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Secular trends in newborn sex ratios

Victor Grech *

Academic Department of Paediatrics, Medical School, Mater Dei Hospital, Malta

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ABSTRACT

A wide variety of factors have been shown to influence the male to female ratio at birth, which invariably displays a male excess. This paper will review and amplify recent work by the author, with specific references to individual countries, regions and entire continents in order to provide a global overview of this subject. It will be shown that stress, including stress related to political events, influences this ratio. Man-made radiation is also shown to have played a significant role in relation to the Windscale fire (1957) and Chernobyl (1986).

Contents

* Corresponding author at: Department of Paediatrics, Mater Dei Hospital, Malta. Tel.: +356 99495813.
E-mail address: victor.e.grech@gov.mt.

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1. Introduction

The male to female ratio at birth invariably yields an excess of males. However, this ratio has been shown to be influenced by a very wide number of factors. This review will enlarge on recent work by the author and will not only provide a general history of and an introduction to this topic, but also provide a global overview. It will also be shown that stress related to political events has influenced this ratio, as has radiation from accidents including nuclear facilities.

2. Definitions

The male to female ratio at birth (technically known as the secondary sex ratio) is commonly abbreviated as M/F, a potentially misleading term as this defines the ratio of male to total births (M/T). M/F will be used in this paper, denoting male live births divided by total live births.

3. Historical aspects

In ancient times, it was widely believed that an infant's gender was determined by the degree of heat that a man's ejaculate was exposed to during insemination. It was only until much later that formal analysis of M/F was undertaken. Such a statistical study requires not only raw data but also statistical tools for calculations that provide probabilities of deviation from preset values. The collection of data from London in the 1600s allowed John Graunt (1620–74) to publish the first descriptive statistical analysis of M/F data [1].

Graunt's work included an analysis of annual variation of M/F in London and Romsey. He noted that male births exceeded female births and that this excess was greater in urban London than in rural Romsey. His findings were statistically non-significant but he noted secular variation in M/F which is significant with modern day testing.

John Arbuthnott (1667–1735) was a mathematics teacher in London who went on to study medicine [2]. He demonstrated that M/F is significantly in excess of 0.5, the first use of inferential statistics [2].

Ronald Fisher (1890–1962) was an English statistician, evolutionary biologist, geneticist, and eugenicist who popularised the theories of Carl Düsing of Jena [3]. The Fisherian explanation for the skew in M/F is that were male births less common than female births, a male would have better mating prospects and would sire more offspring. Thus, parents genetically disposed to produce males would have more offspring and this tendency would spread within the community, increasing male births, such that this advantage disappears when M/F of 0.5 is reached. The converse would apply were there a dearth of females [4]. These studies comprised the first application of mathematical methods and models to evolutionary biology.

4. Broad epidemiological aspects of human M/F

Random meiosis would lead to a mean (Mendelian) M/F of 0.5, with binomial variation around this value. However, this is based on the following assumptions:

1. Males produce equal numbers of X- and Y-bearing sperm in mammalian species.
2. X- and Y-bearing sperm stand equal chances of achieving conception.
3. Equal numbers of male and female zygotes are conceived.

Thus, any M/F variation would be due to sex-selective foetal wastage. In humans, M/F exhibits a male excess and is expected to approximate 0.515 with a range of 0.505 to 0.520 [5].

The excess of male births may be nature's compensatory mechanism for increased postnatal male mortality. A veritable legion of factors has been proposed for this disparity potentially influencing it [5,6].

5. M/F physiology

Evolutionary theory proposes that mutations may produce individuals who are fitter in a given environment and who are therefore likelier to survive and procreate, dispersing their advantageous genes. One such adaptation could be the maternal ability to influence M/F outcomes in pregnancy. In polygynous species, only the fittest males reproduce. For this reason, parental investment in a “good quality” son would, on average, yield greater numbers of descendants than an equivalent investment in a “good quality” daughter. It may therefore be advantageous for a mother to produce sons when she has sufficient resources to give them a better than average edge that will then give them a greater chance to reproduce, and daughters when she does not have. This is known as the Trivers–Willard hypothesis [7].

Recent studies have revealed that around 73% of natural singleton conceptions fail to survive beyond six weeks of gestation. Pregnancy is thus an opportunity for selection and/or culling, and significant wastage occurs before maternal or clinical recognition of pregnancy. It is also believed that multiple pregnancies may constitute over 12% of all natural conceptions but only approximately two percent reach term as live twin births, and 12% of these result in single births [8].

The sex ratio at conception in humans may be 0.545, with the highest sex ratio of foetal deaths in the second trimester. This data also suggests that late foetal deaths may be postponed to early infancy [9].

Male vulnerability is also manifest in premature births, as well as in term babies, with higher morbidity and mortality rates that persevere into early childhood. Women who fail to abort male foetuses in times of stress also reduce their own odds of survival due to the higher metabolic requirements necessitated by the gestation of a male baby to term. Conversely, a female who aborts a male baby under stressful circumstances fails to invest heavily in what would potentially result in a frail son, and makes herself available to potentially bear a daughter, or a robust son in future and less adverse times [10].

6. Factors known to influence M/F

The literature is replete with such factors [11], and the more important ones are listed hereunder.

6.1. Hormones

While the physiological basis for the influences of external factors on M/F is not understood, alterations in parental sex hormone level/s and/or differential gender-based survival modulated by stress during embryogenesis have been proposed as likely mediators. The hormonal theory is heavily subscribed to by William H. James, the foremost expert in the field. This theory states that higher levels of maternal gonadotrophins and progesterones lower M/F while elevated levels of testosterone and oestrogen increase M/F [12]. The luteal surge in the middle of the menstrual cycle has therefore been proposed to be the cause of