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Conflicts in the Last Fifty Years and Subsequent Effects on the Male: Female Ratio at Birth

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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 births occur slightly in excess of female births. In man, the ratio of male divided by total live births (M/F) is expected to approximate 0.515. Warfare has been shown to exert significant effects on M/F. This study was carried out in order to identify any such effects on M/F in belligerent countries in recent conflicts.
Methods: Births were obtained from a World Health Organisation Mortality database. Recent wars (post Second World War) were identified. Chi-square tests were used throughout. Male and female births in belligerent countries were compared to the aggregate of the previous and following years. Countries included were those with available data for periods spanning identified wars.
Results: This study analysed 260747284 live births. M/F in the United States increased significantly during the Korean (p=0.011) and Vietnam (p=0.011) conflicts but decreased during the Gulf War (p=0.02) and there were no changes during the invasion of Iraq. There was no significant shift in M/F in Greece during the invasion of Cyprus, in England and Argentina in the Falkland war and in the Balkans during the Yugoslavian wars. The South Ossetia and Abkhazia Wars were associated in rises in M/F in the Southern Caucasus (Armenia, Azerbaijan, Georgia) only after the wars, and then serially to the end of the 20th century (probably due to sex-selective terminations of pregnancy in favour of male births). The Portuguese Colonial War lowered Portugal's M/F during the last year of conflict (1974, p=0.0001).

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Discussion: This study confirms the observation that M/F rises during lengthy periods of warfare, and may fluctuate even during short periods of conflict. The former has been attributed to increased coital rates which increase conception rates early in the menstrual cycle, skewing M/F in favour of male conceptions. The latter may be due to the known M/F lowering effect of stress.

*Keywords: War; birth rate/*trends; sex ratio; infant; newborn.*

1. INTRODUCTION

In mammals, 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 (when the calculation is actually M/T). This abbreviation will be used. For humans, M/F is anticipated to approximate 0.515 [2].

The reason for this discrepancy is uncertain but a plethora of factors have been put forward [2]. Of particular relevance to this study, stress has been shown to decrease M/F [3]. Short periods of warfare have been shown to have the same effect, with a decline in M/F, and this has also been attributed to stress generated during such conflicts [4].

On the other hand, long periods of warfare (such as the First and Second World Wars) increase this ratio, possibly due to increased coital frequency, as will be discussed [2,5,6].

One of the earliest references to M/F and war was by the theologian Johann Peter Süssmilch who almost presciently posited that M/F increases in association with warfare due to Divine wisdom, “thus compensating for the higher male losses due to the recklessness of boys, to exhaustion and to dangerous tasks, to war, to sailing and to emigration” [7].

Historical studies dealing with the last century have been surprisingly contradictory in terms of the relationship of M/F with warfare. No change in M/F was noted in the United States during the First World War by some researchers and this was attributed to the fact that only up to 4% of the population in this country was mobilised at any one time, and then, only for short periods of time. This is in stark contrast with the situation in belligerent countries in Europe where up to 22% of populations were mobilised for most (if not all of the duration) [8].

Some researchers also claimed that there was no general effect on M/F by the Second World War [9,10]. However, a review comparing M/F for the period 1906-1914 (just prior to the First World War) with the war period (1914-1918) in twelve European countries showed an overall increase [11]. In addition, it was definitively shown that M/F increased in all belligerent countries during the First World War and immediately after, up to 1923 (Germany, Austria, Belgium, Bulgaria, France, the United Kingdom, Hungary, Italy, Rumania, Australia, New Zealand and South Africa), but not in neutral countries (Denmark, Spain, Finland, Norway, Sweden, Switzerland) [12]. A rise in M/F in both World Wars was noted in Austria, Belgium, Bulgaria, England, France, Germany, Hungary, Italy, Romania, and South Africa [6,12,13].

Moreover, pooled data showed significant increases in M/F in both First and Second World Wars for Belgium, France, the United Kingdom, Germany, the United States, Austria, Denmark and the Netherlands [14]. Indeed, for the Second World War, when only reliable data was used with regard to analysis of United States data (discarding states wherein birth registration was incomplete) M/F was shown to have risen at statistically significant levels [15].

During the years 1941-46, M/F in England was the highest ever recorded the introduction of birth registration in this country since 1841 [16]. M/F increased concurrently in the Netherlands [17] and in Finland [18]. M/F also rose significantly in the United States during this conflict [15].

This study was carried out in order to analyse the effect of recent warfare on M/F in belligerent countries.

2. METHODS

2.1 Data Sources

Annual male and female live births were obtained from a World Health Organisation (WHO) Mortality database.

Wars following the Second World War were identified and incorporated in this study if natality data covering the relevant periods was available in the WHO dataset. Named wars and participant belligerent countries are shown in Table 1. Slovenia was not included in the analysis as this country has already been discussed in the context of the recent Balkan conflicts [4].

2.2 Statistics

Comparison for years of interest were made against baselines of only a few years (typically five years) before and after such years since M/F. This constraint was applied as it is known that M/F at national and supranational levels exhibits secular variations, [19] the effects of which this study strove to avoid.

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-square tests were applied using the Bio-Med-Stat Excel add-in for contingency tables [21]. A simple chi test with Yates correction was carried out on 2x2 tests. Chi-square tests for trend (Cochran-Armitage test) was carried to test for departure/s from linear trend (with one degree of freedom).

Data was missing for the following countries and years: all natality data for Bosnia-Herzegovina, 1984 natality data for all of the Southern Caucasus countries and 1991 natality data for Serbia and Montenegro. For Argentina, natality data for the sum of the five years following 1974 only was used as data prior to this was unavailable. For the Korean War, US natality data was only compared for the period after the war since natality data for the period prior to the war (prior to 1950) was not available.

The null hypothesis was that there were no significant shifts in M/F in association with wars. A p value ≤ 0.05 was taken to represent a statistically significant result.

3. RESULTS

This paper analysed a total of 260747284 live births and results are summarised in Table 2, excluding the Vietnam conflict due to its length.

M/F in the United States was significantly higher during the Korean War (1950-53; p=0.011) compared to the period immediately following. During the Vietnam War (1956-75), M/F rose almost continuously (Fig. 1) at a highly statistically significant level (chi-square for trend=27.1, p<0.0001). M/F decreased significantly thereafter (1975-2009: chi-square for trend=49.9, p<0.0001). M/F fell during the Gulf War (p=0.02) but did not exhibit any changes during the invasion of Iraq.

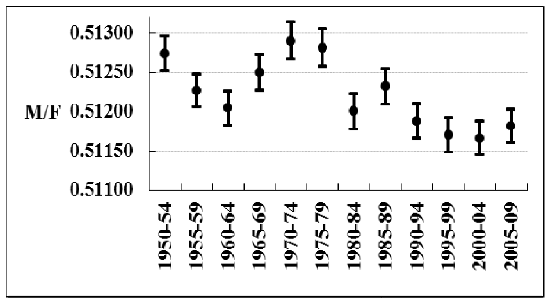

Fig. 1. 5 year M/F for the United States, 1950-2009

Table 1. Wars, years and countries studied

War	Year/s	Country/s
The Portuguese Colonial War	1961-1974	Portugal - Regime overthrown by a military coup in 1974.
The Turkish invasion of Cyprus	1974	Greece (Cyprus not available).
The Falklands war	1982	Argentina and the United Kingdom.
The South Ossetia War	1991-1992	Southern Caucasus (Armenia, Azerbaijan, Georgia).
The War in Abkhazia	1992	Georgia.
The Yugoslavian Wars	1991-1995	Serbia and Montenegro, Croatia and Macedonia.
Korea	1950-1953	United States (Korea not available)
Vietnam	1956-1975	United States (Vietnam not available)
Gulf War	1990-1991	United States (Iraq not available)
2003 invasion of Iraq	2003	United States (Iraq not available)

Table 2. Comparison and analysis of male and female births and M/F by country and era for individual conflicts

	Portugal		Greece		Argentina		United Kingdom	
	1974	**1969-73 plus 1975-79**	**1974**	**1969-73 plus 1975-79**	**1982**	**1983-87**	**1982**	**1977-81 plus 1983-87**
M	88062	917161	74386	747503	347820	1731965	321352	3265241
F	83917	856722	69683	698176	334180	1663631	304579	3094068
Total	171979	1773883	144069	1445679	682000	3395596	625931	6359309
UCI	0.5144	0.5178	0.5189	0.5179	0.5112	0.5106	0.5146	0.5138
M/F	0.5121	0.5170	0.5163	0.5171	0.5100	0.5101	0.5134	0.5135
LCI	0.5097	0.5163	0.5137	0.5162	0.5088	0.5095	0.5122	0.5131
x	15.6		0.3		0		0	
p	0.0001		NS		NS		NS	

	Armenia		Azerbaijan		Georgia	
	1991-2	**1986-90 plus 1993-97**	**1991-2**	**1986-90 plus 1993-97**	**1991-2**	**1986-90 plus 1993-97**
M	76145	332797	191891	861738	83167	390393
F	72261	307887	179826	797419	78555	360458
Total	148406	640684	371717	1659157	161722	750851
UCI	0.5156	0.5207	0.5178	0.5201	0.5167	0.5211
M/F	0.5131	0.5194	0.5162	0.5194	0.5143	0.5199
LCI	0.5105	0.5182	0.5146	0.5186	0.5118	0.5188
x	19.5		12.1		17.0	
p	<0.0001		0.0005		<0.0001	

	Croatia		Serbia and Montenegro		Macedonia	
	1991-95	**1996-2000**	**1991-95**	**1996-2000**	**1991-95**	**1996-2000**
M	126599	126258	291177	336144	86119	76322
F	119501	119047	268760	311232	79964	70420
Total	246100	245305	559937	647376	166083	146742
UCI	0.5164	0.5167	0.5213	0.5205	0.5209	0.5227
M/F	0.5144	0.5147	0.5200	0.5192	0.5185	0.5201
LCI	0.5124	0.5127	0.5187	0.5180	0.5161	0.5176
x	0.7		0.7		0.8	
p	NS		NS		NS	

	Korean War-US		Gulf War-US		Invasion of Iraq-US	
	1950-53	**1954-8**	**1990-91**	**1985-89 plus 1992-96**	**2003**	**1998-02 plus 2004-08**
M	7719635	10598881	4231013	20016300	2093535	21025269
F	7334470	10087462	4038106	19069774	1996415	20062057
Total	15054105	20686343	8269119	39086074	4089950	41087326
UCI	0.5130	0.5126	0.5120	0.5123	0.5124	0.5119
M/F	0.5128	0.5124	0.5117	0.5121	0.5119	0.5117
LCI	0.5125	0.5121	0.5113	0.5120	0.5114	0.5116
x	6.5		5.4		0.3	
p	0.011		0.020		0.6	

M/F in Portugal in 1974 dipped significantly during the Portuguese Colonial War.

In the countries that comprise the Southern Caucasus region of the former USSR, M/F continued at the baseline level. Indeed, there was no significant difference in M/F for the period 1986-1990 vs. 1991-2 (Armenia: chi-square=2.4, p=0.1; Azerbaijan: chi-square=0.04, p=0.8; Georgia: chi-square=0.5, p=0.5). M/F rose significantly for all three countries after cessation of hostilities (Armenia, chi-square for trend=118.7, p<0.0001; Azerbaijan, chi-square for trend=382.4, p<0.0001; Georgia, chi-square for trend=116.0, p<0.0001).

There was no significant effect on M/F in Greece following the Turkish invasion of Cyprus and on England and Argentina in the Falkland War. There was also no effect on M/F in Serbia and Montenegro, Croatia and Macedonia for the years comprising the Yugoslavian wars (1991-5).

4. DISCUSSION

The increase in M/F due to long duration warfare (such as during the First and Second World War) has been attributed to coital frequency. In times of war, an adult sex ratio imbalance prevails, with more males being away from their partners. It has been mooted that during wartime, non programmed copulation and high coital rates co-exist, with more conceptions occurring early or late in menstrual cycle, increasing M/F [22].

The wartime rise in M/F has been ascribed to M/F variations in the primary sex ratio (the sex ratio at conception) that occur due to timing of conception within the menstrual cycle. This is because M/F follows a U-shaped regression on cycle day of insemination, with female conceptions resulting more often from conceptions around ovulation, and male conceptions occurring more frequently at the beginning and end of the menstrual cycle [23,24].

Increased sexual activity has been mathematically shown to increase the likelihood of conception early in the menstrual cycle [25]. If it is assumed, *ex hypothesi*, that demobilization leaves and short wartime leaves result in higher levels of coitus, then conceptions earlier in the menstrual cycle are likelier to occur, skewing M/F toward male births.

However, wars also generate stress, which in turn has been shown to decrease M/F. Indeed, the effects of general stress in the absence of warfare were elegantly demonstrated in relation to the severe economic downturn that engulfed Eastern Germany after Germany's reunification in 1991, significantly dropping M/F [3].

M/F did not change in some of the countries involved in the conflicts studied in this paper. This may have been due to a type 2 error since M/F changes may short and transient, as was shown in Slovenia using monthly analysis of M/F [4]. However, such an analysis could not be done in this study as only annual data was available. This may explain the lack in significant M/F change in the Balkan countries analysed in this paper for the period encompassing the wars in Yugoslavia.

The unavailability of monthly data is an important limitation for the analysis of short conflicts as it has been shown that psychological stress related to the 10-Day Balkan War in Slovenia (26 June-7 July, 1991) not only reduced sperm motility, but also reduced M/F in Croatia, when data (not available in this study) was analysed by month. The M/F decline was tentatively attributed to changes in sperm motility [4]. M/F also declined in Iran and Iraq during the Iran-Iraq War of 1980–88 [26].

When substantial proportions of the populace are in the armed forces (15-22% in the principally affected European countries during the Second World War), significant M/F shifts were noted. Conversely, M/F shifts were trivial or non-existent in neutral countries or those wherein the general population involvement in conflicts was minimal [27]. The negative findings shown in this study in relation to the Turkish invasion of Cyprus and the Falkland War may therefore potentially be explained by the small population proportion involved in the conflicts.

Interestingly, a study based on a sample of 21000 births in the United States and Canada born between 1940 and 1980 confirmed that M/F increased in the Second World War, and indicated that M/F increased in the Korean and Vietnam Wars [28]. M/F in Canada showed a pattern similar to that depicted in Fig. 1 despite the fact that this country was not a belligerent in this conflict [28]. A facile explanation for this phenomenon is not available.

Between the Korean War's outbreak in June 1950 and the armistice agreement in 1953, Selective Service inducted over 1.5 million men in the US [29]. Another 1.3 million Americans volunteered [30]. Based on the 1950 US Census which estimated the resident population of the United States at 150697361 this represented just 1.7% of the population [31].

This study confirmed that M/F was higher in the United States during the Korean conflict but it is possible that the observed high M/F was merely an extension of the rise that has been previously documented for the Second World War [14].

Vietnam Veterans represented 9.7% of their generation [32]. A total of 2761350 individuals were drafted between 1956 and 1973, [30] and based on the United States 1970 Census (total population 203302031),[33] this represented just 1.4% of the total population.

The M/F fluctuations noted in the United States during its conflicts confirms previous findings. Conflicts of long duration tend to elevate M/F, as seen during the Vietnam conflict. However, during short conflicts, no such effects (or even opposite effects) are witnessed. This is particularly the case when a small fraction of the population is involved in active warfare.

Interestingly, an extended M/F decline was noted in this country after the Vietnam War, and this had led to the proposal that M/F might be used as a sentinel health indicator [34]. However, this decline (or parts thereof) may simply have been due to a natural reduction of M/F to the country's lower, non-warfare baseline.

The apparent drop in M/F in countries comprising the Southern Caucasus is misleading as in fact, M/F in these countries rose almost continually (to the end of the 20th century) after the wars in South Ossetia and Abkhazia. This is in keeping with findings from Asia [35]. Indeed, in the Caucasus, it has been proposed that the increase in M/F that is also noted in this study comprises part of the overall trend that utilises sex-selective abortions to increase male offspring in Asia [36].

Psychological stress may have influenced Portugal's decline in M/F in that the Portuguese Colonial War ended the so-called "Carnation Revolution" on the 25 April 1974. The year was characterised by a popular campaign of civil resistance culminating in a military coup [37]. Privation of any kind has also been shown to decrease M/F, and any reduction in caloric availability per capita correlates negatively with M/F [38]. Indeed, 1974 exhibits the second lowest M/F (0.51205) in the Portuguese dataset for the period available (1950-2009). A combination of stress and privation may have been responsible for the fall in M/F in 1974.

Unfortunately, this study only had access to male and female births. The effects of other factors that are known to impact on M/F, such as caloric availability, was not available for analysis, and this is an unavoidable limitation to this paper.

Two hypotheses other than the earlier menstrual cycle conception theory have been proposed as possible explanations for the overall M/F rise associated with lengthy periods of warfare.

The "more quickly fertile parents" theory hypothesises that couples who conceive quickly generally produce offspring with a higher M/F. Such couples are likelier to conceive in the short leaves that returning soldiers have during wartime [13].

Moreover, a "returning soldier effect" has been noted in that service records for British soldiers in the First World War show that survivors were, on average, 3.3cm taller than their fallen comrades [39]. Since taller parents tend to have a higher M/F, [40] it has been estimated that this phenomenon suffices more than twice over to account for M/F rise in the UK during and after the First World War [39].

It is unlikely that the temporal changes described in this study are due to the known cyclic temporal variations in M/F since such shifts are gradual and based over decades [19].

Due to the restricted numbers of births studied in each conflict, this study has limited power in detecting changes relating to events such as conflicts. This is an unavoidable potential source of type 2 error and has been acknowledged in most studies relating to M/F. This limitation has been amplified in three important publications relating to M/F [41-43]. The potential levels of error, based on the number of births studied, are shown numerically in Table 3 and graphically Fig. 2.

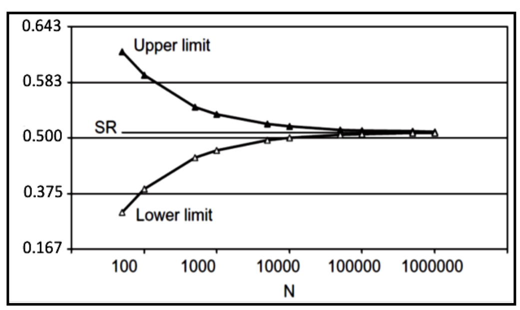

Fig. 2. Confidence interval for M/F by sample size (N) on a logarithmic scale. SR denotes 0.515, the conventionally expected value for M/F (modified from Fellman and Eriksson, 2011) [43]

Table 3. The 95% confidence limits for some sex ratios at birth in the usual range with specified numbers of observed births (modified from Visaria, 1967) [41]

The number of observed births	The 95% confidence limits for an observed sex ratio at birth of			
	0.5098	**0.5122**	**0.5146**	**0.5169**
100	0.4118-0.6078	0.4142-0.6101	0.4166-0.6126	0.4189-0.6149
1000	0.4789-0.5409	0.4811-0.5432	0.4906-0.5455	0.4859-0.5479
10000	0.5-0.5197	0.5022-0.522	0.5047-0.5243	0.5071-0.5267
100000	0.5067-0.5129	0.5091-0.5153	0.5115-0.5176	0.5139-0.5199
1000000	0.5088-0.5108	0.511-0.5134	0.5134-0.5155	0.516-0.5178

5. CONCLUSION

In conclusion, even relatively minor conflicts may affect M/F, albeit not at consistent high levels.

CONSENT

Not applicable.

ETHICAL APPROVAL

Not applicable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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