Abnormal sex ratios in human populations: Causes and consequences

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In the absence of manipulation, both the sex ratio at birth and the population sex ratio are remarkably constant in human populations. Small alterations do occur naturally; for example, a small excess of male births has been reported to occur during and after war. The tradition of son preference, however, has distorted these natural sex ratios in large parts of Asia and North Africa. This son preference is manifest in sex-selective abortion and in discrimination in care practices for girls, both of which lead to higher female mortality. Differential gender mortality has been a documented problem for decades and led to reports in the early 1990s of 100 million ''missing women'' across the developing world. Since that time, improved health care and conditions for women have resulted in reductions in female mortality, but these advances have now been offset by a huge increase in the use of sex-selective abortion, which became available in the mid-1980s. Largely as a result of this practice, there are now an estimated 80 million missing females in India and China alone. The large cohorts of ''surplus'' males now reaching adulthood are predominantly of low socioeconomic class, and concerns have been expressed that their lack of marriageability, and consequent marginalization in society, may lead to antisocial behavior and violence, threatening societal stability and security. Measures to reduce sex selection must include strict enforcement of existing legislation, the ensuring of equal rights for women, and public awareness campaigns about the dangers of gender imbalance.

Asia | sex ratio | son preference

Just over half of the human population is male. In 2004, males accounted for 50.4% of the global total (1), but in some regions of the world the proportion is considerably above this average. Here, we examine the reasons for this rise and explore its consequences. We first explain how some natural fluctuation in sex ratio occurs in human populations, and we illustrate this with the example of the effects of war. We then demonstrate how the tradition of preference for male offspring has led to huge distortions in the sex ratio in some countries. The wider social and political consequences of these distortions are discussed, with particular reference to China, India, and South Korea. Finally, we suggest measures that will help to reduce sex selection and lead, eventually, to normalization of the sex ratio.

The Sex Ratio at Birth and the Population Sex Ratio

These two terms need to be clearly differentiated. The "sex ratio at birth" is defined as the number of male live births for every 100 female births. Accurate figures for sex ratio at birth are difficult to obtain in many populations because of inadequacy of vital statistics registration (2). In particular, births occurring at home and births of unwanted or abandoned infants often go unrecorded. In China, the One Child Policy presents specific challenges to accurate data collection because there may be collusion between parents and authorities to hide births that are not approved within the Policy (3).

In the absence of manipulation, the sex ratio at birth is remarkably consistent across human populations, with 105–107 male births for every 100 female births. This slight excess of male births was first documented in 1710 by John Graunt and colleagues for the population of London (4), and many studies of human populations have confirmed their finding. A key study of births for the period 1962 to 1980 in 24 countries in Europe showed a sex ratio of 105–107, with a median of 105.9 (5). The latter figure is widely used as the baseline for calculating deviations in the sex ratio.

Over 30 demographic and environmental factors have been studied for their effects on the sex ratio at birth, including family size, parental age, parental occupation, birth order, race, coital rate, hormonal treatments, exposure to environmental toxins, stress, several diseases, and war (6–9). The finding of a small but significant increase in male births during and after war has been documented in Europe and the U.S. in both the First and Second World Wars (10–12), and in the U.S. for the Korean and Vietnam Wars (13). However, studies of the Balkan Wars (14) and of the Iran–Iraq war (15) did not reproduce these findings. Proposed biological explanations for the observed increase in sex ratio during war include stress to adult males, affecting the viability of XY-bearing vs. XX-bearing sperm; changes in the age structure of the pop-

ulation; and higher frequency of intercourse, leading to conception earlier in the menstrual cycle, all of which have been associated with increased sex ratios in other studies (16–18). Alternatively, evolutionary explanations argue that the increase represents an adaptive equilibrium after the decimation of males during war (13), although critics argue that the increase does not last long enough to compensate for wartime casualties (19, 20). The cause of this alteration in sex ratio at birth during war remains a curiosity.

The "population sex ratio" refers to the total number of males for every 100 females in the population. Figures for this ratio are generally taken from census data and are regarded as more reliable than figures for sex ratio at birth. The population sex ratio depends on three factors: the sex ratio at birth, differential mortality rates between the sexes at different ages, and losses and gains through migration (5). Although sex ratio at birth favors males, differential gender mortality favors females (8). Females have greater resistance to disease throughout life and greater overall longevity, so in circumstances where they have the same nutrition and health care as males, females have lower mor-

talities across all age groups (21). The situation for men is compounded by their greater tendency to engage in risk behaviors and violence, thus increasing their risk of premature mortality (22). By using Western life tables, drawn from gender-neutral countries, the population sex ratio is calculated at between 97.9 and 100.3 (5).

The Problem of Son Preference

In many countries, however, the sex ratio deviates from these norms because of the tradition of son preference. Son preference is most prevalent in an arc of countries from East Asia through South Asia to the Middle East and North Africa (23). Sons are preferred because (*i*) they have a higher wage-earning capacity, especially in agrarian economies (24); (*ii*) they continue the family line; and (*iii*) they are generally recipients of inheritance (25, 26). Girls are often considered an economic burden because of the dowry system; after marriage they typically become members of the husband's family, ceasing to have responsibility for their parents in illness and old age (27).

Son preference is manifest prenatally, through sex determination and sex-selective abortion, and postnatally through neglect and abandonment of female children, which leads to higher female mortality (28). Since prenatal sex determination became available in the mid-1980s it has made a major contribution to imbalances in the sex ratio seen in many Asian countries (29). However, it is the combination of sex-selective technology *and* a small-family culture that has caused the highest sex ratios (29, 30). When large family size is the norm and access to contraception is limited, son preference has little influence on sex ratio because couples continue bearing children, largely irrespective of the gender of the children (31). Female infanticide, abandonment of newborn girls, and neglect of daughters have been used in such societies to increase the male-to-female ratio in families, especially in situations where poverty has limited the number of desired children (25). When the family size norm is moderate and only contraceptive methods are available, couples may consider the sex distribution of their existing children and decide whether or not to use family planning, weighing the need for a son against their desired family size (31). However, when fertility rates are low, by choice or coercion, female births must be prevented to allow for the desired number of sons within the family size norm.

Postnatally, discrimination against daughters leads to neglect of their

Table 1. Numbers of missing females for selected Asian countries, 2001

Country	Calculated no. of missing females, in millions*
Afghanistan	0.5–1
Bangladesh	1.8–3.7
China	34–41
India	27–39
South Korea	0.2–0.3
Pakistan	2.6–4.9
Taiwan	0.4–0.6
Iran	0.8–1.2

*Adapted from refs. 28 and 45.

health care or nutrition, resulting in higher female mortality. A number of studies have shown that unequal access to health care is the most important factor (32, 33). This is especially the case in societies where health care costs have to be borne by the family (34–36). In 1990, Sen (21) estimated that differential female mortality had resulted in ≈100 million "missing females" across the developing world. Klasen (30) and Coale (5) arrived at figures of ≈93 million and ≈90 million, respectively, with the highest percentages of missing females occurring in the Indian subcontinent: Pakistan (11% of all missing females), India (9.4%), and Bangladesh (8.9%).

Since the mid-1980s, female disadvantage in mortality has declined substantially, only to be replaced by a different type of disadvantage: sex-selective abortion (28). The combination of widespread access to noninvasive sex-selective technology (ultrasound) and the advent of the small-family culture happened to coincide in some Asian countries in the mid-1980s and has led to a greatly increased sex ratio at birth (25, 31, 37). Realization of the potentially disastrous effects of this distortion has led many Asian governments, in-

cluding those of India and China, to outlaw prenatal sex determination and sex-selective abortion, yet these techniques are still being carried out on a large scale, with virtual impunity (38, 39).

The Impact of Son Preference on Sex Ratio

The impact of son preference on the population sex ratio can be seen in census data for 2001. Asia is the only continent with a sex ratio >100, at 104; North America stands at 96.8 and Africa at 99.8 (40). Table 1 shows estimates for numbers of missing females for Afghanistan, Bangladesh, China, India, South Korea, Pakistan, Taiwan, and Iran. Across these countries, an estimated 67–92 million females were missing in 2001. Three of these countries are of particular interest: South Korea because it has succeeded in reducing the sex ratio very substantially, India because of its marked regional differences in sex ratio, and China with its unique One Child Policy.

South Korea was the first country to report very high sex ratios at birth, because the widespread use of sex-selective technology in South Korea preceded that of other Asian countries. High-quality health care and accurate vital information registration have meant that differential gender mortality and underreporting have not contributed to abnormal sex ratios (29). The sex ratios began to rise in the mid-1980s in cities, and ultrasound was already widely available even in rural areas by 1990. The large city of Taegu reported a sex ratio of 122–130 in 1990, although it had been normal in 1980 (29). The sex ratio across birth order is well illustrated by data for South Korea during the highest sex ratio years of the late 1980s and early 1990s (see Table 2). These data show that South Koreans sex-select

Table 2. Sex ratios at birth, by birth order: China and South Korea

Year	Total	Birth order				
		1	2	3	4	5+
China						
1981	108	105	107	113	115	109
1989	114	105	120	125	133	130
2001	116	106	124	128	131	
Urban	116	113	130	119	119	
Rural	115	105	123	129	132	
South Korea						
1980	104	106	104	103	99	
1989	112	104	113	185	209	
1992	114	106	113	196	229	
2001	108	106	108	120	128	

Adapted from refs. 27 and 61.

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even in their first pregnancy because there is traditional preference for the first-born to be male (31) and that the tendency to sex-select rises for third and fourth births as parents try to ensure that they produce a son. In 1992, the sex ratio for fourth births in South Korea was an astounding 229, whereas the overall ratio was 114 (31). From the mid-1990s, the government launched a public awareness campaign warning of the dangers of such distortion. Laws forbidding sex-selection technology were more strictly enforced, and there was a widespread and influential media campaign focusing on the anticipated shortage of brides (31, 41). Together, these actions led to a decline in the sex ratio from 116 in 1998 to 110 in 2004 (1).

In India, because of incomplete birth registration, sex ratios in young children are used as a proxy measure. The sex ratio in children under age 6 rose from 106 in 1991 to 108 in 2001 (42), showing that improved health care and general conditions for females have been offset by increased recourse to sex-selective abortion (2). However, distinct geographical differences in sex ratio have appeared across the country; several states in the north and west have very high population sex ratios. For example, in the Punjab, Delhi, and Gujarat, ratios are between 114 and 126, but in the south and east, several states such as Kerala and Andhra Pradesh have sex ratios of ≈105 (42). The underlying reasons for this divide are unclear and are not explained by any of the more obvious factors, such as income level, availability of medical resources, variations in economic growth, religion, or differences in female education (2). What is clear is that where sex selection occurs it is strongly influenced by the gender of the preceding child; for second births with one preceding girl the ratio is 132, and for third births with two previous girls the ratio is 139. In cases where the previous child was a boy, sex ratios are normal (39). In contrast, in Pakistan and Bangladesh sex-selective abortion is much less acceptable and available. In both of these countries, improved health care and conditions for women have led to lower sex ratios (28). The proportion of missing women in Pakistan and Bangladesh has been estimated to have declined from 11% and 8.9%, respectively, in 1981 to 7.8% and 6.9% 10 years later (30). Data for Pakistan for 1998 showed further improvement, to 6.3% (28).

In China alone, approximately 1 million excess male births are reported every year (41). Because of the One Child Policy introduced in 1979, China is unique in having a compulsory low-fertility culture, and this is combined with a strong tradition of son preference. In China, there has been a steady increase in the reported sex ratio at birth from 106 in 1979 to 111 in 1990, and to 117 in 2001 (43), increasing to as high as 130 in some rural counties (44). The sex ratio by birth order is particularly interesting in China because of the urban/rural differences in implementation of the One Child Policy (see Table 2). In urban China only one child is allowed, so some urban Chinese make the choice to sex-select with their first pregnancy. In most rural areas, if the first child is a girl the couple are allowed a second pregnancy. So, if the second (or subsequent) pregnancies are female, either the fetus is aborted or the newborn female child may be abandoned or sometimes simply not registered, allowing the couple to go on to have another child (38).

The Consequences of High Sex Ratios

Because prenatal sex determination only began to be available in about 1985, the resulting large cohorts of "surplus" young men are only now reaching reproductive age. Because of this, the consequences of this male surplus are largely speculative. Many of the outcomes that we have described as consequences, for example increased levels of violence, are likely to be multifactorial in causation and therefore impossible to attribute simply to gender imbalance. However, it is not in dispute that over the next 20 years in large parts of Asia there will be an excess of males. In parts of China and India, there will be a 12–15% excess of young men. These men will remain single and will be unable to have families, in societies where marriage is regarded as virtually universal and social status and acceptance depend, in large part, on being married and creating a new family (45).

An additional problem is that many of these men are rural peasants of low socioeconomic class and with limited education (46). When there is a shortage of women in the marriage market, the women can "marry up," inevitably leaving the least desirable men with no marriage prospects (47). For example, in China 94% of all unmarried people age 28–49 are male and 97% of them have not completed high school (48). So, in many communities today there are growing numbers of young men in the lower echelons of society who are marginalized because of lack of family prospects and who have little outlet for sexual energy. A number of commentators predict that this situation will lead to increased levels of antisocial behavior and violence and will ultimately present

a threat to the stability and security of society (31, 45–49).

There is some empirical evidence to fear such a scenario. Gender is a well-established individual-level correlate of crime, and especially violent crime (50). It is a consistent finding across cultures that an overwhelming percentage of violent crime is perpetrated by young, unmarried, low-status males (50–52). In India, a study carried out between 1980 and 1982 showed a strong correlation between homicide rates in individual states across the country and the sex ratio in those states, after controlling for potential confounders such as urbanization and poverty (53). The authors concluded that there was a clear link between sex ratio and violence as a whole, not just violence against women as might be assumed when there is a shortage of females. These analyses were repeated by Hudson and Den Boer (46), who showed that the relationship between sex ratio and murder rates at the level of the Indian state persisted through the late 1990s. In China, young male migrant workers are thought to be responsible for a disproportionate amount of urban crime, especially violent crime. It is reported that migrants account for 50% of all criminal cases in the major receiving cities for migrants, with some cities reporting up to 80% (54).

There is also evidence that, when single young men congregate, the potential for more organized aggression is likely to increase substantially (45, 53). Hudson and Den Boer, in their provocative writings on this subject (45, 46), go further, predicting that these men are likely to be attracted to military or military-type organizations, with the potential to be a trigger for large-scale domestic and international violence. With 40% of the world's population living in China and India, the authors argue that the sex imbalance could impact regional and global security, especially because the surrounding countries of Pakistan, Taiwan, Nepal, and Bangladesh also have high sex ratios.

A number of other consequences of an excess of men have been described, but there is very little evidence for causation. It is intuitive that if sexual needs are to be met this will lead to a large expansion of the sex industry, including its more unacceptable practices such as coercion and trafficking. The sex industry has expanded in both India and China in the last decade (55, 56); however, there are a number of reasons for this expansion, and the part played by a high sex ratio is impossible to isolate without specific research addressing this question. Indeed, in China the highest numbers of sex workers are in areas

where the sex ratio is least distorted, for example in the border areas of Yunnan Province (57). The recent rise in numbers of sex workers in China has been attributed more to greater mobility, increased socioeconomic inequality, and a relaxation in sexual attitudes, than to an increase in the sex ratio (57, 58).

There is much anecdotal evidence regarding increases in trafficking of women, both for the sex industry and marriage, in both India and China (59, 60), although it is impossible to say whether gender imbalance is a contributory factor in this rise. Reports would suggest that trafficking is more common in parts of Africa and Eastern Europe where the sex ratio is normal (61). It has also been suggested that a shortage of women may lead to a rise in homosexual behavior (31), not implying that the shortage of women will produce homosexuals, but rather that an increasing tolerance toward homosexuality, together with the surplus of males, may lead to large numbers of covert homosexuals openly expressing their sexuality.

The latter could be viewed as a positive outcome, and there are others. First, access to prenatal sex determination results in an increase in the proportion of wanted births, leading to less discrimination against girl children and lower female mortality. India, South Korea, China, Pakistan, and Bangladesh have all reported reductions in differential mortality in the last decade (2, 28). Second, gender imbalance will lead to a reduction in birth rate, which may be particularly beneficial in countries trying to control population growth (47). Third, as the number of women in a society decreases, so their social status should increase and they should benefit from their enhanced value (48). Ultimately, this may lead to more balanced sex ratios because couples will choose to have girls. However, it has also been argued that the increased value of women could have a negative side, especially in rural society; increased female value may not benefit the woman herself, but rather the males around her. Her father, husband, and in-laws all hold her value, so when her value increases her life is more controlled by them. Hudson and Den Boer (45) cite as examples the increase in kidnapping and trafficking of women that has been reported from many part of Asia, as well as the recent large increases in dowry prices in parts of India.

The Solutions

Governments in affected countries are taking action. Nothing can realistically be done in the short term to reduce the current excess of young males, but much can be done to reduce sex selection now, and this will benefit the next generation. China has set an ambitious, but almost certainly unachievable, target: to lower the sex ratio to normal by 2010 (62). In China and India, laws forbidding infanticide, abandonment, and neglect of female children already exist but need to be strictly enforced. For trafficking and kidnapping, penalties are harsh (people-trafficking is a capital crime in China) but detection is difficult. Sex-selective abortion, however, is carried out by medical personnel in hospitals and clinics, and enforcement of the law banning the practice should be straightforward. Stricter enforcement has been successful in reducing the sex ratio in South Korea, where in 1991 eight physicians in Seoul had their licenses suspended for performing sex determination. In the following year, the sex ratio in Seoul fell from 117 to 113 suggesting that this punitive action had a deterrent effect for other physicians (31). Other countries could learn from this example.

Other measures include public awareness campaigns, which should focus on the problems facing young men in finding brides. More importantly, equal social and economic rights for males and females must be guaranteed, for example, in relation to rights of inheritance. Basic health care should be available free of charge, so that parents are not deterred by financial constraints from seeking health care for their daughters. In addition, special supportive measures should be provided for families with no sons, to ensure protection for parents in old age.

The Future

Although the effects of male surplus will be a major problem for several Asian countries over the next two to three decades, there are indications that the situation may then improve. In South Korea, the sex ratio has already declined, and gender preference data from China are also encouraging. In a recent national survey, 37% of the Chinese women surveyed (predominantly younger, urban women) claimed to have no gender preference, and 45% said the ideal family consisted of one boy and one girl (Table 3). Almost equal numbers of the women expressed a preference for one girl as for one boy (63).

There are, therefore, clear indications that the essential fundamental change in attitudes is starting to happen. We believe that both the population sex ratio and the sex ratio at birth will gradually decline over the next two to three decades in these high-sex-ratio countries; however, the damage for a large number of today's young men and boys has already been done.

Table 3. Gender preferences of Chinese women of reproductive age in 2001 (n = 39,344)

No. of boys	No. of girls	n	%
0	1	2,323	5.9
0	2	267	0.7
1	0	2,218	5.6
1	1	17,882	45
1	2	254	0.6
2	0	274	0.7
2	1	1,123	2.8
2	2	566	1.4
No gender preference		14,437	37

Adapted from ref. 60.

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