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Research Article

The sex ratio at birth

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Abstract. The sex ratio at birth (male/total:M/T) is remarkably constant but may be influenced by many factors. Even small changes may result in highly statistically significant variations. The most important factors that impinge on M/T are stress and sex-selective termination. Additional factors include geographical trends, coital rates, radiation, secular trends and seasonality. This paper will summarise these factors but the most important is gendercide, which has resulted in circa 130,000,000 missing women in the world.

Keywords: Birth Rate/*trends, Humans, Nuclear Weapons, Radiation, Radiation Exposure, Sex Ratio

1 Introduction

The human sex ratio at birth is often referred to as M/T (male divided by total births). In humans, male live births such that 515 males are born for every 485 female births (M/T of 0.515) (Grech et al., 2019b). M/T varies and the causes may be classified into two categories: proximate and ultimate. The former refers to events that cause acute changes while it is postulated that the latter have had evolutionary drivers that have adapted the species to its surroundings. The influences that have been shown to affect M/T are legion and this paper will provide a brief outline (James et al., 2017).

2 Historical Notes

Studies and speculation on what influences M/T date to ancient Greek times, and these include allusions to the four elements that were thought to comprise nature: earth, air, fire, and water. For instance, some theories held that an infant's sex was determined by the degree of heat that a man's ejaculate was exposed to during insemination. Theories abounded with no actual scientific basis until the post-Enlightenment world of the 18th century. Those who were intrigued by this conundrum included investigative theologians such as John Arbuthnot and Johann Peter Süssmilch, mathematicians such Nicolas de Condorcet, Pierre-Simon Laplace and Denis Poisson, physiologists such as Johann Daniel Hofacker and organizers of statistical observations such as Joseph Fourier and Adolphe Quetelet (Brian et al., 2007).

Solid statistical analysis was first performed in London by John Graunt (1620-1674) who had access to birth data and published the first ever descriptive analysis of M/T data. John Arbuthnott (1667-1735) extended this data collection to publish the ever first statistical test based on the symmetric binomial distribution, demonstrating that the male excess was statistically significant and not due to chance alone (Brian et al., 2007; Grech, 2019).

A systematic search showed that circa ten factors may have an influence on M/T, with stress and sex-selective termination being the most predominant. Additional factors included geographical trends, coital rates, radiation, secular trends and seasonality (West et al., 2019).

3 Gendercide and Femineglect

Gendercide (the selective abortion of fetuses of one particular gender) and femineglect (the deliberate infliction of lower standards of care of all sorts, especially of health, to female neonates, infants and children, simply because of their gender) is rampant, especially in Asia. This has resulted in severe demographic sex imbalances in many countries (Diamantopoulou, 2000; Grech, 2018b).

This cultural attitude is impelled by the tendency for patrilineal inheritance in patriarchal societies, coupled with a reliance on male children to provide economic support indefinitely. For this reason, due to the patriarchal nature of most societies, male offspring preference is far more common than female preference. In Asia, this attitude is greatly reinforced by the Confucian tradition of strong son preference and female subordination (Diamantopoulou, 2000).

This attitude persists even in Asian communities in

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developed countries and antenatal sexing and gender-selective abortion is the likeliest explanation for the high M/F noted in Asian or Pacific Islander births in the United States when compared with the other races in the same country (Grech, 2017a). The sex ratio at birth decreases with increasing birth order (James, 1980). The theory that sex-selective termination is prevalent in the United States is further reinforced by a birth order analysis by race which showed that M/T decreased with increasing sibling order for all races, as is the norm, except for Asian or Pacific Islander births, where M/T rose progressively to 3rd order births then fell (Grech, 2017b). The implication is that this group may be systematically implementing gendercide. Indeed, the known effects of increasing maternal age and/or decreasing coital rates with time associated with a decrease in M/T are not only excluded in this race, but go contrary to this study's findings as Asian or Pacific Islander births also had the oldest mean maternal ages for all birth orders. The Asian or Pacific Islander strategy is equivalent to a constant loss of 3.5 females fetuses per 1000 live births when compared to White births (Grech, 2017b).

The United Nations divides regions into More Developed, Less Developed and Least Developed countries (as defined by the UN General Assembly). In Less Developed countries (and this group includes Asia), M/T was initially stable at 0.53, then rose after 1984 to 0.545, coinciding with the introduction of ultrasonography and access other antenatal sex determining technologies that could, potentially, support the practice of selective femicide (Grech, 2015c).

The likelihood that gendercide is routinely used in these cultures is reinforced by the observation that in Asian countries where education levels rise, M/T drops to values found in other races. This was observed in South Korea where M/T had peaked at 0.538 in 1990, but dropped to 0.513 by 2013 due to education campaigns and this was the first Asian country to reverse this high and artificial M/T trend (Chung et al., 2007).

It has been estimated that that the number of missing females reached 126 million in 2010 and is expected to peak at 150 million in 2035. The annual number of newly missing females is expected to exceed 3 million every year until 2050 (Bongaarts et al., 2015).

Femineglect also kills antenatally and/or perinatally. For example, in some cultures, when it is known that the fetus is female, failure to attend antenatal clinics and take the tetanus vaccine leads to an excess female neonatal mortality (Bharadwaj et al., 2013). In these cultures, female children may also have poorer vaccine uptake and poorer hospital attendances for acute illnesses, with increased morbidity and mortality such that in South and East Asia, there is higher female under-5 mortality compared to males, in stark contrast to the rest of the world where the opposite occurs. Women in such countries may experience significant social pressure to produce sons, becoming repeatedly pregnant until they do so, as failure may lead them to experience violence, rejection or even death (Grech, 2015d).

4 Acute Stress

Human biological sex is fixed at conception and M/T thus depends on two factors: the gender ratio at conception and its alteration by natural causes of sex-selective embryonic and/or fetal death (miscarriage and/or stillbirth) (James et al., 2019). For example, ambient temperature is a simple and easily measured stressor to test and it has been shown that a 1°C increase in annual temperature (resulting in a milder winters) predicts one more male than expected for every thousand females born in a given year. Interestingly, males from cold-stressed cohorts who have experienced cold weather in-utero culling have, on average, longer life expectancies. This has been calculated as an average decrease in male life-span by 14 days per 1°C increase from one year to the next among those who survived to one year of age (Catalano et al., 2008).

A stress-related acute decline in M/T was demonstrated following the September 11 attacks on the United States with a decrease in M/T four months later (Catalano et al., 2006). This was shown to be due to an excess of male fetal loss during pregnancy (Bruckner et al., 2010). Several terrorist attacks were linked to a transient drop in M/T including during The Troubles in Northern Ireland (late 1960s to late 1990s), the Rodney King riots in Los Angeles in 2012, the Breivik shootings in Oslo in 2011 and the Sandy Hook school shootings in Connecticut in 2012 (Grech, 2015h). A meta-analysis of terrorist attacks further confirmed this phenomenon, (Masukume et al., 2017) even after seasonal correction (Grech et al., 2017a).

A very wide spectrum of stressors has been associated with a decline in M/T and these included the assassination of prominent journalists (Calleja, 2020), the sovereignty referendums in Canada (Grech, 2015i), warfare (Grech, 2013, 2014b), riots in France and terrorist attacks in Japan (Grech et al., 2017b), parliamentary elections in Malta (Grech, 2014c), mass layoffs (Catalano et al., 2010), the assassination of President J. F. Kennedy (Grech, 2015b) and the 2007 recession in the United States (Grech, 2015e). Even natural or relatively insignificant events may transiently lower M/T, and these have included the death of Princess Diana in 1997 in the UK (Grech, 2015f), the Eyjafjallajokull volcanic eruption in Iceland in 2010 (Grech et al., 2016b), earthquakes

(Catalano et al., 2013) and American legislation facilitating immigration from Cuba to the United States so as to allow Cuban citizens to escape from their country (Grech, 2014f). Even stressful metabolic conditions, such as type 1 diabetes, have been shown to reduce the sex ratio at birth (García-Patterson et al., 2016).

A common finding is that with all acute events, the M/T dip witnessed is transient, occurring approximately 4-5 months after the exogenous stressor event (Catalano et al., 2006).

These M/T dips are not only sharp and transient but also dramatic and relatively severe. The perinatal mortality rate (number of stillbirths and deaths in the first week of life/1000 live births) is considered an important metric in the assessment of the quality of health care delivery and is expected to be $< 7/1,000$ in developed countries. The very transient M/T dips observed not only match but sometimes transiently dip to even double or triple this value, making this not only an Public Health issue and inexpensive metric to objectively assess the effects of population stressors (Grech, 2018c).

China's Great Leap Forward (11/1957-1/1961) is an interesting case study in this regard, an event that had tragic consequences with a catastrophic national famine that lasted between 1959 and 1961. This not only resulted in a reduction in births but an additional male birth deficit (Song, 2012). It was estimated that there were 18,286,000 less births in 1959-61 than anticipated with an additional deficit of 196,221 male births. The total birth deficit was circa 301.7 per 1000 with an additional male deficit of 3.2 per 1,000, figures that greatly exceed the ≈6/1,000 for a reasonable value of perinatal mortality. Clearly, extreme political decisions should be taken with caution since they can effect enormous impacts on history and on human biology, including massive effects on births and M/T (Grech, 2018a).

These dips conform with the Trivers-Willard hypothesis (TWH) which supports the notion that evolution should have selected parents with the ability to influence M/T according to conditions in pregnancy. This is because in polygymous species (wherein males have multiple mating opportunities), a robust son who is conceived under favorable conditions therefore has greater reproductive opportunities than an equivalent daughter who is constrained by pregnancy and lactation. However, under adverse conditions, a male fetus requires greater resources (on average 8% more protein, 9.2% more carbohydrates, 10.9% lipids of animal origin and 14.9% lipids of vegetable origin) in order to be carried to term (as males are, on average, larger babies) and will be less likely to survive pregnancy (Tamimi et al., 2003). Should he do so, a frail male may not survive to reproductive age, and if so, will compete poorly with more robust males for mating rights. However, under poor conditions, a frail female is more likely to survive and reproduce. Hence, in unfavorable conditions, the parental passage of genes is more likely if fewer males are produced through the culling of weaker males (Trivers et al., 1973). This theory is supported by many studies (Cronk, 2007; Douhard, 2017).

5 Chronic Stress and Socio-economic Status

Different races have different M/T. This may be due to innate physiological differences or to other factors. In the US, M/T was shown to demonstrate a decreasing trend along the subpopulations Asian or Pacific Islander>White>American Indian or Alaska Native>Black or African American (Grech, 2017b). M/T falls with declines in surrogates of socioeconomic status, presumably due to chronic higher stress levels. The lower baseline M/T of Indian or Alaska Native and Black and African American is equivalent to a constant loss of 3.5-4/1,000 male births when compared to White M/T. Race is the most significant variable associated with wealth inequality in the United States and may be partially responsible for the observed differences (Grech, 2018c). A temporal M/T review showed that in More Developed countries, M/T was stable at 0.53 up to 1979, then fell to 0.525. The reason/s for this decline are uncertain but it has been speculated that this may be due to the trend for delayed pregnancies in educated women with increasing maternal age and possibly decreased coital rates. The Least Developed countries exhibited a stable and lowest M/T of 0.52 and this may be due to chronic stress (Grech, 2018c). A few localised studies, for example in Sub-Saharan Africa, have confirmed the chronic stress effect (Morse et al., 2021).

Several metrics indicate individual countries' health and socioeconomic status and for all available countries M/T and these indicators were compared in order to ascertain whether 'better' levels of these indicators were associated with higher M/T. These metrics included infant mortality rate, under 5 years mortality rate, fertility rate, Human Development Index, gross domestic product per capita, life expectancy for both sexes, females, males, as well as both sexes Health Adjusted Life Expectancy (HALE). All except for the Human Development Index (HDI) correlated with M/T at statistically significant levels (Grech et al., 2019a).

M/T may, therefore, serve as a surrogate, sentinel health indicator (James et al., 2018a).

6 Radiation

Radiation is the only known stressor/toxin which elevates M/T by destroying female in excess of male fetuses, and this is thus far unexplained. Indeed, M/T increases by 0.0036 (over the approximately 0.515 baseline value) when the normal average background radiation dose rate of 0.1141 μSv/hour is doubled to 0.2282 μSv/hour (Scherb et al., 2007). A radiation-related rise in M/T has been shown to occur in proximity to nuclear reactors (Scherb et al., 2019) after the meltdown of the windscale (Sellafield) and Chernobyl reactors in 1957 and 1986, respectively (Grech, 2014a, 2014e). Even heavy rainfall (which precipitates and concentrates ambient natural radioactivity) after Hurricane Katrina revealed a dose-response relation between the amount of rainfall and monthly M/T in the states of Alabama, Louisiana and Mississippi 8-10 months later (Grech et al., 2015).

On a global level, extensive atomic bomb testing was carried out by several countries leading up to the Partial Test Ban Treaty of 1963 which prohibited atmospheric test explosions. 94.5% of births studied showed a uniform reduction in M/T prior to the Treaty, followed by an increase in M/T to the mid-1970s, with a subsequent decline. A negative correlation of M/T with total births was found in 66% of births studied, and these were the regions which exhibited the rising M/T pattern in the 1970s. The birth deficit for countries which displayed significant correlations of total births with M/T (i.e. North America, Europe and Asia) was estimated at 10,090,701 (Grech, 2015a).

7 Excess Coital Activity

The regression of M/T on time of conception within the human menstrual cycle is U-shaped. Due to hormonal activity, females are generally more receptive to coitus mid-cycle, peri-ovulation. Increased coital activity (for reasons uncertain) increases the odds of conception early in the menstrual cycle, thereby skewing the odds toward males, elevating M/T. This explains the finding that during the Great Wars, M/T rose in countries actively at war only (James, 2009). This is probably because in times of war, an adult sex ratio imbalance is manifest, with more males being away from their homes, and soldiers only granted short periods of leave in order to return home (James, 2009). This has been claimed to result in sexual excesses, 'actions [that] were viewed as understandable responses to the Frauenuberschuss,' the excess supply of women (Michel, 1993). The related increased coital activity may have caused the M/T elevations and this has been confirmed by a meta-analysis of births (James, 2008).

A rise in M/T nine months after occasions of public elation has also been reported for example in South Africa nine months after the 2010 World Cup there (Grech et al., 2016c; Masukume et al., 2015), and the high M/T in the UK following the birth of Prince William in 1982 (Grech, 2015f). High coital rates might also explain the reported spike in births and M/T in Hong Kong in the auspicious (to the adherents of the Chinese Zodiac) Dragon years of 1976, 1988 and 2000 (Grech, 2015g), and to misrepresentation of birth year reporting for female babies in Japan in the Fire-Horse year 1966 such that babies born at the beginning or end of this "unlucky" year had their birth years misreported as having occurred in adjacent years (Grech, 2016). The steady decline in coital rates with duration of marriage also explains the decline in M/T of first births with the duration of time between marriage and birth (James et al., 2017, 2018b).

8 Secular and Geographical Variation

M/T may exhibit seasonal variation, peaking as summer approaches and this was demonstrated for the United States with a significant peak in June (Grech et al., 2016a). Global datasets have shown an overall decreasing trend in M/T in Europe and North America (Grech, 2014d). A latitude gradient in M/T is also present, with more males being born in southern, warmer latitudes in Europe. The converse occurs in North America, with more males born in northern latitudes and the reason for this is unknown (Grech et al., 2002; Grech et al., 2000, 2003).

9 Conclusion

While acute events may transiently decrease M/T, or chronically depress M/T in situations of prolonged stress, M/T may also occasionally rise sharply in relation to events that lead to elation possibly due to increased coital activity.

However, these effects simply pale into insignificance when compared to two man-made effects: radiation exposure, and gendercide (with attendant femineglect). These influences have hugely increased M/T, with the potential for demographic havoc in affected countries, notably Asia (Grech, 2015d).

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