

Regional differences in the sex ratio at birth in Mexico

 Victor Grech

Department of Pediatrics, Mater Dei Hospital, Malta

Abstract

Objective: The sex ratio at birth, defined as males/total (M/T) approximates 0.515 but is affected by many factors. Acute and chronic stress have been shown to lower M/T, and both regional and racial differences exist. This study analysed regional differences in M/T in Mexico.

Material and Methods: Live births by sex and year were available for 1994-2020. Regional births were available for 2010-2020 for five regions: North, Centre, West, East and South.

Results: There were 68,423,415 births for 1994-2020 and 25,436,687 for 2010-2020 ($M/T=0.5060$, 95% confidence interval: 0.5058-0.5062). M/T was <0.515 ($p<0.0001$). Live births correlated negatively with year ($p<0.0001$). M/T fell for 1994-2003 then rose to 2020 ($p<0.0001$). M/T was highest in North followed by West, South, Centre and East ($p<0.0001$).

Conclusion: Chronic stress with socioeconomic deprivation may reduce M/T and may explain the low M/T found in this study from Mexico.

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Introduction

The sex ratio at birth, calculated as male number divided by males/total (M/T) is approximately 0.515 (1) but is influenced by various factors (2). Acutely stressful events have been shown to reduce M/T (3) and this accords with the Triver-Willard hypothesis which posits that evolution has favoured parents with the capacity to influence M/T according to periconceptual and gestational conditions (4). This is because in polygynous species (where males have multiple mating opportunities), a robust son conceived under favourable conditions has more reproductive opportunities than a daughter who is naturally constrained by pregnancy and lactation. On the other hand, a male foetus will be less likely to be survive pregnancy to term, and if he does so, a frail male may not survive to reproductive age. Even if he survives, he would contend inadequately with stronger males for mating privileges. However, a frail female is likelier to survive and reproduce. Hence, under unfavourable

conditions, the parental passage of genes is favoured if less males ensue through the culling of weaker males (4).

Regional differences in M/T have also been observed (5). This study was carried out in order to ascertain whether there were any regional differences in M/T in Mexico.

Material and Methods

Ethical approval was not applied for as these are anonymous and freely available datasets from the Instituto Nacional de Estadística y Geografía, the National Institute of Statistics and Geography (6,7). For this reason, informed consent was not obtained. Sex and year as well as region were available for the period January 2010-December 2020 (6,7). These were grouped into five regions, as per Table 1 (6,7).

Statistical analysis

The binomial equations of Fleiss were used to calculate confidence intervals (CI) for proportions (8). Bespoke Excel



Address for Correspondence: Victor Grech

e.mail: victor.e.grech@gov.mt ORCID: orcid.org/0000-0002-3373-0478

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sheets were used to perform chi test, chi tests for trends and Spearman correlation (9,10). A p-value <0.05 was taken to represent a statistically significant result.

Results

There were a total of 68,423,415 births for the period 1994-2020 and 25,436,687 for 2010-2020. Live births correlated negatively and significantly with year [Spearman rho: -0.94, p<0.0001 (Figure 1)]. M/T fell significantly from 1994 to 2003 (chi for trend: 267.3, p<0.0001) then rose significantly to 2020 [chi for trend: 723.3, p<0.0001 (Figure 1)].

For 2010-2020, there were 2,520 births with sex unspecified ("no especificado") and 104,320 non-Mexicans ("extranjero") and these were excluded to yield an M/T of 0.5060 (95% CI 0.5058-0.5062). Live births by sex and region are displayed in Table 1. There were significant regional differences, with M/T highest in the North, followed by the West, South, Centre and East, as shown in Figure 2 (chi for trend: 223.1, p<0.0001). No geographical gradient was present.

Discussion

Fertility has been dwindling in South America for decades (11). Mexico is no exception, as shown in this study, with a fertility

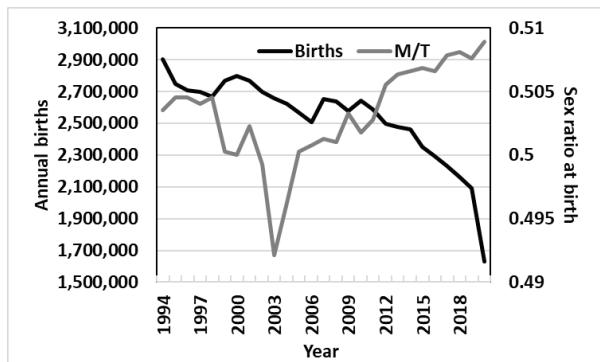


Figure 1. Total births and sex ratio at birth by year, 1994-2020

decline initiated by a government sponsored contraception campaign 40 years ago that was deliberately intended to replace its former nation-building policy (12). Broader changes, such as more women in work and education, and a rise in housing prices, also reduced fertility (12). Indeed, currently circa 40% of married Mexican women undergo sterilisation, possibly due to the lack of other contraceptive measures in some areas of the country and the strict laws against abortion, except in Mexico's capital (12). Moreover, the introduction of emergency contraception in Latin America has further impacted fertility (13).

Acute stress reduces M/T. This includes all types of stress, both due to natural events like earthquakes, smog and floods (14) and man-made events, such as terrorist attacks (3), and contracting economies (15). The M/T was reduced in Mexico in the present study, as noted in previous studies (5) and this country's ratio is significantly less than the expected value of 0.515 based on a world reference range that included 88,875,750 births (chi: 5935.8, p<0.0001) (1). It had been mooted that M/T may be lower in certain ethnicities due to innate physiological differences (16,17). However, chronic stress has also been hypothesised to reduce M/T, in accordance with the Trivers-Willard hypothesis (18). This is supported by the finding that race in the United States is the principal determinant of socio-economic status and the most significant variable associated with wealth inequality and stress (19). Indeed, in the US, M/T is highest in Asian births, followed by White, American Indian/Alaska Native, and Black/African American births (20). This is further supported by the analysis of a United Nations dataset that showed that M/T was lowest in least developed countries (21). Additional results supporting the hypothesis include a multivariate analysis of global M/T with health and socioeconomic indicators which found a significant positive correlation of M/T with these indicators (22).

Mexico has been one of the principal targets of the "War on Drugs", first mooted by US President Richard Nixon in 1971 (23). The Nixon administration attempted to justify the escalation

Table 1. Live births by sex and region, 2010-2020

Region	1: North	2: Centre	3: West	4: East	5: South	Total
M	2,713,563	3,872,332	2,230,794	1,995,633	2,006,317	12,871,350
F	2,626,505	3,796,968	2,165,086	1,962,723	1,961,182	12,564,073
Total	5,340,068	7,669,300	4,395,880	3,958,356	3,967,499	25,435,423
UCI	0.5086	0.5053	0.5079	0.5046	0.5062	0.5062
M/T	0.5082	0.5049	0.5075	0.5042	0.5057	0.5060
LCI	0.5077	0.5046	0.5070	0.5037	0.5052	0.5058

Region 1 (North): Baja California, Baja California Sur, Chihuahua, Coahuila, Durango, Nuevo León, Sinaloa, Sonora, Tamaulipas. Region 2 (Centre): Mexico City, Mexico State, Guanajuato, Morelos, Querétaro, San Luis Potosí, Zacatecas. Region 3 (West): Aguascalientes, Colima, Guerrero, Jalisco, Michoacan, Nayarit. Region 4 (East): Hidalgo, Puebla, Tlaxcala, Veracruz. Region 5 (South): Campeche, Chiapas, Oaxaca, Quintana Roo, Tabasco, Yucatan
M: Male, F: Female, M/T: Males/total, UCI: Upper confidence interval, LCI: lower confidence interval

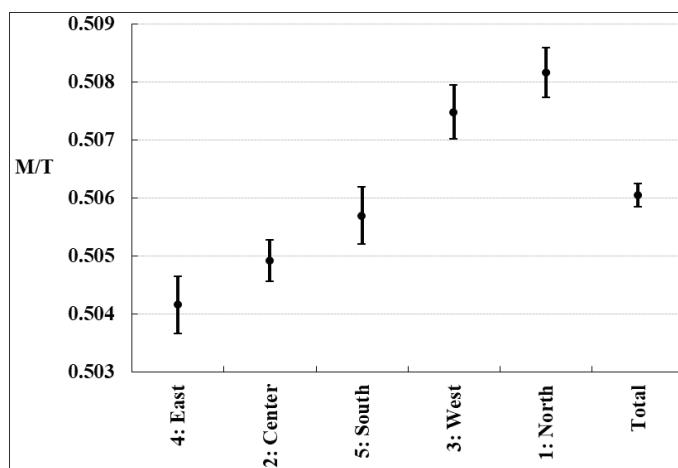


Figure 2. Ranked M/T gradient (per Table 1, regions in table 1 footnotes)

M/T: Males/total

of repressive measures against drug users to counter the increasing accommodation and normalisation of cannabis use as a gateway to more addictive drugs, such as opiates (23). However, the pursuit of a total prohibitionist policy has created a parallel economy fuelled by diverse, extensive and opposing criminal networks which resort to unbridled violence to protect their markets with often lethal effects, especially among young males (24). Governments have responded through police and/or military/paramilitary forces that react in similar fashion, to the extent that in Mexico, the escalation in homicides since the deployment of military forces against drug traffickers in 2006 has resulted in a reduction in national life expectancy (25). These policies have also led to the excessive use of incarceration with lengthy sentences for minor, non-violent, drug-related offences (25). Drug use and injection in prisons is common, and this circulates conditions such as HIV and hepatitis, often complicated by co-infection with tuberculosis (25). Unsurprisingly, this has resulted in a negative effect on population mental health, particularly vis-à-vis communication used by criminal organisations (narcomessages), the viciousness of gang executions, and the violent confrontations between law forces and criminal groups (26). Furthermore, thousands of women in Mexico, and indeed, Central America have been displaced from their countries by violence (27).

Terrorist acts have been linked to acute and transient drops in M/T in already pregnant women, 3-5 months after the event (3,28) and this has been confirmed with a systematic review and meta-analysis (29). The impact of violence varies hugely and depends on many factors; this has shifted the drug market to some extent to different parts of Mexico and to other Central American countries (30).

Finally, the COVID-19 pandemic has caused global disruptions and stress (31) and it has been speculated that this may affect M/T (32). Indeed, there are indications that this happened in Japan (33) South Africa (34) and in some large cities (35). These effects may completely subsume other, relatively smaller stressors and this will be an interesting topic of study, as may be the current war in Ukraine and its global effects.

Study Limitations

This study is limited by several factors. There were significant numbers of births that were of unspecified sex and for non-Mexicans, and these were excluded. In addition, no other data was available that might have allowed comparison, such as maternal or paternal factors. This is typical of most online datasets, preventing any form of multivariate analysis. Furthermore, this is an ecological study and it is therefore impossible to identify what caused these differences.

Conclusion

Mexico has a baseline low M/T, possibly due to chronic stress (associated with the country's underdeveloped status). The M/T has varied over the study period and also varied significantly in different geographical regions of the country.

Ethical Committee Approval: Ethical approval was not applied for as these are anonymous and freely available datasets from The Instituto Nacional de Estadística y Geografía, The National Institute of Statistics and Geography.

Informed Consent: Informed consent was not obtained.

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