



Editorial

Éditorial

From *the Departments of
Community Health and
Epidemiology and of
Obstetrics and Gynecology,
Dalhousie University, and
†the Reproductive Care
Program of Nova Scotia,
Halifax, NS

*This article has been peer
reviewed.*

*Can Med Assoc J 1997;156(1):
46-8.*

Is Canada's sex ratio in decline?

Linda Dodds,*† PhD; B.A. Armson,* MD

Abstract

IN THIS ISSUE (see pages 37 to 41) Dr. Bruce B. Allan and associates report a small but statistically significant decrease — of about 0.2% — in the proportion of male live births in Canada over the period 1970 – 90. In this editorial, factors that have been reported in the literature to influence sex ratio are examined within a Canadian context. The authors suggest that although the reasons for the apparent decline in the sex ratio in Canada are unclear, the increasing use of ovulation induction may be a contributing factor. Data from the Nova Scotia Atlee Perinatal Database are discussed with a view to explaining the trend observed in Atlantic Canada, but no obvious explanation emerges. The authors argue that when the period of observation is extended no overall change in the sex ratio is apparent. This would suggest a tendency toward stabilization rather than decline.

Résumé

DANS CE NUMÉRO (voir pages 37 à 41), le Dr Bruce B. Allan et ses collaborateurs signalent une baisse faible mais significative sur le plan statistique — d'environ 0,2 % — de la proportion des naissances vivantes de sexe masculin au Canada au cours de la période de 1970 à 1990. Dans cet éditorial, on examine dans le contexte du Canada des facteurs qui, selon la littérature scientifique, jouent sur le ratio entre les sexes. Les auteurs indiquent que même si les raisons du fléchissement apparent du ratio entre les sexes au Canada ne sont pas claires, le recours croissant à l'ovulation provoquée peut être un facteur qui y contribue. On analyse des données tirées de la base périnatale Atlee de la Nouvelle-Écosse afin d'expliquer la tendance observée dans la région de l'Atlantique, mais il ne s'en dégage aucune explication évidente. Les auteurs soutiennent que lorsqu'on prolonge la période d'observation, aucun changement global du ratio entre les sexes ne se manifeste, ce qui indique une tendance à la stabilisation plutôt qu'à la baisse.

In this issue (see pages 37 to 41) Dr. Bruce B. Allan and associates present data showing trends in the ratio of male to female births in Canada between 1930 and 1990. They focus their investigation on the years 1970 to 1990 and report that the proportion of male births of total live births during this period decreased by about 0.2%. This finding raises some intriguing and difficult questions. If the proportion of male births is decreasing, what are the contributing factors? Are these factors responsible for other reproductive problems? Is a change in the sex ratio a cause for concern about the future demographic structure of our population?

Before we speculate on these questions, we should scrutinize Allan and associates' results more closely. Some fluctuation in the proportion of males and females born each year can be expected. The challenge comes in determining when such fluctuation exceeds that attributable to chance. Although the magnitude of the change reported in this study is very small, the very large sample size (all Canadian births for a 20-year period) provides the necessary power for statistical significance. The authors underscore the importance of the change they report, noting that it translates to 8639 fewer male births over 20 years.

The authors acknowledge the exploratory nature of their investigation, which they undertook when data for the period 1930–90 indicated that a decrease in the proportion of male births had occurred after 1970. As long as we accept the exploratory nature of the study and interpret its results cautiously, it is interesting to



speculate why a decline in the sex ratio might have occurred. Although some of the variation is likely random, part of it might be related to changes in conditions that influence the probability of a male or female birth.

Potential factors

Vital statistics databases are useful in providing data for entire populations but are somewhat limited in the amount of information they collect. Without factor-specific data, we can only speculate about what may have contributed to the observed change. Some basic information, such as parental age and parity, is available on vital records and might have provided some insight in Allan and associates' study.

Sex ratio is thought to be affected by a wide range of biologic and environmental factors, including race, birth order, parental age, parental hormone levels, timing of conception, ovulation induction, environmental toxins and socioeconomic status.¹⁻⁵ In the following discussion we will speculate on the possible contribution of some of these factors to the decline in sex ratio observed by Allan and associates.

Race

Because the sex ratio seems to vary among racial groups, it might be suggested that changing immigration patterns have affected the proportion of male live births in Canada. The sex ratio appears to be lower in black populations than in white populations and to be slightly higher in Asian populations than in white populations.^{1,3,4} As Allan and associates point out, recent immigration patterns in Canada have resulted in a significant increase in the Asian population, which would be expected to result in an increase rather than a decrease in the sex ratio. The true magnitude of racial variations can be difficult to determine, given the limitations of census data in developing countries, but it appears to be small.¹ Thus, it is unlikely that the changing racial composition of the Canadian population could explain a decline in the sex ratio.

Ovulation induction

It has been suggested that drugs used for ovulation induction result in a significant decrease in the sex ratio, although the magnitude of this decrease is not consistent across study populations.⁶⁻⁸ The decrease may be directly related to increased gonadotropin levels or may be a secondary consequence of follicular phase length or timing of conception, which is often carefully controlled in the treatment of infertile couples. The current prevalence of infertility in Canada is between 7% and 8% (300 000 cou-

ples).⁹ On the basis of US national survey data, it has been estimated that approximately 43% of infertile women seek medical advice for infertility, and of these approximately 20% undergo ovulation induction.¹⁰ If we apply these estimates to the infertile population in Canada, we would expect approximately 6500 births per year resulting from ovulation induction, assuming a 25.0% live birth rate after ovulation. Consequently, it can be estimated that live births resulting from ovulation induction represent approximately 2.0% of live births annually in Canada.¹¹ Assuming that ovulation induction decreases the proportion of male births to 46.0%,⁷ about 350 fewer male births per year would result. Thus, the increased use of ovulation induction may have contributed in part to the observed trend.

Environmental factors

Evidence relating to the impact of pollution, environmental toxins and industrial exposures on the sex ratio is conflicting.¹²⁻¹⁹ Several investigators found an association between an increase in the sex ratio and industrial pollution,^{13,14} but this was later refuted.¹² Associations between various occupational exposures (i.e., to dibromochloropropane, pesticides, inorganic borates, carbon, alcohol and lead) and low sex ratios have been reported.¹⁵⁻¹⁹ It is thought that apparent decreases in the sex ratio may be related to an increase in female offspring secondary to elevated gonadotropin and normal testosterone levels in men exposed to industrial toxins.¹⁶ However, because industrial pollution appears to have a negligible effect on the sex ratio, and given that occupational exposures would affect only a small proportion of the Canadian workforce, it would be difficult to attribute a decline in the sex ratio in this country to these factors.

There has been increasing concern that environmental factors are responsible for an apparent decrease in mean sperm count and semen quality, resulting in an increase in male infertility.^{20,21} However, evidence of declining sperm counts has been challenged by a study that demonstrated no change in sperm counts over the past 25 years in the United States.²² Moreover, an association between declining sperm counts and changes in the sex ratio has not been clearly established.

Abortion

Because of advances in prenatal diagnosis, the number of abortions prompted by major fetal abnormalities has risen in the past decade. If a higher proportion of affected fetuses were male, this would result in a small decline in the sex ratio. However, of the pregnancies terminated for major fetal abnormalities in Nova Scotia from 1991 to



1994, only 45.8% were male (Dr. Robert M. Liston, Department of Obstetrics and Gynecology, Dalhousie University, Halifax: personal communication, 1996). Therefore, pregnancy termination resulting from fetal abnormalities cannot explain a decrease in the proportion of male births.

Other factors

The largest decrease in the sex ratio observed by Allan and associates occurred in the Atlantic provinces. In an attempt to account for this finding, we used the population-based Nova Scotia Atlee Perinatal Database to examine trends within Nova Scotia. In 1980 the database began collecting data on maternal and infant characteristics for live births and stillbirths in the province. We investigated the effect of year of birth, maternal age, parity and smoking on the proportion of males born from 1980 to 1994.

From the Nova Scotia data, we observed a trend similar to that reported by Allan and associates for the Atlantic provinces as a whole. However, the decline we saw in the proportion of male births did not reach statistical significance. As other researchers have found,¹ the proportion of male live births was slightly lower among women who smoked during pregnancy (50.9%) than among those who did not smoke (51.2%). However, rates of smoking during pregnancy have changed very little since 1988 in this population.²³ In Nova Scotia, the sex ratio increased linearly with maternal age from 25 years and up. In contrast with other populations, the sex ratio was highest (51.6% males) among women 20 to 24 years old and lowest (50.8% males) among those less than 20. Elsewhere, increased parity has been associated with a decreasing birth ratio.^{3,24} However, data from the Nova Scotia database do not support this association. Clearly, the factors discussed above — smoking, maternal age and parity — do not account for a decrease in the proportion of male births.

Summing up

There appears to have been a small but significant decline in the sex ratio in Canada from 1970 to 1990. Although the factors responsible for this change are unclear, the increasing use of ovulation induction may have played a role. Whether the decrease in the proportion of male births represents a true secular trend is unclear, however. When one extends the period of observation to 1930–90, variations are evident but with no obvious trends. Ulizzi and Zonta²⁵ demonstrated similar patterns of sex-ratio variation in two other populations and concluded that “no dramatic change in the sex ratio values for total births is observed when the time period is sufficiently long.” Despite the existence of factors that may influence the sex ra-

tio in the short term, there appears to be a tendency for the sex ratio to stabilize. Whether such stabilization is related to natural selection or to human behavioural and psychological factors is debatable, but variation in the ratio away from the expected value may cause negative feedback that results in a gradual shift in the sex ratio back toward the norm.²⁶

References

1. James WH. The human sex ratio. Part 1: A review of the literature. *Hum Biol* 1987;59(5):721-52.
2. Ulizzi L, Zonta LA. Factors affecting the sex ratio in humans: multivariate analysis of the Italian population. *Hum Biol* 1995;67(1):59-67.
3. Erikson JD. The secondary sex ratio in the United States 1969–71: association with race, parental ages, birth order, paternal education and legitimacy. *Hum Genet* 1976;40:205-12.
4. Teitelbaum MS, Mantel N. Socio-economic factors and the sex ratio at birth. *J Biosoc Sci* 1971;3:23-41.
5. James WH. Time of fertilization and sex of infants. *Lancet* 1980;1:1124-6.
6. James WH. Gonadotrophin and the human secondary sex ratio. *BMJ* 1980;281:711-2.
7. James WH. The sex ratio of infants born after hormonal induction of ovulation. *Br J Obstet Gynaecol* 1985;92:299-301.
8. Dickey RP, Taylor SN, Currole DN, Rye PH. Male birth rates are influenced by the insemination of unselected spermatozoa and not by clomiphene citrate. *Human Reprod* 1995;10:761-4.
9. *Proceed with care: Final report of the Royal Commission on New Reproductive Technologies*. Vol 1. Ottawa: Canada Communications Group, 1993:187-9.
10. Wilcox LS, Mosher WD. Use of infertility services in the United States. *Obstet Gynecol* 1993;82:122-7.
11. *Births 1991*. Ottawa: Statistics Canada, 1991:43. Cat no 84-210.
12. Williams FLR, Ogston SA, Lloyd OL. Sex ratios of births, mortality, and air pollution: Can measuring the sex ratios of births help to identify health hazards from air pollution in industrial environments? *Occup Environ Med* 1995;52:164-9.
13. Lloyd OL, Lloyd MM, Holland Y, Lyster WR. An unusual sex ratio of births in an industrial town with mortality problems. *Br J Obstet Gynaecol* 1984; 91:901-7.
14. Lloyd OL, Smith G, Lloyd M, Holland Y, Garley F. Raised mortality from lung cancer and high sex ratios of births associated with industrial pollution. *Br J Ind Med* 1985;42:475-80.
15. Whorton D, Krauss S, Marshall S, Melby T. Infertility in male pesticide workers. *Lancet* 1977;2:1259-61.
16. James WH. Occupations associated with low offspring sex ratios. *Am J Ind Med* 1994;25:607-8.
17. Whorton MD, Haas JL, Trent L, Wong O. Reproductive effects of sodium borates on male employees: birth rate assessment. *Occup Environ Med* 1994;51:761-75.
18. Milham S. Unusual sex ratio of births to carbon setter fathers. *Am J Ind Med* 1993;23:829-31.
19. Dickinson H, Parker L. Do alcohol and lead change the sex ratio? *J Theor Biol* 1994;169:313-5.
20. Carlsen E, Giwerman A, Kerding N, Skakkebaek NE. Evidence for decreasing quality of semen during the past 50 years. *BMJ* 1992;305:609-13.
21. Auger J, Kunstmann JM, Czyglik F, Jouannet P. Decline in semen quality among fertile men in Paris during the past 20 years. *N Engl J Med* 1995;332:281-5.
22. Fisch H, Goluboff ET, Olson JH, Feldshuh J, Broder SJ, Barad DH. Semen analyses in 1283 men from the United States over a 25-year period: no decline in quality. *Fertil Steril* 1996;65:909-11.
23. Dodds L. Prevalence of smoking among pregnant women in Nova Scotia from 1988 to 1992. *Can Med Assoc J* 1995;152:185-90.
24. James WH, Rostron J. Parental age, parity and sex ratio in births in England and Wales, 1968–77. *J Biosoc Sci* 1985;17:47-56.
25. Ulizzi L, Zonta LA. Sex ratio and natural selection in humans: a comparative analysis of two Caucasian populations. *Ann Hum Genet* 1993;57:211-9.
26. James WH. What stabilizes the sex ratio? *Ann Hum Genet* 1995;59:243-9.

Reprint requests to: Dr. Linda Dodds, Reproductive Care Program of Nova Scotia, Izaak Walton Killam–Grace Health Centre, 5980 University Ave., Halifax NS B3H 4N1