



Original Article

Secular trends and latitude gradients in sex ratio at birth in Asia during the past 60 years

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Abstract *Background:* Latitude gradients and secular trends in Europe and North America have been found in the male–female ratio at birth (M/F: male births divided by total births), which is anticipated to approximate 0.515. *Methods:* Annual national data for Asian countries for male and female live births were obtained from the World Health Organization and analyzed with contingency tables. *Results:* A total of 245 938 211 live births were analyzed. An overall increasing trend in M/F was found ($P < 0.0001$). A latitude gradient was also noted, with more boys being born in southern, warmer latitudes ($P < 0.0001$). There was an overall deficit of 1 351 757 male births based on an anticipated M/F of approximately 0.515. *Conclusion:* M/F is increasing overall in Asia, unlike the decline previously noted in Europe and North America. Moreover, it had been shown that there is a higher incidence of male births in southern Europe than in the north, with the opposite gradient in North America. This paper shows that M/F latitude gradients in Asia are in keeping with those of Europe. The overall M/F in Asia may be rising due to improving socioeconomic conditions, and the interplay of several poorly understood factors is likely.

Key words Asia, birth rate, infant, newborn, sex ratio, Southeastern Far East, trends.

Gender is determined at conception in mammals, and male births occur slightly in excess.¹ The male to female ratio of live births is expressed as the ratio of male live births divided by total live births (M/F), and for humans this is expected to approximate 0.515.¹ The reason for this discrepancy is uncertain but a plethora of factors have been proposed.² Indeed, the study of M/F has become a subspecialty in its own right, with numerous and ongoing studies in this field. Findings from this research may be relevant in a wider sense because M/F has been proposed to function as a surrogate health indicator, as will be outlined.³

Latitude variation in M/F

M/F varies in geographical space, with a latitude gradient that is different in Europe and North America. More boys are born towards the south of Europe, in contrast with the North American continent, where more boys are born towards the north of that continent.^{4,5}

Secular variation in M/F

Several studies have also shown that M/F varies in temporal fashion, mostly declining in the aforementioned two continents.⁶

This study identifies secular trends in M/F in Asia from a World Health Organization (WHO) dataset that includes the past 60 years. Secular trends and trends by geographical latitude are

also analyzed. The null hypothesis is that there were no significant geographical or secular differences in M/F.

Methods

Data sources

Annual male and female live births were obtained directly from WHO. Asia is conventionally divided into the low latitudes (0–23°N), the middle latitudes (24°N–40°N) and the high latitudes ($\geq 41^\circ\text{N}$), and this categorization was applied.

Statistics

Excel was used for data entry, overall analysis and charting. The quadratic equations of Fleiss were used for exact calculation of 95% confidence intervals for ratios.⁷ Chi-squared tests and chi-squared tests for trends for annual male and female births were used throughout. Statistical significance was set at $P \leq 0.05$.

Results

There were 245 938 211 live births available for analysis.

Secular trends

Five year total live births and sex ratios at birth, in 5 year intervals, are listed in Table 1. There have been significant increases and also decreases in M/F in different countries (Table 2), as well as in available births by year for each country.

An overall increasing trend in M/F was found in all regions ($P < 0.0001$; Table 3).

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Table 1 Five year total live births and sex ratios at birth

	Year	1950–54	1955–59	1960–64	1965–69	1970–74	1975–79	1980–84	1985–89	1990–94	1995–99	2000–04	2005–09	Total
0–23°N Singapore, Thailand, Philippines, Hong Kong, Sri Lanka	M	4 184 253	4 599 757	5 960 918	6 586 973	6 483 922	7 424 128	8 189 666	2 367 096	312 951	274 482	234 258	288 232	46 906 636
	F	3 862 670	4 206 522	5 466 644	6 105 124	6 008 666	6 964 218	7 780 775	2 255 313	292 115	254 278	217 190	260 832	43 674 347
	Total	8 046 923	8 806 279	11 427 562	12 692 097	12 492 588	14 388 346	15 970 441	4 622 409	605 066	528 760	451 448	549 064	90 580 983
	UCI	0.52033	0.52266	0.52192	0.51926	0.51930	0.51624	0.51305	0.51255	0.51848	0.52045	0.52036	0.52627	0.51794
	M/F	0.51998	0.52233	0.52163	0.51898	0.51902	0.51598	0.51280	0.51209	0.51722	0.51911	0.51890	0.52495	0.51784
	LCI	0.51964	0.52200	0.52134	0.51871	0.51874	0.51572	0.51256	0.51164	0.51596	0.51776	0.51744	0.52363	0.51774
24°N–40°N South Korea and Japan	M	5 194 549	4 235 529	4 211 114	4 558 468	5 194 359	4 551 335	3 915 672	5 217 454	5 018 513	4 824 982	4 340 219	3 234 836	54 497 030
	F	4 923 429	4 006 711	3 979 197	4 283 299	4 873 524	4 289 047	3 704 531	4 883 652	4 604 455	4 497 248	4 067 332	3 060 953	51 173 378
	Total	10 117 978	8 242 240	8 190 311	8 841 767	10 067 883	8 840 382	7 620 203	10 101 106	9 622 968	9 322 230	8 407 551	6 295 789	105 670 408
	UCI	0.51371	0.51422	0.51450	0.51589	0.51624	0.51516	0.51421	0.51683	0.52183	0.51790	0.51657	0.51420	0.51582
	M/F	0.51340	0.51388	0.51416	0.51556	0.51593	0.51483	0.51385	0.51652	0.52151	0.51758	0.51623	0.51381	0.51573
	LCI	0.51309	0.51354	0.51382	0.51523	0.51562	0.51451	0.51350	0.51621	0.52120	0.51726	0.51589	0.51342	0.51563
41°N–82°N Russian Federation	M													
	F													
	Total													
	UCI													
	M/F													
	LCI													
	M													
	F													
	Total													
	UCI													
	M/F													
	LCI													

LCI, lower confidence interval; M/F, male births divided by total births; UCI, upper confidence interval.

Table 2 Temporal trend vs latitude in M/F for Asian countries

	Country	Years	Total boys	Total girls	χ^2 trend	<i>P</i>	M/F	Overall trend
0–23°N	Singapore	1950–2009	1 478 771	1 384 428	1.3	0.262	0.51648	NS
	Thailand	1950–88	19 677 284	18 213 388	1960.4	<0.0001	0.51932	Decreasing
	Philippines	1950–84	18 026 727	16 702 669	88.7	<0.0001	0.51906	Decreasing
	Hong Kong	1960–09	1 982 156	1 845 191	14.6	<0.0001	0.51789	Increasing
	Sri Lanka	1950–71, 1977–86	5 741 698	5 528 671	4.1	0.044	0.50945	Increasing
24°N–40°N	South Korea	1985–2006	7 270 392	6 555 126	147.0	<0.0001	0.52587	Increasing
	Japan	1950–2009	47 226 638	44 618 252	15.6	<0.0001	0.51420	Decreasing
41°N–82°N	Russian Federation	1980–2009	27 226 408	25 784 064	107.7	<0.0001	0.51360	Increasing

M/F, male births divided by total births.

Latitude gradients

A clear latitude gradient for M/F is seen in Table 3, which is highly significant (chi-squared test for trend: 8399, $P < 0.0001$). More boys are born at southern, warmer latitudes.

There was an overall deficit of 1 351 757 male births based on an anticipated M/F of approximately 0.515.

Discussion

Latitude variation in M/F

M/F exhibits a variable latitude gradient. More boys are born towards the south of Europe while more boys are born toward the north of the North American continent.^{4,5,8} The present Asian dataset supports the former latitude gradient, with more boys born at the southern and warmer latitudes.

Secular variation in M/F

M/F has been shown to be declining in Europe and in North America,⁶ but these Asian results show the converse, with a temporally increasing M/F. Studies that have analyzed data from before 1950 have noted generally increasing trends in M/F before this period, with a decreasing trend thereafter,⁹ but these data were not available for analysis from the available data source.

M/F declines when adverse environmental factors are present. It has been shown, for example, that M/F declines after traumatic events such as after warfare,¹⁰ earthquakes,¹¹ and a miscellanea of environmental disasters.¹² Such events appear to encourage stressed females to spontaneously abort male fetuses in excess of female fetuses.¹³ And it is for this reason that M/F has been proposed as a surrogate sentinel health indicator.³

It may well be for a similar reason that societies that are socioeconomically contracting also exhibit a decline in M/F.¹⁴ Conversely, it has been shown that caloric availability per capita correlates positively with M/F.¹⁵ Moreover, in countries with good standards of antenatal care, such as in developed countries,

wherein prenatal losses are low, M/F tends to be increased, with the converse finding, a lowering of M/F in areas of lower health and antenatal care standards.¹⁶

Asian economies are generally in expansion and these macroeconomic circumstances may explain, in part or in whole, the observed overall rise in M/F. But even as early as 1967, data on fetal mortality rates only weakly supported this hypothesis, leading to the conclusion that there may be inherent racial differences that may influence M/F.¹⁷ If economic and health status play a significant role in M/F, varying rates of implementation of socioeconomic and health improvements across different countries in this region may also have played a role in the latitude gradient noted.

James has suggested a 30 year M/F cycle, with a homeostatic mechanism that negatively correlates M/F with the adult sex ratio at the time of conception.¹⁸ The Asian data may partially support this hypothesis only for countries in latitudes 0–23°N, because these exhibit a peak of 0.52233 in 1955–59, dipping to 0.51209 in 1985–89 (20 years later), and rising to 0.52495 in 2005–09 (Table 1). No evident peaks are noted for the other regions.

Conclusion

While this study further extends understanding of M/F gradients with latitude, several factors may be interacting to not only produce these gradients, but also to produce differing secular trends in M/F, with, on the one hand, more boys born in cooler latitudes in North America, while more boys are born in warmer latitudes in Asia and Europe. In Asia, these trends produce significant demographic shifts, resulting in a male excess of 1 351 757 births over the period studied.

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Table 3 Summary statistics and significance testing

	Total boys	Total girls	χ^2 trend	<i>P</i>	UCI	M/F	LCI	Overall trend
0–23°N	46 906 636	43 674 347	291.7	<0.0001	0.51794	0.51784	0.51774	Increasing
24°N–40°N	51 173 378	51 173 378	187.9	<0.0001	0.51582	0.51573	0.51563	Increasing
41°N–82°N	27 226 408	25 784 064	107.7	<0.0001	0.51374	0.51360	0.51347	Increasing

LCI, lower confidence interval; M/F, male births divided by total births; UCI, upper confidence interval.

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