

# State and Regional Differences in the Male-to-Female Ratio at Birth in the United States of America, 1995–2012

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## ABSTRACT

**Introduction:** In humans, live male births slightly exceed females and this ratio is conventionally expressed as male live births divided by total live births (M/F). A wide variety of factors have been shown to influence M/F including latitude, stress, socio-economic status and race. This study was carried out in order to ascertain whether there are differences in M/F in different states and in different geographical regions in the United States of America (USA).

**Methods:** Annual live births by gender for the period 1995–2012 were obtained from the website of the US Centers for Disease Control and Prevention. These were grouped according to the four regions devised by the United States Census Bureau, Geography Division.

**Results:** This study encompassed 52 601 559 live births for the period 1995–2012 (M/F: 0.5117; 95% CL: 0.5116, 0.5118). Southern states tended to have a lower male-to-female ratio. Hawaii had a high M/F ( $p < 0.0001$ ). The male-to-female ratio for the South region was significantly less ( $p = 0.004$ ). This region had the highest proportion of Black mothers.

**Conclusion:** The high Hawaiian M/F is in keeping with Micronesian island findings. The M/F latitude gradient accords with that previously noted in the USA. Historically, Blacks have been shown to have a lower M/F than other races. Long-term stress related to maternal socio-economic status has also been shown to influence M/F, and Blacks are known to be disadvantaged to this day. It is possible that the low M/F historically noted in this race may be due to chronically poor socio-economic circumstances.

**Keywords:** Birth rate, birth trends, infant, newborn, sex ratio, United States of America

# Diferencias Estatales y Regionales en la Razón Hombre a Mujer en los Nacimientos en los Estados Unidos, 1995-2012

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## RESUMEN

**Introducción.** En los seres humanos, los nacimientos de varones nacidos vivos superan ligeramente a los de las hembras, y esta razón se expresa convencionalmente en términos de varones nacidos vivos divididos por el total de nacimientos (H/M). Se ha demostrado que una amplia variedad de factores influyen en la razón H/M, entre los que se cuentan la latitud, el estrés, la situación socio-económica, y la raza. Este estudio se llevó a cabo con el fin de determinar si existen diferencias en la razón H/M en diversos Estados y en distintas regiones geográficas en los Estados Unidos de América (EE.UU.).

**Métodos:** Los datos de los nacidos vivos por género cada año en el período 1995–2012 fueron obtenidos del sitio web de los Centros para el Control y la Prevención de Enfermedades, EE.UU., y agrupados de conformidad con las cuatro regiones determinadas por la División de Geografía del Buró de Censo de Estados Unidos.

**Resultados:** Este estudio abarcó 52 601 559 nacidos vivos para el período 1995–2012 (H/M: 0.5117; 95% CL: 0.5116, 0.5118). Los Estados sureños mostraron una tendencia a tener una razón hombre-mujer menor. Hawái tuvo un alta razón H/M ( $p < 0.0001$ ). La razón hombre-mujer en la región del sur fue significativamente menor ( $p = 0.004$ ). Esta región tenía la mayor proporción de madres negras.

**Conclusión:** La alta relación H/M hawaiana está en consonancia con los resultados de las islas de Micronesia. El gradiente latitudinal H/M concuerda con el observado previamente en Estados Unidos. His-

tóricamente, los negros han demostrado tener un H/M menor que otras razas. Se ha observado que también el estrés a largo plazo relacionado con el estatus socio-económico materno influye en H/M, y se sabe que los negros han estado en desventaja hasta hoy. Es posible que la baja razón H/M observada históricamente en esta raza se deba a circunstancias socioeconómicas caracterizadas por una pobreza crónica.

**Palabras claves:** Tasa de natalidad/tendencias, infante, recién nacido, razón de sexo, Estados Unidos de América

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## INTRODUCTION

In humans, the gender ratio of live births is slightly skewed toward male births [approximately 3% in excess] (1). This ratio is conventionally expressed as male live births divided by total live births (M/F).

A wide variety of factors have been shown to affect M/F (1, 2), and these include stress (3), socio-economic status (4) and race (5, 6). Indeed, even the passage of legislation in a distant country with implications for migration has been shown to transiently influence M/F (7).

Latitude has also been shown to play a role. For example, it has been shown that M/F increases with increasing latitude in the United States of America (USA) and increases with decreasing latitude in Europe (8). The United States has not been studied in this fashion by state and by geographical region.

This study was carried out in order to ascertain whether there are differences in M/F in different states and in different geographical regions in the USA.

## SUBJECTS AND METHODS

Annual live births by gender for the period 1995–2012 were obtained from the website of the US Centres for Disease Control and Prevention [CDC] (9). These were grouped according to the four regions devised by the United States Census Bureau, Geography Division [Fig. 1] (10).

*Region 1 – Northeast:* Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York and Pennsylvania.

*Region 2 – Midwest:* Illinois, Indiana, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota and South Dakota.

*Region 3 – South:* Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, Washington DC, West Virginia, Alabama, Kentucky, Mississippi, Tennessee, Arkansas, Louisiana, Oklahoma and Texas.

*Region 4 – West:* Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming, Alaska, California, Hawaii, Oregon and Washington.

The following data were relevant and also available (from the same website), and were downloaded for 2005, the midpoint year for the period studied: maternal race, maternal age, marital status and maternal education.

Excel was used for data entry, overall analysis and charting. The quadratic equations of Fleiss were used for exact calculation of 95% confidence intervals for ratios (11). Chi tests and Chi tests for trends for annual male and female births were used throughout using the Bio-Med-Stat Excel add-in for contingency tables (12). A  $p$ -value  $\leq 0.05$  was taken to represent a statistically significant result.

## RESULTS

This study encompassed 52 601 559 live births for the period 1995–2012, comprising 26 917 846 males and 25 683 713 females; M/F was 0.5117 (95% CL: 0.5116, 0.5118).

Ranked M/F by state is shown in Fig. 2. Southern states tended to have lower M/F. Hawaii had a high M/F, when compared with the amalgamation of the other states (Chi = 18.0,  $p < 0.0001$ ; Fig. 3).

Analysis using the four regions devised by the Geography Division of the United States Census Bureau showed that M/F in the South region was significantly less than the amalgamation of the other three regions (Chi = 8.4,  $p = 0.004$ ; Fig. 4). Regional ranked M/F, from lowest to highest was: South, Midwest, West and Northeast.

Maternal race by region is shown in Table 1. The South region had the highest proportion of Black mothers. Marital status by region is shown in Table 2 and displays an almost inverse relationship with M/F. Maternal age by region is shown

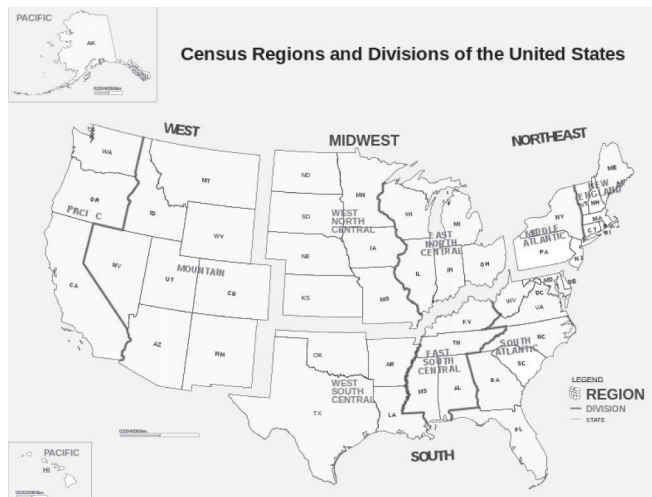


Fig. 1: Census regions and divisions of the United States of America (10).

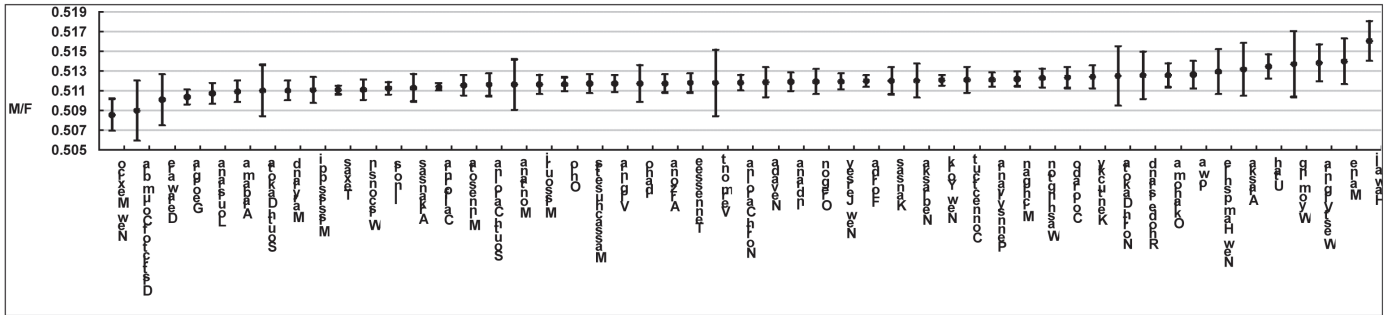


Fig. 2: Male-to-female ratio at live birth (M/F) by state, 1995–2012.

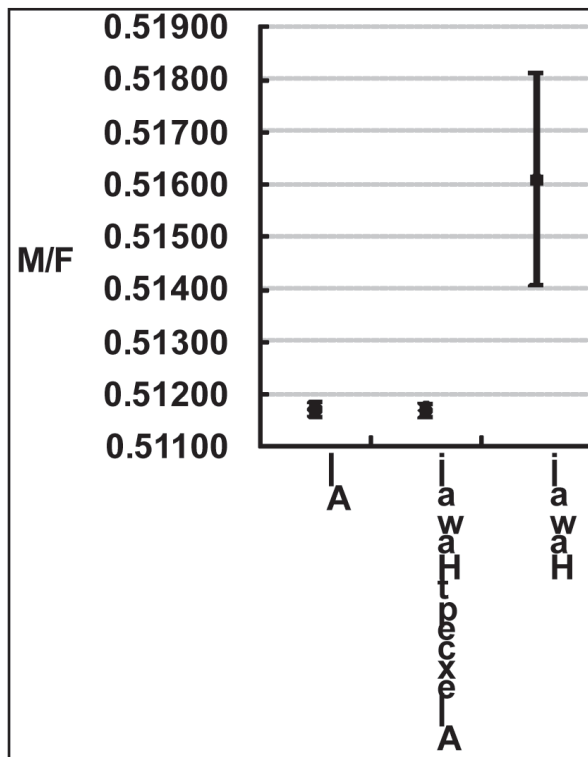


Fig. 3: The male-to-female ratio at live birth (M/F) for the United States of America, for the amalgamation of all states (except for Hawaii), and for Hawaii alone, 1995–2012.

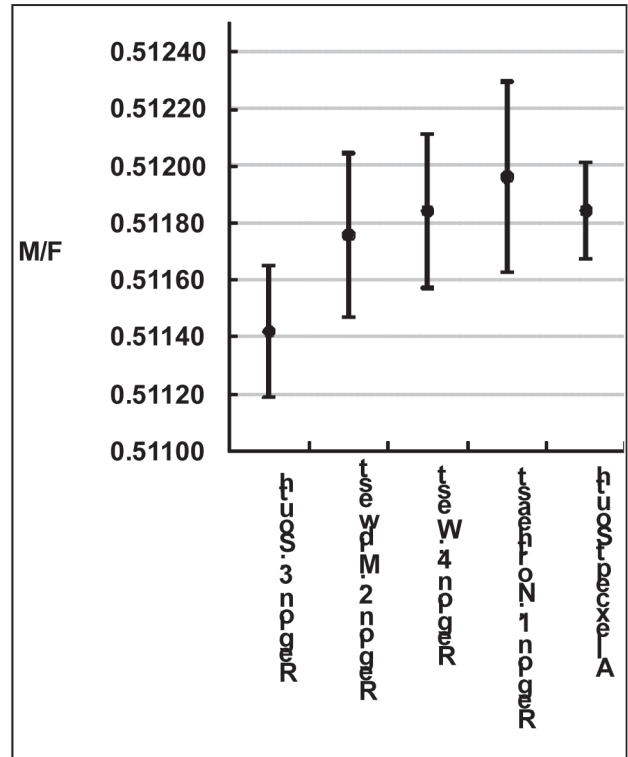


Fig. 4: Male-to-female-ratio at live birth (M/F) by region (as per Geography Division, US Census Bureau), 1995–2012.

Table 1: Maternal race by region (percentage) for 2005

|    | White | Black | American Indian | Asian/Pacific Islander |
|----|-------|-------|-----------------|------------------------|
| SO | 73.4  | 22.6  | 0.7             | 3.2                    |
| MW | 82.2  | 13.4  | 1.0             | 3.5                    |
| WE | 83.0  | 4.8   | 2.2             | 10.0                   |
| NE | 75.8  | 16.9  | 0.3             | 7.0                    |

SO: South; MW: Midwest; WE: West; NE: Northeast

Table 2: Marital status by region (percentage) for 2005

|    | Married | Unmarried |
|----|---------|-----------|
| SO | 60.5    | 39.5      |
| MW | 63.8    | 36.2      |
| WE | 65.3    | 34.7      |
| NE | 64.8    | 35.2      |

SO: South; MW: Midwest; WE: West; NE: Northeast

Table 3: Maternal age by region (percentage) for 2005

|    | < 20 years | 20–29 years | > 29 years |
|----|------------|-------------|------------|
| SO | 12.2       | 54.9        | 32.9       |
| MW | 9.7        | 54.3        | 36.0       |
| WE | 9.6        | 52.0        | 38.4       |
| NE | 7.2        | 45.1        | 47.7       |

SO: South; MW: Midwest; WE: West; NE: Northeast

in Table 3 and shows that M/F is higher with fewer young mothers but also higher with older mothers. Education could not be analysed as 18% of the data were missing.

## DISCUSSION

The high Hawaiian M/F is in keeping with earlier studies that have shown an equally high M/F in the Micronesian Islands (13, 14). This was attributed to habitually increased coital rates, even for couples with higher parental ages and high birth orders (15, 16). This is because M/F follows a U-shaped regression on cycle day of insemination. Hence, male conceptions occur more frequently at the beginning and end of the menstrual cycle while female conceptions result most often from conceptions that occur around ovulation (17, 18). Thus, couples with increased coital rates skew M/F in favour of a male excess and this was proposed as an explanation for the increased M/F in Micronesia.

The converse was found in a more recent study dealing with the islands of the Bahamas, Barbados, Puerto Rico, Trinidad and Tobago, and Mauritius where M/F was significantly lower than the expected value of around 0.515 (19).

Analysis of European births has shown a higher ratio of male births in the south of Europe than in the north (20). The same technique was then applied to the North American continent which was divided by latitude into Canada (> 50° N), USA (30–50° N) and Mexico [< 30° N] (20). The converse latitude gradient was found in the North American continent (21).

The latitude gradient noted in the USA in this study is in accordance with that previously shown for the North American continent, with a lower M/F to the south. However, this study has also shown that the South region had the highest proportion of Black mothers. Historically, Blacks have been shown to have a lower M/F than other races (5, 6, 22–26). This difference persists even when races co-exist such as in South Africa and the West Indies (6) and in England and Wales (27).

Innate physiological differences have been mooted as a cause for this difference (5, 6, 22, 23). It has further been theorized that this difference may be causally related to peri-conceptual parental hormone levels (27, 28).

However, it is possible that the lower M/F noted in Blacks may be stress-related. It is known that stress may reduce M/F. This may be the result of an acute event in the setting, for example, of contracting economies as evidenced in

East Germany in 1991, the year after German reunification in 1990 (29). Or acutely after stressful events, such as after the September 11, 2001, attacks on New York (30), which also affected the entire country (31).

Long-term stress related to maternal socio-economic status has also been shown to influence M/F, such that well-nourished mothers are likelier to produce sons than daughters (4, 32). In addition, an analysis of M/F and caloric availability per capita in over two hundred countries showed that these variables were positively correlated. The same study demonstrated that increases or decreases in caloric availability were associated with corresponding changes in countries' M/F. The authors speculated that this effect is probably related to higher intrauterine male mortality rates due to nutritional deficiencies and associated stressors (33). It has also been shown in Venezuela that a higher maternal educational status increased M/F, while extreme poverty decreased it (34).

Furthermore, several studies have shown a decreasing M/F in association with surrogates of socio-economic status, such as "descent in the social scale" (35). Indeed, it was shown as far back as 1931 that families with higher levels of education, economic means and higher social class had higher M/F (36).

Moreover, it has been shown that M/F is increased in royal families (37). Conversely, M/F is lower in men who perform personal services, such as domestic servants, inn-keepers, barmen, waiters, hall porters, barbers and cleaners (38).

All of these influences accord with the Trivers-Willard hypothesis which proposes that nutritionally stressed mothers are likelier to produce daughters since they are less costly from the nutritional point of view and are therefore less likely to be frail and likelier to survive and reproduce in a harsh environment (39).

It has repeatedly been shown that Black Americans have not completely recovered from the positional degradation of slavery that was imposed on their ancestors. Indeed, evidence abounds proving that race is the most significant variable associated with unequal wealth distribution in the USA, with deeply entrenched racial inequality in national, social and economic structures (40). These imbalances also extend to health-care (41) and it is known that poor antenatal care increases prenatal losses, with excessive male losses that tend to lower M/F (42).

The South region had the highest proportion of Black mothers and unmarried mothers, and both factors are associated with a lower M/F (1, 2). This region also had the youngest mothers and this is associated with a higher M/F (1, 2). It appears that race may have played a deciding role in lowering M/F in the South region and this may be due to socio-economic inequalities that continue to afflict such individuals to this day.

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