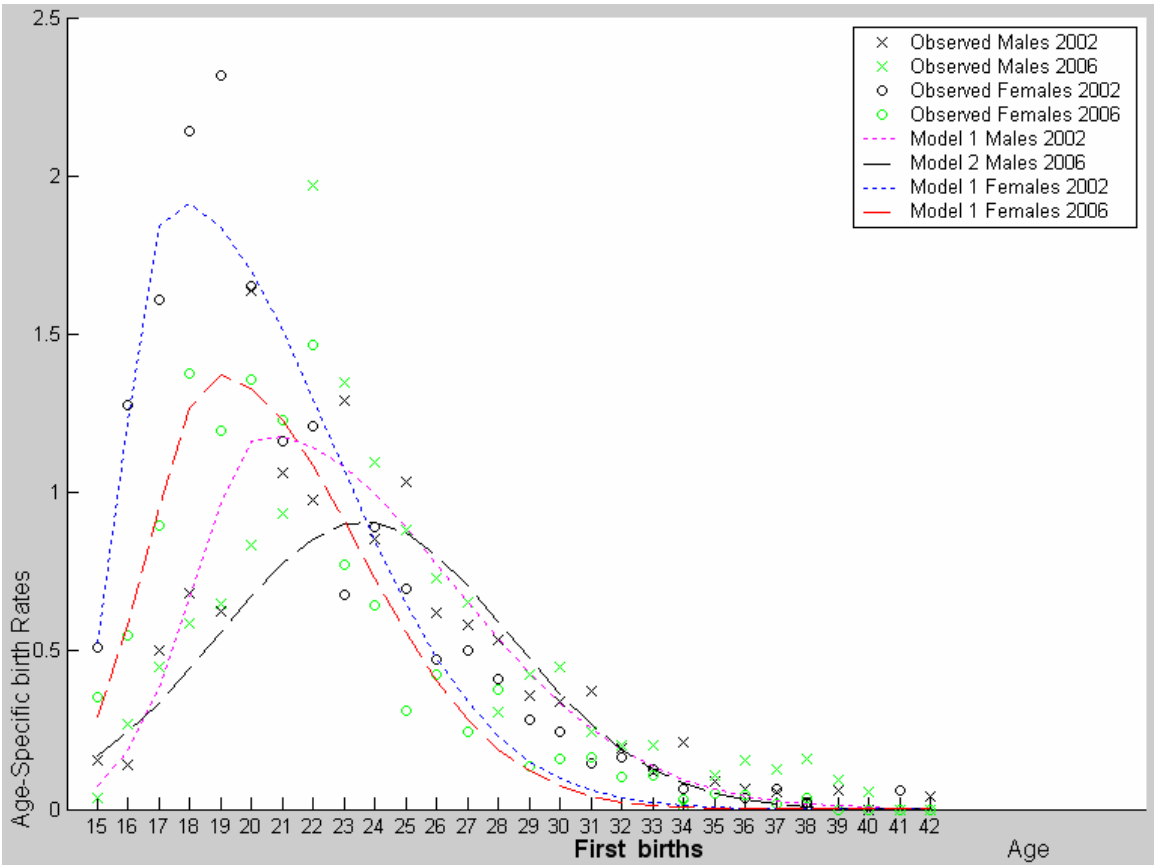

Figure 10: Observed and estimated age-specific fertility rates (first births) for the non-Hispanic population

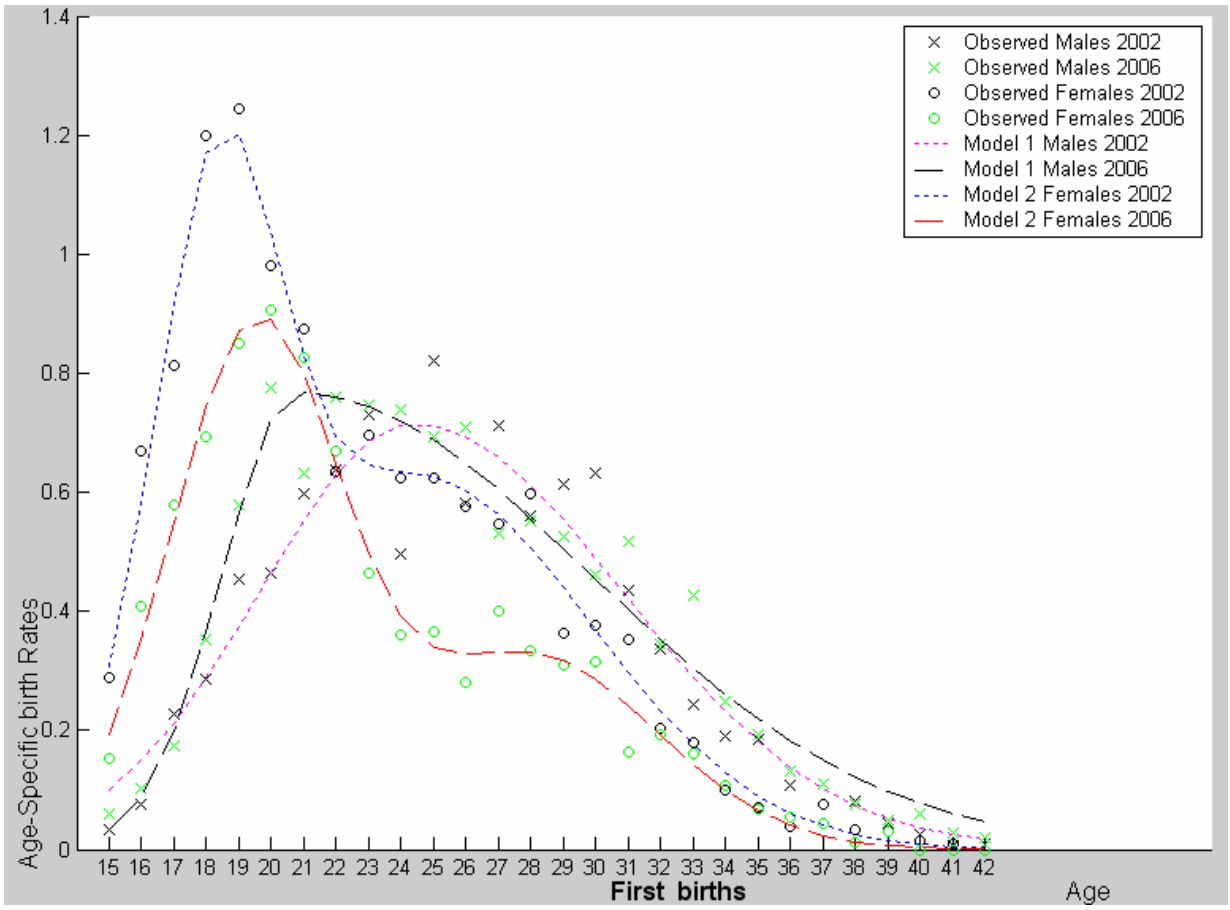

Figure 11: Observed and estimated age-specific fertility rates (second births) for the total population

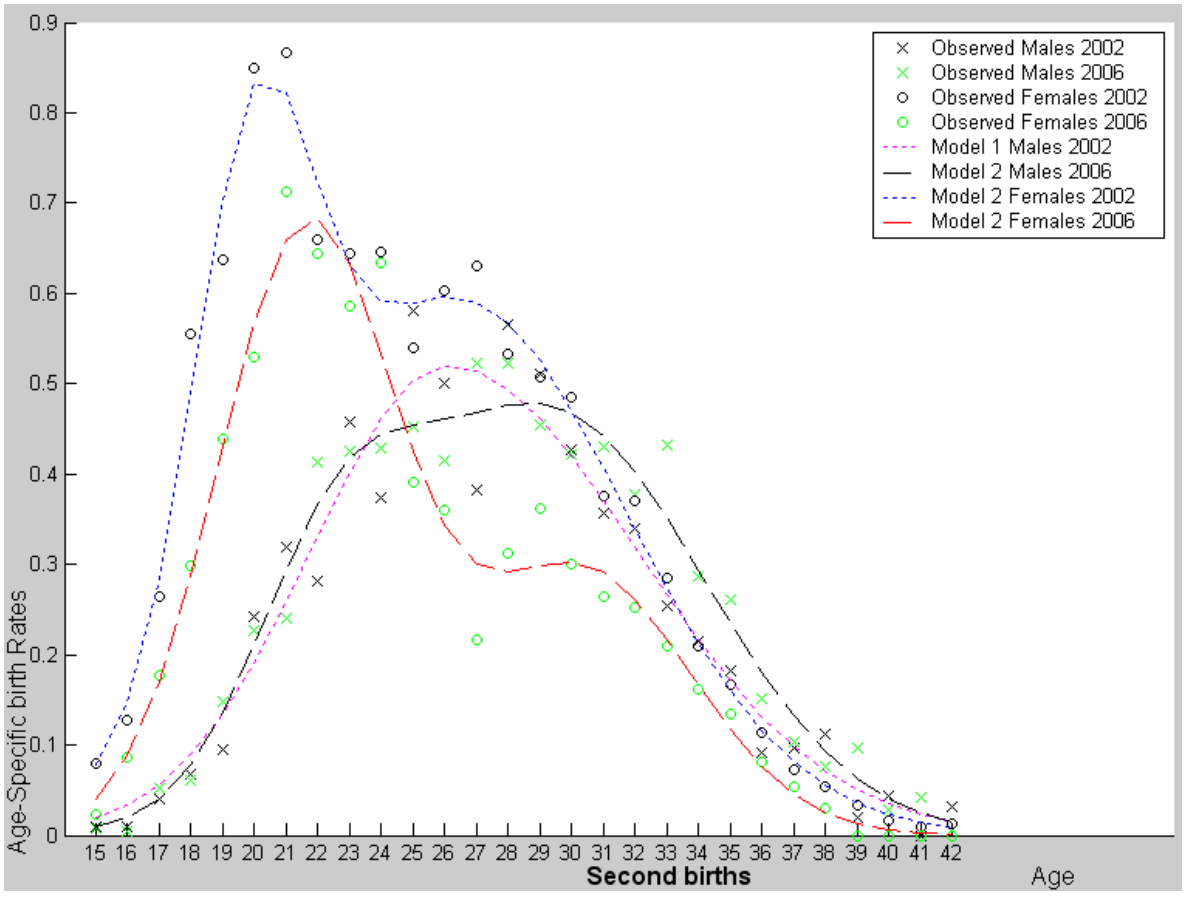

Figure 12: Observed and estimated age-specific fertility rates (second births) for the white population

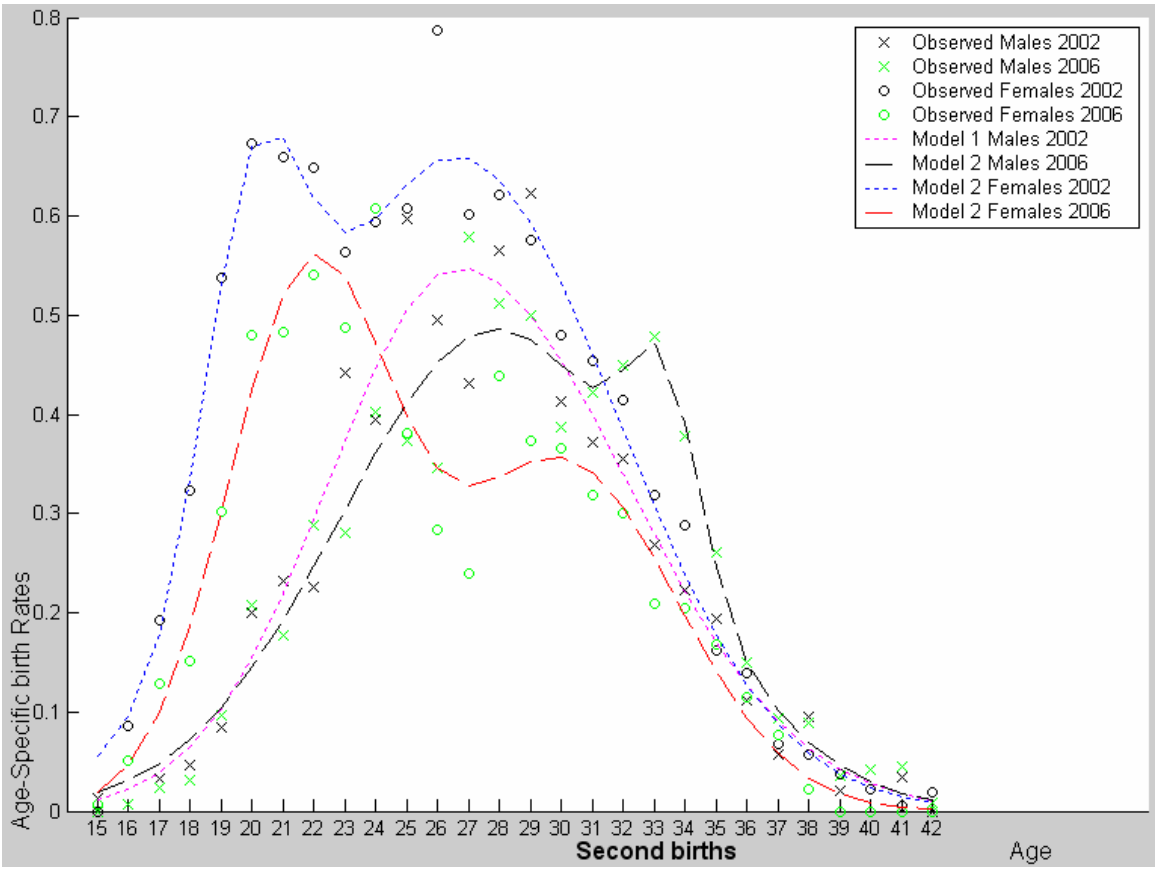

Figure 13: Observed and estimated age-specific fertility rates (second births) for the black population

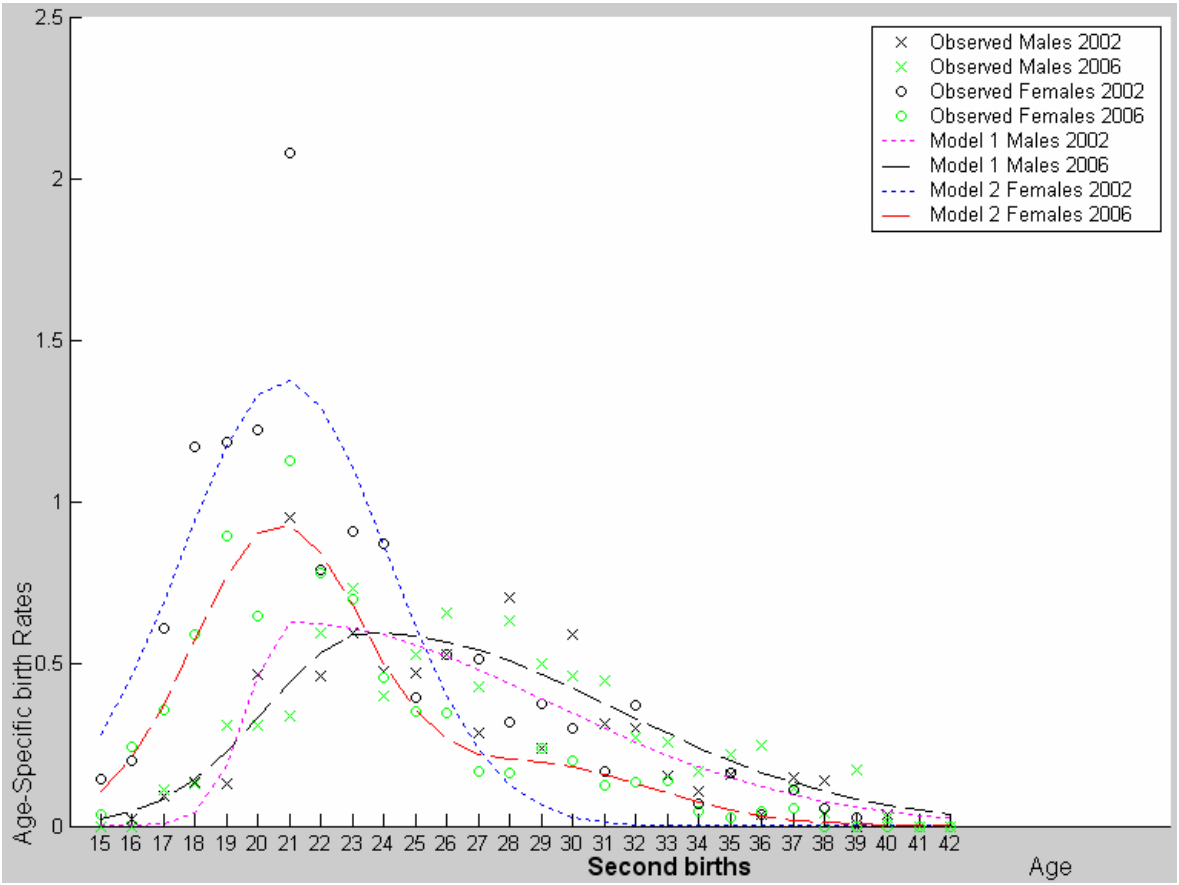

Figure 14: Observed and estimated age-specific fertility rates (second births) for theHispanic population

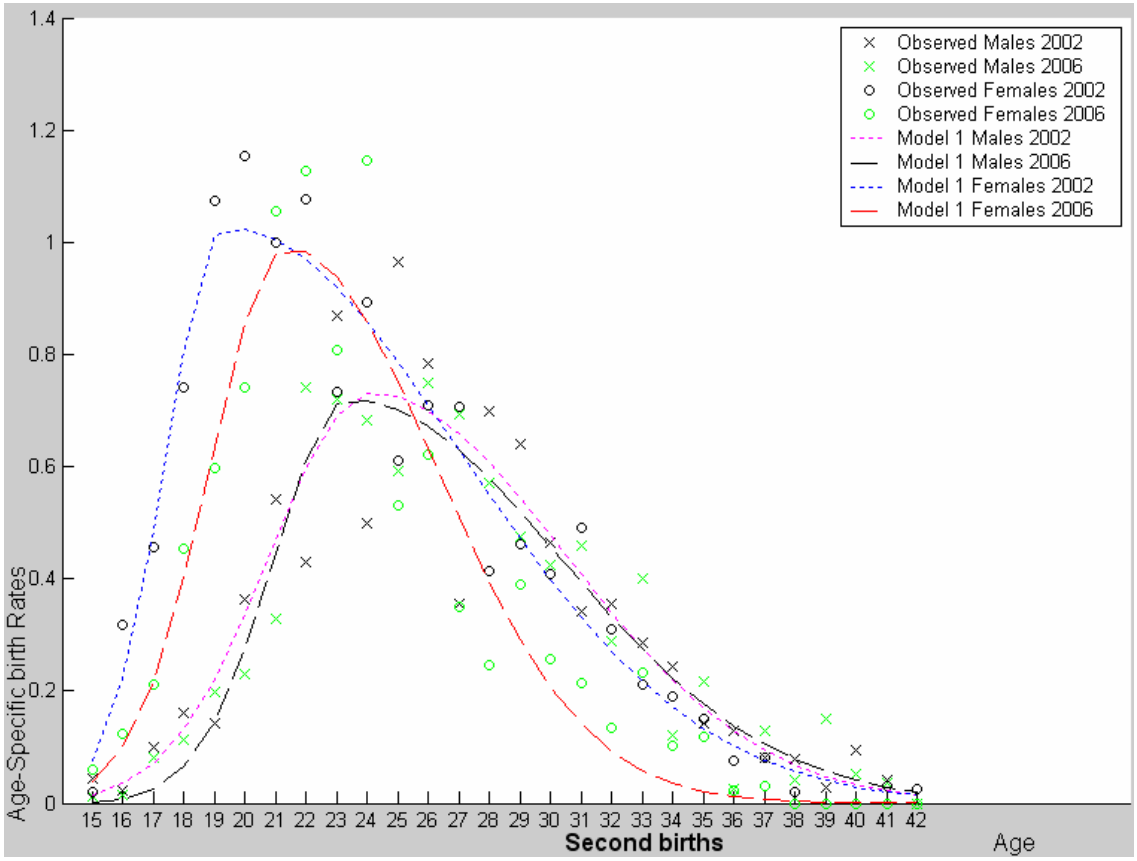

Figure 15: Observed and estimated age-specific fertility rates (second births) for the non-Hispanic population

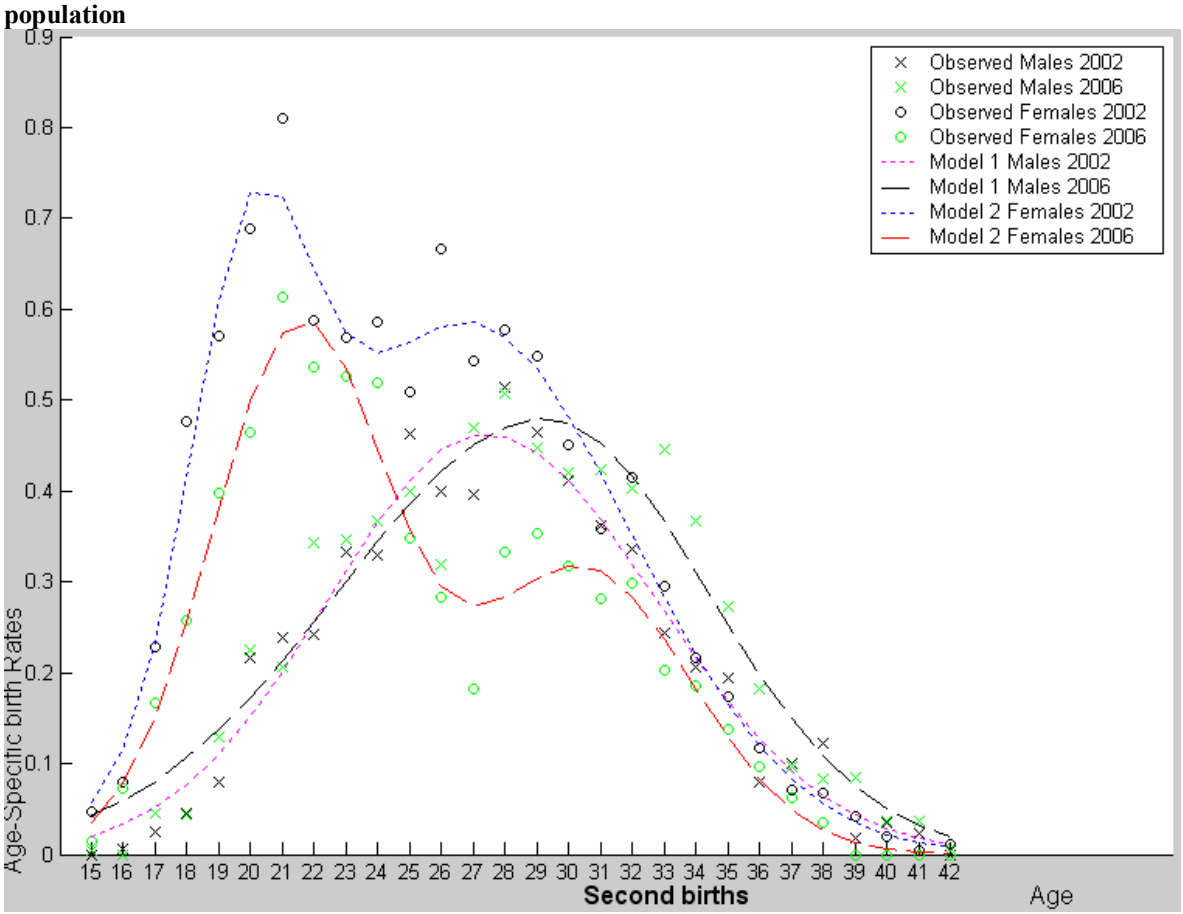

Table 1: Estimated parameters for total births by race and ethnicity

	Total Population				White			
	2002		2006		2002		2006	
Total births	Females	Males	Females	Males	Females	Males	Females	Males
	1,06	0,18	1,84	0,96	2,05	1,61	1,39	0,94
	19,42	29,51	20,79	21,95	19,11	25,31	20,94	22,37
	2,45	7,87	4,135	4,29	2,49	5,57	3,87	4,45
	2,10	0,31	1,01	1,25	1,02	0,11	1,09	1,27
	24,86	22,86	29,25	29,43	26,23	35,55	29,24	30,26
	9,19	5,20	6,29	7,12	7,99	2,27	6,54	6,01

	Black				Hispanic			
	2002		2006		2002		2006	
	Females	Males	Females	Males	Females	Males	Females	Males
	3,96	1,46	2,64	1,43	3,30	2,07	2,63	
	19,08	20,97	19,95	28,31	18,71	22,02	20,34	
	3,32	1,49	3,76	7,69	2,89	4,28	3,79	
	9,47	1,45	0,89	1,13	11,98	11,85	9,028	
		25,72	27,15	21,43				
		8,75	7,25	4,33				

	Non Hispanic			
	2002		2006	
	Females	Males	Females	Males
	1,10	1,43	1,67	1,41
	19,27	26,57	20,81	25,86
	2,81	7,33	4,09	7,69
	1,92	8,25	1,02	10,49
	25,97		29,69	
	8,30		6,05	

Table 2: Estimated parameters for first births by race and ethnicity

	Total Population				White			
	2002		2006		2002		2006	
First births	Females	Males	Females	Males	Females	Males	Females	Males
	1,41	0,09	0,30	0,68	0,91	0,78	0,78	0,62
	18,14	21,15	19,56	21,55	18,39	19,95	19,85	21,76
	3,32	3,77	3,81	4,25	2,36	0,89	3,59	4,23
	11,03	0,26	0,97	0,47	0,71	0,18	0,37	0,513
		26,98	27,81	28,19	24,75	25,49	28	28,71
		7,56	5,53	7,16	7,10	7,17	5,33	6,45

	Black				Hispanic			
	2002		2006		2002		2006	
	Females	Males	Females	Males	Females	Males	Females	Males
	2,01	1,14	1,37	0,93	1,92	0,88	1,37	0,91
	15,97	20,29	18,33	19,46	17,45	20,83	18,86	23,64
	4,32	3,33	2,88	2,82	2,15	3,79	3,09	6,66
	0,01	8,21	0,27	11,38	7,24	0,56	6,48	0,53

18,88	23,72	25,56	26,36
5,92	5,66	6,81	0,04

Non Hispanic			
2002		2006	
Females	Males	Females	Males
0,88	0,72	0,33	0,77
18,34	24,43	19,49	20,79
2,64	6,73	3,67	3,26
0,63	9,01	0,86	12,68
24,48		27,92	
7,54		5,59	

Table 3: Estimated parameters for second births by race and ethnicity

Second births	Total Population				White			
	2002		2006		2002		2006	
	Females	Males	Females	Males	Females	Males	Females	Males
co	0,54	0,14	0,67	0,22	0,66	0,47	0,35	0,48
c1	19,95	22,69	21,67	22,50	20,02	28,30	21,85	27,93
	2,65	3,68	3,98	3,62	2,25	6,59	3,74	7,20
	0,59	0,47	0,29	0,47	0,378	0,14	0,53	0,18
	26,35	28,01	30,28	29,28	26,61	24,04	30,05	33,32
	7,55	6,79	4,90	6,85	7,31	4,32	5,18	1,59

Black				Hispanic			
2002		2006		2002		2006	
Females	Males	Females	Males	Females	Males	Females	Males
1,38	0,63	0,85	0,59	1,03	0,31	0,99	0,74
17,47	21,01	18,58	23,56	19,33	23,46	21,37	26,08
0,65	1,82	0,39	4,65	2,684	3,52	3,54	6,74
0,04	11,64	0,68	10,97	10,96	0,534	6,90	0,10
20,85		21,23			27,21		27,73
4,64		4,59			7,3179		0,382

Non Hispanic			
2002		2006	
Females	Males	Females	Males
0,48	0,46	0,58	0,48
19,96	27,39	21,56	29,31
2,63	7,02	3,93	9,21
0,58	7,56	0,31	7,12
26,78		30,44	
7,31		4,82	