Two World Wars and Belgium: Missing Births and Birth Sex Ratio Changes

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ABSTRACT

Introduction: The sex ratio at birth (male/total births, M/T) is expected to approximate 0.515. M/T is influenced by many factors including stress. Both World Wars have been implicated as influencing birth rates and M/T. This study was carried out to analyse the effects of two World Wars on Belgium vis-à-vis missing births as well as M/T changes.

Methods: Belgian male and female births were available for 1830–2019 and annual population was available from Statista. ARIMA models were used to estimate and project birth losses. The effect of wars was assumed to begin in the years following the commencement of each war and extend to the year after cessation of hostilities i.e., 1915–1919 and 1940–1946 for the First and Second World Wars respectively.

Results: This study included 27,346,178 live births for 1830–2019, M/T 0.5124. There was a decreasing trend in births for 1830–2019, significant for 1950–2019. There were dips in births in association with both Wars resulting in over 440,000 missing births, 3.80% of the Belgian population for the First World War and 1.91% for the Second World War. M/T rose non-significantly for the First World War and significantly for the Second World War.

Discussion: The declining birth rate and M/T in developed countries is a recognised phenomenon. The missing births in relation to wars are of demographic importance but are often overlooked with emphasis usually on casualties and deaths. M/T may rise in wars, possibly due to increased coital activity as well as other factors.

KEYWORDS

humans; sex ratio; Belgium; World War I.; World War II.; live birth

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WHAT IS ALREADY KNOWN

The sex ratio at birth (male/total births, M/T) approximates 0.515 and is affected by many factors.
Stress has been implicated as influencing birth numbers and sex ratios at birth.
Both World Wars have been implicated as influencing birth rates and M/T.

WHAT THIS STUDY ADDS

This study (27,346,178 live births) showed a decline in births (1830–2019) and in M/T (1950–2019) in Belgium.

There were >440,000 war-related missing births, equivalent to 3.80% of the population for WW1 and 1.91% for WW2.

M/T rose non-significantly for WW1, significantly for WW2.

INTRODUCTION

The sex ratio at birth (male/total births, M/T) is expected to approximate 0.515 (2). M/T is influenced by many factors, and these include stress (3). All manner of stressful events have been implicated in reducing M/T, and these include natural disasters such as smog, flooding and earthquakes (4, 5) and after man-made tragedies such as the September 11 attacks (6) and other terrorist events (7), as well as acute followed by chronic starvation and privation (8). Chronic stress has also been implicated in chronically reducing M/T in socioeconomically deprived groups (9). On the other hand, radiation has been shown to elevate M/T, the only known stressor to do so (10, 11).

Both World Wars have also been implicated as influencing birth rates and M/T (12). This study was carried out to analyse the effects of two World Wars on Belgium vis-à-vis missing births as well as birth sex ratio changes in relation to both wars.

METHODS

Ethical approval was not applied for as these are anonymous and freely available datasets from Statbel, the Belgian statistical office, for the period 1830–2019 (1). Belgium's annual population was available from Statista (13). To estimate and project birth losses at which significant deviations from the time series trend in total births per year, the current study relied on ARIMA models (see Appendix) (14, 15).

The two World Wars encompassed 1914–1918 and 1939–1945. As a result, the effect of these wars on birth numbers and M/T was assumed to begin in the years following the commencement of each war and extend to the year after cessation of hostilities i.e., 1915–1919 and 1940–1946 for the First and Second World Wars respectively. An ARIMA model was fitted to the M/T ratio from 1901 to 2019 excluding war years. The fitted model predicted the mean value for WW1 and WW2 respectively. One sample Wilcoxon signed rank test was used to test whether, during these two war periods, the observed M/T diverged from their predicted mean. A p value of ≤ 0.05 was taken to represent a statistically significant result.

RESULTS

This study included 27,346,178 live births over the period 1830–2019 (14,011,806 males, 13,334,372 females, M/T of 0.5124 (95% confidence intervals CI: 0.5122–0.5126). There was a decreasing trend in births for 1830–2019 (Figure 1). A significant decline was noted for the period 1950–2019 (Table 1).

Tab. 1 Tests on M/T ratio

Year	M/T Mean	One Sample t-test (p value)
1830–2019	0.5124	0.285
1950–2019	0.5124	0.003
Year	**M/T Predicted Mean**	**Wilcoxon signed rank test (p value)**
1915–1915	0.50979	0.075
1940–1946	0.51143	0.018

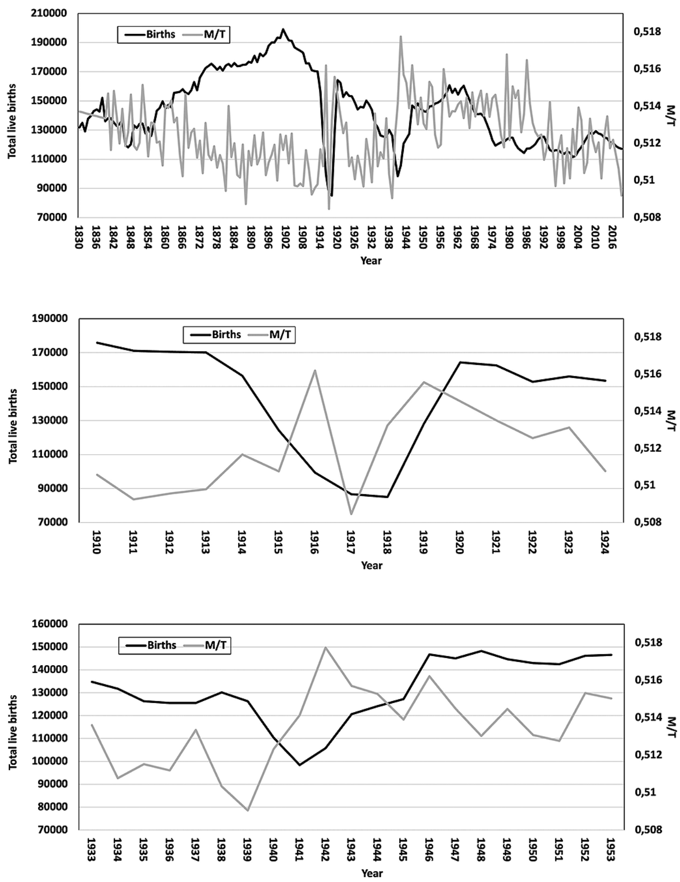

Fig. 1 Total births and MT for Belgium, 1830–2019 (top), World War 1 and adjacent years (middle), World War 2 and adjacent years (bottom).

Births increased till the end of the 19th century, then decreased thereafter (Figure 1 top panel). There were dips in births in association with both World Wars (Figure 1). An ARIMA (0, 1, 3) model was fitted to births over the period 1901–1938, a period that ends to just before the Second World War (Table 2). The years comprising the First World War were excluded, so the years included in the time series model were 1901–1913 and 1920–1938. The expected live births were described by the equation resulting in a significant decline:

$$\textit{Expected births}_t = -0.3832\epsilon_{t-1} - 0.0306\epsilon_{t-2} - 0.5862\epsilon_{t-3} - 2228.87 \quad (1)$$

To capture the effect of the second world war, an ARIMA model was fitted to total births over the period 1901–2019, where both the First World War and the Second World War were excluded (Table 2). Hence, the years included in the time series model were 1901–1913, 1920–1938, 1946–2019. The expected live births were described by the equation:

$$\textit{Expected births}_t = 0.2867\epsilon_{t-1} + 0.3677\epsilon_{t-2}. \quad (2)$$

The model fit showed the year 1946 was marked as a significant level shift outliers respectively ($p < 0.0001$) indicating that dip in the Second World War started to recover before the end of the war.

Tab. 2 ARIMA model

Arima model for births – 1901–1938 – ARIMA (0, 1, 3)			
	Coefficients	**T-Stat**	**P[|T| > t]**
Theta (1)	-0.3832	-2.11	0.044
Theta (2)	-0.0306	-0.17	0.8696
Theta (3)	-0.5862	-3.2	0.0035
mu	-2228.87	-20.68	0.0000
Arima model for births – 1901–2019 – ARIMA (0, 1, 2)			
Theta (1)	0.3982	3.43	0.001
Theta (2)	0.3081	2.68	0.0093
Arima model for M/T – 1901–2019 – ARIMA (0, 1, 1)			
Theta (1)	0.8087	-13.95	0.0000

Based on these equations, observed, and expected values of births over the two war periods are shown in Table 3 and Figure 2. There were over 440,000 missing births. These equated to 3.80% of the population for the First World War (total population 7,510,000) and 1.91% of the total population for the Second World War (total population 8,280,000).

M/T was modelled by the ARIMA (0.1,1) model as described:

$$\textit{Expected M/T}_t = -0.8087\epsilon_{t-1}. \quad (3)$$

Tab. 3 Observed vs expected values for births after model fit

Year	Observed	Expected	Difference
1914	156,389	170,807	14,418
1915	124,291	168,650	44,359
1916	99,360	167,439	68,079
1917	86,675	165,326	78,651
1918	85,056	165,209	80,153
Total WW1	**551,771**	**837,431**	**285,660**
1939	126,257	134,771	8,514
1940	110,323	136,094	25,771
1941	98,417	137,418	39,001
1942	105,749	138,742	32,993
1943	120,665	140,066	19,401
1944	124,075	141,390	17,315
1945	127,245	142,714	15,469
Total WW11	**812,731**	**971,195**	**158,464**

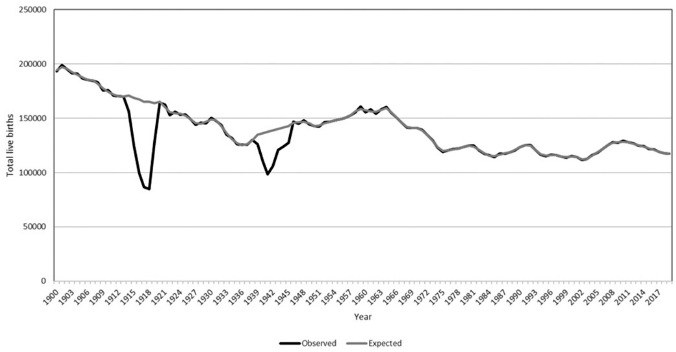

Fig. 2 Total births Belgium, 1900–2019 – Observed against expected values following ARIMA model fit.

The predicted mean value for the first world war was 0.50979, while that for the second world war was 0.51143 (Table 1). M/T rose significantly for the Second World War (Table 1).

DISCUSSION

The declining birth rate in developed countries in association with a decline in M/T is a recognised phenomenon commencing from around the second half of the 20th century (16).

War is cruel and typically targets not only the armed forces, but also civilians of belligerent, and sometimes even non-belligerent countries, including women and children (17). Births of many European countries plummeted drastically during the First World War, by up to 50% in some countries (18). The Belgian army was comprised of about 130,000 soldiers (19), and around 40,000 died (19), but this is far less than the estimated missing births. On the other hand, the Belgian army in the early part of the Second World War was around 650,000 (20), and circa 88,000 soldiers died (21), a much large value than the estimated missing births.

It is difficult to ascertain why the proportions are different and two factors may have played parts: the higher proportion of deaths in the first war or a smaller effect on births in the second war. These missing births are of demographic importance but are often overlooked and frequently, only casualties and deaths arising from these wars are given import.

The effects of stress on both birth rate and M/T are recognised, and the cause is often ascribed to the Trivers-Willard hypothesis of parental periconceptual and pregnancy condition (22). This avers that a male who reaches reproductive age in good mating condition is expected to out-reproduce a female in good 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 mating rights, thus producing no or fewer offspring than a weak female daughter would. This implies that evolution has developed processes whereby pregnant females subjected to environmental stressors bias M/F by culling male fetuses that are least likely to eventually yield grandchildren. Males are specifically selected for spontaneous abortion as a live born male in poor condition is likelier to die before reaching reproductive age than a female in similar condition (22).

An oft quoted example is China's "Great Leap Forward", a socio-economic campaign waged by the Chinese Communist Party from 1958 to 1962 to rapidly convert the country from an agrarian economy into a manufacturing society which led to widespread famine and death (23). The famine was associated with a decline in births and M/T from April 1960 to October 1963 (circa 2 years after the famine ended) followed by a rise between October 1963 – July 1965 (8). This was associated with an estimated 18,286,000 fewer births in 1959–61 than anticipated, tantamount to a total birth deficit of circa 301.7 per 1000 with an additional male deficit of 3.2 per 1000 (24).

With regard to warfare, the situation is different, with declines in births often associated with a rise in M/T. It has been noted that the First World War led to M/T increases in belligerent countries, a rise that was not present in neutral countries (25), or in the United States (26). The post-war period was characterized by great instability and lead to the Great Depression through the 1920s, with the prospect of another World War, and both factors may have contributed to a decline in births after the war (27). Belgium played a crucial role in the war's early stages as Germany violated Belgium's neutrality to quickly defeat France. The Belgian army resisted but failed against overwhelming odds. The atrocities committed by German occupying forces in Belgium, including civilian massacres and the destruction of entire towns, shocked the world and fuelled anti-German sentiment. The Battle of Ypres in Belgium, was particularly significant with the first ever delivery of poison gas on large scale, with devastating consequences. The Western Front in Belgium was characterized by entrenched stalemates and brutal trench warfare. The war had a profound impact on the country with causing widespread destruction, loss of life, and economic hardship and enduring legacy of geopolitical changes while setting the stage for the next World War. Belgium, like many other nations, faced significant post-war challenges, including reconstruction while grappling with the traumatic aftermaths of the conflict (28).

Similarly, in the Second World War, M/T rose in the United States, Canada, England and Wales (29), and Germany (30). A particular study claimed that additional European countries (including Belgium) also experienced M/T rises using pooled data but this study used datasets that temporally extended well beyond the war years (31). This has been criticised as while the power of the study increases by the inclusion of great numbers of births, bias may be introduced by the known secular variations of M/T over the decades. For this reason, wartime M/T should be contrasted with adjacent years. Moreover, some recent studies have not only failed to demonstrate a rise in M/T (32), but also displayed a fall in M/T (33).

In the Second World War, Belgium found itself once more in the midst of conflict. In 1940, a German Blitzkrieg swiftly invaded Belgium with an occupation that lasted until 1944, leading to the country experiencing hardships and resistance activities. The Battle of the Bulge in 1944 was a significant episode on the Western Front where Belgium witnessed intense fighting as the Allies countered a major last-ditch German offensive. The Ardennes became a focal point, with the Allies ultimately repulsing German forces. Post-war Belgium, like other European nations, faced reconstruction challenges having to deal with physical and economic devastation, loss of life, and the enduring memory of occupation (21).

A potential mechanism for a rise in M/T in wartime is the theory that there is increased coital activity in such periods (e.g., soldiers returning on brief periods of leave from the front) (34). Since the regression of M/T on time of insemination within the menstrual cycle is reportedly U-shaped, with more males conceived at the beginning and end of the cycle, this skews M/T toward a higher male proportion (34). However, the entire area of M/T scholarship remains challenging in that even basic foundations of studies in this field such as the Trivers-Willard hypothesis of parental periconceptual and pregnancy condition (22) are regularly cast in doubt (35). There may even be innate racial differences that complicate such studies (36).

It is worth noting that over the time periods studied, there has been a drastic overall global reduction in fertility rates and in neonatal, infant and childhood mortality, due to societal changes and medical advances which may also have influenced birth rates and M/T ratios (37,38). And finally, these influences are as nothing when compared with the role of femicide in male offspring preference with tens of millions of missing women (39, 40).

SUMMARY

Both World Wars have been implicated as influencing birth rates and M/T. In Belgium, the wars resulted in >440,000war-related missing births, equivalent to 3.80% of the population for WW1 and 1.91% for WW2.

Furthermore, M/T rose non-significantly for WW1 and significantly for WW2.

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APPENDIX

ARIMA MODEL

The ARIMA model can be described as the combination of AR(p), I(d) and MA(q) models as follows (15):

$$\text{ARIMA} = (\mathbf{p}, \mathbf{d}, \mathbf{q}) \tag{3}$$

Where
p is the order of the Auto Regressive (AR) model
q is the order of the Moving Average (MA) model
d is the order of differencing to make the series stationary

In more Greek terms, the Auto-regressive process of order p denoted as AR(p), is described by the following equation:

$$y_t = \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + \cdots \varphi_p y_{t-p} + \epsilon_t \tag{4}$$

Where

ϵ_t is white noise $\epsilon_t \sim N(0,\sigma^2)$

The moving average of order q, denoted as MA(q) is described by the following equation:

$$y_t = \theta_1 \epsilon_{t-1} + \theta_2 \epsilon_{t-2} + \cdots \theta_q \epsilon_{t-q} + \epsilon_t \tag{5}$$

Where

ϵ_t is white noise $\epsilon_t \sim N(0,\sigma^2)$

Difference used to make the series stationary of order d, denoted by I(d) is described by

$$(1 - B)^d y_t = \epsilon_t \tag{6}$$