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## **Population Stress, Civil Unrest and the Male to Female Ratio at Birth in Chile, Argentina, Australia and Finland**

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### **Author's contribution**

*The sole author designed, analyzed and interpreted and prepared the manuscript.*

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### **ABSTRACT**

**Introduction:** Male live births occur slightly in excess of female births but the ratio is influenced by a very large variety of factors. This ratio is remarkably stable but may exhibit sudden shifts in response to influences such as population stress. A World Health Organisation dataset comprising annual live births by year and country was analysed not only to pinpoint outlier values but also to attempt to identify historical causes for such outliers.

**Methods:** The WHO HFA (Health for All) mortality database was used to identify outlier M/F values. Data was analysed using chi tests and chi tests for trend. Comparison for years of interest were made against baselines of only up to five years before and after such years since M/F exhibits potentially confounding long-term secular variations.

#### **Results:**

- *Chile:* There was a significant difference in M/F between the period 1967-1971 and 1972 ( $p < 0.0001$ ). There was a decline over 1972-1976 ( $p < 0.0001$ ).
- *Argentina:* Increases were noted in 1978, 1988 and 1994 ( $p < 0.0001$ ).

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- *Australia*: M/F rose sharply in 1956 ( $p=0.0008$ ).
- *Finland*: There were increases in 1962 and 1971 ( $p<0.0001$ ).

**Discussion:** Stress has been shown to affect M/F. Almost all of the observed outliers were temporally associated with political events or political decisions that influenced the respective countries' economies. M/F ratios worldwide provide tantalising hints that even transient stress may influence this ratio, making it a sensitive indicator of overall population stress.

*Keywords: Civil disorders; sex ratio; dissent and disputes; birth rate/\*trends; infant, newborn.*

## 1. INTRODUCTION

Male live births occur slightly in excess of female births [1]. The ratio of male to female live births (the secondary sex ratio) is generally expressed as the ratio of male live births divided by total live births, and is usually (albeit technically incorrectly) abbreviated as M/F. This abbreviation will be used. For humans, male births exceed female births by approximately 3% but this ratio is influenced by a very large variety of factors [1,2].

It is believed that natural selection may have influenced the species such that pregnant females who are stressed are likelier to abort spontaneously if gestating a male than if gestating a female foetus. Stress may be physical or psychological and produced by poor ambient conditions. Examples of natural disasters that have been shown to reduce M/F (possibly due to induced stress) include earthquakes [3], and floods [4]. Man-made disasters include famine [5], short duration wars [6], severely contracting economies [7], and terrorist attacks [8]. Male births are therefore reduced.

This is in accordance with the Trivers-Willard hypothesis and is based on the assumption that a male who reaches reproductive age in good condition is expected to outreproduce a female in similar condition. Conversely, if both are in poor condition, a female is expected to out-reproduce a male. This is because a weak son would compete poorly with stronger males for the same cohort of females, thus producing fewer offspring than a weak female daughter would.[9] Less males are therefore produced under stressful conditions.

Pregnant women who are stressed or who are exposed to toxins have therefore developed mechanisms that allow them to cull male fetuses that are least likely to eventually sire grandchildren and thereby fail to propagate their genes. A population's M/F therefore falls under such circumstances. This was shown after the

September 11 attacks on New York since M/F in the entire United States dipped, and this was shown to be due to excess male foetal loss [10].

It has been demonstrated that certain political events reduce M/F, presumably due to stress engendered within populations. This was clearly shown in the East part of Germany during a severe recession shortly after the reunification of this country in 1990. The recession in this part of the country was associated with a transient and significant drop in M/F [7]. Similarly, it has been shown that M/F dropped sharply in Ireland in the last quarter of 2007 in relation to the onset of the economic recession [11].

Thus, political and economic turmoil within a country may also lead to population stress and both may lower M/F. The analysis of a World Health Organisation (WHO) dataset comprising annual live births by year and country has yielded several instances whereby M/F dropped in temporal relation to political events, and some examples will be given. In Israel, Egypt and Kuwait, significant M/F dips were shown to occur in relation to escalations of conflicts and other political events in this region [12].

In Cuba, significant short dips in M/F were found in association with American legislation that facilitated mass Cuban emigration from communist rule to the United States [13]. In Malta, parliamentary elections were shown to reduce M/F but other political nonelectoral events raised M/F [14]. And this same WHO database has also been used to identify conflicts in the last 50 years and to show that many of these influenced M/F [15].

This study analysed the same WHO dataset, pinpointed outlier values and also attempted to identify historical causes for such outliers.

## 2. METHODS

### 2.1 Data Sources

The WHO HFA (Health for All) mortality database was used to identify outlier M/F values [16].

Access was provided directly to the download area by WHO authorities (Mie Inou – personal communication). During the data processing of M/F at continental level, several outlier years were noted. These were Chile (1961-1994) and Argentina (1961-1996) for South America [17], Finland (1950-2009) for Scandinavia [18] and Australia (1950-2009) [19].

Outliers were arbitrarily defined by the author as data points whose statistical significance (alpha) exceeded 0.001 (0.1%), a more rigorous value than the conventional value of 0.05 (5%). This was deemed appropriate due to the large number of datapoints reviewed, in order to minimise the risk of a type 1 error (error of the first kind) with the incorrect rejection of a true null hypothesis, which in this case, was the assumption that there were no true outlier values.

## 2.2 Statistics

Excel was used for data entry and analysis. The quadratic equations of Fleiss were used for exact calculation of 95% confidence intervals for M/F ratios [20]. Chi tests were applied using the Bio-Med-Stat Excel add-in for contingency tables. A simple chi test with Yates correction was carried out on 2x2 tables. Chi test for trend (Cochran-Armitage test) was carried to test for departure/s from linear trend (with one degree of freedom) [21].

Comparison for years of interest were made against baselines of only up to five years before and after such years since M/F exhibits long-term

secular variations, [22] the effects of which this study strove to avoid.

A p value of  $\leq 0.001$  was taken to represent a statistically significant result.

## 3. RESULTS

### 3.1 Chile

There was a significant difference in M/F between the period 1967-1971 (Fig. 1) and the year 1972 ( $p < 0.0001$ ). The decline in M/F for the period 1972-1976 was also significant ( $p < 0.0001$ ).

### 3.2 Argentina

Outliers were noted in 1978, 1988 and 1994 (Fig. 2). When compared to the previous and following two years for each instance, all three outliers were highly statistically significant ( $p < 0.0001$ ).

### 3.3 Australia

There was a sharp rise in the Australian M/F in 1956 (Fig.3) and this was significantly higher than the previous and following 5 year periods ( $p = 0.0008$ ).

### 3.4 Finland

Annual M/F for Finland is shown in Fig.4. The increases in 1962 and 1971 were highly significant when compared to the aggregate of the previous and following two years for each event ( $p < 0.0001$ ).

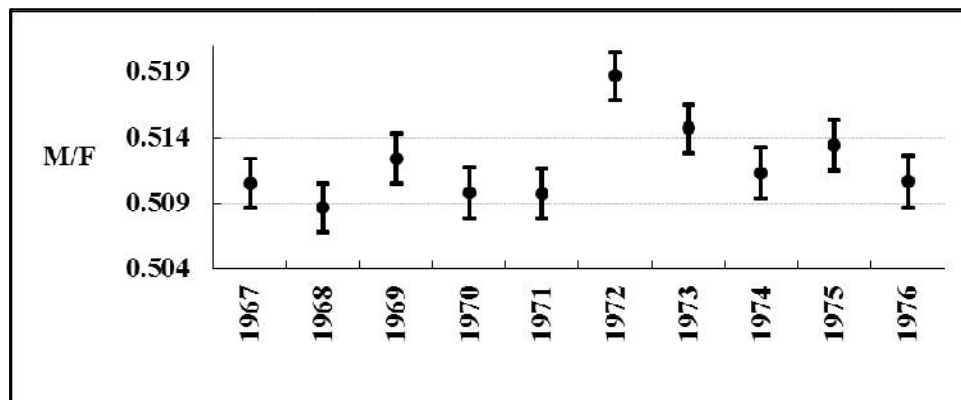


Fig. 1. Annual M/F for Chile for the period 1967-1976 [17]

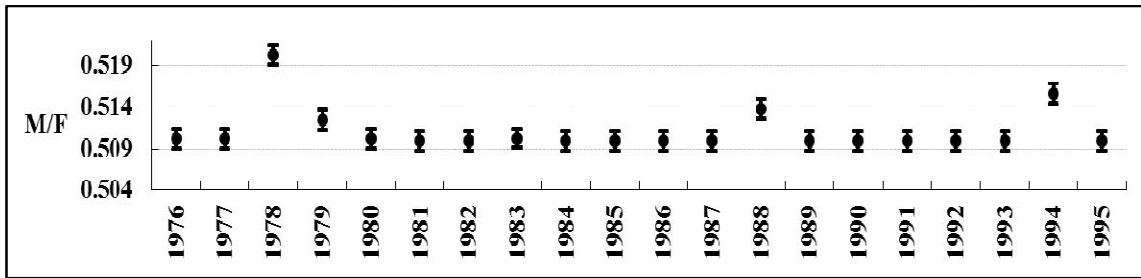


Fig. 2. Annual M/F for Argentina for the period 1976-1995 [17]

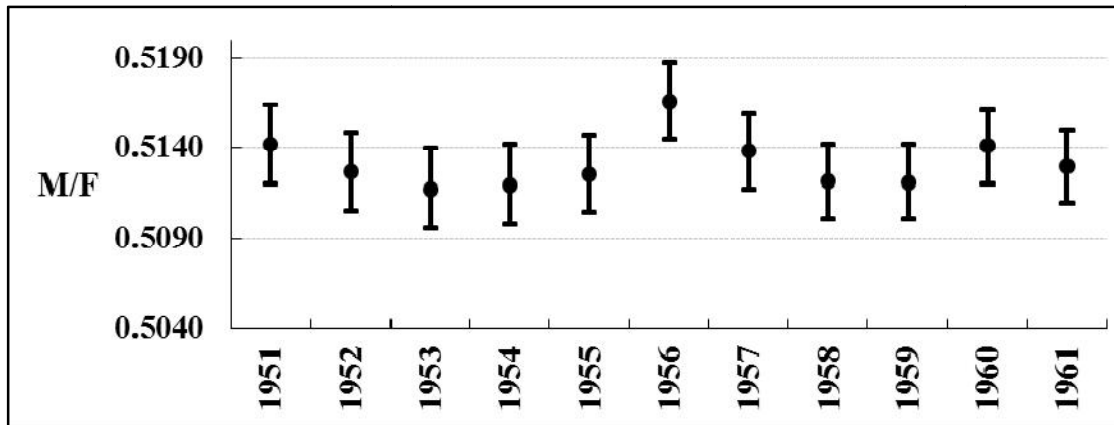


Fig. 3. Annual M/F for Australia, 1951-1961 [19]

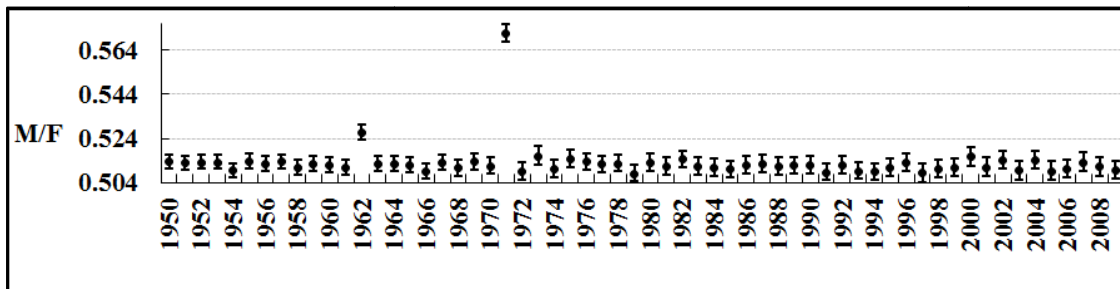


Fig. 4. Annual M/F for Finland, 1950-2009 [18]

#### 4. DISCUSSION

This study has the advantage that the countries analysed do not commonly employ sex-selective abortion. Stress has been shown to affect M/F, and even relatively mundane events may have significant effects. For example, it has recently been shown that the World Cup influences M/F in selected countries [23].

Directly witnessing violent events such as involvement in short duration wars has been shown to depress M/F. For example, the very short war in Slovenia (26 June–7 July, 1991)

reduced M/F to 0.504 in Slovenia and to 0.483 in Ljubljana, 6 to 9 months later [6]. Even terrorist events have been shown to exert an influence on M/F. The September 11 attacks on the United States depressed M/F not only in New York [8], but also in California where the events were witnessed over the media [24]. Moreover, it was shown that M/F dipped transiently in the entire United States due to excess male foetal loss [10].

It has also been shown that such M/F dips may be quite sudden, occurring less than nine months after the event, and may last just a few months

[7,8,11]. Thus, it appears that some of the influences reduced M/F after just a few months while others may have exerted their ultimate influence after nine months.

#### 4.1 Chile

In Chile, under President Allende, inflation had peaked at 463% in 1973, exacerbated by civil strife that included strikes (sometimes simultaneous) by the medical and teaching professions, students, truck owners and copper workers. The regime was overthrown in September 1973 by General Augusto Pinochet. While harshly repressive, the Junta's new economic policies rapidly resulted in the drop of inflation rates to double and single digits [25].

Economic stress may be hypothesised as an explanation for the low M/F (circa 0.509) evidenced in 1970-1, and the improved economic situation after the coup may also have resulted in the higher M/F after 1972. This theory however does not explain the M/F rise to 0.518 in 1972, just before the coup, and the decline thereafter. A potential explanation of the latter was the repressive nature of the dictatorship which brooked no opposition and led to the disappearance of thousands of young dissidents [26].

#### 4.2 Argentina

In 1978, the 11<sup>th</sup> soccer World Cup was held in Argentina (and the Argentina also won). It is known that increased coital rates increase the chances of conception at the beginning and end of the menstrual cycle. It is also known that conceptions that occur at the extremes of the menstrual cycle skew M/F toward male births [27]. It is possible that exuberance in anticipation of the World Cup (with higher coital rates) may have resulted in the observed excess of male conceptions [23].

However, the rise in 1978 also occurred during a time of turmoil, which included the so-called "Dirty War" waged by the military regime, an ideological program that attempted to eliminate the perceived social base for anti-government insurgency. This included the assassination of middle class students, intellectuals and labour organisers [28]. Theoretically, these events should have decreased M/F. It is possible that the positive effects on M/F by football outweighed the negative effects on M/F by violence.

The M/F rise in 1994 may have been caused by the governments change in policy to an embracement of neoliberalism, with the enactment of a fixed exchange rate in 1991, the removal of protectionist barriers, the establishment of business regulations and privatisations. These measures stabilised the economy up to 1996, which went into decline thereafter [28]. No explanation could be found for the 1988 spike in M/F.

#### 4.3 Australia

In Australia, the 1950s were characterised by four elections, in 1951, 1954, 1955 and 1958. These were close run events, with  $\leq 4\%$  points differences between elected and runner-up parties and  $>95\%$  turnout for elections. Moreover, the 1954 election was tainted by conspiracy theories of communist spy rings in Australia, fuelled by the Petrov Affair, wherein Vladimir Petrov, an attaché to the Soviet embassy in Canberra, defected to the West. He too claimed that these spy rings existed. Since the 1951 Australian election had been contested over the issue of whether to make the Communist Party of Australia illegal, this claim appeared *prima facie* legitimate. This led to the incumbent government (the Liberal Party in coalition with the Country Party) writing to Vyacheslav Molotov, the Soviet Foreign Affairs Commissar, who assured him that no such rings existed, a declaration that was made public and helped win the election with the administration remaining in power, defeating the Labour Party. These events were closely watched and debated in Australia and caused significant furore among the populace [29].

This defeat led to the "great split" of the Labour Party in 1955, with the Liberal/Country coalition remaining in power for the next seventeen years [30]. It is possible that the ensuing turmoil may have influenced M/F, which spiked significantly in 1956. The 1954 election may thus have caused a chain of events that caused a fluctuation in M/F.

#### 4.4 Finland

During the Cold War, while officially claiming neutrality, Finland entered into the Finno-Soviet Pact of Friendship, Cooperation and Mutual Assistance (YYA Treaty). The Finnish leadership of the time leaned toward the Soviet Union but the country retained a Western European market economy.

At the end of October 1961, the Soviet Union sent a diplomatic note to the Finnish authorities, claiming that neo-Nazism and militarism in West Germany were a threat to both the USSR and Finland [31]. Two-stage presidential elections were held in this country in 1962 with an 81.5% turnout and these were deemed crucial by the populace for the future neutrality of Finland [32]. It is possible that the election result and the events leading up to it may have somehow increased M/F that year.

A demographic shift may have been responsible for the 1971 spike in M/F. When the so-called “baby boomers” entered the workforce in the late 1960s and early 1970s, the economy failed to generate jobs at a sufficiently high rate and hundreds of thousands of Finns emigrated to the more industrialized Sweden, with emigration peaking in 1969 and 1970, to the extent that the country’s population contracted [33]. It is likely that emigration from Finland was predominantly male, potentially producing a “marriage squeeze” for the remaining females. This may have, in some way, influenced M/F. However, it is not possible to test this hypothesis as the Population Statistics Department of Statistics Finland does not have emigration data divided by gender for this time period (Ms. Irma Pitkanen, Personal Communication).

This study has several limitations. Since only male and female live births were available, only political historical information could be used in order to pinpoint possible causes for the perceived perturbations, an unavoidable limitation. This study was dependent on the quality of the data supplied to the central repository, a fact of which WHO is fully cognisant, as specifically stated in WHO reports [34]. This is an inherent and unavoidable limitation of this study. Furthermore, the sex ratio at birth naturally depends on the definition of a live birth, which may vary from country to country, and this is another inescapable limitation of this study.

Yet another limitation was data incompleteness. Data was available for the following years and countries Chile: 1955-94, Argentina: 1955-96, Finland: 1950-2009, Australia: 1950-2009.

Another point that must be considered in the interpretation of datasets of this nature is that statistical testing (Chi square or indeed, any other), may provide statistically significant

results, even though the population effect size is negligible.

## 5. CONCLUSION

In conclusion, M/F ratios may have been subtly (and sometimes not so subtly) influenced by political events that fall short of outright warfare. These effects may cause population stress due to socio-economic upheaval or repression or simply due to psychological effects. M/F ratios worldwide thus provide tantalising hints that even transient stress may impinge on M/F, making this a possible indicator of overall population stress since events identified in this paper provide only contextual evidence and may not be causal [35].

## CONSENT

Not applicable.

## ETHICAL APPROVAL

Not applicable.

## COMPETING INTERESTS

Author has declared that no competing interests exist.

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