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Sex Differences in Mortality Rates Have Increased in China Following the Single-Child Law

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Male behavior and physiology is designed for enhanced competitiveness at the expense of longevity, resulting in higher mortality rates compared to females in most species. These differences vary across populations consistent with factors indicating the intensity of male mating competition. Reproductive dynamics are strongly influenced by the relative proportions of potentially reproductive males and females in a population. Because the reproductive strategies of men and women are somewhat divergent, market influences on the intensity of mating competition and selectivity for partners produce different outcomes in female biased and male biased populations. The single-child law implemented in China in 1979 has led to increasing proportions of men in the Chinese population. Using historical mortality data, we found a trend for increasing sex differences in Chinese mortality rates from 1982 to 2000. This increase was most prevalent in young adulthood, when male mating competition is most intense as males reach sexual maturity and seek female partners. In contrast, males exhibited more survival gains than females in infancy and early childhood.

Keywords
sex differences, mortality, Operational Sex Ratio, China, single-child law

Introduction

Aggregate sex differences are shaped by the processes of sexual selection, intersexual selection and intrasexual competition. Females usually invest considerably more in offspring and are thus choosier in considering partners (Bateman, 1948; Trivers, 1972). Human women invest a nine-month pregnancy; undergo risky childbirth, provide nutrition through lactation, and perform the vast majority of childcare, which can last into the offspring's teenage years.

Male reproductive success depends largely on attaining mating opportunities, through intrasexual competition with other males that can include fighting for rank or territory, and because of the attractiveness of their traits and displays to females in intersexual selection (Darwin, 1871). Males who succeed in these competitions have more offspring; this shapes traits that enhance average mating success, even if they also increase risk of injury, sickness, and early death (Daly & Wilson, 1978; Møller, Christe, & Lux, 1999). Selection shapes traits not for the welfare of individuals or species, but for benefits at the genetic level (Dawkins, 1976; Williams, 1957).

The optimum balance of male investment is shifted towards reproductive effort and away from maintaining the body, and towards mating effort at the expense of parental effort, compared to females. Sex differences in psychology and behavioral tendencies, including the stronger male tendencies for risk-taking, competitiveness, aggression, and sensitivity to position in social hierarchies, are consequences of sexual selection (Cronin, 1991). Human male mating competition includes potentially lethal violence in conflicts both within and between groups (Chagnon, 1988).

Sex differences in human mortality rates arise from genetic, physiological, behavioral, social, and demographic causes that are best understood when integrated in an evolutionary life history framework (Kruger, 2010; Kruger & Nesse, 2004, 2006, 2007). Sex differences shaped by sexual selection interact with the environment for patterns with some consistencies but also expected variations due to differential environmental conditions. Socio-demographic factors related to the degree of variation and skew in male reproductive success and the intensity of male mating competition predict the degree of excess male mortality (Kruger, 2010; Kruger & Nesse, 2006, 2007).

The population sex ratio exerts a powerful influence on reproductive patterns across species. Because the reproductive strategies of men and women are somewhat divergent, imbalances produce different outcomes in female biased and male biased populations. Male biased sex ratios intensify male mating competition and raise the quality of male attributes necessary for securing female partners (Pedersen, 1991). Men with lower social status and fewer resources will have an especially difficult time getting married (Pollet & Nettle, 2008). Male biased metropolitan areas across the USA have greater rates of excess male mortality, following from the intensification of risky strategies (Kruger & Nesse, 2005).

Manipulation of the population sex ratio may influence behavioral strategies. Increasing the proportion of males in mosquito fish populations

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led to an increase in the number of aggressive male behaviors, whereas increasing the proportion of females led to more mating behaviors (Cureton, Martin, & Deaton, 2010). Following the implementation of China's single-child law for population control in 1979, sex-specific abortions and higher rates of female infant mortality have resulted in a surplus of men, especially in rural areas, in the world's largest national population (Ding & Hesketh, 2006; Zhu, Lu, & Hesketh, 2009). Urban residents were allowed one child and rural residents were allowed a second child after five years, but generally only if the first-born child was a female (Hesketh, Lu, & Xing, 2005). In Chinese culture, a son takes care of his elderly parents whereas a daughter lives with her husband's family. Also, sons but not daughters perpetuate the family name (Hesketh et al., 2005). Thus, families selectively abort female fetuses (Chan, Blyth, & Chan, 2006). The sex ratio at birth increased from 108 in 1982 to 111 in 1990, and to 117 in 2000 (Wei, 2007). Chinese census data from 2005 indicated an overall OSR of 119, and some areas are reporting an OSR as high as 130 (Ding & Hesketh, 2006; Zhu et al., 2009).

The degree of male bias in a population is directly related to the intensity of male competition for social status, resources, and reproductive partners. We predict that the increasingly male biased Chinese population will exhibit higher male to female mortality ratios. We expect to see the greatest increase in young adulthood, when mating competition may peak as males reach sexual maturity and seek female partners.

Materials and Methods

We calculated the Male:Female Mortality Ratio (M:F MR) in China with data summarized by Banister and Hill (2004). Age specific mortality rates were available for ages 0-1, 1-5, and in five-year increments thereafter during four time periods: 1964-1982, 1982-1990, 1990-1999, and 1999-2000. We calculated and graphed the percentage change in the M:F MR between 1964-1982 and the three more recent time periods for each age interval.

Results

Our graphs depict the percentage by which sex differences in mortality rates have increased or decreased across age intervals in more recent time periods compared to 1964-1982. Results indicate that the first subsequent time period, 1982-1990, exhibited increases in the Male:Female Mortality Ratio (M:F MR) at an average of 20% during young adulthood (ages 20-44) and an average of 9% in later adulthood (45-69, See Figure 1). The M:F MR decreased by 15% for infants under one year old, by 2% for children aged one to four, and by 11% for those 90 years of age and older. The largest increase was 24% for ages 30-34.

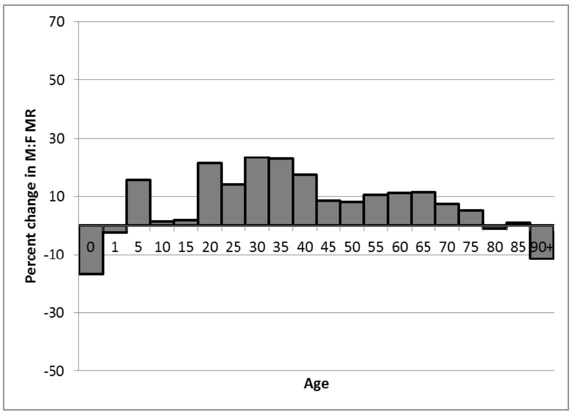

Figure 1. Percent change in the M:F MR from 1964-1982 to 1982-1990

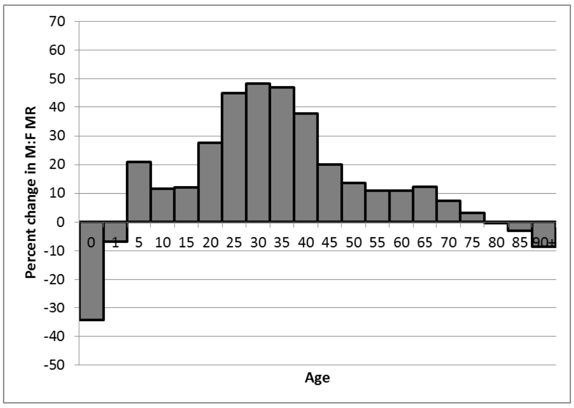

Figure 2. Percent change in the M:F MR from 1964-1982 to 1990-1999

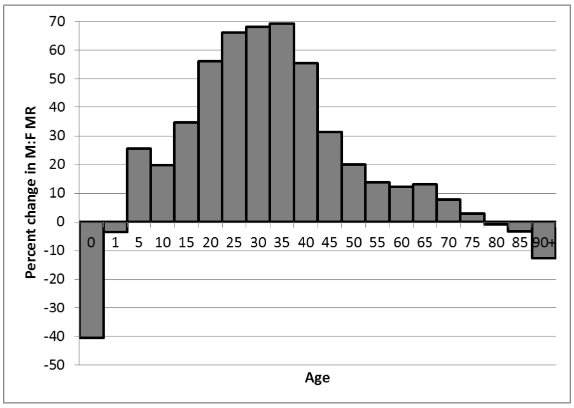

Figure 3. Percent change in the M:F MR from 1964-1982 to 1999-2000

Sex differences in mortality rates continued to increase in 1990-1999 (See Figure 2). The M:F MR increased an average of 41% during young adulthood (ages 20-44) and an average of 11% in later adulthood (45-69, See Figure 1). The M:F MR decreased by 34% for infants under one year old, by 7% for children aged one to four, and by 8% for those 90 years of age and older. The largest increase was 48% for ages 30-34.

The greatest increases in excess male mortality occurred in the most recent time period with available data, 1999-2000 (See Figure 3). The M:F MR increased an average of 63% during young adulthood (ages 20-44) and an average of 14% in later adulthood (45-69, See Figure 1). The M:F MR decreased by 41% for infants under one year old, by 4% for children aged one to four, and by 12% for those 90 years of age and older. The largest increase was 69% for ages 35-39.

Conclusion

Our analyses indicate that fluctuations in the Operational Sex Ratio have dramatic effects on sex differences in mortality rates in a modern human population. As predicted, we found an increasing trend in excess male mortality in young adulthood during the years of peak male mating competition. In contrast, males exhibited more survival gains than females in infancy and early childhood, consistent with preferences for male offspring resulting in differential treatment. These patterns are driven not by increases in male mortality rates, but rather by greater female gains in survival. China's population has experienced dramatic gains in survival rates and average longevity with increasingly modernized medical and public health infrastructure (Banister & Hill, 2004).

Some substantial proportion of the mortality divergence is likely due to increases in socio-economic inequality. The Eastern European transition to market economies in the 1990s and the associated rise in income and wealth disparities also lead to greater sex differences in mortality rates, though more modest increases than those documented here (Kruger & Nesse, 2007). Our data do not indicate the specific causes of death underlying the mortality differences. They are likely a combination of accidents from risky behaviors, morality from violence, and physiological consequences of stress, as seen in other populations (Kruger & Nesse, 2004, 2006, 2007).

We also expect to see effects of the changing population sex ratio in other domains, especially in sexual relations between women and men. Women in high sex ratio societies can make sexual access a scarce commodity and thus enhance their value in the marriage market (Guttentag & Secord, 1983). In the 19th Century American Far West, sex ratios were much higher than in other parts of the country, women married at a younger age and had higher fertility rates (Wells, 1975). To service the desires of the heavily male biased population, stores, saloons, gambling houses, and brothels were established in railroad cars that moved westward with the construction of the railroad (Sprague, 1940).

Chinese women and their families may become increasingly selective of their mates and men will need to provide substantial resources and commit to long-term relationships whenever possible to secure and retain a partner (Pedersen, 1991; Pollet & Nettle, 2008). We can expect to see social consequences such as a thriving sex industry that may include coercion of women, migration and importation of women from neighboring countries, as well as organized criminal activity attracted by the spiraling bride prices offered by desperate single men (Fong, 2009). Zhu et al. (2009) predict that by the year 2020 there will be 24 million more men than women in China, and that if these men do not get married by age 40, they will stand a minimal chance of ever getting married, will have fewer resources, and will be reliant on social security in old age.

It should be readily apparent that the OSR is an important indicator and predictor for those with interests in creating stable, healthy societies. Overall, our study demonstrates the value of an evolutionary theoretical framework for predicting and understanding human mortality and demographic patterns.

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