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Correlation of sex ratio at birth with health and socioeconomic indicators

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ABSTRACT

Introduction: The sex ratio at birth (male divided by total live births: M/T) has been mooted as a potential sentinel health indicator. Several metrics indicate individual countries' health and socioeconomic status. In this study, in all available countries (where such data was accessible), M/T and these indicators were compared in order to ascertain whether better (vis-à-vis health and socioeconomic status) levels of these indicators were associated with higher M/T in available countries.

Methods: The following were obtained (by country) from various sources: M/T, 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). Pearson correlation was performed comparing M/T and these indicators.

Results: Despite weak correlation values, all except for the Human Development Index (HDI) correlated with M/T at statistically significant levels.

Discussion: A decrease in mortality and an increase in life expectancy and GDP/capita are indicators of socioeconomic wellbeing. In this study, mortality was negatively correlated with M/T. Life expectancy and GDP/capita were both positively correlated with M/T, indicating that M/T may also serve as a surrogate health indicator, and incidentally, also supporting the Trivers-Willard hypothesis. Improving economies lead to increasing education, which in turns tends to lower fertility rate in association with a declining M/T. In conclusion, the global correlation of health and socioeconomic indicators with M/T suggests that M/T may be a useful sentinel health indicator.

1. Introduction

The sex ratio at birth (male divided by total live births: M/T) has been mooted as a potential sentinel health indicator [1], with possible public health implications since shifts in M/T may indicate significant impacts on populations [2]. Events that lead to such changes may be temporally both acute and transient, or chronic and long-lasting [3]. Such events may be both natural (such as seasonal variations [4,5] or man-made [3].

There is some evidence that M/T may act as a sentinel public health indicator [2]. For example, a South African study showed that over the years 2003–2010, M/T was significantly positively correlated with life expectancy and significantly negatively correlated with infant mortality, under 5 year mortality and total fertility rate [6]. Thus, not only a fall but also a rise in M/T that has shown to have occurred in association with health improvements also supports the contention that M/T may serve as a public health indicator.

Several metrics indicate individual countries' health and socioeconomic status, and these are listed in Table 1 along with their definitions. In this study, in all available countries (where such data was accessible) M/T and these indicators were compared in order to ascertain whether better (vis-à-vis health and socioeconomic status) levels of these indicators were associated with higher M/T in available countries.

2. Methods

2.1. Data sources

The following were obtained (by country) from various sources. M/T, infant mortality rate, fertility rate, human development index and gross domestic product per capita for 2016 were obtained from the website of the Central Intelligence Agency Worldfact Book [7]. Under 5 years mortality rate for 2016was obtained from the website of the World Bank [8].

Life expectancy for both sexes, females, males, as well as both sexes Health Adjusted Life Expectancy (HALE), were obtained from the website of the World Health Organization (2015 data published in 2016) [9].

These are available as a supplementary dataset.

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Table 1
Indicators used in this study for the assessment of a country's health and general socioeconomic status.

Indicator	Definition
Infant mortality rate	The number of deaths of children under one year of age per 1000 live births, in a given year.
Under 5 years mortality rate	The number of children who die by the age of five, per thousand live births per year.
Both sexes life expectancy at birth	The average number of years that a newborn could expect to live if he or she were to pass through life subject to the age-specific mortality rates of a given period.
Female life expectancy	As above, female only.
Male life expectancy	As above, male only.
Both sexes HALE	Health Adjusted Life Expectancy (HALE) is a measure of population health that takes into account mortality and morbidity by adjusting overall life expectancy by the amount of time lived in less than perfect health.
GDP/capita	Divides a country's gross domestic product by its total population, making this the best measurement of a country's standard of living.
Total fertility rate	The number of children who would be born per woman if she were to pass through the childbearing years bearing children according to a current schedule of age-specific fertility rates.
Human development index (HDI)	HDI is a composite index of life expectancy, education, and per capita income indicators, which are used to rank countries into four tiers of human development. HDI rises with increasing lifespan, education level and GDP/capita.

Table 2
Summary statistics for M/T for 223 available countries.

n	223
Mean	0.5120
Median	0.5122
Standard deviation	0.007
Minimum	0.4535
Maximum	0.5575
Confidence level (95.0%)	0.0009

2.2. Analysis

For all of the abovementioned metrics, indicators available for each country were paired in a bespoke spreadsheet, where such indicators were available (indicators were missing for a few countries despite availability of M/T for said country but this comprised < 2% for total missing data). Pearson correlation was then performed comparing M/T and these indicators.

3. Results

M/T summary statistics are shown in Table 2. Table 3 displays correlation of M/T with the abovementioned health and socioeconomic indicators. Despite weak correlation values (r^2), all except for the Human Development Index (HDI) correlated at statistically significant levels.

Mortality was negatively correlated with M/T and life expectancy, GDP/capita and fertility rate were positively correlated with M/T.

4. Discussion

The Trivers-Willard Hypothesis applies to polygnous species wherein males have multiple mating opportunities, and suggests that nature has favoured parents who can (to some degree) regulate M/T depending on their condition periconceptually and in early pregnancy. This is because under poor conditions, a male foetus, who requires more maternal resources to be carried to term [10,11], may not reach term, and if he does, many not survive infancy and childhood. Indeed, a male pregnancy requires 10% higher daily energy intake than women who gestate a female embryo, consuming on average 8% more protein, 9.2% more carbohydrates, 10.9% lipids of animal origin and 14.9% lipids of vegetable origin [11]. Male embryos may therefore be more susceptible to energy restriction and therefore more likely to be aborted spontaneously [11].

However, under poor conditions, even if he does reach term, a frail male will compete poorly for mating privileges with more robust males. Hence under poor conditions, the passage of parental genes is favoured if a male pregnancy is spontaneously aborted so as to allow a new pregnancy, which may result in a male who may be conceived under better conditions and progress to term, or a female foetus. It should be noted that even under poor conditions, a female is likelier to survive and become pregnant. However, under good conditions, a male is better at passing on parental genes since he is unconstrained by pregnancy and lactation, with multiple mating opportunities [10].

A decrease in mortality and an increase in life expectancy and GDP/capita are indicators of socioeconomic wellbeing. In this study, mortality was negatively correlated with M/T and life expectancy and GDP/capita were both positively correlated with M/T, indicating that M/T may also serve as a surrogate health indicator, and incidentally, also supporting the Trivers-Willard hypothesis.

Improving economies lead to increasing education, which in turns tends to lower fertility rate since women in such societies tend to have fewer children [11,12]. Hence, as socioeconomic status and education improve, fertility is expected to fall. The Human Development Index (HDI) is a composite index and hence, effects of one of the factors that

Table 3
Correlation of sex ratio at birth (male divided by total births: M/T) with health and socioeconomic indicators.

	Infant mort.	Under 5 years mort.	Both sexes life expect.	Female life expect.	Male life expect.	Both sexes HALE	GDP/capita	Tot. fertil. rate	HDI
n	223	185	183	183	183	183	223	222	223
r^2	−0.26	−0.32	0.24	0.26	0.23	0.26	0.26	−0.29	0.06
df	221	183	181	181	181	181	221	220	221
t	−3.97	−4.51	3.38	3.56	3.14	3.55	4.05	−4.45	0.89
p	0.0001	0.00001	0.0009	0.0005	0.002	0.0005	0.00007	0.00001	0.4

N indicates total number of countries wherein both M/T and the indicator in question were both available.
Mortality: deaths per 1000.
Life expectancy: in years.
GDP (gross domestic product): in US$ per capita.
Total fertility rate: children born/woman.
df: degrees of freedom.
HDI: Human Development Index.

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