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Studies in Population

Sex Selection of Children

Edited by NEIL G. BENNETT

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1983, 248 pp/ISBN: 0-12-114380-5

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CONTENTS:

Introduction and Overview. Natural Fertility and Its Proximate Determinants. Regulated Fertility and Its Proximate Determinants. An Aggregate Fertility Model. Applications of an Aggregate Fertility Model. A Macrosimulation Model and Applications to Fecundity and Natural Fertility. Family-Size Control. Birth Spacing. Sex Preselection. Each chapter contains references. Subject Index.

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with BARBARA VAUGHAN

1983, 504pp./ISBN: 0-12-177080-X

FROM THE BOOK:

"This second edition of ***Regional Model Life Tables and Stable Populations*** incorporates an extension in range of the original tables, an extension that will be particularly useful in applications to populations with low mortality. In the first edition, the model tables terminated with an open interval beginning at age 80, for persons and deaths. Sometimes deaths and populations beyond age 80 are of little demographic interest because there are so few survivors to age 80 at moderate to high mortality, and because only a very small fraction of the population is found at advanced ages in populations with high fertility. In the lowest mortality model life tables, however, the proportion surviving from birth to age 80 is over 50%, and in low-fertility populations the fraction of the population over 80 can be comparable to the fraction under 10. The absence of information above age 80 in the first edition is therefore a potential handicap in applications to modern low mortality populations. Moreover, the highest expectation of life at birth represented in the first edition of model life tables (77½ years) has been surpassed in several countries. In this second edition, the life tables and stable populations are tabulated by 5-year age intervals to age 100, in all but the highest mortality levels, in which the last 5-year tabulation is from 90 to 95."

CONTENTS:

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SEX SELECTION OF CHILDREN

This work presents a comprehensive, multidimensional analysis of significant issues in the development and use of sex-selection technology. Experts from a broad range of disciplines review past work, discuss currently available or newly proposed methods, and explore the determinants and consequences of selecting children by gender. This book introduces models that demonstrate the use of sex-selection technology. In addition the contributors examine parental gender preferences around the world and show how researchers have attempted to measure these preferences. In-depth consideration is also given to the ethical and legal issues surrounding sex selection.

Sex Selection of Children deals with such questions as

- What factors would cause a couple to choose a given technique?
- How would the emergence of an effective and widely accessible technique affect society?
- How would laws in various countries impinge on the use of sex-selection techniques
- How can the complex, and sometimes conflicting, ethical problems associated with gender selection be resolved?

The thorough coverage in *Sex Selection of Children* will be invaluable to specialists in sociology, medicine, biology, public health, economics, law, and ethics.

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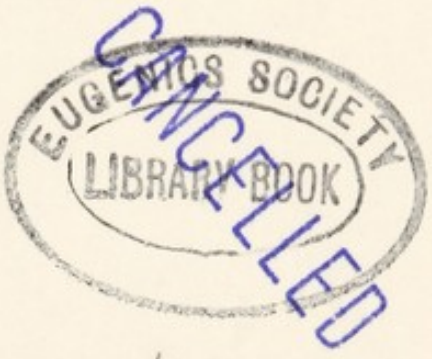

Sex Selection of Children

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Sex Selection of Children

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NEIL G. BENNETT AND ANDREW MASON

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Foreword

Every new technology opens the way to new choices, and exercise of individual choice has collective effects. The collective effects can be perverse, to the point where they offset the advantages to society and even to the individuals who choose to apply the new technology. Foreseeing such a possibility, voices are heard arguing for suppression of the new technology. This argument must go back to the beginning of time; even fire, however great its use for warming people and cooking their food, could set the forest alight, and one can imagine a primitive moralist urging against the release of fire to the public.

The issues of individual choice and collective consequences are especially poignant in the capacity of parents to determine the sex of their children. That capacity has of course existed in the past; the observed sex ratios of surviving children in some primitive social groups leave little alternative to the hypothesis of selective infanticide. We regard the infant as a person, so selection has to be pushed back to the fetal stage, where it can now be exercised through amniocentesis from about the third month. But even many who favor the free choice of abortion to avoid pregnancies that are unwanted because a woman has all the children she can handle oppose abortion to suppress a child because of its sex. This is an issue that will be bypassed as soon as technology goes the one stage further of arranging which kind of sperm will fertilize a particular ovum. Such an invention will shift the debate from the moral principle of purposive abortion to the utilitarian question of the consequences of sex selection for the constitution of populations.

The first fear is that, in a social group that has an ever so slight but universal preference for boys, only boys will be born, and after 50 years the group will die

out due to a lack of fertile women. Such a fear is absurd. As many scholars have pointed out, the shortage of girls in the population would begin to be felt within much less than 50 years, and this would act back on the preferences of parents. It could even act so strongly that for a while there would be an excess of girls. Such delayed responses produce waves, but one can be sure that in this case they would be of declining amplitude, and a stable condition would soon be reached in which the sex ratio need be little different from that of the era preceding sex control.

One consequence seems clear: To the degree to which parents have an objective in their family building that specifies the sex of children, sex control will diminish the number of children they need. The magnitude of this effect depends on the strength of the sex preference. At the extreme, if only girls are wanted, or only boys, the birth rate would be cut in half. But in most societies the preferences are mild; initially parents may want a boy, but after they have one they want a girl. In short, sex selection would affect more the order within individual families than the ultimate ratio attained.

One can even imagine a higher level of indifference. Choosing could be a burden for many; if forced to choose they might toss a coin! The X and Y chromosomes being nature's equivalent of a coin, indifferent parents would simply disregard the new technology.

The preceding speculations apply to societies like that of the United States, where the two sexes seem to be about equally desired. For parts of the world in which sex preferences are strong, the technology, if it were simple enough for all to use, could have important social effects. Aside from reducing family size, it could be a major force for sex equality.

Those societies in which boy children are strongly favored are usually those in which women are subordinate to men. The correlation between sex preference at birth and later inequality may be the key to eliminating this kind of inequality. If as a result of sex selection women become fewer, their relative position will change. They will become more desirable in marriage, and the dowry that has to be paid along with a daughter to obtain a suitable husband will drop, perhaps to zero, perhaps being replaced by a bride price. This drastic change in the marriage market will have effects on equality within the family—a woman who is badly treated will leave her husband, knowing she can easily find a new one.

If some occupations are sex-typed for females, the smaller number of women available will increase the wages for them, and this outside demand for their services will further raise the standing of women within families. One can imagine the process going far enough that the preference for boy babies will disappear. If that happens and the sex ratio reverts to unity, it will be on a very different basis from before: The inequality of adult men and women will presumably have been permanently banished.

Such a scenario is the basis for my assertion that in any society where both

parental preference for boys and depressed condition of women are present, sex selection will make a major contribution to the equality of the sexes. Farseeing men in such countries may well express principled opposition to sex selection, based on a sophisticated religious rationale.

Too often we have to wait until an invention has been in use a long time for social science to investigate and explain its effects. We are fortunate in this instance that a group has taken the initiative to start the social investigation before the invention comes to technical maturity and long before it is actually adopted.

Nathan Keyfitz
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Preface

In casual conversation the topic of sex selection of children often evokes a chuckle. The reason is clear: Many people believe that any technique purporting to select a baby of a particular sex must be pure hokum. Indeed, for millennia this perception was entirely true, and until very recently the reputation of most sex-selection researchers as charlatans was certainly well-deserved. In the introductory chapter of this book, I describe some of the more humorous past approaches to sex selection. In recent years, however, research on this controversial subject has matured and gained legitimacy in scientific circles. Some techniques for controlling the sex of children are already available; others are under intensive development.

Certain issues must be addressed in order to understand fully where this technology may lead us. Under what conditions would a couple employ a given technique? How would a couple best use the technology to achieve their desired family composition? If an effective and widely accessible technology becomes available, what will be the repercussions for society? What legal factors in various countries around the world might impinge on the use of sex-selection techniques? And last, how might we resolve the many, and sometimes conflicting, ethical considerations associated with the use of this technology?

The contributors to this book bring an exceptionally diverse set of backgrounds to these important questions. Never before has such a comprehensive and multifaceted view of sex selection been presented in one volume. We hope that by our efforts specialists in a wide variety of fields—sociology, economics, biology, public health, law, and ethics—will be stimulated to explore further the complex issues surrounding sex selection of children.

I would like to thank the Population Studies Center at the University of Michigan and the Mellon Foundation for their support during the compilation of this volume. Kathy Duke provided exceptional assistance with the nitty-gritty editorial work during the final days of the project.

Sex Selection of Children

1

Sex Selection of Children: An Overview

NEIL G. BENNETT

HISTORICAL OVERVIEW

For ages, people have exhibited a strong curiosity toward the mechanisms that dictate the sex of offspring. Closely linked with this curiosity is the desire, on the part of some, to control the sex of offspring. Certainly some of the investigations into the determinants of gender have been more scientific than others. The oldest approaches involve changes in environment or human behavior around the time of conception. They are primarily folk methods, which, we realize today, are scientifically unfounded.

Aristotle observed that a higher proportion of females were conceived in the presence of a cold southern wind. He also believed that facing north during sexual intercourse would result in conception of a greater number of males. Following the notion that the right testis was provided with a warm and generally superior blood supply favoring the production of male-engendering semen and the left testis was associated with a cold and inferior blood supply producing "weak" semen, the Greek philosopher Anaxagoras inferred that tying off one of the testes prior to coitus would determine the sex of the conceptus (Gordon, 1979). Other folk methods of sex selection include having a man wear boots or a woman wear a man's clothing during intercourse in order to produce a son. A man might also hang his pants on the right or left side of the bed, depending on

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whether he desired a son or daughter, respectively. Finally, a couple might have intercourse on even days of the menstrual cycle to obtain a son and on odd days to obtain a daughter (Rinehart, 1975).

CURRENT RESEARCH AND AN OVERVIEW OF THE CHAPTERS

Most current research on sex selection has followed one of three approaches: (a) sperm separation *in vitro* and subsequent artificial insemination, (b) the timing of coitus relative to ovulation within the menstrual cycle, and (c) selective abortion after gender identification of the fetus. Clearly, the first two approaches may be called sex *preselection,* as selection occurs prior to fertilization; the third refers to *postfertilization* techniques, a category to which many distinct legal and moral issues apply.

The impetus for this research is a desire by many couples to control the sex of a given birth. If there were no sex preference, then there would be no need or demand for a sex-selection technology. Couples would be wholly satisfied with the flip-of-the-coin approach available to us since the beginning of our existence. That sex preference exists in most parts of the world has been established by many scholars, most notably Nancy Williamson, who summarizes much of the knowledge on this subject in her chapter (7) of this volume. Specifically, she reviews intersocietal differences in the strength and direction of sex preferences and how preferences vary with social characteristics. From her past experience with the evaluation of a sex-selection clinic in Singapore (Williamson, Lean, and Vengadasalam, 1978) she argues that few couples would correctly use the techniques necessary to achieve sex control. Furthermore, Williamson doubts that the impact of such a technology on the sex ratio would be any greater than that experienced in the past resulting from war and sex-selective migration.

Although we do have good evidence of sex preference in many countries, precise measurement of these preferences is lacking. In his chapter (2), Gary McClelland describes some problems associated with such measurement. For example, data from surveys on attitudes and intentions are usually poor predictors of behavior. A woman may do well in predicting her future fertility given her present circumstances; she may not, however, clearly foresee her *future* circumstances, which of course would have greater bearing on her future fertility than would her present situation.

Parity progression ratios are also inadequate as a measure of sex preference. Transition probabilities from one parity to the next underestimate the extent of sex preferences because of the heterogeneity of preferences and the fact that

preferences can dissuade as well as persuade a couple to have a next child. Because the parity progression ratio is a behavioral measure taken at the aggregate level, it incorporates the actual behavior of women with possibly diverse preferences. It may be the case that when we compute the probability that a woman will proceed to the next parity given the present sex composition of her children, there will be little or no difference in progression among women with different compositions. This could result from either of two reasons: (a) sex preference is absent in the population, or (b) several types of sex preference are present and cancel each other out, thereby giving the spurious impression of no preference.

Further complicating the use of parity progression ratios is the ambiguity attached to observed reproductive behavior at the individual level. That a woman proceeds to the next parity or chooses to cease childbearing can be symptomatic of any of several factors. Continuation of childbearing does not necessarily indicate displeasure with the current sex composition of children; it could also result from a desire for more children, regardless of sex, or from an unterminated accidental pregnancy. Conversely, a woman might stop childbearing not because she is satisfied with her current family composition, but because she fears having a child of the undesired sex. Incorrect perceptions of the probability that the next child will be of a given sex also cloud the interpretation of a woman's reproductive behavior. In earlier work, McClelland has shown that many people adhere to "the gambler's fallacy," that a woman who bears a string of children of one sex is due for a child of the other sex, or to "the trend fallacy," that she is bound to have yet another child of the same sex (McClelland and Hackenberg, 1978).

McClelland feels that surveys can still be of great use to us in clarifying the relationship among sex preferences, fertility decision-making, and the use of sex-selection techniques. Future efforts, he concludes, should focus on conditional intentions. To this end, he suggests that the evaluation of measures of sex preference should be based on the following three general criteria: "(a) sensitivity to the multiple determinants of fertility decision, (b) sensitivity to individual differences in values, preferences, and beliefs, and (c) ability to distinguish between those decisions influenced by sex preferences . . . and those that are not [p. 26]." Models jointly taking into account sex preferences and the identification of potential users of sex-selection techniques would aid us considerably in predicting the consequences of a sex-selection technology.

Of course, a couple's decision to act on their preferences will depend on the reliability and convenience of the methods at hand. One approach to selection is the separation of X-bearing and Y-bearing sperm followed by artificial insemination. Prior to this decade, success could be verified only when the pregnancies resulting from artificial insemination came to term. Research has expanded rapidly since development of a procedure for prior evaluation (Barlow and Vosa, 1970), in which any one of several quinacrine compounds, such as quinacrine

dihydrochloride, is used to stain the stem end of the Y-chromosome, thereby distinguishing the Y-bearing from the X-bearing sperm population. Unfortunately, the dye kills cells as it identifies them, so those sperm subjected to the stain cannot be used for insemination. The procedure is, nevertheless, extremely useful in determining the efficacy of any sperm-separation technique under development.

Various separation procedures have been studied. One technique assumes that X- and Y-bearing sperm differ in charge and attempts to separate them using ion-exchange column chromatography (e.g., Downing, Black, Carey, and Delahanty, 1976). Experiments of this sort have met with little success, indicating that uncontrolled factors confound the problem or that the two types of sperm do not possess the charge differentials hypothesized. Other methods rely on differences in mass and motility of X- and Y-bearing sperm that permit separation by sedimentation and centrifugation. Dmowski, Gaynor, Rao, Lawrence, and Scommegna (1979), for example, modify a technique developed by Ericsson, Langevin, and Nishino (1973) and manage to isolate the highly motile, Y-sperm-rich semen fraction by passing the sample through layers of human serum albumin. This method, however, is complex and not yet practical for widespread use. And like all separation techniques, when perfected it will be combined with artificial insemination, which most couples would find unpleasantly intrusive.

Over the past several decades, many researchers have explored the possible relationship between the time of insemination within the menstrual cycle and the sex of offspring. In his chapter (4), William James recounts the history of this approach and some of the resulting controversies. James presents his own hypothesis—that the probability of conceiving a child of a given sex varies with maternal gonadotrophin levels at the time of insemination. As Guerrero (1975) has shown, male zygotes tend to be conceived early and late in the fertile period, and female zygotes near the middle. This pattern appears to be strongly correlated with the rise and fall of hormone levels during a woman's menstrual cycle. In a previous study, James (1980) noted that the proportion of males born to women whose ovulation was induced by either clomiphene or gonadotrophin was .44, a highly significant departure from the .51 level normally found. James further describes how this hypothesis explains variations in the sex ratio at birth by race and by season.

Methods of selection that rely on careful timing of coitus generally founder on the need to predict ovulation accurately or at least detect it. It is of no use to tell a couple that they should have sexual intercourse no closer than, let us say, two days prior to ovulation if there is no precise means of determining in advance the time at which ovulation will occur. However, there are a number of ways, of varying accuracy, to ascertain the time of ovulation.

One such procedure is known as the *calendar method*. Because the postovulatory or luteal phase of the menstrual cycle is less variable in length among

women than the preovulatory or follicular phase, it is posited that the time of ovulation can be estimated fairly well as 14 days prior to the onset of menstrual bleeding (which defines the beginning of the menstrual cycle). Assuming constant cycle length, a woman can then estimate the time of ovulation using the first day of bleeding as her reference point. Variability of the luteal phase does, however, confound this calculation and may render the entire method useless, especially where the follicular phase is irregular as well (e.g., Ross and Piotrow, 1974; Treloar, Boynton, Behn, and Brown, 1967). In particular, the cycles of postpubertal and perimenopausal women tend to be highly unpredictable (Moghissi, 1980).

The *basal body temperature* (*BBT*) *method* (the BBT is the temperature recorded immediately upon waking up in the morning, prior to any physical activity) relies on a slight surge (½–1°F) in body temperature at ovulation in response to increased blood levels of progesterone. (In addition, this rise is sometimes preceded by a small dip in temperature.) For example, then, the BBT method might prove useful to those couples who wish to have a daughter and are following the Guerrero scheme, in which case they would have intercourse on the day of the BBT shift.

Results from studies conducted in the United States and Great Britain (The Alan Guttmacher Institute, 1977) suggest a major difficulty with the BBT method. It appears that a substantial proportion of women (20–25 percent) do not exhibit a rise in temperature with an increased level of progesterone. Therefore, it is not safe to conclude that relatively constant BBT indicates a woman is in the preovulatory phase of her menstrual cycle. Also, temperature changes resulting from illness will obscure the progesterone effect.

Other means of detecting ovulation include the inspection of changes in the physical and chemical characteristics of cervical mucus and the vaginal cytology during the menstrual cycle (Moghissi, 1980). Currently, however, even using these methods in combination there is no procedure that predicts the time of ovulation accurately enough that a couple may time intercourse effectively in order to conceive a child of the desired sex.

The most effective means of choosing the sex of one's child, of course, is sex-selective abortion. The gender of the fetus is first determined through amniocentesis, a procedure that Golbus, Loughman, Epstein, Halbasch, Stephens, and Hall (1979) found to predict fetal sex correctly in all but 2 of the 3000 cases they examined. In addition, they concluded that amniocentesis is safe, thus dispelling some of the doubts associated with prenatal diagnoses. In this volume, Frances Kobrin and Robert Potter (Chapter 3) have examined the consequences of the use of sex-selective abortion, as indexed by the expected numbers of pregnancies, prenatal diagnoses, and abortions required to achieve a desired family goal. For both types of family goals considered—compositional and its special case, sequential—the expected values and variances are high. They show mathe-

matically what is intuitively quite clear: that a woman who is satisfied with compositional goals (e.g., two boys and one girl), rather than having a desire for specific ordering of the sexes of her children (e.g., boy–girl–boy), will achieve her ideal family with significantly fewer pregnancies, diagnoses, and abortions. However, a woman using sex selection merely to satisfy compositional goals is still subject to many more pregnancies than is her counterpart who is satisfied with any family composition. The interpretation of these results is that women will rarely use selective abortion as a means of determining the sex composition of their offspring. It is likely that only those couples with unusually strong sex preferences will avail themselves of a method that places such excessive demands on a woman who wishes to bear children of the desired gender.

At some time in the future, when a practical array of sex-selection techniques is available, it may well be that the methods used to select for one sex will not be as effective as methods available to choose children of the other sex. For example, the sperm-separation method explored by Dmowski *et al.* (1979) (see previous discussion) offers an increased probability of conceiving a boy but not a girl. In our chapter (5), Andrew Mason and I develop a decision-making model of the use of sex-selection techniques, in an effort to understand how a couple would put these techniques to optimal use in pursuing a desired family compositional goal. We also demonstrate how the direction and extent of bias in the technology (the difference between the maximum probability of obtaining a boy and that of obtaining a girl) might affect the strategy of a couple desiring a specific sex distribution of children.

Chapter 6 by David Bloom and Gilles Grenier outlines an economic approach to sex preferences and sex selection, and explores the potential fruitfulness of economic modeling. In particular, they develop a general model that shows how the probability of advancing from one parity to the next is related to the degree of the household's aversion to risk, the extent of the household's sex preferences given risk aversion, the probability of acquiring a child of the less-desired sex, the extent to which the already existing sex distribution of children is balanced, and the degree of price differences of male and female children. They also suggest a possible agenda for further research on this subject. One suggestion is to develop a parametric model of birth intervals in which the estimated parameters would depend on covariates reflecting risk and sex preferences, the degree of fertility control, and the current sex composition of children. Another possible line of research is to modify recent models of fertility response to child mortality (e.g., Olsen, 1980) so they could be used to examine differential replacement effects stemming from the mortality of male and female children.

Jeffery Evans (Chapter 8) undertakes the formidable task of analyzing the legal problems that might arise with the emergence of a sex-selection technology. On what legal grounds would a society limit the decision-making freedom of its individual members? How are conflicts to be resolved when the best

interests of society and the individual run counter to one another? Evans examines four types of sex-selection methods, the three mentioned previously and selective implantation (where the eggs are fertilized *in vitro* and an embryo of the desired sex is transferred to the womb of the biological or surrogate mother), and describes the legal similarities and differences among them. Although Evans develops the legal perspective primarily from United States law, he contrasts this perspective with those that might exist in several other countries, including the Soviet Union, China, and India.

The moral climate in a country, much less the speed at which it is changing, is often very difficult to assess accurately. However, it is clear that no matter what the relative rates of advancement in research may be among the three types of approaches to sex selection, moral attitudes could well be the limiting or final factor in the determination of which technique will ultimately predominate.

John Fletcher (Chapter 10) carefully examines the ethical conflicts that will arise when choice is possible. His objective is to lay out the framework with which policymakers in the relevant agencies can decide whether to promote or discourage research that could result in a viable sex-selection technology. He invokes a rule-utilitarian approach to ethical conflicts where advantage to one individual opposes the welfare of another or that of society as a whole. This approach "is utilitarian in that it estimates the value of actions by reference to their consequences, but the actions are not divorced from the obligation to follow moral rules [p. 223]." His arguments follow the moral principles of freedom with fairness. *Freedom* refers to the freedom from the imposed restriction of voluntaristic behavior, in addition to the freedom to satisfy basic personal needs. *Fairness* refers to the "impartial and equal treatment of those who participate in voluntaristic activities [p. 216]." Fletcher concludes that until the availability of a sex-selection technology is shown to inflict social harms, policymakers should not impede a couple's ability to choose the sex of their children.

Guided by the principle of equality, Tabitha Powledge (Chapter 9) also concludes that the freedom to select the sex of one's child should be protected. At the heart of her opinion is the view that the limitation of sex selection would jeopardize a woman's right to control her reproduction. Although Powledge does not wish to restrict the use of a sex-selection technology, neither does she wish to promote its use. To this end, she recommends the elimination of funding for sex-preference studies, for improved methods of fetal sex detection, and for the development of new, or the refinement of existing, sex-selection techniques.

Should a safe, practical, and easily affordable method of sex selection be developed, it remains unclear just who would use it. Certainly users would be motivated by a set of preferences that was encouraged and reinforced by the prevailing social structure and cultural context of the population.

Social norms may affect the costs and benefits that children present, and thus can have great bearing on parental sex preferences. In societies characterized by

a patrilocal system of marriage, for example, a woman assumes the residence of her husband's family. After marriage, she gives her time and labor to her husband's family instead of to her family of origin. Within such a system, one can easily see the advantage of having sons rather than daughters. Similarly, in societies with a dowry custom, marriage of daughters may represent a considerable financial burden. In societies with a bride-price custom, by contrast, marriage of daughters may bring financial rewards.

There is a clear cross-national association between level of development and degree of sex preference. One reason for this is ultimately economic in nature. As governments increasingly assume economic and social-security functions previously borne by family and kin groups, parents are liberated from the economic necessity of producing sons. Furthermore, technical change accompanying modernization necessitates the adoption of relatively rational or meritocratic criteria in the employment of labor, leading to greater interchangeability of male and female roles. The spread of education tends to equalize the fund of skills held by men and women while it erodes traditional views about women's status. Through these processes of modernization, the marginal economic utility of male offspring, as well as the ideological underpinnings of male sex preference, are diminished.

Despite such a general association between the phenomena of modernization and the roles and status of women, other social factors may impinge on gender preferences for offspring. Coombs and Sun (1981) have shown that even in rapidly developing societies, preferences for children of one sex over the other may die hard. In Taiwan, although fewer and fewer women expect their children—in particular, their sons—to support or reside with them in old age, the preferred sex ratio of children was virtually constant over the birth cohorts 1934–1938 to 1949–1953, and remained constant during the period 1965–1976. The reduction over cohorts in the proportion of women who would try to bear two sons, regardless of the number of children they already had, can be explained almost entirely by the decline in the total number of children preferred by women.

Thus, although expectations of support from sons have diminished in Taiwan, strong son preference persists (Coombs and Sun, 1981). This can be accounted for, at least in part, by the Chinese patrilineal religious ideology in which ancestors are seen as dependent on sacrifices performed by the male line of descent. This explains the importance attached to the provision of a male heir and to maintaining the family lineage (Coombs and Freedman, 1979; Coombs and Sun, 1981).

The People's Republic of China is attempting to effect a dramatic shift in the structure of families and the relationship between the family and the state. The *Beijing Review* reports, for example, that "the new measures now being tried out

in Sichuan stipulate that elderly widows and widowers should be well taken care of. In the countryside, the state and people's communes guarantee that their standard of living will be a little higher than the average [The Population Council, 1979, p. 378].'' Further efforts are currently aimed toward increasing the satisfaction of a couple who has a single female child. Indicative of the kinds of policies being implemented to achieve this objective is the practice, in some parts of the country, of allowing a daughter to inherit her father's factory position on his retirement. In addition, sons *and* daughters are now legally responsible for the economic support of their elderly parents (Wren, 1982).

Still, by all accounts son preference remains strong in the People's Republic of China. The policy of encouraging couples to have one or at most two children must inevitably prevent many families from attaining their desired number of sons, and the problem of son preference has thus been brought into stark relief. Evidence for this is indirect, but suggestive. Stories of beatings and expulsion from the family indicate that wives who do not produce sons may be in jeopardy. Additional evidence of the desire for sons in China came in a December 1982 speech by Prime Minister Zhao Ziyang condemning the practice of female infanticide (Haupt, 1983).

It is readily apparent, even in the most economically advanced nations, that son preference is still common. Sex preferences may reflect to some extent the level of inequality between the sexes in a particular society. As Williamson (1976, p. 166) has noted, ''parents would not have sex preferences unless the social and economic and familial roles of boys and girls were distinctly different.'' Coombs (1977), in a study based on the 1973 cycle of the National Survey of Family Growth, determined that one-half the wives in the United States prefer boys. (Approximately one-third were found to prefer girls and one-fifth a balanced family.) In analyses of the 1970 and 1975 rounds of the National Fertility Study, it has been shown that it is very common for a couple to prefer a son for the first birth and equal numbers of each sex thereafter (Pebley and Westoff, 1982; Westoff and Rindfuss, 1974).

Although many couples in both more and less developed areas of the world may wish to choose the sex of their offspring, a safe, reliable method is not yet at hand. As previously discussed, several prefertilization techniques appear promising, but none is now suitable for widespread use. Much attention has also focused on postfertilization techniques in which sex determination of an early embryo is coupled with selective abortion. Clearly, this approach will be acceptable only where diagnosis of pregnancy and fetal gender is prompt and abortion is very early. Herein lies the current problem: Abortion is safest during the first month of pregnancy, before accurate diagnosis can be made. Most pregnancy tests now in use are not reliable within only 3–4 weeks after conception (Kessel, 1975; Kessel, Brenner, and Stathes, 1975; Potter and Fortney, 1977). Clinicians

in the People's Republic of China report using a small sample of fetal cells aspirated through the mother's cervix to diagnose accurately (93 of 99 cases) gender at gestational age of 7 weeks (Mathews, 1977; Whelan, 1977). Abortion, on the other hand, is far safer and less troubling within 4 weeks of conception, when the uterus can be cleared by suction without cervical dilation (Dawn, 1975; Kleinman, 1976; Van der Vlugt and Piotrow, 1973, 1974). Maternal mortality is nonexistent, complication rates and morbidity are low, and psychological trauma appears to be reduced in comparison to that associated with abortions of greater gestational length (Kessel, Brenner, and Stathes, 1975). The problem, then, is still one of timing. Currently, the minimum duration necessary for the accurate diagnosis of pregnancy and the accurate identification of fetal gender is not consistent with the short duration of pregnancy optimal for safe abortions.

Given a belief in the concept of quantum leaps in technological advancement, a practical and effective *pre*fertilization technique may soon come to the fore. The *New York Times* (''Embryo 'Donation' Criticized,'' 1982, p. 9) has reported that Dr. Robert Edwards and Dr. Patrick Steptoe, developers of artificial implantation, intend to freeze excess embryos for donation to infertile women. Their plan was vigorously attacked by the chairman of the British Medical Association's ethics committee, Dr. Michael Thomas, who stated that ''medical technology is running ahead of morality.''

The President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research, created by Congress in 1978, also addressed the issue of using genetic screening for purposes of sex selection. The commission noted that the prospective parents' desire to undergo such screening is ''morally suspect,'' as that desire would sometimes be an ''expression of sex prejudice,'' usually in favor of males. In this light, they concluded that widespread use of amniocentesis for sex selection would serve to perpetuate ''the historical discrimination against women.'' Further, the commission stated that parental concern with the sex of the fetus (especially to the point of selective abortion) ''seems incompatible with the attitude of virtually unconditional acceptance that developmental psychologists have found to be essential to successful parenting.'' Genetic screening, taken at the extreme, conjures up the morally abhorrent notion that children are mere objects to be designed by their parents. The commission concluded that ''public policy should discourage the use of amniocentesis for sex selection''; legal prohibition was not recommended because enforcement of such a statute would be difficult and ''might depend on coercive state inquiries into private motivations [President's Commission, 1983, pp. 57–58].'' Thus it becomes clear from the preceding discussion that the legal and moral implications of the development and use of a sex-selection technology—implications that are relevant to the field of genetic engineering as a whole—are issues with which we must contend.

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2

Measuring Sex Preferences and Their Effects on Fertility*

GARY H. McCLELLAND

INTRODUCTION

Biologists predict that in the not-too-distant future, couples will be able to use medical techniques to alter the probability of having a child of a given sex on their next pregnancy. In effect, couples will be able to select the sex of their children (e.g., see Rinehart, 1975). In order to anticipate the impact that sex-selection techniques could have on fertility, it is important to be able to measure sex preferences, their present impact on fertility, and their likely impact given the use of sex-selection techniques. This chapter reviews currently available methods for measuring sex preferences, discusses how these measures might be used to assess the direct consequences of sex-selection techniques on fertility, and suggests improvements that might be made in existing measures.

This chapter has three goals: (a) to guide attempts to estimate the effects of sex selection using data collected with existing methods, (b) to guide collection of new data to estimate the effects of sex selection, and (c) to clarify thinking about

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and provide insights into the ways in which sex selection might change fertility patterns. These purposes imply an emphasis on theory and method rather than on the substantive results obtained to date. One may refer to Williamson (1976) for a discussion of the major substantive results about sex preferences. The primary foci of this chapter are a psychological model of sex preferences, the implications of this model for the measurement of sex preferences, and the effects of these preferences. Before presenting the model, I discuss the types of effects sex preferences might have and present examples illustrating these effects.

POTENTIAL EFFECTS OF SEX SELECTION

There are three possible direct effects of sex selection on fertility. Depending on the preferences of those couples who would use such techniques, sex selection might change fertility rates, change the sex ratio, and/or change the birth order of sexes within families. In order to discuss these effects, we introduce the following notation: (2, 1) refers to a completed family of two boys and one girl, without regard to birth order; B–G–B refers to the same completed family with the exact birth order specified.

A number of indirect effects would undoubtedly follow if any of the three direct effects were to occur. For example, a major change in the sex ratio would probably cause dramatic societal changes. Although those indirect changes are perhaps ultimately more important, they will not be considered here (see Etzioni, 1968; Westoff and Rindfuss, 1974; and Williamson, this volume). Instead, this chapter concentrates on the direct fertility-related effects of sex selection, which must mediate any other effects. The following section investigates through examples the mechanisms by which sex selection might affect fertility rates, the sex ratio, and birth orders.

EXAMPLES OF THE POTENTIAL EFFECTS OF SEX SELECTION

Change Fertility Rates

Consider a couple whose first six choices for completed family compositions are, in order of preference: (2, 1), (1, 2), (1, 1), (2, 0), (0, 2), (3, 0), (0, 3). In

other words, this couple would like to have a family of three children as long as the three were not all of the same sex. Having three children of the same sex is so undesirable to this couple that they would rather have only two children, no matter what the sexes, than have three of the same sex. Even though this couple most prefers a family of three children, if their first two children were of the same sex, they might well stop at two rather than take the risk of having a third of the same sex. If perfectly reliable sex selection were available, however, they could have a third child without taking that risk. (The issue of the effects of sex selection techniques that are not perfectly reliable is addressed later in this chapter.) In this case the availability of sex selection could serve to *increase fertility*.

Now consider another couple with the following preferences for completed family composition: (1, 1), (2, 1), (1, 2), (2, 0), (0, 2). That is, they want to have two children as long as they have one of each sex. If they were to have two children of the same sex, however, they might have a third in order to reach the more desirable compositions (2, 1) or (1, 2). If sex selection were available this couple could achieve the sex balance they desire without having three children. This is the type of preference pattern usually assumed when the impact of sex selection on fertility is discussed. In this case the availability of sex selection could serve to *decrease fertility*.

Finally, it should be noted that if there were approximately equal numbers of couples with preferences of the preceding two types, then the net aggregate effect of sex selection on fertility rates would be negligible.

Change Sex Ratio

Consider a group of couples who all want to have three children (no more, no less) regardless of sex composition, but who most prefer the composition (2, 1). Without sex selection, the distribution of family compositions over these couples would be approximately (assuming boys and girls are equally likely)

Composition:	(3,0)	(2,1)	(1,2)	(0,3)
Probability:	.125	.375	.375	.125

Because there would be an equal number of boys and girls the sex ratio (boys/girls) would be approximately 1. With sex selection, the preferred composition (2, 1) could be achieved by all couples, giving a sex ratio of 2. For this hypothetical group, the sex ratio would have changed without a change in the fertility rate. Again note that if as many couples prefer (1, 2) as prefer (2, 1) there would be no aggregate change in the sex ratio.

Change Birth Order of the Sexes

Consider a group of couples who all want two children regardless of sex composition, but who most prefer the composition (1, 1) with the first-boy, then-girl birth order (B–G). Without sex selection, the distribution of birth orders for these couples would be approximately

Birth Order:	B–B	B–G	G–B	G–G
Probability:	.25	.25	.25	.25

This distribution gives a sex ratio of about 1 and a fertility rate of 2. Boys and girls appear in equal numbers in each birth position. With sex selection, the order B–G could be achieved by all couples. This would leave the fertility rate and sex ratio unchanged, but only males would occupy the first-born position.

In order to facilitate later discussion of the effects of sex selection on birth orders, we introduce an index, *birth order ratio,* which is the average birth rank for boys divided by the average birth rank for girls. For the example just given, without sex selection the birth-order ratio would be 1 and with sex selection it would be 0.5 (birth-order ratios less than 1 indicate that boys occupy earlier birth ranks than girls). Of course, if as many couples preferred the order G–B as preferred B–G, there again would be no net aggregate effect of sex selection on birth orders even if every couple were to use such techniques.

Implications of the Examples

Some important implications can be extracted from the preceding examples. First, the three possible direct effects of sex selection are logically independent in that one could occur without the other two. Of course, such changes are not likely to be independent statistically. The importance of the logical independence is that different measures may need to be developed for each effect.

A second important implication is that effects of sex selection on individual couples do not necessarily imply a net aggregate effect. If family composition and birth order preferences are heterogeneous, it is possible for many individual (or in this case couple) effects to cancel so that there is no net effect. This is a very important point in anticipating the effects of sex selection. With sufficient heterogeneity of preferences in the population, sex selection might have none of the three possible direct effects even if every couple used sex-selection techniques.

Conversely, the lack of an aggregate effect does not imply that there are no individual effects. This means that it is difficult, if not impossible, to infer the existence of sex preferences and the probable use of sex selection from aggregate

behavioral data. I discuss this issue in greater detail in the context of behavioral measures of sex preferences.

It should be noted that although sex selection has three possible fertility-related effects, sex preferences can currently only affect fertility rates, increasing or decreasing fertility in individual cases. Without the availability of sex selection, sex preferences cannot alter either the sex ratio or the birth-order ratio. This too will be an important point in the discussion of behavioral measures, for it means that it will be difficult to infer the effect of sex selection on the sex ratio and the birth-order ratio from observations of the behaviors of couples who have no access to sex-selection techniques.

A final implication of these examples is that a decision-making model is a useful tool for considering the effects of sex selection. The implicit model in the examples, especially the first two (concerning changes of fertility rates), is that a couple deciding whether or not to have another child compares the desirability of their present family composition to the desirability of the compositions they might obtain were they to have another child. This simple model is expanded and formalized in the following section.

A DECISION-MAKING MODEL FOR SEX PREFERENCES

Having an explicit model of how sex preferences affect fertility decisions will make it easier to consider the strengths and weaknesses of existing measures of sex preferences and to devise new measures for assessing the consequences of sex selection. The model presented in this section is based on the sex-preference model of Coombs, Coombs, and McClelland (1975) and the decision-making model of McClelland (1979a, 1980).

Let us examine the decision problem facing a couple with the current family composition (B, G). The couple has essentially two alternatives with respect to fertility: (a) they can choose to stay with their current family composition by deciding to have no more children or (b) they can change their current composition by having another child. Although there are, of course, a large number of ways to implement either alternative—for example, choice of contraceptive method for the first alternative—the model represents only the two-alternative choice.

What are the conditions under which the couple with composition (B, G) is likely to want another child? To answer this question we introduce a value function v so that v(B, G) represents the value or desirability (on some arbitrary scale) of the composition (B, G) to the couple. If they decide to have another

child, then they will (ignoring the small probability of multiple births) obtain either the composition (B + 1, G) if they have a boy or (B, G + 1) if they have a girl. The answer to our question can be obtained by comparing the desirability of these two outcomes to the desirability of the status quo (B, G). If v(B + 1, G) and v(B, G + 1) are both greater than v(B, G), then the couple would most likely want to have another child, because no matter what the sex of that next child the couple would be happier with their new family composition. On the other hand, if v(B + 1, G) and v(B, G + 1) are both less than v(B, G), then the couple is most likely not to have another child, because no matter what the sex of the next child they would be happier with the status quo. Neither of these cases presents the couple with a difficult decision problem.

Risky Decisions

The interesting decision problem arises when one, but not both, of the two values of having another child is greater than the value of the status quo family composition. That is, whenever

$$v(\mathrm{B} + 1, \mathrm{G}) > v(\mathrm{B}, \mathrm{G}) > v(\mathrm{B}, \mathrm{G} + 1)$$

or

$$v(\mathrm{B}, \mathrm{G} + 1) > v(\mathrm{B}, \mathrm{G}) > v(\mathrm{B} + 1, \mathrm{G})$$

the couple confronts a risky decision. (There are, of course, many risky aspects associated with fertility-related decisions; however, in this chapter *risky* always means "risky with respect to sex preferences.") If they decide not to have another child, then they are giving up the possibility of the composition they want for fear of obtaining the composition they do not want. If they do decide to have another child, then they are taking a gamble that, depending on the sex of the child, they may win or lose. How does the couple decide whether to accept the risk? A reasonable first model is based on the expected value. Because the probabilities of having a boy or a girl are approximately equal, the expected value (*EV*) of the gamble is simply the average of v(B + 1, G) and v(B, G + 1). If the expected value of the gamble is greater than v(B, G), the couple would be likely to take the risk (assuming they want to maximize *EV*) and they would be unlikely to take the gamble otherwise. Formally, this decision rule is:

If *EV*(have another child) > v(B, G), then have a child;
If *EV*(have another child) < v(B, G), then stop having children,

where $EV = [v(\mathrm{B} + 1, \mathrm{G}) + v(\mathrm{B}, \mathrm{G} + 1)]/2$.

Subjective Probabilities

Although the preceding model provides a good start toward a descriptive model, it is unfortunately too simple. One major problem with the model is that it presumes that the couple correctly recognizes that the probability of a boy on the next birth approximately equals the probability of a girl. Many people may believe incorrectly that the probability of, say, a boy on the next birth somehow depends upon the family's current sex composition. For example, some people may believe that if a family's first three children are girls, then the family is "due" to have a boy and thus the fourth child is more likely to be a boy then a girl. Such a belief is often referred to as the *gambler's fallacy*. Another frequent incorrect belief about probabilities is the trend fallacy. In the context of family sex composition, the *trend fallacy* is a belief that the currently predominant sex in the family is more likely on the next birth. People who believe the trend fallacy would think that a family whose first three children were girls were "girl producers" and so expect that the fourth child would more likely be a girl than a boy.

Ben-Porath and Welch (1976), using the public use sample of the 1970 United States census, have shown that there is a slight trend effect in actual births. If the first three children are boys, then the probability of a boy on the fourth birth rises from .513 (the probability of a boy on the first birth) to .534. However, even this small change in the probability does not occur unless all the previous children are of the same sex. For example, if the family consists of three boys and one girl the likelihood of a boy on the fifth birth is only .515, which is essentially the same as the probability of a boy on the first birth. Thus, it is reasonable to conclude that couples *should* assume that without sex selection the probability of a boy is always approximately equal to the probability of a girl.

If the subjective probabilities for many people systematically deviate from the objective probabilities, then it is important to include the effect of subjective probabilities in the decision-making model for two reasons. First, consider a family whose first three children were girls; assume that they very much want to have a boy but do not want to have a fourth girl. According to our definition, they are faced with a risky decision. However, they may fail to recognize just how risky their decision is if they believe in either the gambler's fallacy or the trend fallacy. For example, if they believe in the gambler's fallacy then they might incorrectly believe that a boy on the next birth would be almost certain, so they would be more likely than they should be to accept the implicit gamble. On the other hand, if they believe in the trend fallacy then they might incorrectly believe that the undesired fourth girl would be almost certain, so they would be less likely than they should be to accept the gamble.

A second reason for incorporating subjective probabilities in the model is that

knowledge of these probabilities is important for anticipating the use of sex-selection techniques that are not perfectly reliable. For example, if a couple who wants a boy on the next birth incorrectly believes, based on the existing composition of their family, that they are very likely to have a boy on their next birth (say their subjective probability equals .85), then they would be unlikely to pay the cost and suffer the inconvenience of a sex-selection technique that only changed the actual probability of a boy to, say .75. On the other hand, a couple desiring boys who incorrectly believed that they were girl producers (subjective probability of a boy less than .50) might find attractive a sex-selection technique that could only increase the probability of a boy to .60.

Even given this reasoning, it would still not be worthwhile to add subjective probabilities to the decision-making model unless it were demonstrated that a significant proportion of couples believe either of the two fallacies for sex probabilities. McClelland and Hackenberg (1978) show that for their two samples—one in the Philippines and one in the United States—systematic, within-individual errors in subjective probabilities are pervasive. Respondents in their study were asked multiple-choice questions of the following type: "If a family already had *B* boys and *G* girls and they were going to have another child, do you think it more likely that they will have (a) a boy than a girl, (b) a girl than a boy, or (c) a boy as likely as a girl?" (*B* and *G* in this question were replaced with specific numerical values.) In the Filipino sample, 78 percent gave responses to the entire set of questions that were consistent with the gambler's fallacy and only 4 percent consistently gave the "equally likely" response. In the United States sample (college students at a major university), 35 percent gave responses consistent with the gambler's fallacy, 18 percent with the trend fallacy, and 34 percent gave the correct response of approximately equally likely. Furthermore, as suggested in the example given earlier, those in the Filipino sample for whom subjective probabilities and preferences matched (i.e., the preferred sex for the next birth was also believed to be the more likely sex for the next birth) were more likely to state an intention to have another child than were those for whom subjective probabilities and preferences did not match. Specifically, 65 percent of those respondents whose probabilities and preferences matched stated that they would have another child if they had two boys and one girl, but only 43 percent of those whose probabilities and preferences did not match so stated. Clearly, agreement between the direction of the probability error and the direction of the sex-composition preference increases the likelihood of a stated intention to have another child. This interactive effect between subjective probabilities and preferences on fertility intentions has not been replicated in our samples of United States college students. Nevertheless, the effect of subjective probabilities in the Filipino study and the potential importance of those probabilities in a couple's evaluation of a less than perfectly reliable sex-selection technique suggest that they be included in the model.

Incorporation of subjective probabilities into the decision-making model is easy. Instead of basing the decision rule on *EV*, the expected value, we simply substitute the subjectively expected value (*SEV*), a weighted average in which the subjective probabilities serve as weights. Formally, let $P(\mathrm{B}, \mathrm{G})$ = the subjective probability that the next child will be a boy given that the present family sex composition is (B, G). To simplify notation I use just P for $P(\mathrm{B}, \mathrm{G})$ in the equations, but it should be remembered that this subjective probability is conditional on the existing composition. Similarly, let Q equal the subjective probability that the next child will be a girl given the present family composition. P and Q need not sum to one because they are subjective, not objective, probabilities. Then,

$$SEV = P \times v(\mathrm{B} + 1, \mathrm{G}) + Q \times v(\mathrm{B}, \mathrm{G} + 1).$$

Replacing *SEV* with *EV* in this decision rule effectively incorporates subjective probabilities into the model.

The $N \times S$ Model

We can improve the model still further by being more specific about the value function v. Coombs *et al.* (1975) investigated several possible models for describing sex composition preferences. Their $N \times S$ model best described the preferences of respondents in both Taiwan and the United States. Subsequent studies (see L. C. Coombs, 1976) in a variety of cultures have confirmed the choice of the $N \times S$ model. According to this model the value (desirability) of a given family sex composition can be decomposed into the sum of two independent components—the desirability of a family of size $N = \mathrm{B} + \mathrm{G}$ and the desirability of a family with a sex difference of $S = \mathrm{B} - \mathrm{G}$. Formally,

$$v(\mathrm{B}, \mathrm{G}) = u(N = \mathrm{B} + \mathrm{G}) + w(S = \mathrm{B} - \mathrm{G})$$

where u and w are the evaluation functions for N and S, respectively. Both u and w are single-peaked evaluation functions, in which preference falls monotonically from one most-preferred alternative on the N and S dimensions. Substituting this decomposition of the value function into the equation for *SEV* yields

$$SEV = P \times [u(N + 1) + w(S + 1)] + Q \times [u(N + 1) + w(S - 1)]$$

which, according to the model, is compared to the value of the status quo family composition, *SQ*, which is

$$SQ = u(N) + w(S).$$

What has been gained by adding the $N \times S$ model to the basic decision-making model? The primary contribution is the separation of the effects of sex prefer-

ences [$w(S)$] and size preferences [$u(N)$], which are confounded in the simple family-composition preference function $v(\mathrm{B}, \mathrm{G})$. This separation (a) enables independent measures to be constructed for sex and size preferences, and (b) enables a more precise characterization of the type of fertility decisions affected by sex preferences. Earlier we characterized fertility decisions as risky or nonrisky. In the $N \times S$ model, a nonrisky decision occurs in two instances: (a) when sex preferences are nonexistent, that is, when $w(S) = w(S - 1) = w(S + 1)$; or (b) when sex preferences are dominated by size preferences, that is, when

$$|w(S) - w(S \pm 1)| < |u(N) - u(N + 1)|.$$

If sex preferences are not dominated by size preferences, a risky decision results. In this case sex and size preference are in conflict. For example, consider a couple with the preference ordering

$$(\mathrm{B} + 1, \mathrm{G}) > (\mathrm{B}, \mathrm{G}) > (\mathrm{B}, \mathrm{G} + 1).$$

Their sex and size preferences could conflict in three distinct ways: (a) the desire for an additional child conflicts with the fear of an unwanted girl, (b) the desire for a boy conflicts with the desire to maintain the existing family size, or (c) the desire for an additional child conflicts with a desire to maintain the existing sex composition.

Decisions about Sex Selection

So far we have assumed that the couple must choose between two alternatives—they can either have another child or not. There is, of course, a third alternative that will become increasingly available—having another child using sex-selection techniques. To model this choice we assume that the couple chooses the one alternative of the three with the highest subjective value; that is, the highest-valued of *SQ*, *SEV-WO* (subjectively expected value without sex selection), and *SEV-W* (subjectively expressed value with sex selection), where *SQ* and *SEV-WO* are defined as earlier. *SEV-W* must include the subjective (or objective) probabilities given the use of a particular sex selection technique, and the costs of using that technique. That is,

$$SEV\text{-}W = P \times v(\mathrm{B} + 1, \mathrm{G}) + Q \times v(\mathrm{B}, \mathrm{G} + 1) - COSTS,$$

where P and Q are the relevant subjective probabilities given use of the technique and *COSTS* are its associated costs. *COSTS* includes not only the monetary cost of the technique but also the psychological and emotional costs that would result from using sex selection. Both types of costs are likely to be considerable for techniques involving artificial insemination, amniocentesis, and selective abor-

tion. We will not model those costs further here, but such modeling would be necessary if the model were to be used to make fine predictions about who would and would not use sex selection. Modeling of costs should not be especially difficult and could be accomplished using essentially the same measurement procedures Coombs *et al.* (1975) used to develop the $N \times S$ model.

Even without refinement of the *COSTS* variable, this simple model can be used to define several interesting decision patterns. For example, a couple's combination of values and probabilities could be such that

$$SEV\text{-}W > SQ > SEV\text{-}WO.$$

That is, they are not willing to try to have a child of the sex they want without sex selection, but will try with sex selection. For this couple the availability of sex selection would result in a fertility *increase*. For another couple the ordering might be

$$SEV\text{-}W > SEV\text{-}WO > SQ.$$

This couple would have another child even if sex selection were not available, but would use it if they can. In this case the availability of sex selection would leave the fertility decision unchanged, but could change the sex ratio and/or birth order within the family.

A couple without sex preferences would presumably always have $SEV\text{-}WO > SEV\text{-}W$, whether the status quo was valued above, below, or between the two alternatives. This couple would reject use of sex selection at every decision point, as might a couple with very high perceived costs of using sex selection. Still another couple might value use of sex selection most highly at some decision points but reject it at other points because of incorrect beliefs that the chances of having a child of the desired sex without sex selection were as high or higher than those given the use of sex selection. For example, a couple with three girls and no boys who believes that they are due to have a boy (say, $P = .8$) would not want to incur the costs of a selection technique that would only ensure $P = .75$. Finally, a couple might produce the ordering

$$SEV\text{-}WO > SEV\text{-}W > SQ.$$

This couple considers use of sex selection preferable to retaining the status quo, but decides to have another child without using selection; their decision not to use sex selection might well be altered if the associated costs were to be lowered.

One further complication must be added to the model. A couple willing to consider sex selection must also choose a particular technique. This simply means that there will be several *SEV-W*s, one for each technique being considered. Presumably, the couple would choose the technique with the highest *SEV-W* given that it exceeds *SEV-WO*. With or without refinement of the *COSTS* variable and consideration of alternative sex-selection techniques, the simple

decision-making model presented earlier carries an important implication: The decision to use sex selection will depend upon the couple's sex and size preferences, the subjective probabilities with and without sex selection, and the objective and subjective costs of the particular selection technique.

Other Decision-Making Models

Our primary purpose in describing a model of fertility decision making with respect to sex preferences is to provide a guide for consideration of various techniques of measuring sex preferences. Our goal is not to claim superiority for this model over other sex-selection models. Nevertheless, because so many decision-making models have been introduced, we must consider how a few of the more important models relate to that presented earlier.

A number of mathematical studies have asked what the effect of sex preferences on family size and sex ratio would be with and without sex selection (e.g., Goodman, 1961; Jones, 1973; Mason and Bennett, 1977; McDonald, 1973; Mitra, 1970; Sheps, 1963; Smith, 1974). In order to calculate expected family sizes and sex ratios, these studies have generally assumed that a couple has a preference for a fixed minimum number of boys and a fixed minimum number of girls. McDonald (1973), for example, makes this assumption and then calculates the strategies a couple should follow to attain the desired minima in the smallest number of births by using sex-selection techniques with various probabilities. Although such studies may be useful for estimating the maximum possible impact of sex preferences on fertility, they are not particularly useful for our purpose of examining different methods of measuring sex preferences. The primary problem lies in the representation of the couple's preferences in terms of fixed minima. Coombs *et al.* (1975) found little support for fixed-minima (threshold) models; instead, their data (and subsequent studies such as that of L. C. Coombs, 1976) support the $N \times S$ model described previously. The $N \times S$ model does not presume fixed minima but instead assumes that size preferences and sex preferences are traded off against each other. Further, the fixed-minima model also implies that sex preferences can only increase, not decrease, fertility. This assumption is untenable given the model presented earlier, and has been refuted by data reported by Widmer, McClelland, and Nickerson (1981). Finally, such studies are more concerned with developing prescriptive than with descriptive models of how couples actually make fertility decisions. A descriptive model is clearly required for our purpose of considering measurement techniques.

Ben-Porath and Welch (1976, 1980) present an economic model of fertility decision making with respect to sex preferences. Although they employ some

economic concepts not incorporated into our model (e.g., price elasticity), most of the important implications from the two models are the same. For example, both models assume that couples may have incorrect subjective probabilities, that sex preferences can logically decrease as well as increase fertility, and that diverse individual effects of sex preferences can be obscured in aggregate data. The one important difference is that Ben-Porath and Welch model sex preferences as a function of B and G instead of *N* and *S*. However, *N* and *S* could easily be incorporated in their model. Thus, those readers who prefer more formal economic models can substitute the Ben-Porath and Welch model for ours in the remainder of the discussion.

Goodman (1961) did not present a formal model, but did consider many of the issues raised by our model. Our model has the advantage only of making more systematic such ideas as incorrect subjective probabilities, fertility-inhibiting effects of sex preferences, and so on.

Implications of the Model

It is important not to take our model too literally. We do not really believe, for example, that couples actually perform the algebraic manipulations described above when deciding whether or not to have another child, although it might be a good idea to provide couples with decision aids that would in fact do such computations for them (see Beach, Townes, Campbell, and Keating, 1976). Rather, the model is meant to show the variety and direction of forces that can influence fertility decisions with respect to sex preference. We have presented these forces in the context of a model to show that they are logical, reasonable, and interrelated. Before proceeding to a comparison of the various measures of sex preference, we summarize the major implications of the model.

The most important implication of the model is that a fertility decision with respect to sex preferences is a complex function of the couple's values (i.e., their size and sex preferences) and subjective probabilities for the sex of the next child. Because each fertility decision has multiple determinants, it is impossible to infer either the couple's preferences or subjective probabilities from a single behavior (i.e., having or not having another child). For example, if a couple with three girls and no boys decides not to have another child, it is not reasonable to infer that they are satisfied with their current family sex composition. Being satisfied with three girls is, according to the decision-making model, only one of many possible explanations for their behavior. They might want a boy but believe that they are girl producers and so stop trying; they might want a boy very much but also not want more than three children; or they may fear the possibility of a fourth girl so much that they are unwilling to take the chance of having

another child. Any measurement procedure that ignores this variety of possible explanations risks serious misrepresentation of the nature and effect of sex preferences.

A second consequence of the multiple determination of fertility decisions is that two couples may have exactly the same preferences (or subjective probabilities) yet reach opposite decisions because of differing subjective probabilities (or preferences). McClelland (1979b) discusses the effect of this consequence on the correlation between fertility intentions and actual behavior.

A third consequence of multiple determination is that there are many opportunities for individual differences—couples can differ in size preferences, sex preferences, subjective probabilities, perceived costs of sex selection techniques, and so on. If there is much heterogeneity with respect to any of these components of the decision-making model, then aggregating data across couples can obscure even pervasive effects of sex preferences on fertility decisions. That is, it is possible for sex preferences to influence every couple's fertility decisions and yet have no aggregate effect. Our model thus suggests that measures of sex preference based on aggregate data be viewed very cautiously.

A final implication of the model is that sex preferences can only affect fertility in the presence of risky decisions. Risky decisions occur when size and sex preferences are in conflict and when neither dominates the other; in other words, when the couple is willing to add either a boy or a girl, but not both, to the existing family. At nonrisky decision points size preferences dominate sex preferences, which play no role in the decision. The availability of sex selection opens the possibility that couples might use selection techniques to determine birth order, so that sex preferences might affect fertility decisions even at nonrisky points.

In summary, the model of fertility decision making with respect to sex preferences suggests three criteria for evaluating measures of sex preferences: (a) sensitivity to the multiple determinants of fertility decisions; (b) sensitivity to individual differences in values, preferences, and beliefs; and (c) ability to distinguish between those decisions that are influenced by sex preferences (risky decisions) and those that are not.

CONSIDERING MEASURES OF SEX PREFERENCES

The ultimate concern of this chapter is with measurement of the potential effects of sex selection on fertility. However, virtually all existing measures are designed to measure sex preferences rather than the direct effects of sex selec-

tion. These are not, of course, unrelated issues—sex selection is of no concern unless sex preferences are shown to be both strong and pervasive in a population. This suggests a sequence of questions concerning sex preferences and sex selection; it is a sequence in the sense that the relevance of subsequent questions depends on answers to prior ones.

1. Do sex preferences exist? This must obviously be the first question.
2. If so, what pattern do the preferences follow? Is the preference for boys, for girls, or for balance?
3. Do sex preferences affect fertility? As noted earlier, it is logically possible for sex preferences, even very strong sex preferences, to have no effect on fertility. Thus, it is not enough simply to determine the existence and pattern of sex preferences.
4. If sex preferences do affect fertility, how can the effects be estimated quantitatively? Quantification is important because use of sex selection might undo the effects of sex preferences on fertility. For example, if currently the aggregate effect of sex preferences is to increase fertility, then it is likely that the aggregate effect of widely used sex selection would be a decrease in fertility.
5. Under what circumstances, and by whom, will sex-selection techniques most likely be used? Because universal use of sex selection techniques is extremely unlikely, it is necessary to know who the likely users will be, and when in the birth sequence they will use sex selection, in order to make any predictions about the aggregate effects of sex selection on fertility, sex ratio, and birth order.
6. How can the quantitative effects of use of sex selection on fertility, sex ratio, and birth order be estimated? That is, how can answers to the previous questions be combined to yield quantitative predictions?

In the following sections we consider the ability of various measures to provide answers to these questions. We also suggest new measures to answer questions not addressed by available measures. Throughout, the decision-making model guides our assessment. We can classify measures of sex preferences into three categories: behavioral measures, attitudinal measures, and behavioral intention measures. The distinction between the last two categories is that attitudinal measures assess global, diffuse attitudes whereas behavioral intention measures assess intentions (or attitudes toward) specific behaviors. The examples in each section should make this distinction clear.

Behavioral Measures

With behavioral measures the existence of sex preferences and their effects on fertility are inferred from aggregate statistics for actual fertility behaviors. It is

not feasible to list here either all the specific types of behavioral measures or all the studies using any particular measure. Instead, we list some of the more common behavioral measures and cite a study or two illustrating the use of each method. See Williamson (1976, Table 1) for a more complete listing of such studies.

1. Differential parity progression ratios (e.g., Bumpass and Westoff, 1970). Parity progression ratios (the proportion of women at a given parity who have an additional child) are analyzed for dependence on existing family sex composition. If certain sex compositions have lower-than-average progression ratios, it is inferred that the predominant sex in those compositions is the preferred sex. Similarly, if certain sex compositions have higher-than-average progression ratios, it is inferred that the minority sex in those compositions is the preferred sex and that the additional births (relative to the other compositions) are the result of the efforts of many couples to add a child of the desired sex. Finally, if the sex compositions with the lower progression ratios are balanced (i.e., equal numbers of boys and girls), then a preference for balanced family sex compositions is inferred. For example, Bumpass and Westoff (1970) inferred a preference for balanced family sex compositions from a survey of 814 wives from the largest standard metropolitan statistical areas in the United States because additional births were more likely to occur if the preceding births were all of the same sex.

2. Comparison of observed and expected unisex sibships (e.g., Myers, 1949; Rife and Snyder, 1937). This is actually a variant of parity progression ratio measures. Given information about the sex ratio and the distribution of parities for a sample of completed families, it is possible to compute the expected number of unisex sibships. If the observed frequency for unisex sibships of a given sex is lower than expected, then the presumption is that the sex is relatively less desired and that couples with families with children only of that sex tend to continue having children until they have a child of the opposite sex. For example, Myers (1949) inferred a preference for balanced sex compositions from an excess of two-child families with one boy and one girl in an analysis of 999 entries in *Who's Who*.

3. Comparison of sex ratio of lastborns to overall sex ratio (e.g., Winston, 1931, 1932). The assumption on which this measure is based is that couples with an undesirable family sex composition are likely to continue to have children until they obtain a more favorable sex composition. If this is so, then the sex ratio of the lastborns should be biased, relative to the overall sex ratio, in the direction of the more-preferred sex. For example, Winston (1932) analyzed 5466 completed families listed in the *Abridged Compendium of American Genealogy*, finding a sex ratio of 1.174 for lastborns and a sex ratio of 1.213 for completed two-child families. From these data he inferred a preference for boys.

4. Length of birth intervals following boy births and girl births (e.g., Westoff,

Potter, Sagi, and Mishler, 1961). This measure is based on the assumption that if one sex is preferred, the birth of a child of that sex will provide the couple with greater satisfaction, in turn leading the couple to wait longer before deciding to have another child. Conversely, the birth of a child of the less-preferred sex will provide less satisfaction, so that the couple will be eager to try again soon to have a child of the more preferred sex. For example, Ben-Porath and Welch (1976) concluded from a reanalysis of birth interval data from Bangladesh reported by Repetto (1972) that the higher the ratio of boys to girls in the family, the longer subsequent birth intervals were. However, the sex of the last child was *not* a significant predictor of the length of the following birth interval.

Strengths

The obvious strength of behavioral measures is that they are based on analyses of real behaviors rather than verbal statements of attitude. If a behavioral method demonstrates an effect on fertility, we therefore can be confident that such an effect really exists.

A second strength is that behavioral measures can sometimes be calculated from aggregate data sets compiled for other purposes (e.g., Dawes, 1970; Myers, 1949; Winston, 1932).

Problems

There are two major problems with any behavioral measure of sex preferences. First, as we argued earlier, aggregate data will give valid results only if sex preferences are relatively homogeneous within the population. Heterogeneous preferences can cancel to produce no net effect even if sex preferences do indeed influence the behavior of most couples. Behavioral measures will thus underestimate the magnitude of any effect of sex preferences on fertility.

A hypothetical example from McClelland (1979a) illustrates how heterogeneity causes underestimation. In this example, we make the extreme assumption that sex preferences *perfectly determine* fertility decisions at parity two and after. That is, assume that those who want more boys than girls stop if they have two boys and continue if otherwise, those who want equal numbers stop only if they have one boy and one girl, and those who want more girls than boys stop only if they have two girls. Also assume equal probabilities of male and female births. The behaviors of a hypothetical sample of 400 couples are cross-tabulated in Table 1 according to preference and actual composition at parity two. The portion of the sample that would be satisfied are footnoted *b;* for these couples,

TABLE 1

Hypothetical Progression Ratios at Parity Two Assuming Complete Determination of Fertility by Sex Preferences[a]

Desired family composition	*Actual family composition*		
	BB	*GG*	*BG*
BB	39[b]	39	78
GG	32	32[b]	64
BG	29	29	58[b]
Total number	100	100	200
Number satisfied and stopping at parity two	39	32	58
Number dissatisfied and progressing to parity three	61	68	142
Parity progression probabilities	.61	.68	.71

[a]Source: McClelland, 1979a. Marginal preference distribution based on data from Prachuabmoh, Knodel, and Alers, 1974.

[b]Desired composition achieved.

preference matches outcome at parity two. The last row of the table gives the percentage of dissatisfied couples—those who would move to higher parities under the assumption of a perfect relationship between sex preferences and fertility. Had these percentages been obtained in a parity progression study, it would have been concluded that this sample had a slight boy bias because a slightly higher percentage of girl–girl and boy–girl families progress to higher parities than do boy–boy families. It would also be concluded that sex preferences had a slight impact on actual fertility. This conclusion is inconsistent with the assumption on which the example was constructed, that sex preferences perfectly determine all fertility decisions at parity two. Thus, parity progression ratio and other behavioral measures invariably underestimate the impact of sex preferences on individual fertility decisions.

A second major problem of existing behavioral measures stems from the assumption that if couples are displeased with their current family compositions, they will want to have more children. The decision-making model presented earlier implies that this assumption is untenable. For example, a couple may be very displeased with their current composition but may at the same time be fearful of having a child of the undesired sex if they try again. In general, a couple may stop having children at any parity because they are (a) happy with the current composition, or (b) unhappy but afraid to try again. Further, for any given parity for which progression ratios are computed, some couples will intend to have additional children regardless of sex composition. As Ben-Porath and Welch (1976) note,

> If populations are heterogeneous with regard to desired family size, observed patterns [of parity progression ratios] will be blurred even if the population is homogeneous with respect to desired and expected sex ratios. If only completed family size or composition mattered, families expecting to have, for example, ten children, may not be worried that their first two are girls, even if they have a taste for balance [pp. 291–292].

Inaccurate subjective probabilities for sex of next birth further complicate interpretation of parity progression ratios. For example, a couple may stop even though they are not satisfied because they "know" (incorrectly) that their next child will be of the undesired sex.

Thus, behavioral measures will misrepresent the true effect of sex preferences on fertility whenever either size or sex preferences are heterogeneous in the population and/or when misbeliefs about the probabilities of the sex of the next birth are common. There is abundant evidence that size and sex preferences are heterogeneous in most cultures. For example, L. C. Coombs (1976) showed that there is a wide diversity of both size and sex preferences within each of several countries, and L. C. Coombs (1977) reported a wide diversity of sex preferences for a nationwide United States sample. Kahneman and Tversky (1972) and McClelland and Hackenberg (1978) have demonstrated that many people hold subjective probabilities that are incorrectly dependent on the sex of the previous children born.

Sequence of Questions

Even though the preceding analysis indicates that behavioral measures have serious or fatal weaknesses for our purposes, we can still ask whether such measures can address any of the sequence of six questions listed earlier.

1. and 3. We know that sex preferences must exist and do influence fertility if the observed behaviors depend on sex composition. However, if the observed behaviors do not depend on sex composition we can draw no conclusions about the presence or influence of sex preferences.

2. No valid inferences can be made about the pattern of sex preferences, because of (a) the possibility of heterogeneous sex preferences, and (b) the fact that many patterns of preferences and values could lead to the same observed behaviors.

4. Any quantitative estimates of the effect of sex preferences on fertility will be underestimates.

5. and 6. Behavioral measures can yield no information on the use or effects of sex selection beyond the presumption that if sex preferences are strong enough to affect fertility, then they should be strong enough to prompt use of sex selection as the costs of selection techniques decline.

Attitudinal Measures

Dawes (1972) distinguished between two general classes of attitude measures: index measures and representational measures. Index measures depend on face or correlational validity whereas representational measures depend on tests of an explicit model and require a logical consistency among responses for validity. We consider these two classes of attitude measures separately.

Index Measures

Index measures are probably the most frequently used measures of sex preferences. Such measures are justified in terms of either face validity (i.e., the content of the question obviously pertains to sex preferences) or correlational validity (i.e., the index is shown to be related to sex preferences as measured by some other index with face validity). We list just a couple of the many examples of index measures.

1. *Ideal questions.* Often respondents are asked to indicate their ideal, first choice, or most-preferred alternative family composition. For example, respondents in the 1970 National Fertility Study (Westoff and Rindfuss, 1974) were asked, "How many of these [ideal number of children specified in previous question] should be boys and how many girls?" Pebley, Delgado, and Brineman (1980) showed respondents two line drawings, one with more boys and the other with more girls. The interviewer asked, "Which of these two families would you like for your own?" The presumption is that those respondents with a preference for one sex would want an excess of the preferred sex in their ideal family.

2. *Rating scales.* Respondents are asked to rate on an arbitrary scale, say of 1 to 7, their agreement with statements that are presumed to be related to sex preference. For example, "Every family should have at least one son in order to continue the family name" is rated on an agree–disagree scale. The responses to several such items are often summed to form a scale. Interitem correlations are used to assess the reliability of the scale and the correlation between the sum and the response to an ideal question (as in the preceding paragraph) or between the sum and other scales is used to establish the validity.

Strengths

The major strength of index measures is the ease with which they can be developed, administered, and scored. A second strength is that individual responses make dependence on aggregate data unnecessary.

Problems

There are several important problems with index measures. First, answering a single question about ideals (such as in the example given earlier) often confounds logically separable effects. For example, the response to the question "How many boys and how many girls do you want in your ideal family?" depends on both size and sex preferences. Without additional information it is impossible to determine the separate effects of size and sex preferences. However, the example from Pebley *et al.* (1980) demonstrates that such confounding can sometimes be avoided. Both of their line drawings contained the same total number of children. The only problem with their solution is that one total number might not have been appropriate for all their respondents.

A second problem is that situational context effects are often ignored by index measures. For example, even if a couple agrees very strongly with a statement about the importance of continuing the family name, it is still not possible to predict whether continuing the family name would be important enough to justify the extra work of supporting an additional child if the first three births were girls. Thus, tradeoffs and relative preferences are not measured.

A third important problem is that the usefulness of particular index questions is often limited to a specific culture and/or time period. For example, an agree–disagree question such as "I want a son so that he can help me farm my land" would be inappropriate for many cultures.

Fourth, by obtaining data only about first choices, index measures miss important preference information embedded in choices after the first. So many people in the United States prefer to have a family of one boy and one girl that it is not very informative to ask for first choices. Rather, it is often more informative to know the second and subsequent choices. For example, we would expect a couple that does not achieve their first choice of (1, 1) to be more likely to have additional children if their second choice were (2, 1) rather than (1, 0). Terhune and Kaufmann (1973) present a similar argument in the context of family size preferences and L. C. Coombs (1979a,b) has shown in longitudinal studies that choices beyond the first do predict fertility and contraceptive use.

A final problem is that there is often no logical model linking responses on a given index measure either with other indices or with behaviors. Instead, the link is provided by empirical correlations that, because of the problems cited, are not likely to be stable across time within a population or consistent across populations. This means that index measures need to be revalidated whenever they are used.

Representational Measures

Representational measures, in contrast to index measures, depend for their validity on tests of an explicit model and/or tests of the logical consistency

among responses. A key feature of representational measures is that these tests are performed separately for each respondent. In contrast, index measures are usually tested by examining the consistency of the responses (i.e., the correlation) *across* respondents. Following are the only two instances we know of in which representational measures have been constructed for sex preferences.

1. Coombs *et al.* (1975) asked respondents to rank order a deck of 16 cards. Printed on each card were line drawings depicting a family with B boys and G girls. The set of 16 cards included all possible combinations of B and G in which each ranged between 0 and 3. Conjoint measurement (Krantz, Luce, Suppes, and Tversky, 1971) and unfolding theory (C. H. Coombs, 1964) were used to test a variety of preference models for each respondent individually. The only model that survived those tests was the $N \times S$ model described earlier. Once the correct model was identified, it was then possible to derive measures of size and sex preference; note that here the measures are a consequence, rather than an antecedent, of model testing. Respondents were classified into one of seven categories of sex preference based on their ordering of the four family compositions with family size equal to three: (3, 0), (2, 1), (1, 2), and (0, 3); because the $N \times S$ model holds, the same results would be obtained with other family sizes as well. For example, the preference ordering

$$(2, 1) > (1, 2) > (3, 0) > (0, 3)$$

was assigned *IS5*, or a weak boy preference. L. C. Coombs (1976) used this method to describe the sex preferences for several different countries.

2. Heer (1972, reported in Williamson, 1976) presented respondents with five pairs of pictures of families. Within each pair the families differed in sex composition but were the same size. For each picture the respondent recommended whether the family depicted should have another child or not. The sex preference, if any, was scored for each respondent for each pair. To be scored as having a boy preference, the respondent had to recommend having another child for the predominantly girl family but not for the predominantly boy family. The opposite set of recommendations was scored as a girl preference. A neutral score was assigned when both recommendations were the same (i.e., either go on or stop regardless of family composition). Although Heer and his associates did not perform any formal tests of the underlying preference model, this is a representational measure because the score depended on the *pattern* of responses to each pair. For example, recommending that a family of one boy and four girls have another child was not by itself indicative of a son preference. Son preference was attributed only when the respondent also recommended that a family of four boys and one girl not have another child. Unfortunately, the five separate representational measures were simply summed to form an index measure; instead, pattern rules and consistency checks similar to those used for the individual pairs could

have been used to construct on overall representational measure of sex preference for each respondent.

Strengths

Representational measures have several attractive aspects to recommend them for measuring sex preferences. First, the possibility of separate analyses for each respondent makes dependence on aggregate data and its implicit assumption of homogeneity unnecessary. Second, representational measures usually present the respondent with an easier task than do index measures. For example, in the task used by Heer (1972) respondents had only to make a simple recommendation about having another child or not as opposed to making a rating on an unfamiliar numerical scale. Third, representational measures can separate what would otherwise be confounded effects. Both the representational measures described above separated the effects of size and sex preferences. Fourth, because of the above strengths cross-cultural comparisons are easier and more meaningful when representational rather than index measures are used, as has been demonstrated by L. C. Coombs (1976). Fifth, representational measures can be based on and derived from tests of explicit psychological models, which bolsters their logical validity.

Problems

Representational measures also pose several important problems. First are the associated practical difficulties. Although each question posed to the respondent is easy, many very similar questions must often be used. Also, data analysis can be more difficult because of the need to examine patterns of responses and to analyze each respondent's data individually. Second, the representational measures discussed above do not provide good indicators of the relative importance of size and sex preferences. That is, they do not predict whether an individual facing a risky decision will give up size or sex preferences first.

Sequence of Questions

The abilities of index and representational measures to answer the questions in our sequence are similar and are described together.

1. and 2. Attitudinal measures can determine whether or not sex preferences exist and can identify the pattern of those preferences. However, representational measures should generally do better than index measures, especially in identifying the preference pattern.

3. Attitudinal measures cannot indicate if sex preferences affect fertility. Al-

though it is sometimes possible to demonstrate a relationship empirically for a specific population at a specific time, there is never any assurance that such a link would exist in other circumstances.

4. Neither index nor representational measures give estimates of the quantitative effects of sex preferences on fertility.

5. The circumstances under which sex selection would be used could be measured by index questions separate from those tapping sex preferences (e.g., Adelman and Rosenzweig, 1978; Hartley and Pietraczyk, 1979; Markle and Nam, 1971; Rosenzweig and Adelman, 1976; Westoff and Rindfuss, 1974).

6. Quantitative effects of sex selection cannot be estimated by any attitudinal measures.

Behavioral Intention Measures

Measures of behavioral intention contrast with measures of attitude in that the former ask "attitude toward" or intention to perform a specific behavior (e.g., to have another child or to use a given contraceptive method) whereas the latter ask about global attitudes believed to be related to the behavior of interest (e.g., "I am concerned about contributing to the population explosion"). Fishbein and his colleagues (e.g., see Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975) have contributed most to the development of a theory and methodology of behavioral intentions. Although there have been several applications of the Fishbein paradigm to the study of fertility-related behavioral intentions (e.g., Davidson and Jaccard, 1975; Werner, Middlestadt-Carter, and Crawford, 1975), none has been directly related to the measurement of sex preferences. There is, however, one instance in which a measure of sex preference has been based on an analysis of behavioral intentions. This study, by Widmer *et al.* (1981), used a methodology different from that of Fishbein.

Widmer *et al.* used a behavioral intention measure of sex preferences developed by McClelland (1979a). Each respondent stated his or her intentions about having another child in each of 18 different situations. The situations were defined by hypothetical family sex compositions. For example, one question read, "If you already had one boy and one girl in your family, would you want to have another child?" In effect, an intended parity progression ratio was obtained for each respondent. Ajzen and Fishbein (1980) refer to such questions as measures of conditional behavioral intentions. Widmer *et al.* call their procedure a stopping-rule measure because analysis of the 18 intentions identifies a minimal set of family compositions beyond which the respondent would not want to have any additional children. The information from the stopping-rule measure is com-

bined with the representative measure of sex preference from Coombs *et al.* (1975) described earlier in order to identify those respondents whose fertility intentions are influenced by sex preferences.

Respondents with variable stopping rules (i.e., the family size at which no more children are desired depends on sex composition) are obviously influenced by sex preferences. In addition, those respondents with invariant stopping rules but who face risky decisions at one or more of the 18 family compositions are also influenced by sex preferences in the manner described by the decision-making model presented earlier. Widmer *et al.* calculated the net effect of sex preferences for each respondent by comparing the respondent's most-preferred family size with the mathematically expected family size given by his or her stopping rule. Consistent with the decision-making model, they found pervasive effects of sex preferences at the individual level; these effects cancelled to produce a negligible aggregate effect.

Strengths

Because the stopping rule measure in McClelland (1979a) and Widmer *et al.* (1981) was developed in the context of the decision-making model of sex preferences presented earlier, it should not be surprising that this behavioral intention measure has many strengths when evaluated in the context of that model. First, obtaining multiple behavioral intentions (in this case, for 18 different situations) for each individual eliminates the need to draw inferences from single behaviors. Second, the individual analysis of each respondent's behavioral intentions makes dependence on aggregate data unnecessary. The measure can therefore be appropriately used even in populations with very heterogeneous sex preferences. Third, the measure yields a quantitative estimate of the effect of sex preferences on fertility: The difference between the most-preferred and the mathematically expected family size estimates the effect of sex preferences on fertility for each respondent. Fourth, the effects of subjective probabilities for the sex of the next birth are indirectly incorporated into the measure. Although the subjective probabilities are not directly measured, any effect they have on fertility intentions at each family composition is captured by the measure. Fifth and probably most importantly, the measure is based on an explicit, testable psychological model. This ensures logical validity and also enables each respondent's data to be tested for consistency with the model. Widmer *et al.* found that the answers of most of their respondents were consistent with the model, but did identify a number of respondents whose answers contained serious violations of internal consistency. For example, one woman preferred (1, 1) to both (2, 1) and (1, 2), but said she wanted to have another child if she already had (1, 1). Measures of sex prefer-

ence were not calculated for this and other inconsistent respondents. Eliminating such respondents should improve the ability of behavioral intention measures to predict actual fertility behavior.

Problems

Despite its advantages, the stopping-rule measure also has some important weaknesses. In fact, some of the practical problems associated with the use of the measure are directly related to the properties that produce the strengths just described. For example, collecting enough data points that the model can be tested individually requires that each respondent must answer many questions. Collecting conditional behavioral intentions for a large number of conditions in a systematic design can easily consume a substantial amount of each respondent's time. Also, the many individual analyses required are based on ordinal tests rather than standard statistical procedures. If not more complex, these tests are at least more awkward to perform and to summarize. A final problem is that the measure is obviously based on intentions rather than actual behavior. The relationship between intentions and behavior is problematical, an issue discussed subsequently in greater detail.

Sequence of Questions

1. and 2. Because the behavioral intention measure incorporates the representational measure of sex preferences of Coombs *et al.* (1975) as described earlier, both the existence and pattern of sex preferences are assessed.

3. Although the measure cannot determine (without longitudinal data) if sex preferences influence fertility, it can indicate whether sex preferences affect fertility *intentions*. Thus, this question is answered to the extent that intentions predict behavior.

4. Comparison of the most-preferred family size with the mathematically expected family size calculated from the stopping rule estimates the quantitative effect of sex preferences on fertility, again to the extent that intentions predict behavior.

5. As presently constructed, the measure provides no information about the circumstances under which sex selection would be used or about who would use it, other than the expectation that those with no risky decisions would not use sex selection. However, the measure could be extended to obtain such information by including more complex conditions. How this might be done is described in the next section.

6. Because the measure cannot identify the likely users of sex selection, it cannot provide a quantitative estimate of the effects of the use of sex selection on

fertility. However, an extreme estimate can be obtained by making the unrealistic assumptions that sex selection is completely effective and that every couple would use it to achieve their most-preferred family composition. Under these assumptions the magnitude of the expected aggregate effect of sex selection is the same as the quantitative estimate of the effect of sex preferences on fertility (see the fourth question).

UNRESOLVED ISSUES

The review of the measures currently available for assessing sex preferences and their effects raises several unresolved issues and problems. In this section we consider some of these issues and suggest how the remaining problems might be approached. We will consider those issues most relevant to prediction of the effects of sex selection.

Birth Order

Although a few index measures have been used to assess preferences for having a particular sex first (e.g., Adelman and Rosenzweig, 1978; Westoff and Rindfuss, 1974), none of the measures described above is capable of providing quantitative estimates of the effect sex selection might have on birth order ratios. This omission is surprising because some authors (e.g., Etzioni, 1968; Westoff and Rindfuss, 1974) have speculated that in low-fertility countries changes in birth order ratios due to sex selection might be much larger than any changes in fertility rates or sex ratios.

A rough estimate of effects on birth order can be extracted from the Coombs *et al.* (1975) preference measure by determining an ideal birth sequence for each respondent. This is done by assuming that a couple would move to the most-preferred family composition by using sex selection at each birth to attain the most-preferred composition at that parity. For example, if the most-preferred composition were (1, 1), with (1, 0) preferred to (0, 1), then the ideal birth sequence would be B–G. When an ideal birth sequence is determined for each respondent it is then easy to calculate birth order ratios (Widmer *et al.*, 1981). There are two important problems with using the rank order preferences to estimate effects on birth order ratios. First, this procedure does not differentiate those respondents who are likely to use sex selection from those who are not; rather, to estimate the aggregate effect one must assume that sex selection would

be both universally used and perfectly reliable. This problem is considered in great detail in the following discussion. Second, there is no logical reason why a couple could not prefer (1, 0) to (0, 1) if limited to one child but prefer the sequence G–B if there were to be two. This problem could be circumvented by substituting birth orders for family compositions in the preference ranking step of the stopping rule measure. For example, a preference question might be, "Would you rather have a boy then a girl, or a girl then a boy?" The number of such questions generated in a systematic design would be quite large. For example, if the 16 family compositions used in the ranking task by Coombs *et al.* (1975) were replaced by all distinct birth sequences ending in one of those 16 compositions, the respondent would need to rank 69 alternatives. We hope that an intensive study with a small sample could show that valid ideal birth sequences can indeed be extracted from preference orderings of family compositions, thereby eliminating the need for ranking so many alternatives.

Quantitative Estimates

Many of the measures presented earlier can identify the existence of sex preferences and indicate the pattern of those preferences. However, none is able to provide a good quantitative estimate of the effect sex selection might have on either fertility rates or sex ratios. An extreme estimate can be obtained from the stopping-rule measure, but only given the unreasonable assumption that sex selection would be universally used and be perfectly reliable. If the direction (as opposed to the strength) of sex preferences and willingness to use sex selection are uncorrelated, then estimates based on that assumption should overstate the effect of sex selection. If these estimates were to indicate no (or minimal) effects on fertility rates and sex ratios, as was the case in Widmer *et al.* (1981), then collection of data with more complex measures may be unnecessary.

Identifying Users of Sex Selection

An obvious key to improving quantitative estimates of the effect of sex selection on fertility rates, sex ratios, and birth order ratios is characterization of the likely users of sex selection. Identification of likely users is not enough, however, because the decision to use sex selection will undoubtedly be dependent upon the couple's current family composition. Thus, simple index questions (e.g., "Would you be willing to use sex selection?") would not be sufficient. Rather,

willingness to use sex selection must be considered in the context of the decision-making model outlined above.

The decision to use sex selection would depend both on characteristics of the particular sex selection technique and on characteristics of the potential users. Relevant aspects of the technique would include (a) probability of male or female birth given use of the technique; (b) costs in terms of money, time, inconvenience, discomfort, and so on; (c) medical side effects; and (d) other factors such as mechanism of operation (e.g., a couple may not want to use selective abortion for moral reasons). Important characteristics of the potential users would include (a) subjective probability of male or female birth without sex selection, (b) strength of sex preferences (relative to the costs associated with the technique), and (c) the relative weights assigned to the various characteristics of the available techniques.

Once reasonable ranges for characteristics of the available techniques are specified, a new series of questions could be added to the stopping rule measure: "If you already had B boys and G girls would you use a sex selection technique that ensure $p(m)$ [or $p(f)$] and cost . . . ?" Data of this type would not present any theoretical problems; the analysis would be similar to that of Coombs *et al.* (1975) and Widmer *et al.* (1981). However, there would be an enormous practical problem because a complete systematic design would require too many questions to ask of each respondent. It should be possible to obtain a manageable number of questions by sampling from the complete set of questions. Even with a reduced set of questions some tests of the decision-making model would still be possible. The results from these questions could be used to estimate which respondents—and, by extrapolation, which types of people—would use sex selection and at what decision points. This information could then be used to estimate quantitatively, given a representative sample, how different kinds of sex-selection techniques would affect total fertility and the sex ratio.

Status of Intentions

Both the theoretical decision-making model and the review of currently available measures of sex preferences and their effects indicate that reliance on true behavioral measures (e.g., parity progression ratios) is unacceptable. The review also suggests that simple attitude measures are not satisfactory either. That leaves measures of behavioral intentions as the most viable strategy for assessing sex preferences and their effect on fertility with and without sex selection. However, measures of behavioral intentions may also be regarded as unacceptable by those who recall a history of poor fertility predictions based on attitudinal and other

psychological measures. In this section, we argue (a) that no matter how much we would prefer to use a behaviorally based measure, such measures cannot possibly do the job, and (b) that psychological measures can yield valid predictions of fertility behaviors. If sex preferences are heterogeneous within a population—and with development, sex preferences in even traditional male-preference cultures seem to become more heterogeneous (L. C. Coombs, 1976)—then sex preferences based on behavioral measures like parity progression ratios underestimate the present effect of sex preferences on fertility and, consequently, underestimate the number of potential users of sex-selection techniques.

It is interesting to note that others have reached the same conclusion—that aggregate behavioral measures are often not sufficient and must be supplemented or replaced by questionnaire measures—in very different substantive areas. For example, Jones-Lee (1976), when considering economic methods for measuring the value of life in order to be able to evaluate risks and safety improvements, concluded that market mechanisms (i.e., behavioral measures) are insufficient. Because his conclusion and his remedy are so similar to ours, we include the following extensive quotation:

> There are generally two broad avenues of approach to such an estimation exercise. *Either* one may eschew all data sources except the market place, relying entirely upon the revelation of private preferences through choices among alternatives presented through a market mechanism, *or* one may utilize direct inquiry and experimental methods in an attempt to obtain a richer variety of data than is available through observation of market choices alone. However, it was argued earlier that the "public goods" nature of most safety improvements severely restricts the range of safety-improvement devices that are supplied through markets, and it was essentially because of this paucity of market-generated data that the problem of the value of safety was approached in a largely *a priori* manner from very general (and, one hopes, plausible) assumptions concerning individual choice under uncertainty. . . . The only alternative is therefore an experimental, direct-inquiry approach [p. 121].

The argument developed in this chapter is very similar. Behavioral measures such as parity progression ratios are ambiguous due to a "paucity of market-generated data"; this led us to consider a "direct-inquiry approach," namely the assessment of conditional behavioral intentions. Further, procedures for assessing those intentions were based on "very general (and one hopes, plausible) assumptions concerning individual choice under uncertainty." Mishan (1971) and Schelling (1968) reached the same conclusion in the value-of-life context.

The poor performance of some psychological measures in the past should not cast doubt on the utility of the direct-inquiry or behavioral-intention approach. Many of the past failures involved questionnaires with face validity but very little or no theoretical structure. As shown above, measures of behavioral intention can be based on theoretical models of the fertility decision-making process. Such models can be tested and, if validated, will increase our confidence in the predictive value of the measures derived from those models. There are several

longitudinal studies showing that such model-based measures do indeed have predictive validity (e.g., L. C. Coombs, 1979a,b). In summary, we agree with Mishan (1971, p. 705) that "economists seriously concerned with coming to grips with the magnitudes may have to brave the disdain of their colleagues and consider the possibility that data yielded by surveys based on the questionnaire method are better than none." The same applies to demographers wanting to come to grips with the magnitudes of the potential effects of sex-selection techniques on fertility.

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3

Sex Selection through Amniocentesis and Selective Abortion*

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INTRODUCTION

The development of amniocentesis as a means of predicting (and preventing through abortion) the birth of infants with genetically determined birth defects has made possible selection on another genetically determined characteristic—gender. Because the most frequently tested-for condition, Down's syndrome, is associated with an inappropriate number of sex chromosomes, and because many other genetic abnormalities, such as hemophilia, are sex-linked, a major concern in the development of amniocentesis techniques has been the accurate prediction of fetal sex. The technique that is used, karyotypic analysis of cultivated amniotic fluid cells, has been shown to predict infant sex successfully in 99.93 percent of the cases. There were only two karyotyping errors in a group of 3000 amnio-

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centeses (Golbus, Loughman, Epstein, Halbasch, Stephens, and Hall, 1979). This contrasts sharply with the inefficiency of other approaches to sex selection that have been developed so far (Glass, 1977; Rinehart, 1975).

Given that abortion through the end of the second trimester of pregnancy is relatively unresitricted in the United States and several other countries, and the results of amniocentesis can be known during this trimester, there now exists an essentially infallible means for realizing one's preferences for a child or children of a given sex. Because sex preference is widespread (Williamson, 1976), it would seem that many of those with no ethical objections to abortion or sex selection might be willing to assume the risks associated with amniocentesis and second-trimester abortion in order to avail themselves of this opportunity. However, there is an additional disadvantage to this means of achieving control over family sex composition: The numbers of diagnoses and abortions required can be substantial. Much of the debate over this means of sex selection has focused on the ethical and medical aspects. The purpose of the calculations presented in this chapter is simply to estimate how many of these procedures would be required to achieve a sex-tailored family. We examine two strategies. The first is where family-composition goals require a given sex composition (say, one boy and one girl), otherwise called a *compositional family goal*. The second strategy is where, in addition, a specific order is required (such as a boy first, then a girl). These latter requirements are referred to as *sequential goals*. We will estimate the number of pregnancies, diagnoses, and corrective abortions needed to achieve a reasonable range of possible family size–composition configurations.

Using a small set of simplifying assumptions, a series of algebraic relationships is derived. (The actual derivations are presented in the Appendix.) These focus on the concept of a *birth trial*. A birth trial is a process that begins with conception and ends with a live birth. It may contain several pregnancies as a result of spontaneous abortion (in the case of an unregulated birth trial) as well as selective abortion (in the case of a regulated birth trial). A regulated birth trial is one in which diagnosis is expected to be performed for the determination of fetal sex and an abortion performed depending on the outcome of diagnosis. Because the amniocentesis procedure is performed during the second trimester, most pregnancy wastage will occur before the time of diagnosis; some would have occurred afterwards. We will refer to those spontaneous abortions occurring before diagnosis is possible as *early* and to the rest as *late*. Taking $\theta_2$as the total risk of spontaneous pregnancy loss, we have θ_2^*, the proportion of late spontaneous abortions, and $\theta_2 - \theta_2^*$ as the proportion of early spontaneous abortions.

Family composition goals that involve determination of fetal sex for each birth will be the most costly in terms of the number of diagnoses expected (diagnostic load) and the number of abortions as well (abortion load). This will be the case for any sequential goal, as well as for compositional goals involving only one

sex. Other compositional goals make possible the development of an abortion-reducing strategy, or decision rule, that allows birth trials to proceed without regulation until the residual composition (the desired sex composition of the children yet unborn) has only children of one sex. For example, if the family goal is two boys and two girls, at least two birth trials can go unregulated. The number of unregulated birth trials is two if either two boys or two girls are born, leaving a residual composition either of two girls or of two boys; there can be three unregulated trials if the first two result in either sequence of a boy and a girl, so the residual composition still includes a child of each sex. The last birth trial, however, will always be regulated. Under the abortion-reducing strategy, then, the number of unregulated birth trials is a random variable depending on the sex composition desired and the sex ratio at birth.

The discussion proceeds as follows. The assumptions that make a straightforward analysis possible are presented and defined in the following section. Next, the basic probabilities associated with individual birth trials, both regulated and unregulated, are developed. These probabilities are then applied, respectively, to various family compositional goals in three situations: where no regulated birth trials are allowed and therefore no sex selection, where all trials are regulated as in sequential family goals, and where the compositional goal is such that an abortion-reducing strategy is possible. For convenience and plausibility, in each case the range of desired family size is held to four or fewer children. The implications of these results for the use of amniocentesis in sex selection are then discussed.

ASSUMPTIONS

Six assumptions underlie this analysis.

1. Each diagnosis is interpretable and perfectly reliable.
2. Risks of early and late spontaneous abortion are constant among women and over the birth trials of individual women. If diagnoses are done at week 16 these risks are $\theta_2 - \theta_2^* = .22$ and $\theta_2^* = .02$, respectively.
3. The fetal sex ratio at time of diagnosis equals 1.05, identical to the sex ratio at birth. This is equivalent to male and female proportions of .512 and .488.
4. Plural births are insignificant in number.
5. Family goals remain fixed, and couples attempt to realize them independently of the results of intermediate outcomes.

6. Couples are able to have as many pregnancies as are demanded by the conjunction of their family goal, chosen decision rule, and diagnostic outcomes.

The first three assumptions are approximately true, and although the fourth (on plural births) is not, it causes little distortion in exchange for great algebraic simplification. The last two are much more problematic, but underlie the central question of analysis. With regard to the first assumption, it is true that a repeat amniocentesis is sometimes necessary because of failure to obtain clear, cell-bearing amniotic fluid or subsequent laboratory failure. However, Golbus *et al.* (1979) reported successful culture in 98.3 percent of the cases on the first attempt, and 99.7 percent when second attempts were included. Given successful culturing, their karyotypic diagnoses were essentially 100 percent reliable. Support for the assumptions regarding early and late risks of fetal loss comes from French and Bierman's much-quoted life table of fetal mortality (French and Bierman, 1962). Although it has been generally anticipated that amniocentesis would increase the probability of late fetal loss, a number of studies have reported loss rates after amniocentesis that are not noticeably elevated relative to French and Bierman's results in the absence of such a procedure (cited in Golbus *et al.*, 1979). The third assumption, regarding the fetal sex ratio, relies primarily on the work of Yamamoto, Ito, and Watanabe (1977). Sex was determined on aborted fetuses, and the sex ratio was found not to vary in any substantial way by length of gestation. This assumption also implies that the probability of conceiving a child of a given sex is independent of parity and previous outcomes. This would not be true if for some reason couples were heterogeneous with regard to expected sex ratios. Then families whose first child is a given sex would be selective of those prone to having that sex, and less likely to include those prone to having the other sex. James (1975) argued that this is the case and that it results from variation in coital frequency, but the effect seems to be very small.

The final two assumptions are problematic, but necessary to allow the analysis to proceed. We are asking, essentially, "What will happen if family goals remain fixed, in the face of the diagnostic and abortion loads expected?" Therefore, family goals cannot be rationalized to fit the outcomes of intermediate pregnancies, nor can an unfavorable diagnosis be reacted to by deciding that the sex of the child being carried would be all right, after all. In effect, the fifth assumption means that these are the results that would obtain for those whose family-composition goals would not be altered in any way. The last assumption is problematic in a different way. If the fifth assumption implies that couples are willing to proceed as originally planned, no matter what, then the sixth assumption requires that they be able. No allowance is made for the progress of secondary sterility as pregnancies mount. This assumption assures, along with the first assumption, a 100 percent probability of attaining the family goal.

BIRTH TRIAL PROBABILITIES

For unregulated birth trials, the number of diagnoses and selective abortions will be zero, and the number of pregnancies does not depend on the sex of the child. The only factor operating in an unregulated birth trial is spontaneous abortion. Given a constant risk of spontaneous abortion over all pregnancies of $\theta_2 = .24$, the probability that a birth will require a given number of pregnancies looks like this

Number of Pregnancies	Probability
1	.760
2	.182
3	.044
4	.011
5	.003
6 or more	.001

Three-quarters need only 1 pregnancy to produce a birth; nearly a fifth require 2 pregnancies. Fewer than 5 percent will experience 3 pregnancies, and barely 1 percent 4 or more. The average is $(1 - \theta_2)^{-1} = 1.32$ pregnancies, with a variance of .42 pregnancies per unregulated birth trial. The probability of escaping pregnancy wastage is $(.76)^k$ (where k is the number of children desired), which is .58 for 2 children desired, but already less than .5 when 3 are desired.

Introducing a sex constraint, however, raises the number of pregnancies required to achieve a child of a given sex substantially. Table 1 indicates that the number of pregnancies per regulated birth trial is 2.6 where a son is desired and

TABLE 1

Means and Variances of Pregnancies, Diagnoses, and Corrective Abortions in a Regulated Birth Trial, by Sex of Child Desired[a]

	Son desired		*Daughter desired*	
Event	*Mean*	*Variance*	*Mean*	*Variance*
Pregnancy	2.57	4.03	2.70	4.57
Diagnosis	2.00	2.01	2.10	2.32
Favorable Diagnosis	1.03	0.03	1.03	0.03
Corrective Abortion	0.98	1.94	1.08	2.24

[a]See Table A.1 for formulas. Parameter assignments are $\theta_2 = .24$, $\theta_2^* = .02$; the probability of a favorable diagnosis is $h = .512$ or .488, depending on whether a son or a daughter is desired.

2.7 for a daughter. This reflects roughly a 50 percent chance of an unfavorable diagnosis each time one is performed, and a 22 percent chance of a spontaneous abortion before a diagnosis would be performed. The variance is appreciable, with a square root only a little less than the mean. Although nearly half of those successfully carrying a child of the desired sex would require only one diagnosis and no corrective abortion, the skewed distribution results in an average number of diagnoses of roughly 2 per birth trial, and corrective abortions of 1.0. Favorable diagnoses do not exactly equal 1.0 because of the small risk, namely $1 - \theta_L = \theta_2^*/[\theta_2^* + (1 - \theta_2)] = .026$ (where θ_L is the probability that a favorably diagnosed pregnancy ends in a live birth), that a pregnancy associated with a favorable diagnosis will end in late abortion or stillbirth.

When a daughter rather than a son is desired, the probability of an unfavorable diagnosis is slightly higher, .512 compared to .488; thus, the number of expected pregnancies, diagnoses, and corrective abortions is slightly higher when a daughter is desired rather than a son.

FAMILY COMPOSITION WITH NO SEX SELECTION

When we move from a single birth trial to compositional goals involving more than one child, variation in the odds of achieving a given outcome increase. Table 2 indicates the magnitude of this variation when sex selection is not used. In general, a compositional goal is easier to achieve than a sequential goal, except in the case where the composition involves only one sex, in which case sequence is in fact fixed as well. As size increases, and as the preferred sex ratio is more unbalanced, the chances of achieving a given composition fall, and compositions emphasizing girls are more difficult to achieve than those featuring boys. For example, the easiest compositional goal to achieve involving three children, which is any sequence of two boys and a girl, can be expected with a probability of .384. This is a more likely outcome than any four-child composition or any other three-child composition.

For sequential goals, size again reduces the probability of a given outcome, and even more rapidly than for compositional goals. Sex balance is not a favorable factor; rather, for a given size, the more boys desired the greater the chances the goal will be realized. As a result, the difference between sequential goals and compositional goals increases the larger is the number of children wanted or, for a given family size, the more balanced is the goal.

These relationships parallel those in the next two sections governing the number of pregnancies, diagnoses, and selective abortions required using selective

TABLE 2

Probability of Achieving a Sequential or Compositional Family Goal in the Absence of Sex-Selection Technology as a Function of Total Boys and Girls Wanted[a]

Number of boys b *and girls* g *wanted*	*Any sequential goal*	*Compositional goal*	*Difference in probability*
b	.512	.512	.000
g	.488	.488	.000
bb	.262	.262	.000
bg	.250	.500	.250
gg	.238	.238	.000
bbb	.134	.134	.000
bbg	.128	.384	.256
bgg	.122	.366	.244
ggg	.116	.116	.000
bbbb	.069	.069	.000
bbbg	.065	.262	.197
bbgg	.062	.375	.313
bggg	.060	.238	.178
gggg	.057	.057	.000

[a]The probability of achieving a sequential goal involving b boys and g girls is $(.512)^b\,(.488)^g$; that of the corresponding compositional goal is $\binom{b}{b}^{+}\,(.512)^b\,(.488)^g$.

abortion to achieve a given goal for family size. The more difficult a goal is to achieve, the more pregnancies, diagnoses, and abortions will be required.

SEX SELECTION FOR SEQUENTIAL FAMILY GOALS

The most demanding of the family goals in terms of diagnostic and abortion loads and total pregnancies are the sequential family goals. These require that all $k = b + g$ birth trials be regulated. The expected numbers of pregnancies, diagnoses, and abortions as well as their variances depend on the numbers of girls and boys desired, but not, in fact, on their sequence.

Table 3 presents means and variances for each of the three variables—pregnancies, diagnoses, and corrective abortions—for the set of sequential family goals, as well as the associated probability of needing no corrective abortions. In each case the expected numbers are roughly proportional to total children desired, being simply the sum of the values associated with a single boy and girl.

TABLE 3

Means and Variances of Total Pregnancies, Diagnoses, and Corrective Abortions and Probability of Avoiding Corrective Abortions, by Sequential Family Goal[a]

	Mean			*Variance*			*Probability of no corrective abortion*
Family goal	*Pregnancies*	*Diagnoses*	*Corrective abortions*	*Pregnancies*	*Diagnoses*	*Corrective abortions*	
b	2.57	2.00	.98	4.03	2.01	1.94	.51
g	2.70	2.10	1.08	4.57	2.32	2.24	.48
bb	5.14	4.01	1.96	8.07	4.03	3.87	.26
bg	5.27	4.11	2.05	8.61	4.33	4.17	.24
gg	5.39	4.21	2.15	9.15	4.64	4.47	.23
bbb	7.71	6.01	2.93	12.10	6.04	5.81	.13
bbg	7.84	6.11	3.03	12.64	6.35	6.11	.12
bgg	7.96	6.21	3.13	13.18	6.65	6.41	.12
ggg	8.09	6.31	3.23	13.72	6.96	6.71	.11
bbbb	10.28	8.02	3.91	16.14	8.05	7.74	.07
bbbg	10.41	8.12	4.01	16.68	8.36	8.04	.06
bbgg	10.53	8.22	4.11	17.22	8.67	8.34	.06
bggg	10.66	8.31	4.21	17.76	8.97	8.64	.06
gggg	10.79	8.41	4.31	18.29	9.28	8.95	.05

[a]See Appendix, "Sequential Family Goals with Every Birth Trial Regulated," for relevant formulas. Parameter assignments are those cited in Table 1.

One boy requires 2.57 pregnancies whereas two boys requires twice as many, 5.14. A girl requires 2.70 pregnancies, so two boys and a girl require 7.84. The same relationship obtains for diagnoses and corrective abortions, and for the variances associated with each. The expected number of corrective abortions approximately equals the number of children desired and diagnoses are roughly twice that number. Because of the small size of postdiagnosis pregnancy loss, θ_2^*, expected corrective abortions is close to expected diagnoses less k. The number of expected diagnoses is $1 - (\theta_2 - \theta_2^*) = .78$ times expected pregnancies.

The probability of avoiding any corrective abortions declines sharply as the number of children increases. If a single boy is sought, the probability is .51 compared to .07 when four boys are desired. As might be expected, a goal favoring boys yields a slightly higher chance of avoiding corrective abortion than an equivalent one favoring girls. Nevertheless, the loads in every case are very high. Any given two-child sequence requires on average more than four diagnoses, about two corrective abortions, and five to five-and-a-half pregnancies. And the variances are extremely high, so that although about one quarter of the couples would require no abortions, many would require far more than two. A

strategy that has some hope of reducing these loads would seem highly desirable. This is what a compositional family goal makes possible.

SEX SELECTION FOR COMPOSITIONAL FAMILY GOALS

If some number of children of each sex is desired, and the sequence in which they are born is not important, then a strategy can be followed that greatly reduces the number of diagnoses, abortions, and pregnancies. The abortion-reducing rule depends on the future sex composition wanted in such a way as to allow family formation to proceed without regulation as long as a child of either sex is still wanted. This is true for the first birth trial, based on the overall compositional goal, and continues for each succeeding one until only children of one sex are required to meet the goal. In this case the proportion of birth trials that can go unregulated increases with the number of children of each sex desired and with the greater degree of balance preferred in the family composition.

Table 4 displays information on the expected values and variances for pregnancies, diagnoses, and corrective abortions associated with this abortion-reducing strategy. The basic pattern of variation is similar to that achieved as a result of pursuing a sequential goal: Mean corrective abortions are roughly half of mean diagnoses and rise almost in direct proportion to desired family size. Again, for a given family size, they are slightly higher for compositions favoring daughters.

TABLE 4

Means and Variances of Total Pregnancies, Diagnoses, and Corrective Abortions and Probability of Avoiding Corrective Abortion by Compositional Family Goal[a]

	Mean			*Variance*			*Probability of no corrective abortion*
Family goal	*Pregnancies*	*Diagnoses*	*Corrective abortions*	*Pregnancies*	*Diagnoses*	*Corrective abortions*	
bg	3.95	2.05	1.03	4.73	2.17	2.09	.49
bbg	5.85	3.01	1.48	7.13	4.03	3.17	.38
bgg	6.00	3.16	1.60	7.92	4.59	3.63	.36
gbbb	8.07	4.47	2.19	10.84	7.27	4.99	.26
ggbb	7.24	3.08	1.54	7.96	4.32	3.41	.37
gggb	8.39	4.77	2.44	12.39	8.29	5.86	.23

[a]Relevant formulas are found in the Appendix, "Compositional Family Goals Subject to an Abortion-Reducing Rule."

The main difference between the two strategies is that the ratios of diagnoses to pregnancies are consistently lower, and often much lower, by virtue of some birth trials being unregulated. To take the most extreme instance considered, for a compositional goal of two girls and two boys the ratio of diagnoses to pregnancies is .43 (3.08 : 7.24) in contrast to .78 (8.22 : 10.53) when all birth trials are being regulated. This large difference arises in the ratio of diagnoses to pregnancies because for a family goal of two of each sex, only 38 percent of the birth trials, on average, need be regulated under the abortion-reducing rule. The first two trials need never be regulated, and only about half the time need the third be regulated (when either two boys or two girls resulted from the first two trials). The last of the four birth trials is always regulated, so the expected proportion regulated is three-eighths, or 38 percent. Overall, the number of pregnancies is roughly twice the number of desired births. There is about the same number of diagnoses expected as desired births except for the balanced-sex, four-child goal, where balance and size combine to limit diagnoses to barely over three. Corrective abortions average about half the number of desired births, except, again, for compositional goals of two boys and two girls, where the abortion load is reduced as well. To illustrate precisely the gain of the abortion-reducing strategy possible for compositional goals relative to the full regulation needed for sequential goals, Table 5 shows the ratio of pregnancies, diagnoses, and corrective abortions expected for a composition goal relative to its respective sequential equivalent. Ratios for the probability of escaping corrective abortion entirely, and the proportions of birth trials regulated, are also shown.

The reduction in diagnostic and abortion loads is clearly substantial. The

TABLE 5

Comparing Expected Numbers of Pregnancies, Diagnoses, and Corrective Abortions, Probability of Escaping Corrective Abortions, and Proportion of Birth Trials Regulated between a Sequential Goal and Its Compositional Equivalent[a]

Family goal	*Pregnancies*	*Diagnoses*	*Corrective abortions*	*Probability of avoiding corrective abortions*	*Proportion of birth trials regulated*
bg	.75	.50	.50	2.03	.50
bbg	.75	.49	.49	3.07	.50
bgg	.75	.51	.51	3.07	.50
gbbb	.78	.55	.55	4.12	.56
ggbb	.69	.38	.38	6.22	.38
gggb	.79	.57	.58	4.12	.57

[a]The first four columns represent ratios of corresponding values of Tables 3 and 4. Last column values equal $1 - E(z)/k$; k denotes desired family size and the formula for $E(z)$ is given in the Appendix, "Compositional Family Goals Subject to an Abortion-Reducing Rule."

abortion-reducing strategy requires on average only 38 to 57 percent as many diagnoses and corrective abortions. These ratios are governed by the average proportion of birth trials regulated under the abortion-reducing decision rule (last column of Table 5). The ratio of pregnancies required is higher, varying between 69 and 79 percent of those needed for a sequential goal, because during an unregulated birth trial the number of pregnancies is not zero, as it is for diagnoses and corrective abortions, but rather averages $1/(1 - \theta_2)$ or 1.32.

The most dramatic contrast between the two strategies is in the probability of avoiding any corrective abortion. For a two-child family a compositional goal of a boy and a girl will be achievable without recourse to selective abortion more than twice as frequently as a fixed boy, then girl (or girl, then boy) sequence. The two mixed-sex three-child goals can be reached more than three times as easily if only composition is required rather than any given sequence of boys and girls. Mixed-sex, unbalanced families of four children (three of one sex, one of the other) are reached more than four times as easily, and a balanced four-child goal (two of each) will avoid selective abortion 6.22 times as frequently as any sequential goal featuring this composition. The amount of abortion reduction, thus, is substantial.

DISCUSSION

The cost of being sure to achieve a preferred family sex goal, whether of sequence or only of composition, is clearly high. The cost in terms of diagnoses to achieve compositional goal averages roughly one for every child desired, and for a sequential goal about two per child. However, amniocentesis as a procedure is perhaps the least problematic of these costs. It is painful and may be associated with some risk to the fetus, but as discussed earlier the risk is now thought to be extremely low. Abortion costs are quantitatively less, with about one abortion per child expected for sequential goals and one for every two children for compositional goals. The risk associated with this procedure is higher, but still fairly low. The mortality rate for second trimester abortions is reported to be 15 per 100,000 (Chaudry, Hunt, and Wortman, 1976).

The number of pregnancies also varies a great deal among unregulated, sequential, and compositional strategies, and this imposes costs that should be considered in more detail. As Table 5 indicates, although compositional and sequential family goals vary less for pregnancies than for diagnoses or abortions, they still differ appreciably between each other and also differ sharply from a sex-indifferent strategy using no regulation. Table 6 illustrates these contrasts for a popular group of size and sex compositions.

TABLE 6

Pregnancies Expected by Strategy: Selected Goals[a]

	bg	*bbg*	*bbgg*
Unregulated	2.64	3.96	5.28
Regulation for composition	3.95	5.85	7.24
Regulation for sequence	5.27	7.84	10.53

[a]Assumes 1.32 pregnancies per unregulated birth trial. Values for compositional goals and sequential goals are drawn from Tables 3 and 4.

Those who want a two-child family but are indifferent to sex composition and sequence can anticipate 1.31 fewer pregnancies than those who regulate birth trials for a mixed-sex compositional goal, and 2.63 fewer, or half, the pregnancies needed for those who regulate each birth trial in order to achieve a mixed-sex sequential goal. For a three-child goal, two to four additional pregnancies can be expected if regulation is used to achieve the most commonly preferred three-child goal of two boys and one girls, and two to five additional pregnancies become necessary to achieve a balanced-sex four-child family.

These additional pregnancies impose a clear cost in terms of time in addition to the physiological, economic, and emotional costs associated with them. The additional pregnancies are all incomplete, representing corrective abortions as well as some additional spontaneous abortions. Each corrective abortion takes on the average nearly a year, assuming about 6 ovulatory months for conception, 4 months of gestation, and some additional weeks of delay for diagnosing fetal sex and arranging for an abortion. Spontaneous abortions are somewhat less time-consuming, but only amount to about one quarter of the additional pregnancies incurred. This means that the total childbearing period is extended substantially through this method of sex regulation; a couple desiring a three-child family would require on average 4 years longer to achieve a sequential goal than would one opting for a nonregulated family. Part of this extra time would go into the first birth trial, so the age spread between the oldest and youngest child would be less than the total increment; as a family-building strategy, however, regulating every birth trial has a substantial impact on expected child spacing.

It would seem that part of this time could be reduced if first-trimester diagnoses were possible. Some research has been directed at finding alternative, less demanding means of sex determination, usually through measurement of fetal hormones (Belisle, Fence, and Tulchinsky, 1977). This saves culturing time, but measures taken before the fourteenth gestational week so far are quite unreliable. Even if, however, reliable means of early sex detection were found, the savings would not be great. To begin with, although first-trimester diagnoses would

mean a reduced proportion of early spontaneous abortions, these account for a relatively small fraction of additional pregnancies. Furthermore, for pregnancies with favorable diagnoses, the risk of late spontaneous abortion is proportionately increased, which means increased diagnostic and abortion loads. Recall that $\theta_L = (1 - \theta_2)/[\theta_2^* + (1 - \theta_2)]$. If $\theta_2 = .24$ and θ_2^* is raised from .02 to .10, θ_L is lowered from .9744 (.76/.78) to .8837 (.76/.86). The formulas of Table A.1 show that the diagnostic and abortion loads are directly proportional to θ_L^{-1}. Hence the multiplier of diagnostic and abortion loads is $(1/\theta_L^*)/(1/\theta_L) = \theta_L/\theta_L^* = .9744/.8837 = 1.10$. Thus the advantage of earlier corrective abortion comes at the price of requiring an enhanced number of them. And because gestation length is a relatively small part of the total time added by an additional corrective abortion, the effects of shorter pregnancies, but more of them, would tend to be offsetting.

In addition to the time added through additional pregnancies that can be expected on average, the high variances mean that many would experience extremely long birth trial sequences, and more would experience at least one prolonged birth trial. This affects not only the total time spent in childbearing, but also the birth interval between children. It is probable that couples have preferences about birth spacing as well as about sex composition. Direct evidence on this point is not available, so this dimension is not addressed in this analysis. Nevertheless, it might be more plausible to impose some restriction to the sixth assumption, namely, that couples will tolerate no more than a given number of corrective abortions overall or for a given birth interval. After that number of abortions, couples abandon efforts to select the sex of their next child or children and run a risk of failing to achieve their family goal. A full analysis of all these possibilities is beyond the scope of this chapter. As an example, however, the algebra needed to assess the effect of restricting birth trials to a single diagnosis is presented in the Appendix, "Single Birth Trial Subject to a Ceiling of One Diagnosis." Tables 7 and 8 present the results.

Table 7 shows the expected numbers of pregnancies, diagnoses, and corrective abortions for a birth trial in which a son is sought, depending on whether regulation is unlimited or is restricted to a single diagnosis. Similar results obtain for daughters with the expectedly higher means and variances. The greatest impact in terms of expected values is in abortion and diagnostic loads, which are halved. Expected pregnancies are reduced by about one quarter. The constraint obviously lessens sharply the variation expected in diagnoses and abortions; it has the same effect on pregnancies as well, whose variance drops from over four prenancies to one. As Table 8 indicates, in each case nearly 40 percent would require only one pregnancy. However, where a ceiling is operating 77 percent would experience no more than two pregnancies, compared to 63 percent of those fully regulating, and only a third as many would experience four or more pregnancies (7 percent versus 23 percent).

TABLE 7

Means and Variances of Pregnancies, Diagnoses, and Corrective Abortions, in a Regulated Birth Trial Where a Son Is Desired, with and without a Ceiling of One Diagnosis

	Ceiling imposed[a]		*No ceiling imposed*[b]	
Event	*Mean*	*Variance*	*Mean*	*Variance*
Pregnancy	1.94	1.00	2.57	4.03
Diagnosis	1.00	0.00	2.00	2.01
Favorable diagnosis	0.51	0.25	1.03	0.03
Corrective abortion	0.49	0.25	0.98	1.94

[a]Based on formulas from Appendix, "Single Birth Trial Subject to a Ceiling of One Diagnosis."
[b]Values taken from Table 1.

Such a constraint, however, insures that some portion will not achieve their goal. That life is not fair can also be seen from Table 8. Those who are successful in obtaining the sex desired undergo fewer pregnancies, on the average, than those failing to reach their objective. When a boy is the target the average difference is 1.73 pregnancies for the successful, compared to 2.60 for the rest. Under such a constraint this will be the fate of 24 percent of those whose goal was a boy (and 26 percent who were hoping for a girl). The cost of reducing variance in numbers of pregnancies, abortions, and diagnoses is a substantial one in terms of the probability of missing the goal.

TABLE 8

Numbers of Pregnancies in a Regulated Birth Trial Where a Son Is Desired and Success or Failure Attaining It, by Whether a Ceiling of One Diagnosis is Imposed[a]

	Ceiling			*No ceiling*		
Number of pregnancies	*Son obtained*	*Daughter obtained*	*Regardless of outcome*	*Daughter obtained*	*Son obtained*	*Regardless of outcome*
1	.51	.00	.39	—	.39	.39
2	.31	.59	.38	—	.24	.24
3	.12	.27	.16	—	.15	.15
4 or more	.05	.13	.07	—	.23	.23
Mean number	1.73	2.60	1.94	—	2.57	2.57

[a]Values for the case with a ceiling imposed are drawn from the Appendix, "Single Birth Trial Subject to a Ceiling of One Diagnosis." Those for the case with no ceiling are computed from formulas presented in the Appendix, "Sequential Family Goals with Every Birth Trial Regulated."

This analysis suggests that selective abortion for sex-selection purposes is not likely to be practiced widely, given present techniques. The achievement of diagnosis early in the first trimester would reduce somewhat the disadvantages apparent in the technique, but the high variances mean that a run of bad luck can be frequently anticipated. Where regulation is not present, the birth of a child of the wrong sex usually results in considerable adjustment and rationalization, given the normal charms even of a child of the unpreferred sex. Using regulation, however, the run of bad luck leads to less rewarding consequences—increased numbers of diagnoses, abortions, and incomplete pregnancies. Such a situation would undoubtedly put greatly increased pressure on finding an effective means to influence sex at or prior to conception.

SUMMARY

The combination of amniocentesis and sex-selective abortion now makes the complete determination of family sex composition possible. With relatively few simplifying assumptions, we have shown what consequences are associated with the use of this procedure in terms of expected numbers of pregnancies, diagnoses, and corrective abortions.

Two types of family goals were considered, sequential and compositional. In each case, pregnancy, diagnostic, and abortion loads are high, although considerable savings can be expected if couples are willing to pursue only compositional family goals rather than a fixed sequence of sexes. Sequential family goals require that every birth be regulated, with the result that couples can expect on the average to experience from two and a half to three pregnancies, two diagnoses, and one selective abortion for every child desired, with boys carrying slightly lower costs than girls. Compositional goals, on the other hand, can save up to 31 percent of the pregnancies and 62 percent of the diagnoses and selective abortions required by sequential equivalent, with the greatest savings realized for large families and balanced sex compositions.

However, both strategies require large numbers of diagnoses and selective abortions, and particularly of pregnancies. High variances also obtain, so that single-minded pursuit of a family size goal using these procedures can become lengthy, leading to the frequent occurrence of protracted birth intervals. Imposing a ceiling of one diagnosis reduces average loads somewhat and reduces variances substantially, but the cost in terms of failing to get a child of the desired sex is high—half the gain possible over a chance outcome. Unless sex preferences are extremely strong, it does not seem likely that any of these approaches will be widely used.

APPENDIX

Single Birth Trial

Glossary

The following notation is useful.

Parameters

θ_4	probability of a pregnancy ending in a live birth in the absence of selective abortion.
θ_2	$1 - \theta_4$, proportion of all spontaneous abortions.
$\theta_2 - \theta_2^*$	proportion of early spontaneous abortions (occurring prior to time for diagnosis and possible selective abortion)
θ_2^*	proportion of late spontaneous abortions (i.e., late enough so that it occurs after time for diagnosis and possible selective abortion)
θ_L	$\theta_4/(\theta_2^* + \theta_4)$, probability that a favorably diagnosed pregnancy ends in a live birth
h	probability of diagnosing the preferred sex

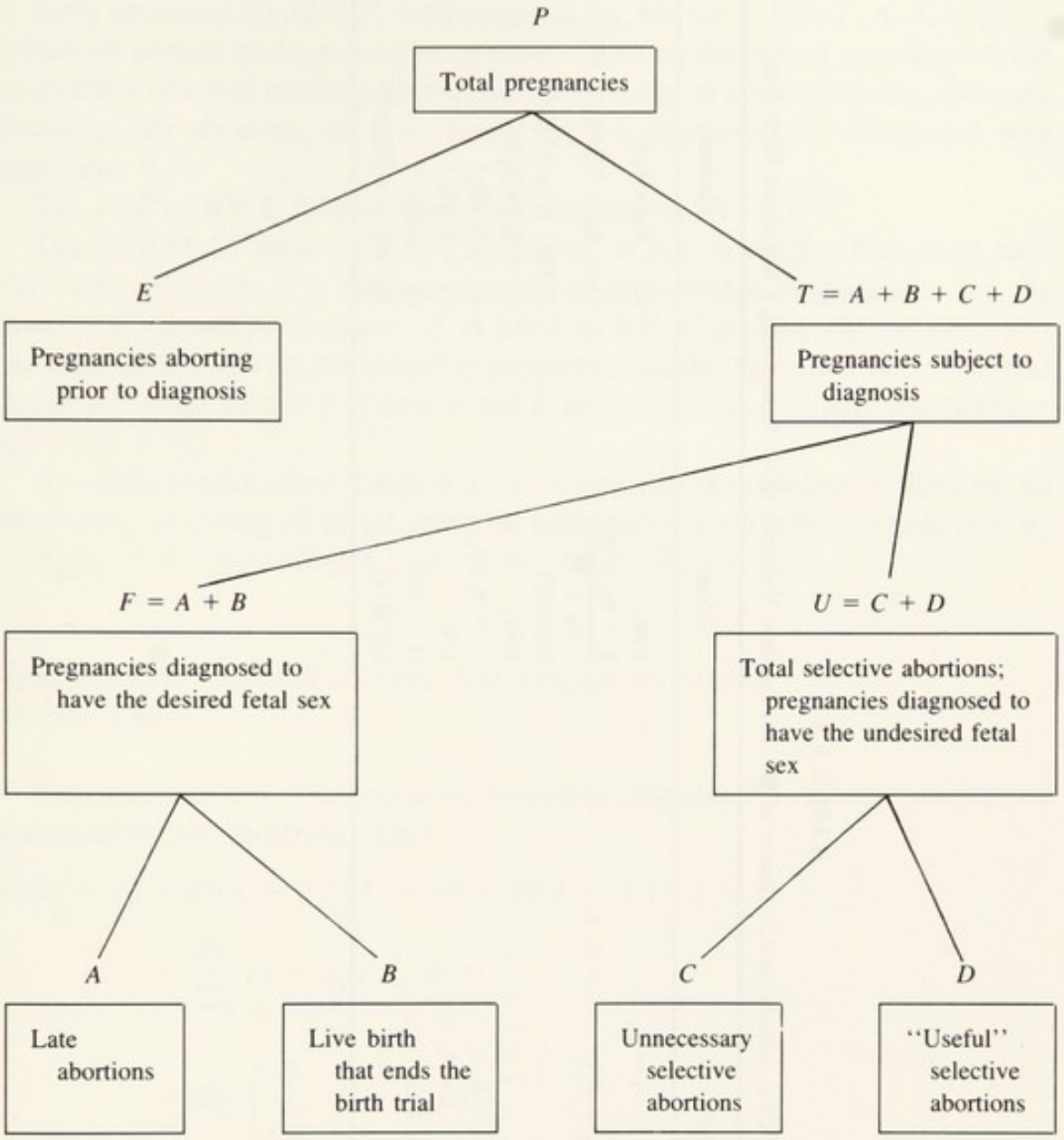
Components of a Regulated Birth Trial

Scheme 1 illustrates the components and sequences of a regulated birth trial.

Probabilities

Barring an early spontaneous abortion, a pregnancy may end in one of four outcomes with probabilities A, B, C, and D as follows:

	Fated for late abortion	
	Yes	No
Favorable diagnoses (h)	$\Pr(A) = (1 - \theta_L)h$	$\Pr(B) = \theta_L h$
Unfavorable diagnoses ($1 - h$)	$\Pr(C) = (1 - \theta_L)(1 - h)$	$\Pr(D) = \theta_L (1 - h)$



Scheme 1.

Two additional random variables are e, the number of early spontaneous abortions directly preceding a next diagnosed pregnancy, and u, the number of unfavorable diagnoses directly preceding the next favorable one.

Table A.1 gives the means and variances of random variables (RVs) P, e, E, T, A, F, u, and U, as well as the probability distribution functions (PDF) of all but E and U. Several comments are in order.

Among all pregnancies, the joint probability that a pregnancy does not abort early, receives a favorable diagnosis, and results in a live birth is $(1 - \theta_2 + \theta_2^*)h\theta_L = \theta_4 h$. The birth trial ends with the first live birth. Hence, RV P is distributed geometrically with parameter $\theta_4 h$.

TABLE A.1

Probability Distribution Functions (PDFs), Means, and Variances of Several Random Variables (RVs) Composing a Regulated Birth Trial

RV	*PDF*	*Mean*	*Variance*
P	$f_P(i) = (1 - \theta_4 h)^{i-1}\theta_4 h, \quad i = 1, 2, \ldots$	$1/h\theta_4$	$(1 - \theta_4 h)/(\theta_4 h)^2$
E	$f_e(i) = (1 - \theta_4 - \theta_2^*)^i(\theta_4 + \theta_2^*), \quad i = 0, 1, \ldots$	$\dfrac{1 - \theta_4 - \theta_2^*}{\theta_4 + \theta_2^*}$	$(1 - \theta_4 - \theta_2^*)/(\theta_4 + \theta_2^*)^2$
σ	—[a]	$E(e)E(T)$	$E(T)\sigma_e^2 + \sigma_T^2[E(E)]^2$
T	$f_T(i) = (1 - \theta_L h)^{i-1}\theta_L h, \quad i = 1, 2, \ldots$	$1/h\theta_L$	$(1 - \theta_L h)/(\theta_L h)^2$
A	$f_A(i) = (1 - \theta_L)^i\theta_L, \quad i = 0, 1, \ldots$	$(1 - \theta_L)/\theta_L$	$(1 - \theta_L)/\theta_L{}^2$
$F = A + 1$	$f_F(i) = (1 - \theta_L)^{i-1}\theta_L, \quad i = 1, 2, \ldots$	$1/\theta_L$	$(1 - \theta_L)/\theta_L{}^2$
u	$f_u(i) = (1 - h)^i h, \quad i = 0, 1, \ldots$	$(1 - h)/h$	$(1 - h)/h^2$
U	—[a]	$E(F)E(u)$	$\mathrm{E}(F)\sigma_u^2 + \sigma_F^2]E(u)]^2$

[a]The PDF lacks a simple expression.

Early abortions E add to P, total pregnancies, but not to RVs T, A, F, u, or U, which all pertain to diagnosed pregnancies. Among diagnosed pregnancies, the probability of a live birth equals the joint probability of a favorable diagnosis and avoiding late abortion, or $\theta_L h$. Hence $f_T(i)$ is geometrically distributed with parameter $\theta_L h$.

The PDF of RV F follows from its definition as RV A + 1.

The PDF of U, total corrective abortions, is not so simple. Preceding each favorable diagnosis is a random number of unfavorable diagnoses u; but the number of favorable diagnoses F is itself an RV. Consequently the mean and variance of U have simple closed expressions, but the PDF does not. Note that because U is the sum of F RVs u, F and U are positively correlated and therefore $\sigma_T^2 > \sigma_F^2 + \sigma_u^2$.

As a final remark about Table A.1, in the absence of sex selection there are no diagnoses, so among all pregnancies the probability of a live birth equals $(1 - \theta_2 + \theta_2^*)\theta_L = \theta_4$. Accordingly, $f_P(i) = (1 - \theta_4)^{i-1}\theta_4$ $i = 1, 2, \ldots$.

Chances of Zero Selective Abortions within a Birth Trial

Required are $A + 1$ consecutive favorable diagnoses if A is the number of consecutive late abortions. Thus

$$\Pr(U = 0) = \Pr(A = 0 \cap U = 0) + \Pr(A = 1 \cap U = 0) + \ldots$$

$$= \sum_{i=0}^{\infty} (1 - \theta_L)^i \, \theta_L \, h^{i+1}$$

$$= h\theta_L \left[\sum_{i=0}^{\infty} (1 - \theta_L)^i h^i \right]$$

$$= \frac{h\theta_L \left\{ \sum_{i=0}^{\infty} [(1 - \theta_L)h]^i \, [1 - (1 - \theta_L)h] \right\}}{1 - (1 - \theta_L)h}$$

$$= \frac{h\theta_L}{1 - (1 - \theta_L)h}.$$

Family Goals Without Sex Selection

The probability of attaining a sequential goal involving b boys and g girls is $(.512)^b(.488)^g$. The particular sequence does not affect the probability. The

probability of achieving the corresponding compositional goal is $\binom{b+g}{b}(.512)^b(.488)^g$, higher by a factor of $\binom{b+g}{b} = \binom{b+g}{g}$.

Total pregnancies equal $k = b + g$ plus a RV S, say, that has a Pascal distribution with parameters k and $\theta_4 = 1 - \theta_2$. That is,

$$f_S(i) = \binom{k+i-1}{i}\theta_2^i(1 - \theta_2)^k, \qquad i = 0, 1, \ldots .$$

Sequential Family Goals with Every Birth Trial Regulated

The number of children desired is $k = b + g$. Let N_P, N_T, and N_U signify total pregnancies, diagnoses, and selective abortions summed over the k birth trials. The probability h of a favorable diagnosis is .512 or .488, depending whether a boy or girl is wanted. Supposing that b boys and g girls are desired,

$$E(N_P) = bE(P|b) + gE(P|g),$$

with

$$E(P|b) = (.512\theta_4)^{-1}$$
$$E(P|g) = (.488\theta_4)^{-1};$$

and

$$\sigma^2_{N_P} = b\sigma^2_{P|b} + g\sigma^2_{P|g},$$

with

$$\sigma^2_{P|b} = (1 - .512\theta_4)/\theta_4^2(.512)^2$$
$$\sigma^2_{P|g} = (1 - .488\theta_4)/\theta_4^2(.488)^2.$$

Analogous formulas apply to $E(N_T)$ and $E(N_U)$ and to $\sigma^2_{N_T}$ and $\sigma^2_{N_U}$. The probability of escaping without selective abortion is

$$\Pr(N_U = 0) = \Pr(U = 0|h = .512)^b \Pr(U = 0|h = .488)^g.$$

One further set of results needed for the analysis of the next section are the second moments around the origin with respect to N_P, N_T, and N_U. These are readily obtained by the relation $\mu_2(N_P) = \sigma^2_P + [E(N_P)]^2$, and analogously for $\mu_2(N_T)$ and $\mu_2(N_U)$.

Compositional Family Goals Subject to an Abortion-Reducing Decision Rule

Any unisex family goal is effectively a sequential goal from the standpoint that every birth trial must be regulated. The formulas of the preceding section suffice for this type of goal.

Suppose that a composition of three boys and one girl is desired. As long as one child of each sex is still desired, the abortion-reducing (AR) strategy says

that the current birth trial may go unregulated. Whether there may be a second or even a third unregulated birth trial depends on the sex distribution of the preceding births. Let z denote the number of unregulated birth trials. If the first unregulated birth trial produces a daughter, leaving three boys wanted, then because the residual composition has become unisexual all the remaining birth trials must be regulated. Hence $z = 1$ in this case. An initial first-boy, then-girl (boy–girl) sequence renders $z = 2$, leaving a residual composition of two boys desired. A boy–boy–girl sequence gives $z = 3$ and a residual composition of one boy. The final possibility is a boy–boy–boy sequence, giving $z = 3$ and a residual composition of one girl. Thus the random sequence of sexes resulting from z unregulated birth trials leads to some unisexual residual composition that dictates the number of regulated birth trials and their target, boys or girls.

Suppose now that b boys and g girls are desired. Let the $k = b + g$ distinct possible residual compositions be denoted by the set $R = (r_1, r_2, \ldots, r_k)$. If their probabilities are $\Pr(r_i)$, $i = 1, 2, \ldots, k$, then

$$\begin{aligned} E(N_T) &= \sum_R \Pr(r_i) E(N_T|r_i) \\ \mu_2(N_T) &= \sum_R \Pr(r_i) \mu_2(N_T|r_i) \\ \sigma^2_{N_T} &= \mu_2(N_T) - [E(N_T)]^2. \end{aligned}$$

The moments $E(N_T|r_i)$ and $\mu_2(N_T|r_i)$ are obtainable by formulas from the preceding section because by definition residual compositions r_i are all unisexual. Parallel formulas exist for the moments of the numbers of selective abortions U.

Another quantity of interest is the probability of achieving a compositional goal without a single selective abortion. Again one conditions on residual composition:

$$\Pr(N_U = 0) = \sum_R \Pr(r_i) \Pr(N_U = 0|r_i).$$

The mean of RV z commands interest as an explanation for the reduction in $E(N_T)$ made possible by the AR strategy, as well as for its reduction of $E(N_U)$ and its increase of $\Pr(N_U = 0)$. The minimum value of z equals b or g, whichever is smaller—that is, $\min(b,g)$. Its maximum equals $b + g - 1$. All intervening values are possible. Thus

$$E(z) = \sum_{i=\min(b,g)}^{b+g-1} \Pr(z = i) i.$$

With respect to total pregnancies N_P under an AR strategy, we must distinguish between ${}_1N_P$, total pregnancies in birth trials preceding first diagnosis, and ${}_2N_P$, total pregnancies during the succeeding regulated birth trials.

Let us assume a desired composition that includes at least one son and one daughter. $z(r_i)$ signifies the value of z conditional on a given r_i. For any given possible residual composition $r_i \epsilon R$, the conditional ${}_1N_P|r_i$ is Pascal distributed with parameters $[z(r_i), \theta_4]$ and distributed independently of ${}_2N_P|r_i$. Therefore,

$$E(N_P|r_i) = E({}_1N_P|r_i) + E({}_2N_P|r_i)$$
$$\sigma^2_{N_P|r_i} = \sigma^2_{{}_1N_P|r_i} + \sigma^2_{{}_2N_P|r_i}$$

and

$$\mu_2(N_P|r_i) = \sigma^2_{N_P|r_i} + [E(N_P|r_i)]^2$$

with

$$E({}_1N_P|r_i) = z(r_i)/\theta_4$$

and

$$\sigma^2_{{}_1N_P|r_i} = z(r_i)\ (1 - \theta_4)/\theta_4^2.$$

As a function of residual composition, ${}_2N_P$ has a mean, variance, and second moment around the origin that can be obtained by formulas in the preceding section.

Although ${}_1N_P$ and ${}_2N_P$ are independently distributed for a given residual composition, they are negatively correlated over residual composition. However, conditional means and second moments around origins are additive over residual composition. Hence, we use

$$E(N_P) = \sum_R \Pr(r_i) E(N_P|r_i)$$

and

$$\mu_2(N_P) = \sum_R \Pr(r_i) \mu_2(N_P|r_i),$$

the results of which allow us to compute the unconditional variance by

$$\sigma^2_{N_P} = \mu_2(N_P) - [E(N_P)]^2.$$

Single Birth Trial Subject to a Ceiling of One Diagnosis

Given a maximum of one diagnosis, the probability of having a child of the desired sex is $h\theta_L + (1 - h\theta_L)h$, where $h = .512$ or $.488$ depending whether a son or daughter is sought. Chances of the diagnosed pregnancy producing the desired birth is $h\theta_L$. There is an accompanying probability of $(1 - h\theta_L)h$ of its

occurring as the result of a subsequent, undiagnosed pregnancy. The complementary probability of not obtaining the sex desired is $(1 - h\theta_L)(1 - h)$. It also follows that the numbers of corrective abortions are zero or one with likelihood h and $1 - h$ yielding a variance of $h(1 - h)$.

Required for Table 8 is the PDF of total pregnancies. When the diagnosed pregnancy produces the birth, the only source of random variation is the number of preceding early abortions. If the diagnosed pregnancy ends either in a late spontaneous abortion or in a corrective abortion, there are two independent but not identically distributed sources of random variation—namely, the number of early miscarriages preceding the diagnosed pregnancy and the number of spontaneous fetal losses, early or late, intervening between diagnosed pregnancy and the pregnancy producing the birth. The PDF of total pregnancies can be shown to be

$$\begin{aligned} f_P(0) &= 0 \\ f_P(1) &= (\theta_4 + \theta_2^*)h\theta_L \\ f_P(k) &= (\theta_2 - \theta_2^*)^{k-1}(\theta_4 + \theta_2^*)h\theta_L \\ &\quad + \sum_{j=1}^{k-1} (\theta_2 - \theta_2^*)^{j-1}(\theta_4 + \theta_2^*)(1 - h\theta_L)(1 - \theta_4)^{k-j-1}\theta_4 \\ &\quad \text{for } k = 2, 3, \ldots . \end{aligned}$$

The corresponding mean and variance are

$$E(P) = \frac{1}{\theta_4 + \theta_2^*} + \frac{1 - h\theta_L}{\theta_4}$$

and

$$\sigma_P^2 = \frac{\theta_2 - \theta_2^*}{(\theta_4 + \theta_2^*)^2} + \left(\frac{1 - h\theta_L}{\theta_4^2}\right)(\theta_2 + h\theta_L).$$

For purposes of Table 8, two further PDFs are needed—namely, total pregnancies conditional on attaining or not attaining the birth sex desired. In the first case we have

$$\begin{aligned} f_P^*(0) &= 0 \\ f_P^*(1) &= \Pi^{-1}(\theta_4 + \theta_2^*)h\theta_L \\ f_P^*(k) &= \Pi^{-1}[(\theta_2 - \theta_2^*)^{k-1}(\theta_4 + \theta_2^*)h\theta_L] \\ &= \Pi^{-1}[h(1 - h\theta_L) \sum_{j=1}^{k-1} (\theta_2 - \theta_2^*)^{j-1}(\theta_4 + \theta_2^*)(1 - \theta_4)^{k-j-1}\theta_4] \end{aligned}$$

$$k = 2, 3, \ldots ,$$

with $\Pi = h\theta_L + (1 - h\theta_L)h$ and a mean of

$$E(P^*) = \frac{1}{\theta_4 + \theta_2^*} + \left(\frac{(1 - h\theta_L)h}{h\theta_L + (1 - h\theta_L)h}\right)\frac{1}{\theta_4}$$

With respect to the second case,

$$f_P^{**}(k) = 0 \qquad \text{when} \quad k = 0, 1$$

and

$$f_P^{**}(k) = (1 - \Pi)^{-1}[(1 - h)(1 - h\theta_L) \sum_{j=1}^{k-1} (\theta_2 - \theta_2^*)^{j-1} (\theta_4 + \theta_2^*) (1 - \theta_4)^{k-j-1}\theta_4]$$

when $k = 2, 3, \ldots$.

The corresponding mean is

$$E(P^{**}) = \frac{1}{\theta_4 + \theta_2^*} + \frac{1}{\theta_4},$$

which plainly exceeds $E(P^*)$.

Single Birth Trial Subject to a Ceiling of One Corrective Abortion

A ceiling of one corrective abortion admits the possibility of $k + 1$ diagnoses when the first k diagnoses are all favorable but each is followed by a late spontaneous abortion. The number of diagnoses, instead of being uniformly 1 as in the preceding section becomes a geometric RV with parameter $1 - h\theta_A$, where $\theta_A = 1 - \theta_L$. Accordingly the number of diagnoses averages $(1 - h\theta_A)^{-1}$. This increase in the number of diagnoses means an improved chance of attaining the sex desired. That probability can be shown to equal

$$\frac{h\theta_L}{h\theta_L + (1 - h)} + \frac{(1 - h)h}{h\theta_L + (1 - h)}.$$

However, as a practical matter, the chance of a favorable diagnosis followed by a late spontaneous abortion is only $h\theta_A$, or .013; the probability of two such events in succession, .0002. Hence the two postulates, a ceiling of one diagnosis or a ceiling of one corrective abortion, give essentially the same results. For example, respective probabilities of attaining the sex desired differ only in the third decimal place.

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4

Timing of Fertilization and the Sex Ratio of Offspring*

WILLIAM H. JAMES

Nothing exists, Mr. Baryton, between the penis and mathematics. Nothing at all! It's a vacuum.
[A doctor in a lunatic asylum infected by the lunacy around him: in *Voyage au Bout de la Nuit* by Louis-Ferdinand Celine,]†

INTRODUCTION

Preconceptual control of sex of infants is a topic that has attracted the attention of hoaxers, incompetents, madmen, and cranks, as well as scientists. It is not always possible to tell which is which, and I shall call them all *sex hypothesizers*. Connoisseurs would detect in sex hypotheses a great potential for confusion. This is so for two reasons:

1. The time interval between human conception and delivery is so long that false predictions made at conception may be forgotten or revised at parturition.

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†Celine, Louis-Ferdinand (1960). *Voyage au Bout de la Nuit*. [Journal to the End of the Night.] (J. H. P. Marks, trans.) New York: New Directions.

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2. Because most of these sex hypothesizers have found that a false prediction does not falsify a hypothesis, but merely indicates the necessity for numerological or other adjustment, the field has been one in which all evidence has been interpreted as corroborative. I do not think I have ever read the words "I was wrong" in the writings of a sex hypothesizer. So sex hypotheses have tended to die with their inventors rather than from an overload of admitted contradictory evidence.

It is not surprising therefore that other scientists should view the topic with intense skepticism. To an uncommitted mind, one sex hypothesis is about as credible as another. A priori, it seems about as likely that the wearing of boots at the time of intercourse should affect the sex of the conceptus as that the time of insemination should do so. So the purpose here—to review the latter hypothesis—may raise eyebrows in some circles. Such skepticism may be assuaged by the knowledge that one of the earlier proponents of the hypothesis was Hippocrates (Whelan, 1977).

The hypothesis is not here pursued over the intervening centuries—only over the last one. During this time it has been resuscitated repeatedly only to be subsequently discarded.

I have reviewed the hypothesis before (James, 1971, 1976b); the present chapter reconsiders the evidence for it in the light of the suggestion that circulating gonadotrophin levels at the time of conception are directly associated with the sex of the zygote (James, 1980b). Readers wanting a summary of this elaboration of the hypothesis should consult the section on maternal gonadotrophin levels. This elaboration of the hypothesis, though it improves its credibility, weakens it (in the logical sense) by widening its explanatory power; as will be seen, much of the data that had previously been interpreted as supporting the hypothesis no longer can be seen in that light. (If a hypothesis can explain *any* set of facts, then no set of facts supports it.)

EARLIER DIRECT DATA

Reports of data in regard to human beings have been reviewed by Asdell (1927), Crew (1927), and Wedervang (1924). Neither Asdell nor Crew was wholly convinced by the data he reviewed. Wedervang felt that published reports supported the suggestion that male conceptions are more likely to occur early in the cycle, but he doubted that statistical significance of this support. However, as can be seen from Table 1, if one were satisfied by the quality of the data, then one would not doubt the existence of such an effect, at least in some data.

Table 1 gives the six sets of data reproduced by Asdell (1927), Table 2 the data

TABLE 1

Number of Conceptions, Distributed According to Sex, Related to Cycle Day of Coitus: Reproduced from Asdell (1927)

	Cycle day of coitus					
	1–9		*10–14*		*15–23*	
Author	*M*[a]	*F*[a]	*M*	*F*	*M*	*F*
Siegel (1916)	37	7	4	9	3	20
Nurnberger (1918)	41	39	29	27	26	21
Jaeger (1917)	32	16	8	14	12	17
Hecker and Buhl (1861) } Schlichting (1889) }	93	82	46	48	63	58
Furst (1886)	40	18	23	28	28	35

[a]M refers to Male, F refers to Female.

of Pryll as reproduced by Crew (1927), Table 3 the data of Blumenfeld (1925), Table 4 the data of Bolaffio (1922), and Table 5 the 1919 data of Rheinholdt as reproduced by Hatzold (1966).

In order to establish the cycle day of a fruitful coitus, one has to know (a) the date of the beginning of the last menstrual period (LMP) and (b) the day on which the fruitful coitus occurred. In general, it seems that women report more accurately on LMP than might be supposed (Treloar, Behn, and Cowan, 1967). But they report (as opposed to record) inaccurately on coital dates (Udry and Morris, 1968). This latter point illustrates one of the weaknesses of the earlier German data. However, Jaeger (1917), Nurnburger (1918), Pryll (1916), and Siegel (1916), all employed the ingenious technique of determining coital dates by ascertaining (from the German War Office) the dates on which their subjects' soldier husbands were home on leave. Hartman (1936), though he praised

TABLE 2

Number of Conceptions, Distributed According to Sex, Related to Cycle Day of Coitus: Data of Pryll (1916), Reproduced from Crew (1927)

Cycle day of coitus					
1–9		*10–14*		*15–22*	
M	*F*	*M*	*F*	*M*	*F*
136	111	69	62	71	67

TABLE 3

Number of Conceptions, Distributed According to Sex, Related to Cycle Day of Coitus: Data of Blumenfeld (1925)

Cycle day of coitus:					
Post-menstruum		*Inter-menstruum*		*Pre-menstruum*	
M	*F*	*M*	*F*	*M*	*F*
20	26	12	8	7	3

TABLE 4

Number of Conceptions, Distributed According to Sex, Related to Cycle Day of Coitus: Data of Bolaffio (1922)

Cycle day of coitus:					
1–10		*11–14*		*15 onward*	
M	*F*	*M*	*F*	*M*	*F*
51	47	11	7	27	64

TABLE 5

Number of Conceptions, Distributed According to Sex, Related to Cycle Day of Coitus: Data of Rheinboldt (1919) as Reproduced by Hatzold (1966)

Cycle day of coitus:					
1–9		*10–14*		*15 onward*	
M	*F*	*M*	*F*	*M*	*F*
34	18	16	15	9	21

Siegel's work, still felt the data to be vitiated by "the prevalent notion as to when women are supposed to conceive." But it is difficult to see how such a notion could have been responsible for Siegel's observations. Indeed, it is difficult to see how any artifact could have caused them. Certainly Siegel's defense of his subjects against charges of unchastity seems needless in this context. It seems unlikely too that any element of fraud was present here—in science there is little cachet in corroborating the work of others. It must be admitted, though, that these data present puzzling features in regard both to the sex ratio of the offspring and to the distributions of alleged cycle days of fruitful coitus.

There is one further difficulty with these data that may be raised. As Hartman (1936) notes, each day of leave was counted by Jaeger, Nurnberger, Siegel, and Pryll as an insemination day. This being so, there should presumably be fractional frequencies of conceptions assigned to the various days. None of these authors report fractional frequencies, so it is reasonable to wonder whether the reported frequencies are gross inflations of the true numbers of conceptions.

Perhaps not surprisingly, these early German data seem to have fallen into disrepute. After they were published it was suggested that the sexes differ in regard to the time interval from insemination to confinement. And it was claimed (e.g., by Ewart, 1918) that this difference impugned the hypothesis. This argument seems invalid. At any rate it is invalid if the authors estimated the LMP for each subject (as a reading of Siegel suggests that he did). I am very interested to have an assessment of the quality of these data from a scholar familiar with the languages of the authors. Anyone wishing to pursue the history of the hypothesis might profitably study Siegel's German critics cited by Huxley (1924, p. 100).

Little scientific interest was paid to the hypothesis during the 1930s and 1940s, but the publication by Kleegman (1954) was to be a further fruitful source of confusion. She found that the sexes of children conceived by artificial insemination showed a different trend to those in the data in Tables 1 through 5. Kleegman's data suggested that boys were conceived from inseminations around ovulation time and girls from inseminations before it. In time the earlier data were forgotten and Shettles (Rorvik and Shettles, 1970) proposed a system of sex determination partially based on Kleegman's data. Shettles's book had considerable vogue and was published in several languages. According to Whelan (1977, p. 67), unpublished data exist that suggest Shettles's system *lowers* the probability of getting—by natural insemination—a child of a preferred sex. The explanation of this failure will become clear later.

Toward the end of his long life, the distinguished Italian statistical scientist Gini (1961a,b) reiterated the view that males are conceived earlier in the cycle than females. He was attacked by Maly and Raboch (1962) for the paucity of his data. Gini (1963) offered a rejoinder; however, it lacks the stature of the pioneer work he had done so many years earlier (Gini, 1908). It seems very possible that

if Gini had turned his attention to the idea earlier in his life, it might now receive wider credence.

MORE RECENT DIRECT DATA

Guerrero (1970, 1974) found that the sex of the zygote is influenced by the time interval between insemination and ovulation as indexed by the basal body temperature (BBT) test. Guerrero's finding has been confirmed by Harlap's (1979) data on births to Jewish women who had ritually abstained from coitus for the week following cessation of menses. It is noteworthy that in the case of natural inseminations, both authors reported an excess of boys from inseminations early and late in the fertile period, and an excess of girls from inseminations in the middle of the fertile period. In regard to artificial inseminations, Guerrero found an opposite tendency, namely, an excess of boys in the middle of the fertile period. This seems the probable cause of the failure of Shettles's method.

The odds that these results could be due to chance are inconceivably small; however, it is a matter of judgment to decide whether some artifact could be responsible rather than the phenomenon claimed. Guerrero's data still give the same result when attention is confined to *single* inseminations (thus avoiding the difficulty of identifying the fruitful insemination from among several inseminations in the same cycle).

These two papers have elicited some comment in the correspondence columns of the *New England Journal of Medicine*. The sort of comment aimed at Guerrero's data was that they referred to women who were unrepresentative because they were subfertile or used a rhythm method of contraception. More to the point, perhaps, all Guerrero's natural insemination women had *failed* with a rhythm method. Thus the suspicion arises that intercourse had taken place during the proscribed days. But a woman might be unwilling to reveal this to clinic personnel: In the first place she might feel that it revealed discreditable animality, and in the second place the fruitful intercourse might have been illicit—and to have revealed that to the clinic might have involved revealing it to her husband (who would usually keep the coital calendar under interested scrutiny).

Another critic claimed that the sperm used in artificial insemination is predominantly from physicians and medical students and that this is likely to yield a disproportionate number of boys (Bernstein, 1975). It seems to me that none of these criticisms has much bite because the critics do not offer any explanation of *how* these features might cause the effect described by Guerrero. The only argument of this sort that I have seen runs as follows. In regard to natural

inseminations, one might wonder whether the heterogeneity of Guerrero's material masked the two following possible effects

1. Early natural inseminations were due to highly fertile people who failed with a rhythm method. Because they are highly fertile they might be expected to have children with a high sex ratio.
2. Natural inseminations on the day of ovulation were presumably mainly to women attending fertility clinics. Because they are subfertile they might be expected to have children with a low sex ratio.

In fact, though, this argument seems false. Guerrero (1968) notes that in his data the sex ratio of infants of women who failed with a rhythm method was lower than that of infants from women who conceived after attending a fertility clinic.

Harlap's (1979) paper has been criticized because

1. The mothers were interviewed about their cycle lengths on the first day postpartum (and therefore their responses might be expected to be even more unreliable than such responses usually are).
2. She uses the formula $Y = N - 14$ where Y is the expected ovulation day and N is the reported mean cycle length for each woman (and this is only a rough approximation).
3. She assumes that Orthodox women have intercourse on the day of the ritual bath and that the intercourse is fertile.

The substance of these criticisms is that the cycle day of fruitful insemination (relative to ovulation day) is inefficiently measured. In defense of Guerrero and Harlap, it is worth remarking that if there is no bias (rather than random error) in these measurements, these comments, far from being criticisms, may be construed as support. The onus is on the critics to show that there *is* bias and that the bias is responsible for the effect. But a realistic appreciation of scientific progress will take account of the fact that some critics will feel that inexact measurement in itself is a ground for skepticism.

There have been two attempts to test this hypothesis using couples who wished to have a child of a given sex. One of these (Williamson, Lean, and Vengadasalam, 1978) was prompted by Shettles's claims. The other was prompted by Guerrero's and was conducted by the now-defunct London weekly newspaper *Reveille* (1977). Williamson *et al.* (1978) give a poignant description of the difficulties experienced in running a sex-selection clinic—the number of dropouts, the number of women (the large majority) who fail to obey the sexual regimen, the failures to understand, the difficulties with husbands: one senses the anaphrodisiac rigors of douches, of care-ridden coital positions, and of deliberate, planned, unspontaneous intercourse.

The *Reveille* study was conducted by mail. Readers were invited to apply for "personalized" coital directions. These were based on the finding of James (1972b) that ovulation is most likely on day $(n/2) - 1$, where n is the mean cycle length of the woman concerned. Those wishing for boys were advised to have intercourse before this day, but not after it. Those wishing for girls were advised to abstain until that day, and then to have intercourse. This latter prescription may well have been in error; at the time it was prepared, Harlap's (1979) paper had not appeared, and it was assumed that the probability of a boy declined monotonically with time across the cycle. In the *Reveille* study too there were a large number of dropouts who failed to indicate the sex of their child. This failure may be at random, or it may be because the child was of the "wrong" sex. At any rate the methodological flaws of these two studies preclude a meaningful assessment of their results.

OTHER MAMMALIAN DATA

Data relating time of insemination and the sex of mammalian offspring have been briefly reviewed by Guerrero (1974). He considered six studies dealing with natural insemination. In each he notes that a nonsignificant trend supports the hypothesis. However, it seems to me that data on lower mammals are at best equivocal in their support: Science may not be served here by an over-strenuous wringing of significance out of obdurate data. This is a field needing a lengthier treatment than is possible now.

However, there is one exception that may be considered here. Kaufman (1973) provided data that, as far as I know, are unique: They give evidence on the sexes of members of mouse litters by the presumed time of fertilization (rather than of insemination). Kaufman examined litters of mice at various times after fertilization. In some of the litters a minority of the eggs had entered the first cleavage division and were showing sexable metaphase plates, whereas the majority were still in the one-cell stage. In other litters examined somewhat later, the majority of eggs were in the two-cell stage, but a few were still in metaphase of the first cleavage.

Let us assume that those eggs that developed sooner were the ones in the litter that had been fertilized earlier. Then, if the hypothesis is correct, the sex ratio of the sexable zygotes should vary with time of examination. Kaufman gives the distributions of 62 male and 61 female zygotes by time after administration of human chorionic gonadotrophin (HCG). If the hypothesis is correct, these two distributions should differ. Their means are almost identical, but their variances are 1.4997 (males) and 1.0767 (females). The ratio of these two values is 1.4. This is the 10 percent point of the F ratio for samples of size 61 and 61. This

value is based on a one-tailed test; however, the data of Guerrero (1974) and Harlap (1979) suggest that the male variance would be greater than the female, so it is reasonable to regard Kaufman's data as supporting the hypothesis at the .10 level (not the .05 level as I mistakenly suggested in an earlier paper [James, 1976b]).

In view of the difficulties in interpreting the direct data on human beings, and of the equivocal support given by the data on lower mammals, it is necessary to review indirect data.

SEX RATIO AND SPONTANEOUS ABORTION

Before examining these data, it is necessary to deal with the view that variations in the secondary sex ratio are due to differential spontaneous abortion of males and females (and that therefore the secondary sex ratio reflects no useful information on the primary sex ratio). In the form that this argument usually takes, it depends on two premises.

1. Spontaneous abortions contain a predominance of males.
2. Spontaneous abortion rates are increased by deleterious environmental circumstances (e.g., increasing maternal age, lower social class).

According to this view, low secondary sex ratios are due to high spontaneous abortion rates; in this way the low secondary sex ratios in Negro births (Teitelbaum and Mantel, 1971) and in births to older women (James, 1972c) were held to be explained. The objection to all this is that the first premise above is false. Evidence is of two sorts, indirect and direct. The indirect evidence is treated first.

Colombo (1957) and Boldrini (1936) strongly urged that the sex ratio among the offspring of women who have never had a spontaneous abortion is very close to that of the surviving offspring of women who *have* had a spontaneous abortion and that therefore the sex ratio of the abortuses must have been about the same as that of the liveborn. As Edwards (1962) remarked, the argument assumes that there is no association between a propensity to abort and the primary sex ratio. However, Edwards' argument runs into difficulties. The incidence of spontaneous abortion is high (James, 1970): One review concludes that it lies between 25 and 75 percent of all pregnancies (Abramson, 1973). Now suppose this were correct, and suppose that Edwards (1962) were correct in suggesting that Boldrini's findings may be caused by an association between a propensity to have male conceptions and a proneness to abort pregnancies. It would follow that the probability of conceiving a boy at each pregnancy (assumed to be roughly constant within each woman at each pregnancy, but varying among women)

varies very considerably among women (Lexis variation). In 1958, Edwards concluded that the variance among couples of the probability of having a live-born boy was of the order of .0025, but in 1966 he revised this estimate to zero. Because he inferred that there is no genetic variability in sex ratio (Edwards, 1970), he presumably had abandoned his 1962 argument. At any rate, if there is no appreciable variation among couples in the probability of a male conception, then obviously the probability of aborting cannot vary with it, and Colombo's argument, namely, that spontaneously aborted fetuses do not contain a disproportionate number of males, is sound.

More recent direct data on the chromosomes of spontaneous abortuses confirm this conclusion (Boué, 1976; Carr, 1971; Creasy, 1977). So as a working hypothesis we may assume that (perhaps with some distortion) variation in the secondary sex ratio reflects variation in the primary sex ratio.

INDIRECT DATA

Human Coital Rate and Sex of Offspring

If it were true that cycle day of fertilization affects the sex of the resulting offspring (early conceptions more frequently being of boys), then coital rate would be associated with the sex of offspring. This is so because under a regimen of frequent intercourse the early "boy" day(s) would be more likely to be hit than if coitus were infrequent.

As far as I know, I made the first serious suggestion (James, 1971) that human coital rate might be causally associated with the sex of the resulting infants, high rates being associated with male infants. It is important to note that different assumptions about reproductive parameters lead to different predictions here. For instance, Revelle (1974) inferred that if Guerrero (1974) were correct, then high coital rates would lead to *female* conceptions. However, I have suggested (James, 1977a) that the model underlying Revelle's inference is false. If it were true that high coital rates lead to high sex ratios, then explanations (of varying plausibility) become available for the established variation of sex ratio with wartime, duration of marriage, parental age, parity, family size, and the presence of twin sibs. These points are discussed in the following sections.

Wartime

There is no doubt that the sex ratio in newborns in belligerent countries rises during and just after wars. For the 1914–1918 war, it was noted, for instance, in

Austria, Belgium, Bulgaria, England, France, Germany, Hungary, Italy, Rumania, and South Africa (Bernstein, 1958; Russell, 1936), but not in the United States where not more than 4 percent of the population was under arms at any time compared with 15–22 percent in some of the principal European countries (More Boy Babies in Post-War Years, 1939). Russell (1936) also noted that in selected neutral countries such an effect was smaller or absent. For the 1939–1945 war, the rise has been noted both in the United States and in England and Wales (MacMahon and Pugh, 1954). In England and Wales, the live-birth sex ratios were higher in 1941–1946 than in any years previously recorded, registration having started in 1841 (Lowe and McKeown, 1950). These wartime rises cannot be entirely accounted for by changes in parity, maternal age, birth interval, or fetal death rates (MacMahon and Pugh, 1954). In the United States during and after the 1939–1945 war, the rise was particularly noted among mothers under the age of 25 (War and the Sex Ratio of Births, 1949) and among primiparas (MacMahon and Pugh, 1954)—presumably, that is, disproportionately among the wives of men in the armed services.

There is a substantial body of British folklore testifying to the coital excesses of returning servicemen (paralleled, it would be polite for an Englishman to assume, in the enshrined traditions of United States veterans). Accordingly I suggest that these high sex ratios during and just after wars are directly associated with the unusually high coital rates that occur during demobilization leave and short wartime leaves.

At this juncture, it is worth outlining the seeming failure of all other attempts to explain this wartime rise in sex ratios.

1. Huxley (1922) suggested that nervous strain might somehow have converted some genetic females into males. But other sorts of disaster seem to have no effect on the sex ratio, such as the United States depression following 1929 (Ciocco, 1938) and the cholera epidemic in Italy 1865–66 (Gini, 1908).

2. Variations in nutrition seem not to be responsible because the famines in India in the final years of the last century had no appreciable effect on the sex ratios there (Gini, 1908). Also, according to Bayer (1938, cited in Lawrence, 1941), sex ratios in small communities in Germany in the 1914–1918 war rose in spite of the fact that such communities were thought to be cushioned against the general malnutrition elsewhere.

3. Bernstein (1958) suggested that the explanation of this wartime rise is that (a) children born at such times are disproportionately the products of couples of high fecundability, and (b) for some unspecified genetic reason such couples produce a higher proportion of boys than other couples.

I believe Bernstein's first suggestion here is correct. I think she is correct in her second suggestion too; however, where she has simply suggested some vague genetic variable as the cause, I think I have identified the variable in question—

coital rate, which is not directly genetic at all. I suggest that highly fecund women bear unusually high proportions of boys because (for reasons of coital frequency rather than genetics) they conceive, on the average, earlier in their cycles than other women.

Duration of Marriage

Bernstein (1958) noted that a higher proportion of males are born to women who conceive within 18 months of marriage than to those who conceive after this interval. Renkonen (1964, 1970) corroborated this on data from Finland and Australia. He observed that for first nuptial conceptions the sex ratio is higher for first month conceptions than for conceptions in any subsequent month. I have unpublished data that powerfully suggest that coital rates in the first month of marriage are higher than during any subsequent month. Coital rates, like sex ratio, decline with duration of marriage. Indeed, to judge from Renkonen's figures, the sex ratio of offspring seems more closely associated with duration of marriage than with parental age. The same feature is evident in respect to coital rates in data published by Westoff and Westoff (1971) and in unpublished data of my own.

It may be objected that Renkonen's data were not controlled for maternal age and that therefore the variation of sex ratio with duration of marriage in his data may be secondary to variation of sex ratio with maternal age. The objection may well apply to the variation of sex ratio of conceptions after the first year of marriage. But it can scarcely be sustained in regard to the rather considerable variation across the first few months of marriage.

Parental Age

In previous discussion on the hypothesis that sex ratio is related to time of insemination, I suggested (James, 1971, 1976b) that the variation of sex ratio simultaneously by maternal age and paternal age gave considerable support to it. It now seems that the nature of the support is rather different from, and less compelling than, that suggested in those papers.

I noted (James, 1971, 1976b) the strong evidence (then as yet unquestioned) that the decline in sex ratio with maternal age was largely secondary to that with paternal age, and I drew attention to the evidence (James, 1974) for a similar feature when marital coital rates were simultaneously analyzed by husband's age and wife's age (viz., that the decline by wife's age was largely secondary to that by husband's age). I inferred that sex ratio was controlled by coital rate (via the intervening variable of time of insemination). The inference is, I still think, correct, but the evidence is now less persuasive.

In the first place, attempts to analyze sex ratio simultaneously by maternal age, paternal age, and parity (Erickson, 1976; Garfinkel and Selvin, 1976; Imaizumi and Murata, 1979; James and Rostron, unpublished) are not unanimous in finding that variation of sex ratio by maternal age is secondary to that by paternal age. This may be because of the numerical inadequacy of these data. But the 6.5 million births in England and Wales between 1968 and 1977 (the largest sample so far analyzed) suggest that sex ratio declines independently with all three variables (James and Rostron, unpublished).

However, recent analysis of marital coital rates has shown that they exhibit a curious and unexplained lability. According to the data of Udry and Morris (1978), United States coital rates reported in 1971 were much less dependent on husband's age than they had been in 1965. In the more recent data, coital rates declined independently with both variables. This lability dictates caution in deriving expectations from the hypothesis: If we are unsure of the relationship between marital coital rates and spouses' ages, then we can make no unequivocal prediction about the variation of sex ratio with spouses' ages from the hypothesis. It seems fair to summarize the data thus: The best evidence is that sex ratio declines independently with both maternal age and paternal age; coital rate also seem to decline independently with husband's age and wife's age. So the data are in conformity with the hypothesis. But a critic might wonder whether this conclusion has involved some picking and choosing of data to suit the hypothesis.

Moreover, elaboration of the hypothesis (see the section on maternal gonadotrophin levels) that sex ratio is dependent on gonadotrophin levels has generated an expectation that seems not to be fulfilled. If this elaboration were correct, then sex ratio should decline with maternal age for two independent reasons: (a) the decline in coital rate with maternal age, and (b) the increase of gonadotrophin levels with maternal age (Bulmer, 1970, p. 80). And if the hypothesis were correct, then sex ratio should decline independently with paternal age (because of the decline of coital rate with paternal age). However, because the decline in coital rate with paternal age is apparently no greater than that with maternal age, one would expect the decline in sex ratio with maternal age to be more substantial than that with paternal age. Yet, the general consensus seems to be that the reverse is the case. Possibly the decline in coital rate with paternal age usually exceeds that with maternal age, and the 1971 data described by Udry and Morris (1978) are atypical.

Parity

Coital rate declines with parity when social class, maternal age, and paternal age (but not duration of marriage) are controlled (James, 1974); and I have unpublished longitudinal data supporting this conclusion in individual couples. These latter data strongly suggest that an immediate and lasting influence of a

new infant is (perhaps not surprisingly) to lower a couple's coital rate. Moreover there is overwhelming evidence that, in general, sex ratio declines with parity, other variables being controlled (Erickson, 1976; Garfinkel and Selvin, 1976; Imaizumi and Murata, 1979; James and Rostron, unpublished). However, as with the variables of paternal age and maternal age, it is difficult to assess the degree of support given by these data to the hypothesis. This is so because of the equivocal predictions one might derive from it, for

1. One would expect sex ratio to *decline* with parity because of increasing gonadotrophin levels as indexed by the increase of dizygotic (DZ) twinning rates independently with both maternal age *and* parity (Bulmer, 1970); yet
2. One might expect sex ratio to *increase* with parity because coital rate correlates positively with parity when duration of marriage is controlled (James, 1974; Thompson and Illsley, 1979).

Because of this latter phenomenon, one might think of the transition from one parity to the next as the occasion for a selection process, couples with higher coital rates being (slightly) more likely to make the transition. The repeated application of this same weak selection mechanism would in the end be quite powerful, so couples with many children may be assumed (at least earlier in their lives) to have had higher coital rates than other couples on the average. And evidence for this (and for the hypothesis) may be seen in the fact that sex ratio at very advanced parities was apparently not as low as at moderate parities (Colombo, 1955) in Italy from 1930 to 1952—a population where this hypothesized selection would presumably not have been masked by the use of efficient contraception. In summary, these data on sex ratio and parity seem in reasonable accord with the hypothesis, but the possibility of equivocal predictions from the hypothesis precludes great enthusiasm.

Sibship Size

As noted previously there is a significant association between coital rate and fertility when duration of marriage is controlled (James, 1974; Thompson and Illsley, 1969). This being so, if the hypothesis were correct, then large sibships should have higher sex ratios than small ones. I have published a table (James, 1975c) giving good evidence for such a phenomenon in Geissler's data. Similar findings have been suggested by Nichols (1906), Repetto (1972), and Schutzenberger (1950). Admittedly Schutzenberger's result is not statistically significant and Nichols gives no control data, but Repetto's results (on samples from contemporary India, Bangladesh, and Morocco) are highly significant. These findings are noteworthy in view of the obvious decline (discussed previously) in sex

ratio with parity. Moreover, it seems that the association between sex ratio and sibship size is not due to economic or psychological causes (James, 1975c).

However, a critic might reasonably remain unimpressed with these data. The hypothesis stood little chance of being damaged by them; if it had turned out that sex ratio correlates negatively (instead of positively) with sibship size, it would not have taxed a seasoned advocate of the hypothesis to suggest that the putative sibship-size effect had been swamped by the parity effect!

The Sexes of Sibs of Dizygotic Twins

The sex ratio of sibs of DZ twins is reportedly high (Schutzenberger, 1950). In previous reviews (James, 1975c, 1976b), I construed this as evidence for the hypothesis because of the evidence (James, 1972c) that mothers of DZ twins have higher coital rates than other women, on the average. Some qualification must now attach to this judgment because mothers of DZ twins would also be expected to have high levels of gonadotrophin, and for that reason to have offspring with a *low* sex ratio. Once again, because the hypothesis does not generate an unequivocal prediction, one cannot say whether the data support it or not.

To summarize these data on coital rate and sex ratio: The hypothesized relationship between these two has been considered as an explanation of the variation of sex ratio with (a) wartime, (b) duration of marriage, (c) parental age, (d) parity, (e) sibship size, and (f) the presence of DZ twins. The evidence seems decisive on only one of these variables, wartime. The widening of the hypothesis to specify gonadotrophin as a direct cause has had the consequence that the hypothesis now fails to yield an unambiguous prediction in regard to most of the other variables. This being so, they cannot form the basis for a defense of, *nor for an attack on,* the hypothesis. Any such attack must deploy an alternative explanation of the rise in sex ratio during and after wars.

The Distributions of the Combinations of the Sexes

If it were correct that the sex of a zygote is dependent on the timing of fertilization, then it would follow that the sexes of zygotes within a polyzygotic litter are not independent. And if this were true, then the distributions of the combinations of the sexes in DZ twins and in mammalian litters would not, in general, be binomial. If the hypothesis under review were true, then (see Appendix) either super- or subnormal dispersion might be expected, according to the relative durations of the interval between the fertilizations of the ova and of the total fertile period.

Human Dizygotic Twins

In a previous review (James, 1977c), I concluded that there is a significant deficit of opposite-sexed pairs as contrasted with binomial expectation. Since then other evidence has come to my attention. Both published data (Nylander and Corney, 1976) and unpublished data tend to strengthen the conclusion. When all these data are pooled, the discrepancy between the numbers of same-sexed and of opposite-sexed DZ twin pairs is significant at the .01 level even taking into account the facts that the sex ratio is not exactly one and that there is a suggestion of Lexis variation (Edwards, 1960) among women in the probability of producing a male zygote (Edwards, 1958; James, 1975b). So, whatever the explanation, it *does* seem that among human DZ twin pairs there is an excess of same-sexed pairs.

Other Mammalian Litters

I have noted that in two species (the pig and the sheep) there is good evidence, and in two others (the mouse and the rabbit) there is fair evidence that the distributions of the combinations of the sexes are subnormal (James, 1975a, 1976a). In other words, within litters the sexes are more equally balanced than binomial expectation (there are too many litters with exactly equal numbers of males and females, and too few unisexual litters). I noted that if the hypothesis under review were correct, it would explain this phenomenon. Moreover, if the hypothesis were not correct, it would not be easy to think of an alternative explanation.

The explanation offered earlier is based on a standard result in probability theory, namely that Poisson variation (not to be confused with Poisson distributions) leads (except as described in the Appendix) to subnormal dispersion (Edwards, 1960). The hypothesized Poisson variation is that of p_{male}, the probability of a male zygote, which is posited to vary systematically among zygotes within litters. The suggestion that p_{male} varies with time is supported by all the direct data discussed earlier.

The Durations of Gestations of Members of Opposite-Sexed Twin Pairs

The direct data of Guerrero (1974) and Harlap (1979) suggest that the variation of sex ratio with cycle day of natural insemination is U-shaped. However, for some purposes it seems that the right arm of the U may be ignored because it

represents relatively so few cases. In other words, it seems that male fertilizations occur earlier, on the average, than female ones. If this were so, then presumably among opposite-sexed twin pairs the male would have a slightly longer gestation than the female. I have shown (James, 1980a) that this expectation is fulfilled at a significant ($p \simeq .035$) level, using the scoring system devised by Dubowitz, Dubowitz, and Goldberg (1970). However, it is not known whether the scoring system assigns a higher score to the heavier baby of two with equal gestations (boys on the average being heavier than their female co-twins). But if the test turns out to be unflawed, these results give direct support to the hypothesis.

Suggested Explanations

The apparently U-shaped regression of sex ratio on cycle day of natural insemination would be a good deal more plausible if some explanation could be found for it.

The pH Hypothesis

There has been a substantial literature on pH values in the female reproductive tract but I have never seen any convincing evidence that they affect sex ratio.

A Physical Hypothesis

It has frequently been conjectured that the slight physical difference between X and Y sperms might form a basis for separating them, and much experimental work has been devoted to this end. In the past, claims for success in this field have usually been followed by failures to replicate; the topic was summarized in a generally skeptical paper by Lord Rothschild (1962). More recently Roberts (1972) has offered a mathematical formulation for the gravitational separation of X and Y spermatozoa, and suggested (Roberts, 1978) that this may be the basis for much of the observed variation in the human secondary sex ratio. There seems little doubt that human X and Y sperms will (to some extent) separate under the conditions required by Roberts's hypothesis (Goodall and Roberts, 1976). It is less clear whether these conditions are met within the human female reproductive tract. The hypothesis requires that in the middle of the fertile period the tract would be subject to peristaltic or other activity (due to orgasm or other causes), and that it would be quiescent at either end of the fertile period. During

these quiescent times, sperms would separate out because of gravitation and thus males would be selected; when the tract was active, according to the hypothesis this activity would preclude such separation. As far as I know, no *in vivo* experiments have been carried out on the effect of tract activity on the separation of X and Y sperms. However, there certainly are grounds for supposing that Roberts's hypothesis is not the sole explanation of all the variation in the secondary sex ratio—his hypothesis would be unable to account for any excess of female conceptions. (This is so because though Y sperms may tend to separate out of a large pool of sperms, there is no comparable excess of X sperms among those remaining.) And it seems likely that there are circumstances in which female conceptions predominate, as are now described.

Maternal Gonadotrophin Levels

Let us suppose for the moment that the sex of a zygote *is* affected by the time of insemination in the U-shaped way suggested by Guerrero (1974) and Harlap (1979). What could cause this? One obvious possibility is the mother's hormone levels, which rise and fall very rapidly across the fertile period. If these hormone levels were to affect the sex of the zygote, then one might expect an excess of girls among the infants born following induction of ovulation by clomiphene or gonadotrophin (because the hormone surge seems to accompany an increased probability of female conceptions in normal cycles).

I have noted (James, 1980b) that the proportion male of live-birth conceptions preceded by induction of ovulation either by clomiphene or gonadotrophin is about .44. The difference between this and the expected proportion (.514) is very highly significant.

These data therefore give good support to the notion that maternal hormone levels directly affect the sex of the zygote. Moreover, this elaboration of the hypothesis seems especially attractive because it offers explanations of two hitherto puzzling phenomena—the variation of sex ratio with race and with season. These points will now be elucidated.

The probability of DZ twinning is thought to be a function of maternal gonadotrophin levels (Bulmer, 1970). This suggestion is strongly supported by the high incidence of DZ twinning among maternities following induced ovulation. Thus, if the present hypothesis were correct, DZ twinning rates and sex ratios might be expected to vary inversely across populations. Now it is well established that Negroes have high DZ twinning rates and Orientals low DZ twinning rates (Bulmer, 1970). Accordingly the low Negro sex ratio (Teitelbaum and Mantel, 1971; Erickson, 1976) and the high reported Oriental sex ratios (Bulmer, 1970, p. 58; Visaria, 1967) may be ascribed to respectively high and low gonadotrophin levels.

This hypothesized inverse relationship between DZ twinning and sex ratio

would also explain seasonal phenomena. In England and Wales there is a highly significant seasonal variation in twinning rates with a winter peak (James, 1976d), and the data indicate that in particular DZ twinning rates show this variation (James, 1980c). Thus the reported low winter sex ratios for the United States (Lyster, 1971) and elsewhere in the northern hemisphere (Colombo, 1957) may be explained by seasonal variation in gonadotrophin levels.

Finally it is worth trying to offer an explanation of *how* gonadotrophin might have the effect suggested. It seems that it is not via sex-selective abortion. The grounds for this claim are twofold: In regard to *recognized* spontaneous abortion the argument has already been given (see the section on sex ratio and spontaneous abortion), and in regard to *unrecognized* spontaneous abortion the following argument seems strong. If early unobserved spontaneous abortion were the result of high gonadotrophin levels, then women with DZ twins should have lower fecundability than other women (taking additional time to get recognizably pregnant because of unrecognized spontaneous abortions). In fact, though, they seem more fecundable; it takes less time to conceive DZ twins than singletons, on the average (Bulmer, 1959; Pollard, 1969).

DISCUSSION

Though it seems that the hypothesis satisfactorily accounts for most of the variation of the secondary sex ratio, there remain a number of questions yet unanswered. They are summarized here in an attempt to indicate where research might usefully be directed.

The regression of sex ratio on cycle day of natural insemination is U-shaped, yet the regression of sex ratio on cycle day of artificial insemination is ∩-shaped (Guerrero, 1974). Why is this? Does the process of artificial insemination somehow interfere with female hormone levels?

Until recently I had supposed that the regression of sex ratio on cycle day of natural insemination declined monotonically across the fertile period. I had chosen to ignore the (seemingly weak) evidence for a U-shaped regression in Guerrero's (1974) data. On the basis of this supposition, I offered the hypothesis that monozygotic (MZ) twins, anencephaly (a congenital malformation of the central nervous system), and female zygotes coexist more frequently than chance expectation because all three are somehow dependent on some form of reproductive delay (James, 1975d). Such delay, after all, was the subject of a well-established hypothesis in regard to MZ twins (Bulmer, 1970); it had been repeatedly suggested in regard to malformations of all sorts (e.g., Witschi, 1970), so it seemed plausible in regard to female zygotes too. Nevertheless Harlap's (1979) data and the gonadotrophin hypothesis sharply call the suggestion into question:

Late fertilizations seem now to be predominantly male, not female. The embarrassing thing is that, on the basis of this rickety hypothesis, I made some apparently correct predictions:

1. The sex ratio of MZ twins *does* seem to be low. Indirect data suggesting this (James, 1975d) have since been confirmed by direct data on monoamniotic twins (James, 1977c) and on acardiac monsters (James, 1977b), yet it is no longer clear why MZ twins should have a low sex ratio.
2. The continuum of placentation in MZ twin pairs (running from dichorionic to monochorionic diamniotic to monochorionic monoamniotic to conjoined pairs) is usually supposed to index some form of developmental delay (Bulmer, 1970). Accordingly I suggested (James, 1977c) that this continuum would be accompanied by a continuum of sex ratio. It was already known that conjoined pairs have a very low sex ratio, but my prediction turned out to be correct in regard to direct data on the sex of monoamniotic pairs (James, 1977c) and of monochorionic versus dichorionic pairs (James, 1980d). So the questions still remain
   a. Why do MZ twins have a low sex ratio?
   b. Why is there a continuum of sex ratio across the MZ pairs as indexed by the various placental forms?
   c. Why are anencephalics predominantly female?

Readers may find this last question an obtrusive irrelevance at this stage of the discussion. But perhaps it is not. Many human congenital malformations have characteristically biased sex ratios. Arena and Smith (1978) noted that of 52 single localized defects of human morphogenesis, 42 showed a nonrandom predilection to attack one sex or the other. Some such sex ratios may be explained on the basis of normal anatomic or hormonal differences between the sexes; in others, some genetic explanation may be available; in others, there may be differential fetal wastage by sex. But in others it is tempting to wonder whether developmental timing is responsible. If it can be established that timing is associated with the sex of normal individuals, then additional plausibility is conferred on the suspicion that some congenital malformations are the consequence of anomalous developmental timing. The present thrust of research may lead not only to the power to manipulate sex ratios, but to the understanding of some forms of congenital malformation.

SUMMARY

In this chapter an attempt has been made to assess the evidence for the hypothesis that timing of fertilization influences the sex of the zygote. It seems

that much of the evidence previously adduced in its favor is no longer to be interpreted in this light. Equivocal predictions in regard to some variables may be derived from the newly elaborated form of the hypothesis (involving gonadotrophin levels). In the absence of unambiguous expectation (based on the hypothesis) we cannot assess the support given by these data to it. However, in regard to other variables, the hypothesis seems to give satisfactory explanations. Anyone who seriously doubts that there is *anything* in it might try to provide alternative accounts of the direct data (Guerrero, 1974; Harlap, 1979); of the variation in sex ratio with wars (James, 1971), season, and race (see the section on maternal gonadotrophin levels); and of the distributions of the combinations of the sexes in human DZ twin pairs (James, 1976c) and in other mammalian litters (James, 1975a, 1976a). It seems very possible that the hypothesis will form the basis for (a) the manipulation of the sex ratio both in human beings and in other species, and (b) the understanding of some forms of congenital malformation.

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APPENDIX

Here it is demonstrated how a modified form of Poisson variation could explain both the *supernormal* dispersion of the distribution of the combinations of the sexes in human DZ pairs, and the *subnormal* dispersion of the distributions of the combinations of the sexes within litters of some mammalian species.

The Model

Let us consider a model for polyzygotic fertilization. It seems that fertilization is not at all likely unless insemination occurs during a relatively short time interval—say about 48 hours—within the human intermenstruum (James, 1973, 1978; Potter, 1961).

If p_{male}, the probability that a zygote will be male, takes the values p_1 and p_2 in the two zygotes of a pair of DZ twins, then P, the probability that the twins are of the same sex, is given by

$$P = p_1p_2 + (1 - p_1)(1 - p_2)$$
$$= 2(p_1 - \tfrac{1}{2})(p_2 - \tfrac{1}{2}) + \tfrac{1}{2}.$$

Whence

if p_1 or $p_2 = \tfrac{1}{2}$, then $P = \tfrac{1}{2}$;
if p_1 and p_2 both exceed $\tfrac{1}{2}$, $P > \tfrac{1}{2}$;
if p_1 and p_2 are both less than $\tfrac{1}{2}$, $P > \tfrac{1}{2}$; and
if p_1 and p_2 lie on opposite sides of the value $\tfrac{1}{2}$, $P < \tfrac{1}{2}$.

If it is hypothesized that p_{male} declines monotonically during the fertile period, then P declines as the time interval between the two fertilizations increases. More generally, if p_{male} declines monotonically during the fertile period, then the variance of the distribution of the combinations of the sexes in polyzygotic litters declines as the variance of the timing of the fertilizations increases.

Now if p_{male} is U-shaped across the fertile period (instead of declining), clearly P takes a high value (½ or more) if the interval between the two fertilizations is zero. P also takes a high value if this interval is large, so the two fertilizations occur at either end of the fertile period. However, for practical purposes this latter situation can be ignored because, to judge by the data of both Guerrero (1974) and Harlap (1979), so few fertilizations occur in the right arm of the U.

Accordingly, let us consider the variance of the distributions of the combinations of the sexes in polyzygotic fertilizations on the assumption that p_{male} decreases monotonically across the fertile period. Bearing in mind that there may be some slight Lexis variation between dams in p_{male} (Edwards, 1958; James, 1975b), it seems that two possibilities could arise according to the variance of the timings of the fertilizations:

1. If this variance is small compared to the length of the fertile period, then there will simply be an addition to the supernormal dispersion contributed by the Lexis variation.
2. If this variance is considerable, then it may overwhelm the effect of the Lexis variation and cause the dispersion to be subnormal.

Let us now consider the two cases of human DZ twin fertilizations and of polyzygotic fertilizations in other mammalian litters.

1. Human DZ twin fertilizations. The time interval between the two fertilizations in DZ twins is partially dependent on the timing of the arrival of the ova. These are thought to arrive closely in time (Dahlberg, 1926), but presumably

they do not arrive simultaneously because if they did, it would be difficult to account for the evidence (admittedly indirect) that human DZ twinning probabilities are positively related to parental coital rate (James, 1972a). It was noted earlier that there is an excess of same-sexed DZ twin pairs, even bearing in mind the possibility of Lexis variation in p_{male} from woman to woman and the fact that the sex ratio in DZ twins is not exactly one. Accordingly, it seems reasonable to hypothesize (whether or not the Lexis variation actually exists) that there is, in human DZ twinning, a modified form of Poisson variation. It is being suggested here that

a. The probability of a male zygote declines with time across (most of) the fertile period, and
b. The zygotes within one pair of DZ twins do not have the same probability of being male (because they are not formed simultaneously), and
c. Same-sexed human DZ twin pairs outnumber opposite-sexed pairs because the mean time interval between the fertilizations of the two zygotes is small compared with the length of the fertile period.

2. Polyzygotic fertilizations in other mammalian litters. In the case of some polytocous animals, it seems that the fertilizations occur over a considerable time interval. For instance, the mean time interval between the fertilizations of the first ovum and the last in litters of mice, rats, and rabbits have been estimated at 3¾, 3½, and 3 hours respectively (Austin and Braden, 1954; Braden and Austin, 1954). The point about these observations is that they are at least consistent with the hypothesis. Had the ova been fertilized more or less simultaneously, then the idea that p_{male} changes substantially from one member of a litter to another would have seemed less plausible. For the hypothesis to account for the subnormal dispersions of the distributions of the combinations of the sexes in litters of some species, one would further have to hypothesize that in these species (in contrast to human beings), the time interval over which p_{male} progressively changes does not greatly exceed the time from the first to the last fertilization in one litter.

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5

Decision Making and Sex Selection with Biased Technologies

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INTRODUCTION

Research into methods of selecting the sex of a child has yet to result in any methods that are both practical and effective. As various methods become available, there is little reason to believe that they will be equally effective in selecting sons as in selecting daughters. For example, a sperm-separation method (Population Reference Bureau, 1976; Dmowski, Gaynor, Rao, Lawrence, and Scommegna, 1979), which has received a good deal of press, seems to raise the probability of bearing a son (perhaps up to .90) without affording similar improvements in success for those interested in bearing a daughter. Couples might still only be able to resort to the standard method of obtaining a girl (with approximately .485 probability of success). Hence, we could have a situation in which the respective maximum probabilities of conceiving a boy or a girl differ substantially.

With the exception of reports by McDonald (1973), Smith (1974), and Mason

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and Bennett (1977), the literature has generally assumed that future sex-selection technology will be unbiased, that is, that equally effective techniques will be available for selecting sons or daughters. In many instances it is furthermore assumed that the available techniques will be determinate; parents would be able to choose the sex of their child with complete certainty. The achievement of practical perfect techniques may occur at some time in the distant future. The techniques currently under examination, however, do not conform to this ideal.

A few terms should be explicitly defined. A *sex-selection technique* is a method that determines the probability that a subsequent child will be a son (or a daughter). The *natural technique* is that of doing nothing consciously to change the probability of bearing a son (.515) or a daughter (.485). A *son-producing technique* is one for which the probability of bearing a son is greater than .515. A *daughter-producing technique* is one for which the probability of bearing a daughter is greater than .485. The *sex-selection technology* is the set of all practical sex-selection techniques. The sex-selection technology is said to be *biased* if, out of all such available sex-selection techniques, the maximum probability of bearing a son is not equal to the maximum probability of bearing a daughter.

THE DECISION-MAKING MODEL

We employ a decision-making model to describe the use of sex-selection techniques by couples who wish to have a specific number of sons and daughters over their entire childbearing period. Alternatively, we can view the model as one relevant to a cross section of women who are making a decision, each woman at her own particular stage in childbearing (i.e., parity). Couples have available to them a given sex-selection technology consisting of a set of techniques that can be used to raise (or lower) the probability of conceiving a boy or girl. Prior to the conception of each child, the couple must choose a technique of sex selection (including the natural technique of doing nothing). We present here only a brief recapitulation of the characteristics of the model because they are discussed in detail elsewhere (Mason and Bennett, 1977).

Various assumptions are made for purposes of simplifying our decision-making model. First, it is assumed that the economic and psychic costs of the sex-selection techniques are negligible. Second, we have precluded the possibility that couples will have additional children in response to sex-selection failure. This implies that, in our model, family-size goals dominate family-composition goals. Third, it is assumed that couples are indifferent to the order in which they bear their sons and daughters. Fourth, it is assumed that couples are "rational,"

in the sense that they use the available techniques over the childbearing years that maximize the probability of bearing the desired number of sons and daughters.

The optimal sex-selection technique to be used for a given birth depends upon the desired size and composition of the completed family and the outcomes of those children already born. If a woman has given birth to S^* sons and D^* daughters and the couple desires S sons and D daughters at the completion of their childbearing, then the couple will maximize the probability of bearing $s = S-S^*$ additional sons and $d = D-D^*$ additional daughters. If the couple overshoots their mark by achieving a greater number of sons (daughters) than desired, it will maximize the probability that all remaining births will be daughters (sons).

More formally stated, we have

$$\begin{aligned} c &= C - C^* \\ s &= \begin{cases} S - S^* & \text{if } 0 \le S - S^* \le c \\ 0 & \text{if } S - S^* \le 0 \\ c & \text{if } S - S^* \ge c \end{cases} \\ d &\equiv c - s, \end{aligned}$$

where C is the total number of desired children, C^* is the number of children already born, and c is the number of desired additional children.

The sex-selection technology may be represented as a vector of probabilities of producing a son (or a daughter) on the subsequent birth. For the current birth, the couple chooses the sex-selection technique i, with an association probability of bearing a son $P^i\{S\}$, which will maximize the probability of bearing exactly s additional sons out of c additional children, $P^i_{c,s}$. The probability of acquiring the desired number of additional sons using technique i for the current pregnancy and using the optimal technique for each of the subsequent births is mathematically represented as

$$P^i_{c,s} = P^i\{S\}\, P_{c-1,s-1} + (1-P^i\{S\})P_{c-1,s}\,, \tag{1}$$

where $P_{c,s}$ is the maximum probability of obtaining s additional sons and $c - s$ additional daughters.

The first term on the right-hand side of Equation (1) represents the probability of bearing a son currently and $s - 1$ sons subsequently (using the optimal techniques throughout the childbearing period). The second term gives the probability of obtaining a daughter on the current birth and s sons subsequently (again assuming optimal strategy). These two routes are the only means by which a couple can achieve s sons out of c additional children.

We now can see how a couple can select the optimum technique to use for the current birth. The couple chooses the method that maximizes the probability of moving along the more desirable of the two paths just described. We obtain a

mathematical representation of this as we take the maximum of both sides of Equation (1) and manipulate the terms:

$$P_{c,s} = \underset{i}{\text{Max}}[P_{c-1,s} + P^i\{S\}(P_{c-1,s-1} - P_{c-1,s})] \; . \qquad (2)$$

Hence, if $P_{c-1,s-1} - P_{c-1,s}$ is positive, it would be optimal strategy to maximize $P^i\{S\}$, that is, to try for a boy by using the maximum son-producing technique. If the value is negative, the couple would want to minimize $P^i\{S\}$ by using the maximum daughter-producing technique. If the value is zero, the couple is indifferent to the choice of technique.

Equation (2) simplifies our problem. We see that the only two techniques of concern to the couple are the one that maximizes the probability of bearing a son and the one that maximizes the probability of bearing a daughter. Two parameters can now fully represent the state of the sex-selection technology: The maximum probability of bearing a son, which we shall call $P_s\{S\}$ (the subscript denotes the sex for which the couple is selecting and the argument denotes the sex of the child actually borne using the given technique), and the maximum probability of bearing a daughter, which we shall call $P_d\{D\}$. A sex-selection technology can be defined as biased if $P_s\{S\} \neq P_d\{D\}$.

Table 1 presents a graphic solution to the optimal control problem of the use of sex-selection techniques. The value within each cell, $P_{c,s}$, assumes that $P_s\{S\} = .900$ and $P_d\{D\} = .485$. The structure of the table allows the couple to choose the optimal technique at any point during the childbearing period. For each birth, the couple chooses the technique that maximizes the probability of advancing to the cell (out of the two possible) with the higher probability of success. For example, if a couple desired three sons among four additional children, it will have a probability of .729 of achieving its goal if the current birth is to a girl, whereas the probability of success would be .746 if the current birth is to a boy. The couple would choose to maximize the probability of obtaining a son and use technique i with $P^i\{S\} = .900$. Using this strategy, the couple has a probability of (.900) (.746) + (.100) (.729) = .745 of achieving the compositional goal.

We can see the way in which such a table is constructed. In order to derive all the values, we begin at the final birth (the first row). Couples desiring a daughter will use the daughter-producing technique and $P_{1,0} = P_d\{D\}$. Couples who want a son will use the son-producing technique and $P_{1,1} = P_s\{S\}$. With these values and Equation (2), we can derive the entire table. For the first column, where $s = 0$, we take $P_{c-1,s-1}$ to equal zero. Using these values in Equation (2), we have in these special cases $P_{c,0} = (P_d\{D\})^c$ and $P_{c,c} = (P_s\{S\})^c$.

It is our object now to find the general solution to the equation of the line separating the decision spaces (to use the son- or daughter-producing technique). In other words, we would like to identify the point at which a couple opts for the son-producing technique, in terms of the proportion desired sons of desired additional children. To this end, we algebraically reduce the optimal control matrix to a single value, specifically, the proportion of sons cutoff (PSC). If a

TABLE 1

Maximum Probabilities of Acquiring s Additional Sons out of c Additional Births

Desired additional children	*Desired additional sons*										
	0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	.485	.900[a]									
2	.235	.686	.810[a]								
3	.114	.454	.746	.729[a]							
4	.055	.279	.596	.745[a]	.656[a]						
5	.027	.164	.433	.668	.736[a]	.590[a]					
6	.013	.093	.294	.547	.701	.721[a]	.531[a]				
7	.006	.052	.191	.417	.621	.711	.702[a]	.478[a]			
8	.003	.028	.119	.300	.516	.665	.710[a]	.680[a]	.430[a]		
9	.001	.015	.072	.207	.405	.588	.687	.707[a]	.655[a]	.387[a]	
10	.001	.008	.043	.138	.303	.494	.636	.696	.702[a]	.628[a]	.349[a]

[a]For these cells, the technique associated with $P_s\{S\} = .900$ is used. For all other cells, the technique associated with $P_d\{D\} = .485$ is used.

couple would like more than that proportion of their desired additional children to be sons, it uses the son-producing technique. If a couple desires fewer, it uses the daughter-producing technique.

Returning to the situation in which a couple desires three sons out of four additional children, suppose that out of three additional births the probability of acquiring two sons and one daughter were equal to the probability of acquiring three sons (i.e., suppose $P_{3,2} = P_{3,3}$). We may then say that the couple is indifferent to the sex of the current birth because the couple would have an equiprobable chance of achieving its family-composition goal (three sons, one daughter) by acquiring either a son or a daughter on the current birth. The PSC is intimately related to the point of indifference. Indeed, as we shall see later, in continuous space the points of indifference would comprise a line whose slope is the reciprocal of PSC. PSC in our hypothetical case is precisely ¾ or .75. If the couple desired more than 75 percent of its additional children to be sons, it uses the son-producing technique. If the couple desires fewer than 75 percent of its additional children to be sons, then it uses the daughter-producing technique.

This hypothetical analysis was carried out in the $s = 3$ column. Suppose we switch to the $s = 1$ column for the sake of mathematical tractability, to the end of finding a general equation for the PSC function. In the same way that we hypothetically had $P_{3,2} = P_{3,3}$ for the case of $s = 3$, we posit that there exists a c' such that $P_{c',0} = P_{c',1}$ (in the actual model). We hope to find the slope of the PSC function by noting that it is a straight line passing through the origin, and then determining where the line intersects the $s = 1$ column.

Let us find the general formulas for $P_{c,0}$ and $P_{c,1}$. We have

$$\begin{aligned} P_{1,0} &= P_d\{D\} \\ P_{2,0} &= (P_d\{D\})^2 \\ P_{3,0} &= (P_d\{D\})^3 \\ &\vdots \\ P_{c,0} &= (P_d\{D\})^c \ . \end{aligned}$$

For $s = 1$, the following equations hold true only for the zone in which the son-producing technique is used initially and until a son is produced, after which the couple switches to the daughter-producing technique. We have

$$\begin{aligned} P_{1,1} &= P_s\{S\} \\ P_{2,1} &= P_s\{S\}[P_s\{D\} + P_d\{D\}] \\ P_{3,1} &= P_s\{S\}[(P_s\{D\})^2 + P_s\{D\}P_d\{D\} + (P_d\{D\})^2] \\ &\vdots \\ P_{c,1} &= P_s\{S\} \sum_{x=0}^{c-1} (P_s\{D\})^x (P_d\{D\})^{c-1-x}. \end{aligned}$$

If there exists a c' such that $P_{c',0} = P_{c',1}$, it is at cell $(c' + 1,1)$ that the couple is indifferent as to which sex-selection technique it uses. PSC is in turn defined as the reciprocal of the quantity $(c' + 1)$ (i.e., the number of desired additional sons, 1, divided by the number of desired additional children, $c' + 1$). To solve for the cutoff proportion, we first set out to solve for c'. Setting $P_{c',0}$ equal to $P_{c',1}$, we obtain

$$(P_d\{D\})^{c'} = P_s\{S\} \sum_{x=0}^{c'-1} (P_s\{D\})^x (P_d\{D\})^{c'-1-x}. \tag{3}$$

To simplify notation, let us define $\alpha = P_d\{D\}$ and $\beta = P_s\{S\}$. This implies that $1 - \beta$ is equal to $P_s\{D\}$, the probability of acquiring a daughter using the son-producing technique. Equation (3) is now in the form

$$\alpha^{c'} = \beta \sum_{x=0}^{c'-1} (1 - \beta)^x \alpha^{c'-1-x}.$$

To continue with the derivation, we have

$$\alpha^{c'} = \beta\alpha^{c'-1} \sum_{x=0}^{c'-1} (1 - \beta)^x \alpha^{-x},$$

which reduces to

$$\alpha/\beta = \sum_{x=0}^{c'-1} [(1 - \beta)/\alpha]^x. \tag{4}$$

Recognizing that the right side of Equation (4) is the finite sum of a geometric progression, we have

$$\sum_{x=0}^{c'-1} [(1 - \beta)/\alpha]^x = \frac{[(1 - \beta)/\alpha]^{c'} - 1}{[(1 - \beta)/\alpha] - 1}.$$

Substituting into Equation (4), we obtain

$$(1 - \alpha)/\beta = [(1 - \beta)/\alpha]^{c'}.$$

Solving for c' and implementing the previously mentioned relationship between c' and PSC, we then derive

$$\text{PSC} = \frac{\log[\alpha/(1 - \beta)]}{\log[\alpha/(1 - \beta)] + \log[\beta/(1 - \alpha)]}. \tag{5}$$

Indeed, when we generate the probabilities in Table 1 for extreme values of c and s, it is clear that the actual cutoff converges to precisely the value given by Equation (5).

For the parameters associated with Table 1 ($\alpha = 0.485$ and $\beta = 0.900$), the cutoff value is .739. The couple decides the desired proportion sons among their

desired number of additional children and compares this figure with the cutoff proportion of .739. So, for example, if the couple wants four more children and of those wants three to be sons, then it uses the maximum son-producing technique. If the couple would like four additional children but wants only two of these to be sons, it instead would use the maximum daughter-producing technique.

It is interesting to note the behavior of the PSC function at various critical values of α and β, where, by definition, $\beta > 1 - \alpha$ and $\alpha > 1 - \beta$. Expressing Equation (5) in an alternative form, we have

$$\text{PSC} = \left\{ 1 + \frac{\log[\beta/(1-\alpha)]}{\log[\alpha/(1-\beta)]} \right\}^{-1}$$

If α equals one, couples can obtain daughters with complete certainty. Consequently, the optimal strategy is to use the son-producing technique until all sons are born, and then to employ the daughter-producing technique to obtain the additionally desired daughters with complete certainty. Although Equation (5) is undefined at α equal to one, PSC approaches zero as α approaches one. On the other hand, Equation (5) has a limit of one as β approaches one. Thus, if β equals one, couples should employ the son-producing technique only when sons are desired for all additional births. When both α and β equal one, the model obviously loses its stochastic nature and the question of cutoffs is nonsensical. If α equals β (i.e., in the case of an unbiased sex-selection technology), the two components of the denominator are equal and PSC equals one-half. This result is intuitively logical, because if our maximum son- and daughter-producing techniques are of equal efficacy, the couple merely uses the techniques associated with whichever sex is that of the majority of the desired additional children. We should note that when α and β sum to one (in the case where no sex-selection techniques are available) the PSC function assumes an indeterminate value. This is expected as the basis for the model is reduced to a binomial expansion. The probability of acquiring a child of one sex is just the residual of that of acquiring a child of the other sex (i.e., one is the complement of the other). There is, in effect, no decision to make.

In Figure 1 we graph the line separating the decision spaces on the Cartesian plane analog of the matrix given in Table 1. Lines X and Z are for reference purposes, where line X is that for the equation $c = 2s$ and line Z is that for $c = s$. The equation for line Y is, in general, $c = \kappa s$, where the slope, κ, is the reciprocal of PSC. For $\alpha = 0.485$ and $\beta = 0.900$, we have $c = 1.354s$.

If a couple is at a point in its childbearing period where it is above the decision line, then it will always use the son-producing technique on the current birth and the following holds true: if the couple is more than 1 − PSC sons away from the cutoff line, it will use the son-producing technique on the subsequent birth as well, independent of the outcome of the current birth. If the couple is fewer than 1 − PSC sons away from the line, it will use the daughter-producing technique if

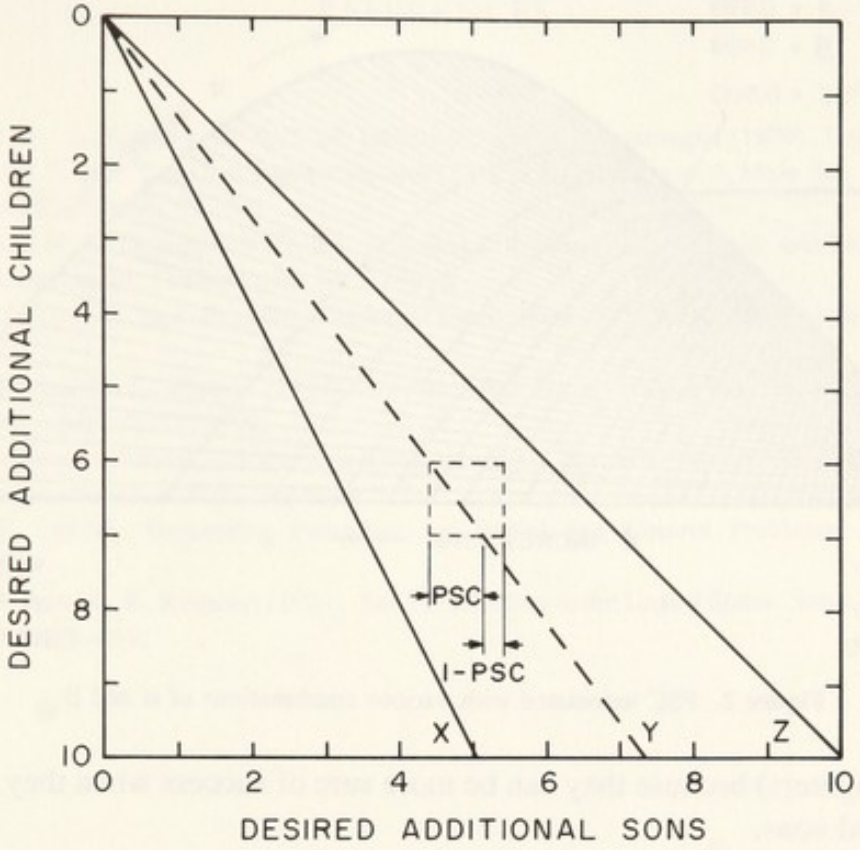

Figure 1. Graph of the line separating the decision spaces (to use the son- or daughter-producing technique), line Y, for $\alpha = 0.485$ and $\beta = 0.900$. Note: Lines X and Z are for reference purposes, where the equation for line X is $c = 2s$; for line Z, $c = s$; and for line Y, $c = \kappa s = s/\text{PSC} = 1.354s$.

the current birth is to a son. The couple is indifferent as to choice of method on the subsequent birth if it is currently exactly 1 − PSC sons away from the line and a son is produced.

If a couple is at a point in its childbearing period where it is below the decision line, then it will use the daughter-producing technique on the current birth and the following holds true: if the couple is more than PSC sons away from the cutoff line, it will use the daughter-producing technique on the subsequent birth as well, independent of the outcome of the current birth. If the couple is fewer than PSC sons away from the line, it will use the son-producing technique if the current birth is to a daughter. The couple is indifferent as to choice of method on the subsequent birth if they are currently exactly PSC sons away from the line and a daughter is produced. Under no circumstances will a couple switch to the alternate technique unless the preceding birth produced a child of the desired sex.

In Figure 2 we show the PSC associated with various combinations of α and β. The general conclusion that may be drawn is that, in a son-biased technology, as α and β diverge from the state of equal efficacies the PSC increases. For example, when α and β both equal 0.510, PSC = 0.500. However, with the same α and $\beta = 0.999$, PSC = 0.897. When β is increased, the couple can delay its attempts to acquire sons (and therefore spend more time trying to obtain their

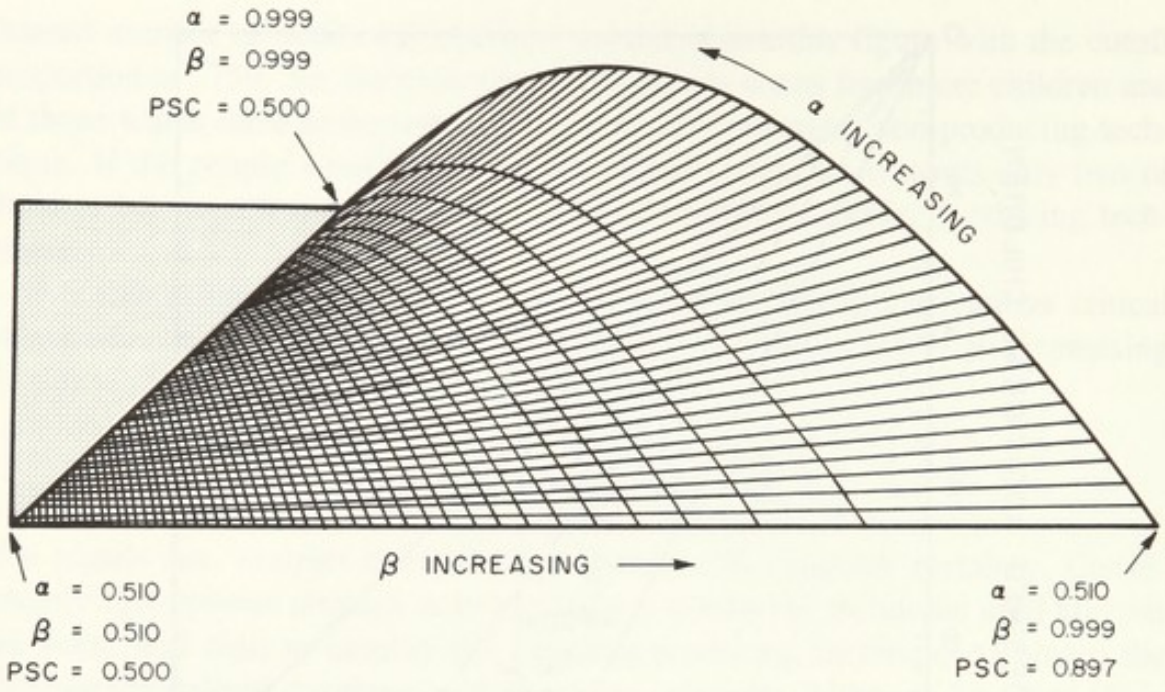

Figure 2. PSC associated with various combinations of α and β.

desired daughters) because they can be more sure of success when they do try for their desired sons.

DISCUSSION

Violation of the assumptions noted at the outset would bias certain macrolevel results derived from the model. For example, use of the model provides only a minimum estimate of the increased sex ratio due to the availability of a son-biased technology when we realize order preferences would in fact play a part in the family planning of some couples (Westoff and Rindfuss, 1974; Mason and Bennett, 1977; Pebley and Westoff, 1982). Further attempts at modeling sex selection may focus on incorporating varying costs and probabilities of success associated with the hypothesized array of techniques. Although the specific results obtained here apply only to an idealized state, the present model provides us with insight into the mechanisms behind optimal use of sex-selection techniques.

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6

The Economics of Sex Preference and Sex Selection

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INTRODUCTION

Researchers in many social science disciplines have shown considerable interest in parental sex preferences. Such interest has, at least in part, been fueled by both actual and expected technical advances in prenatal sex detection and sex selection and by the observation that sex-selection technology has potentially important implications for the aggregate sex ratio and the birth rate. Included in this group of researchers are several economists whose attention has focused primarily on the existence of pure sex preference, the costs and benefits to parents of children of different sex, and the determinants and consequences of the use of sex-selection techniques. The purpose of this chapter is to discuss the economics of sex preference and sex selection. The following section reviews the economists' approach to this subject. The next section presents and discusses a model of the decision to have another child, dealing explicitly with parental sex preferences and risk preferences and with the availability of sex-selection techniques. The implications of the insights gained from the model for future research on sex preference and sex selection are summarized in the final section.

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REVIEW OF THE ECONOMIC APPROACH

The application of economic theory and methods to the study of human fertility has generated a good deal of controversy among social scientists. On the one hand, critics of this development claim that the fundamental determinants of fertility are biological and sociological in nature and that fertility is not a choice variable in the usual economic sense. On the other hand, proponents of economic analysis argue that observed fertility depends, at least in part, on parental preferences for children and on the price of children. In some respects, the strength of the evidence that economists have presented to support their approach to the study of fertility is disappointing. However, enough confirming evidence has been presented to justify continued interest in this area.[1]

Briefly, the economic approach to the study of fertility focuses on the benefits and costs of having children. Included in the benefits are the contributions of children to present and future family income, to the (nonmarket) household work force, and to parental happiness. Offsetting these benefits is a long list of real and psychic costs of raising children, such as the costs of food, clothing, shelter, time, and various foregone opportunities. Given this array of present and expected future benefits and costs as well as the benefits of alternative uses of parental resources, parents are faced with a classic economic problem: they may devote more (scarce) resources to producing and raising children or they may devote more resources to other benefit-yielding activities. To generate a determinate solution to this problem, economists assume that parents are rational in the sense that they choose levels of all possible activities that maximize their net benefits. When formulated mathematically, the assumption of rationality imposes enough structure on this problem to generate demand functions for children and other economic goods. The arguments of these functions are the exogenous factors that condition the decision-making process, such as taste and preference parameters, relative prices of children and other goods, parental wages, value of time, nonlabor income, and technological factors governing the production and rearing of children.

Among the interesting characteristics of the literature on the demand for children is the explicit attention given to the heterogeneity of children.[2] In some analyses, this characteristic is captured by including child quality as a separate choice variable in a household-utility function. Technical relationships for the

[1]A fine collection of economic analyses of human fertility is contained in a special supplement to the *Journal of Political Economy* (Becker and Lewis, 1973).

[2]This includes both heterogeneity between families (see Becker and Lewis, 1973; Ben-Porath and Welch, 1972; DeTray, 1973; and Willis, 1973) and heterogeneity within families (see Becker and Tomes, 1976). In this chapter, we are primarily concerned with heterogeneity within a family.

production of child quality are then postulated and the economic calculus alluded to previously is redone, albeit in one more dimension. Of course, it is also possible to capture the notion of heterogeneity by focusing attention on a vector of child traits over which parental preferences are defined, and which can be produced by the input of scarce resources. Economic calculus can again be applied to compute conditionally optimal behavior.

Perhaps the most obvious child trait, although by no means the trait that has received the most attention, is sex. Boy children are physically and culturally different from girl children and it has been established that, in many parts of the world, they are not regarded as perfectly substitutable for each other. For example, Khan and Sirageldin (1977) reported a three-to-one preference for sons over daughters in a survey of Pakistani couples. Coombs's (1977) analysis of United States National Survey of Family Growth data (Cycle I) also provided evidence of son preference. Finally, Williamson (1976) and Freedman and Coombs (1974) presented large bodies of evidence demonstrating the existence of parental sex preferences in many parts of the world.

With regard to the economic literature on sex preference, economists have tended to focus their efforts on four basic issues. The first, and probably the most prominent, issue pertains to the existence and significance of sex preferences. As mentioned, a number of studies have demonstrated the existence of sex preferences using the results of survey data. For the economist, though, the distinction between what people say and what people do is of fundamental importance. In this connection, Welch (1974) analyzed a sample of 1970 United States census data and found small but statistically significant differences in parity progression ratios that are conditioned on previous sex composition.[3] More specifically, Welch found that families with extreme sex ratios are more likely to have another child than families with moderate sex ratios. Thus, Welch (1974, p. 3) concluded that "families indeed care about sex of children" and have propensities in favor of balanced sex compositions. DeTray (1980) also studied the effect of family sex composition on the probability of having another child. The setting for this study was Pakistan, a country in which the stated preference of parents for sons is almost legendary. DeTray concluded that although sex composition does influence the *desire* for more children in Pakistan (see Khan and Sirageldin, 1977), it does not result in behavior that actually leads to more children. In this same vein, it is worth noting that Repetto (1972, p. 75) concluded, on the basis of an analysis of a wide range of survey results from developing regions of the world, that there is "no support whatever for the idea that in countries with strong son preference, the limitation of fertility is constrained by the strong desire to ensure the survival of one or more sons."

[3]Parity is the demographer's term for children ever born. The parity progression ratio is the proportion of women of a given parity who go on to a higher level of parity.

Taken together, the results of DeTray and Repetto are quite interesting because they illustrate a divorce between behavior and intent and because they suggest that sex preferences may not be an important determinant of fertility behavior in developing regions. In other words, in societies demonstrating little ability to control fertility in general, it is unlikely that even very strong sex preferences will affect fertility.

In connection with the existence of sex preferences, it is worth noting that economists have expressed little interest in a closely related problem—the nature of sex preferences. For example, preferences that can be summarized in terms of stopping rules, such as "not more than two boys," imply fundamentally different fertility behavior than models in which utility-maximizing households demand hypothetical child services that are asymmetrically determined by the number of boy and girl children. All of the well-known formal economic analyses of sex preferences have adopted the latter approach,[4] although the former approach has received some treatment in the demographic and biostatistics literature.[5] Nevertheless, modeling the demand for children under different specifications of the nature of sex preferences might prove to be a worthwhile exercise.

The second major focus of economic analyses of sex preference involves interfamily differences in the intrinsic probability of obtaining a boy child. This is an important issue for two reasons. First, sex preferences, no matter how strong, cannot affect aggregate sex ratios unless the intrinsic probability of a boy child differs across households—that is, "if all coins have a 50 percent chance of producing a head when tossed, then no mechanism for deciding which coins should be tossed can possibly affect the proportion of heads in all tosses [Welch, 1974, p. 4)." Second, if there is variation across families in the probability of having a boy child, then the existing sex composition of children in a family has informational content for the prior probability of another boy, which presumably affects future decision making.[6] Regarding the empirical evidence on interfamily differences in the probability of a boy child, Welch (1974) modeled sex of child as a Bernoulli process with a sex parameter that varies randomly across families. Welch then showed, using a nonparametric estimator and 1970 United States census data that the probability of a boy child is .512 with a standard deviation across families of .063. Using a more restrictive parametric approach, Welch

[4]The fact that stopping rules are lexicographic orderings and cannot be represented by continuous utility functions may explain why economists have not based their analyses on this approach.

[5]See Goodman (1961) for a survey of alternative "stopping rules" and for an attempt to analyze their implications for the aggregate sex ratio.

[6]The early economic literature on sex preferences also tried to model the process by which families learn about their intrinsic sex parameters (see Ben-Porath and Welch, 1972). However, this line of development was not actively pursued since it proved quite difficult to empirically distinguish between various models (see Ben-Porath, 1973; Ben-Porath and Welch, 1976 and 1980). Furthermore, in populations in which total family sizes tend to be small, there is little opportunity for this learning to take place.

then concluded that variations in the sex parameter across families are statistically significant. Thus, to the extent that parents do have sex preferences Welch has shown—at least in principle—that they matter. In practice, however, Welch was forced to conclude that the likely effect of sex preferences on both the aggregate sex ratio and continuation probabilities is small.

To appreciate the significance of Welch's findings, it must be understood that the early economic research on sex preferences was plagued by questions about the importance of such preferences. Clearly, by establishing the existence of circumstances under which sex preferences matter, Welch made continued research on the economics of sex preferences possible. However, to the extent that technical advances have already made, or soon will make, it possible to influence the sex of a child, an alternative and potentially more important set of conditions under which sex preferences matter will be established. Moreover, because such technical advances may affect boy or girl probabilities significantly,[7] doubts about the ability of households to perceive interfamily differences in boy probabilities of the order reported by Welch will be deflated. Thus, there is likely to be renewed interest in the economics of sex preferences as the potential for such preferences to influence both individual and aggregate fertility behavior increases.

The third focal point for the attention of economists interested in sex preference and sex selection is the possibility of differential costs and benefits associated with boy and girl children. For example, in many societies boy children contribute more to family income than girl children and are relied on for old-age support more than girl children. Alternatively, boy children may eat more than girl children and their education may consume more household resources than the education of girl children. But whatever the source, it is clear to economists that differences in the costs and benefits of boy and girl children will affect the demand for children and may make households with no sex preferences behave as if they have sex preferences.

Because it is exceedingly difficult to measure the costs and benefits of boy children and girl children, and because these costs and benefits are determined jointly with child quality, economic analyses have tended to avoid the different costs–different benefits issue. However, the results of several large research projects, some of which date back to the early 1970s, on the net value of children should lead to more careful treatments of family budget considerations in both theoretical and empirical work on sex selection.[8]

The fourth major focal point for economists interested in sex preferences is the

[7]For example, see Population Reference Bureau (1976), which reported the development of a sperm separation technique that when used prior to artificial insemination, increases the probability of a boy child to between .65 and .90.

[8]For interested readers, the work of Fawcett (1972), Arnold, Bulatao, Buripakdi, Chung, Fawcett, Iritani, Lee, and Wu (1975), and Butz and Greenberg (1975) provide a good introduction to research on the costs and benefits of children.

prior uncertainty associated with the sex of a child. The underlying motivation for this concern is the notion that households are risk-averse. This means, for example, that a household will prefer 100 units of child services with certainty to a lottery ticket yielding 50 units of child services with a .5 probability and 150 units of child services with a .5 probability. Another way to think of the concept of risk aversion is to view the household as attaching a cost to any good with an uncertain payoff, such as a child of unknown sex.

Welch (1974) presented an analytical treatment of the effect of prior uncertainty on completed fertility, building on earlier work presented in Ben-Porath and Welch (1972). Welch showed that the effect of prior uncertainty on optimal family size will be negative or positive depending on whether the demand for child services is price-elastic or price-inelastic.[9] This conclusion follows from an identity in Welch's model according to which $\alpha n = P_c C$, where α is the exogenously determined cost per child, n is the number of children in a household, P_c is the price of a unit of child services, and C is the number of units of child services (which depends in some general way on the number of children and the proportion of boy children). Because elastic demand means that $P_c C$ will decrease when P_c increases marginally, it follows that increasing uncertainty (which can be interpreted as increasing P_c in Welch's model) will decrease the demand for children. A similar argument applies to yield the opposite result for the inelastic case.

Although early concerns with the prior uncertainty associated with child traits focused primarily on the effect of uncertainty on desired family size, the uncertainty issue has recently begun to take on added significance in connection with the attention given to current developments in sex-selection technology. Therefore, it would be worthwhile to endogenize the use of sex-selection techniques in a model of the demand for children. This issue is briefly addressed in the context of a model of sequential-fertility decision making developed in the next section.

A MODEL OF SEQUENTIAL FERTILITY

The purpose of this section is to present a simple model of the fertility behavior of a household with explicit sex and risk preferences. In developing the model, it is assumed that the household makes its decisions sequentially, that the

[9]Elasticity is a frequently used economic measure of the standardized response of one variable to changes in a related variable. More specifically, the elasticity of variable Y with respect to changes in variable X is defined as the percentage change in Y that is caused by (or associated with) a 1 percent change in X ($= \partial \log Y / \partial \log X$).

household's decisions are conditioned on the number and sex composition of previous children, and that the household has perfect control of its fertility although the sex of a child is unknown prior to its birth. The model may now be represented by the following four equations:

$$U = U(HS) \tag{1}$$

$$HS = HS(X, CS) \tag{2}$$

$$CS = \gamma_M(n, p)M + \gamma_F(n, p)F \tag{3}$$

$$P_x X + P_c n = Y , \tag{4}$$

where U is current household utility; HS is an index of utility-producing household services; X is a composite consumption good; CS is child services; n is the number of children in the household; p is the proportion of children that are boys; M and F are dichotomous variables that take the value unity if a newborn child is male or female, respectively (M or F is zero otherwise); P_x and P_c are the respective prices of the composite consumption good and an additional child; Y is exogenously determined household income; and γ_M and γ_F are parameters that reflect the contribution of boy and girl children to the production of child services, respectively.

Briefly, the assumptions underlying Equations (1) to (4) are (a) that the utility function is twice continuously differentiable, increasing, and strictly concave in HS, its one argument; (b) that household services are produced by both child services and by the composite consumption good, with household services always positive and increasing in both of these arguments; (c) that child services are producible only by having children, with the rates of transformation depending on the number of live children, the proportion of boys among them, and the sex of the newborn child;[10] and (d) that the family is budget-constrained according to Equation (4) with the prices of boy and girl children being equal. Note that the combination of this last assumption and the two-good nature of the model implies that increased consumption of child services must be paid for by decreased consumption of the composite good, on a dollar-for-dollar basis.[11]

With the stage set in this manner, it is possible to introduce the prior uncertainty that characterizes the sex of a child by defining Π as the household's intrinsic probability of a boy child ($1 - \Pi$ is therefore the intrinsic probability of a girl child). In this framework, unborn children can be viewed as simple lottery tickets from the household's point of view: they represent a set of possible outcomes

[10]Note that $\gamma_M \neq \gamma_F$ implies the existence of household sex preferences.

[11]This can be shown formally by taking the total differential of Equation (4), which yields $P_c n = -P_x X$.

(i.e., a boy child or a girl child), each of which has a specified probability of occurrence. Furthermore, given the household's sex preferences and risk preferences, it is possible to compute the maximum price (in terms of foregone consumption of the composite good) that the household would rationally pay for such a lottery ticket.[12] The household decision rule can then be defined by comparing that maximum price to the amount that the household actually has to pay. It also seems reasonable to suppose that anything that increases (decreases) the maximum amount a household would be willing to pay for the lottery ticket will also increase (decrease) the probability of an additional birth (because the actual price of a child is fixed).[13] Thus, the properties of this model of sequential fertility are examined by looking at the effect of various household characteristics on the value of the lottery ticket.

Consider now the utility function represented in Figure 1 where, for the sake of exposition, it is assumed that a boy child produces more household services than a girl child. In particular, observe the concavity of the utility function in HS. This property of the utility function is equivalent to stating that the household is risk-averse. To see this equivalence, note that the concavity of U guarantees that

$$\Pi \cdot U(H^{M}) + (1 - \Pi) \cdot U(H^{F}) < U(\Pi \cdot H^{M} + [1 - \Pi]H^{F}) \qquad (5)$$

where $0 < \Pi < 1$ and where H^{M} and H^{F} are the quantities of household services produced by having a boy child and a girl child, respectively. In other words, the household's expected utility from a lottery ticket is less than the utility of the expected outcome of the lottery. Thus, because the household dislikes the risk associated with a lottery ticket, it would not be willing to pay Z utils to purchase the lottery ticket (even though that is the utility of the expected payoff). Rather, the household would require an expected outcome of at least EH' before it would pay Z utils for the lottery ticket. Alternatively, the maximum the household would pay for the given lottery ticket is $\bar{H}$.

Having presented the basic model, we proceed to investigate some implications of the model for household behavior.[14]

1. *In the absence of sex preferences ($\gamma_M = \gamma_F$), neither uncertainty about the sex of a child nor risk aversion on the part of the household will affect the probability of an additional birth.*

[12]To compute the maximum price rigorously, however, it must be assumed that household utility (Equation [1]) can be expressed as the sum of utility derived from the household services associated with the consumption of the composite good X plus utility derived from the household services associated with the consumption of child services. Because we are dealing with household decisions at the margin, this assumption is not too restrictive in an appropriately chosen neighborhood.

[13]Although specifying the stochastic elements underlying our model is beyond the scope of this chapter, we do assume that such elements are present. This explains our use of the term *probability*.

[14]All of the results stated in the remainder of this section can be proven algebraically. However, in the interest of simplicity, geometric arguments are appealed to whenever possible.

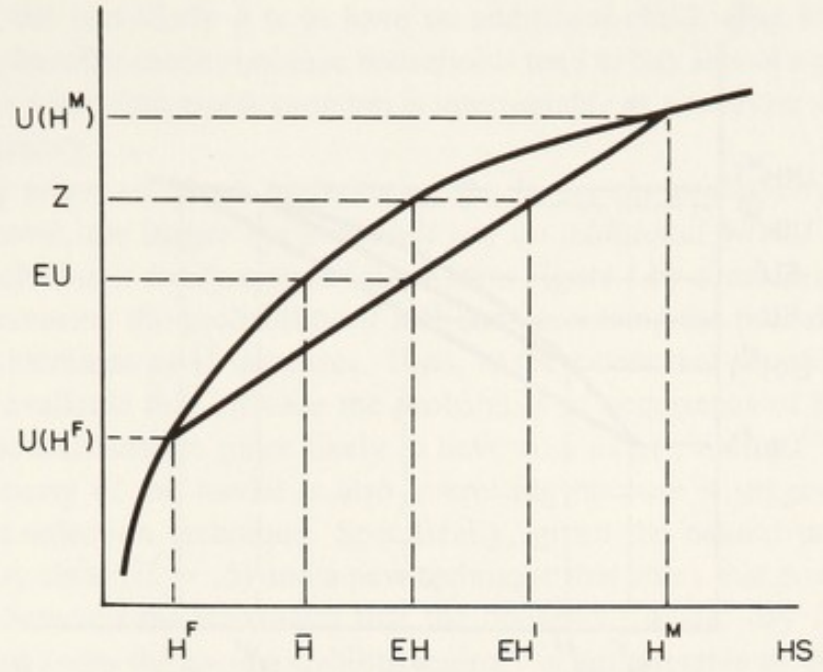

Figure 1.

This conclusion can be shown to follow directly from Figure 1 by equating H^F (the addition to household services that results from a female child) and H^M (the addition to household services that results from a male child). Intuitively, if the household has no sex preferences, then children are not risky goods and utility-maximizing households would be willing to forego as much as Z utils to buy a littery ticket with an expected payoff of Z utils. In addition, because the household services contributed by boy and girl children are equal ($= H^C$), it follows that $\Pi U(H^M) + [1 - \Pi]U(H^F) = U(H^C)$, so varying the parameter Π will have no effect on the probability of a new birth.

2. *Holding expected utility constant, increasing the strength of household sex preferences reduces the probability of an additional birth when the household is risk-averse.*

This result can be seen to follow from Figure 2, in which H^F and H^M are farther apart than $H^{F'}$ and $H^{M'}$ although the expected outcome EH is the same under both sets of preferences. Clearly, the maximum amount the household would be willing to pay for the child lottery ticket under the extreme set of preferences is less than it would be willing to pay under the more moderate preferences. Thus, the household's aversion to risk (which makes less-risky goods more desirable to the household) leads to a reduction in the probability of having an additional child, the magnitude of which is directly related to the magnitude of the perceived risk.

3. *Even if they have the same sex preferences, more risk-averse households are less likely to have additional children than less risk-averse households.*

To see this point, consider Figure 3, which portrays the utility functions of two

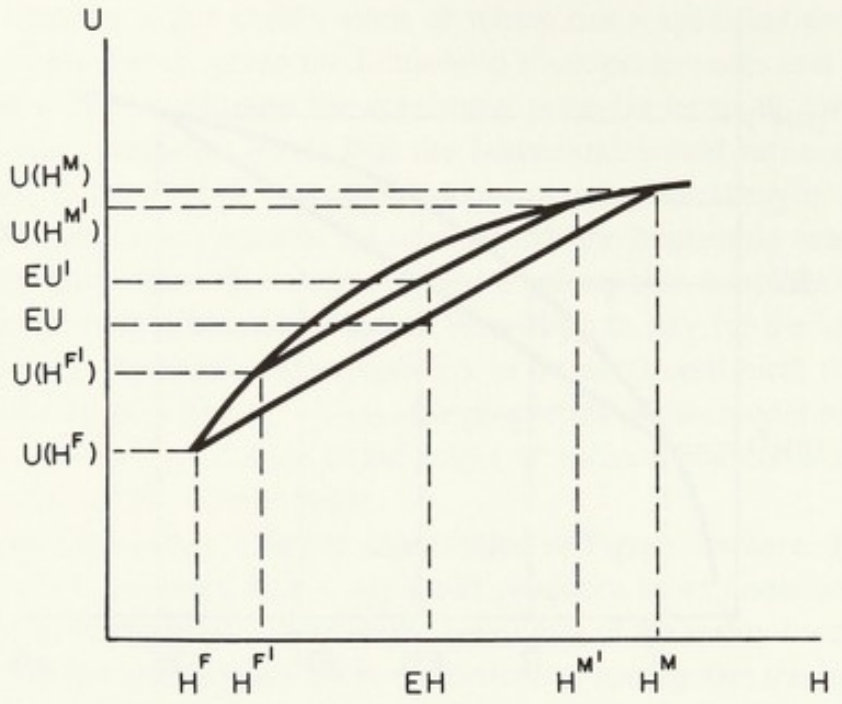

Figure 2.

separate households. Observe that the two utility functions imply equal sex preferences, as an additional girl or an additional boy will yield the same utility to both households. However, U^A is more concave than U^B (in the relevant range), which indicates that household A is more risk averse than household B.[15] Clearly, the maximum that household A would be willing to pay for the child lottery ticket is $\bar{H}'$ and the maximum that household B would be willing to pay for the lottery is $\bar{H}$, which is greater than $\bar{H}'$. Thus, the more risk-averse a

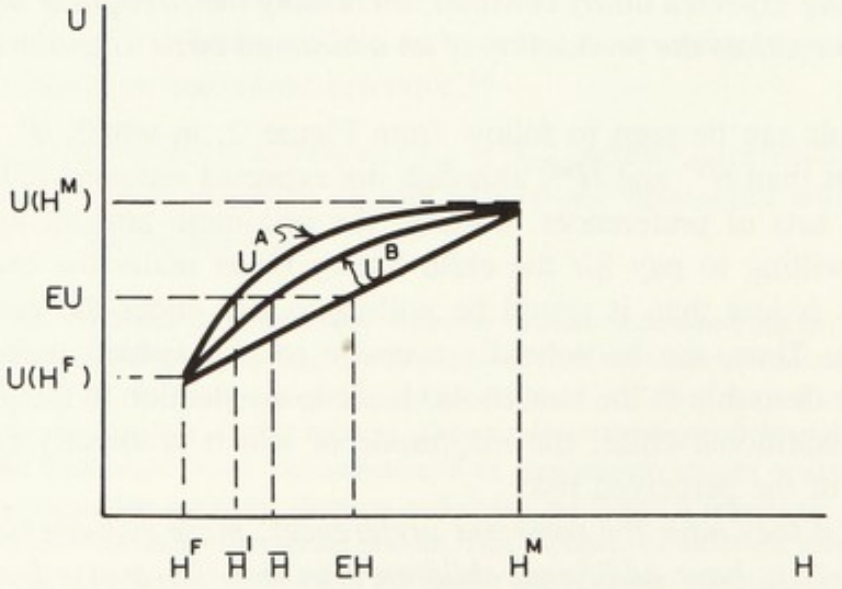

Figure 3.

household, the less likely it is to have an additional child. This is, in fact, an intuitively plausible result, because households tend to buy less of a good when it is expensive and because risk aversion is interpretable as a measure of the cost of prior uncertainty.

4. *For a given set of sex preferences, the larger the probability of the preferred outcome, the larger the probability of an additional birth.*

This conclusion is easily seen to follow from Figure 1 by considering the effect on $\bar{H}$ of increasing the probability of H^{M} and decreasing the probability of H^{F}. Clearly, $\bar{H}$ increases as Π increases. Thus, to the extent that sex-selection techniques are available that increase the probability of occurrence of the preferred outcome, households are more likely to have additional children.[16]

This property of the model is also interesting because it suggests a way to value a sex-selection technique. Specifically, given the natural probability of having a boy child ($\Pi \approx .5$) and a new technique that alters that probability, the difference between the maximum that the household would pay for the child lottery ticket under the two probability regimes is interpretable as the maximum that the household would pay for access to the new technique. This value is relevant to household decision making to the extent that sex selection techniques may involve nontrivial pecuniary or psychic costs.

5. *Assuming households prefer balanced sex composition to unbalanced sex composition, the sex composition of previous children will affect the probability of additional children, with balanced households having lower continuation probabilities than unbalanced households provided that the nonpreferred outcome is not particularly adverse to the unbalanced household and that the unbalanced household is not highly risk-averse.*

To investigate the effect of previous sex composition on the continuation probability, it is useful to compare the preference structures of households with balanced prior sex compositions and households with unbalanced prior sex compositions. In Figure 4, U^{B} indicates the likely sex preferences of a household with a balanced sex composition. Notice that this household has a preferred outcome, H_{B}^{M}, but that the utility difference between the preferred and the nonpreferred outcome (H_{B}^{F}) is small. On the other hand, Figure 4 also illustrates the likely sex preferences of a household with an unbalanced sex composition (U^{U}).

[15]This can be expressed mathematically by noting that the second derivative of U_{A} is greater than the second derivative of U_{B} between H_{F} and H_{M}. In other words, since the endpoints are the same for both functions, the second derivatives can be used as indicators of the degree of risk aversion. (This is not the case generally, as is well known, because the second derivative is not invariant to the units in which household utility is measured; (see Arrow, 1965).

[16]Note that this statement is not equivalent to the statement that continuation probabilities are positively related to the uncertainty of the outcomes. In fact, the latter statement is incorrect because, for example, any deviation of π from .5 will decrease uncertainty but will only increase the continuation probability if π increases (where π is the probability of the preferred outcome).

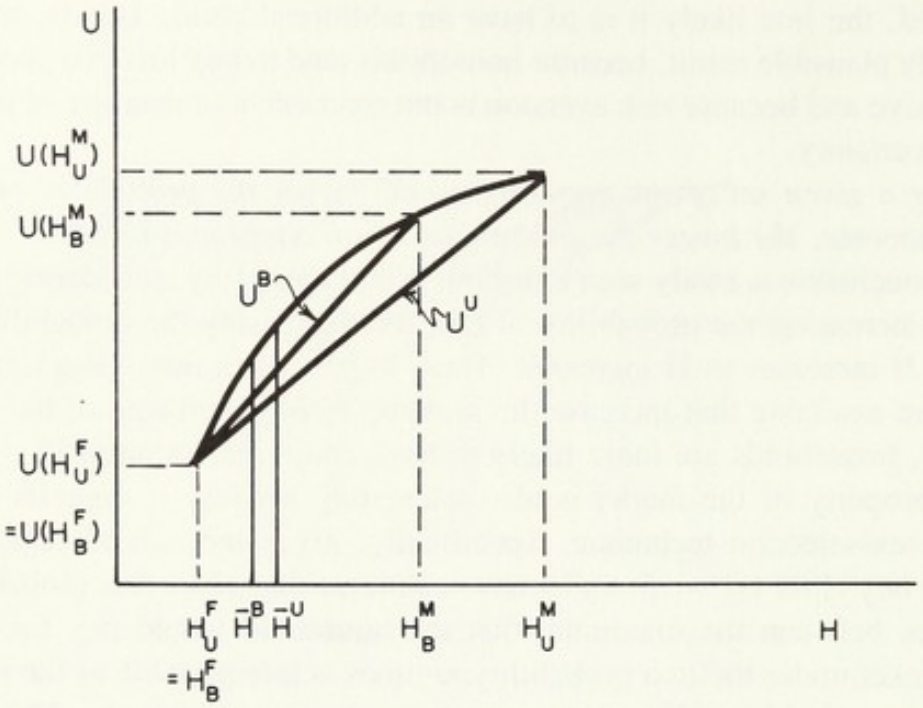

Figure 4.

For this household, the utility of the preferred outcome is greater than that for the balanced household. Presumably this reflects the higher marginal utility of a male (female) child in a household with few males (females) compared to a household with more males (females). It is assumed that the preferred outcome for both the balanced and the unbalanced household is the outcome that would improve the balance of the unbalanced household. Observe also that the utility of the nonpreferred outcome is represented as being the same in the balanced and unbalanced households. The rationale for representing household preferences in this way is that the nonpreferred outcome provides the utility of a child in general, whereas the preferred outcome provides the utility of a child of the "right" sex. Thus, one can argue that the utility of the nonpreferred outcome will be about the same in both types of households. It is, however, worth noting that the assumption that balanced and unbalanced households will receive the same utility from the nonpreferred outcome may not be an accurate representation of their preferences. Instead, it might be the case that the utility of the nonpreferred outcome is lower for the unbalanced family than for the balanced family. In this case, the continuation probability for the unbalanced family declines and it is impossible to determine which of the two household types has a higher continuation probability. In fact, if the nonpreferred outcome is particularly undesirable to the unbalanced household, then its continuation probability is likely to be lower than the continuation probability for the balanced household. However, in view of the empirical results in Welch (1974), it seems likely that the earlier assumption is more realistic.

Set up in this way, it is clear that the household with an unbalanced sex composition would be willing to pay more for the child lottery ticket than the household with a balanced sex composition (observe $\bar{H}_U$ for the unbalanced household compared to $\bar{H}_B$ for the balanced household). (Of course, strong risk aversion by the unbalanced household can reverse this conclusion. See Observation 3 in this list.) It therefore follows that families with unbalanced sex compositions are more likely to have additional children than families with balanced sex compositions. This conclusion is, in fact, consistent with the empirical findings in Welch (1974) mentioned earlier.

6. *Different prices for boy children and girl children will lower continuation probabilities if the household has no sex preferences but is risk-averse.*

In specifying the household budget constraint in Equation (4), it was assumed that the prices of boy children and girl children were equal. However, an implication of a good deal of the economics literature on fertility behavior is that this is a poor assumption (see the previous section). If, in fact, the prices are unequal, then the household is faced with price uncertainty when it decides to have an additional child. Furthermore, because the model only admits two goods, price uncertainty that affects one of the goods makes the other good seem risky (because the ability to consume the composite consumption good depends on the price of children). As a result, risk-averse households will be willing to pay less for the child lottery ticket when the price of a child varies according to its sex. Thus, continuation probabilities will be negatively related to the magnitude of variations by sex in the price of a child.

In this connection, it is also worth noting that the existence of sex preferences can either magnify or reduce the effect of different prices on the continuation probability. For example, if the preferred outcome is associated with a lower price than the nonpreferred outcome, then the overall risk associated with the childbearing decision is increased and the continuation probability is further reduced. On the other hand, if the preferred outcome is associated with a higher price than the nonpreferred outcome, then the preference-based risk is, at least in part, diversified away by the price-based risk, leading ultimately to a higher continuation probability.

SUMMARY, CONCLUSIONS, AND SUGGESTIONS FOR FURTHER RESEARCH

The purpose of this chapter has been to review the economist's approach to the study of sex preference and sex selection and to present an economic analysis of this subject. With regard to past work on the subject of sex preferences, econo-

mists' attention has focused primarily on four topics: (a) the existence and significance of sex preferences, (b) interfamily differences in the intrinsic probability of having a boy child, (c) differences in the costs and benefits of boy children and girl children, and (d) the effect of prior uncertainty associated with the sex of a child. In general, the existing state of knowledge seems to be that sex preferences are prevalent in many parts of the world, although the extent to which preferences carry through to behavior has been weakly demonstrated at best, especially for developing countries. In addition, it seems well established that there is interfamily variation in the intrinsic probability of having a boy child, implying that sex preferences can affect aggregate sex ratios. Moreover, to the extent that major advances in sex selection technology and wider acceptability of such technology are on the horizon, the potential for sex preferences to affect aggregate sex ratios and household fertility behavior will be substantially increased. Finally, the degree to which different costs and benefits of boy and girl children underlie stated sex preferences (as opposed to pure sex preferences) is not well known, nor is the importance of the prior uncertainty associated with the sex of a child.

An economic model of household fertility was presented in this chapter. The main feature of this model is its explicit focus on sex and risk preferences and its sequential nature. Analysis of the model showed that even under fairly nonrestrictive assumptions about household behavior, the probability of having an additional child is negatively related to the strength of the household's sex preferences (assuming risk-aversion), the degree of the household's aversion to risk, the probability of occurrence of the nonpreferred outcome, the degree of balance in the sex composition of existing children, and the magnitude of the difference in the price of boy and girl children.

Overall, the results of this chapter suggest that there is much room for further research on the economics of sex preferences. First, it would be useful to specify the stochastic elements in an economic model of fertility (such as the one developed in this chapter) and to test the model using data from countries with a fairly wide range of stated sex preferences and degrees of contraceptive control.[17] In this same vein, it would also be worthwhile to redo the Welch (1974) comparison of parity progression ratios, conditioning not just on existing sex composition of the household, but also on other dimensions along which preferences might vary, such as race or religion. Comparing these parity progression ratios at two points in time would also be interesting to the extent that it would make it possible to

[17]For example, the model developed in the previous section suggests that continuation probabilities depend on sex preferences (which could be proxied by covariates if direct survey information is not available), existing household sex composition, the relative prices of boy and girl children, and the household's aversion to risk (which might be controlled for by including household income as an explanatory variable, because even if all households have the same utility function, different households will operate in different neighborhoods of the utility function).

confirm the hypothesis that improved fertility control facilities and translation of preferences into behavior.

Second, empirical work investigating the effect of sex preferences on interbirth intervals would yield useful information on the existence and strength of sex preferences. Studies of this nature have, in fact, already been done (see Welch [1974] for an example), but some extensions are still possible. In particular, it might be fruitful to employ a parametric model of interbirth intervals, letting the estimated parameters depend on covariates chosen to reflect sex preferences, risk preferences, degree of fertility control, and the existing household sex composition.

Third, the existing body of literature on interfamily differences in the intrinsic probability of having a boy child could be usefully extended by testing whether the intrinsic probability also varies with age of mother or with parity. This is not an unlikely possibility given the finding of interfamily differences and would have important implications for household fertility behavior.

Fourth, there is a need for more careful models of household sex preferences, for example, specifying the exact form of Equation (3). For example, the model could be extended to account for the fact that the decision to have one more child explicitly includes the decision to have further children, conditional on sex of that child. Moreover, in view of Observation 6 in the previous section, it would be useful to examine the relationship between pure sex preferences and the prices of boy and girl children in different countries.

Fifth, further work on the extent to which sex preferences are reflected in actual fertility behavior (as opposed to intended fertility behavior) would be interesting. For example, one promising approach to this problem would involve extending recently developed models of the effect of child mortality on fertility to determine empirically whether boy child mortality evokes significantly different replacement fertility responses than girl child mortality (see Olsen [1980] for details on this literature).

In conclusion, then, it seems clear that sex preference and sex selection is a topic that may benefit from further economic analysis and one that will undoubtedly become more important as new techniques for sex selection are developed and marketed.

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7

Parental Sex Preferences and Sex Selection

NANCY E. WILLIAMSON

INTRODUCTION

Sex-selection research has a rather poor scientific reputation. Sex-selection techniques have been widely publicized before being tested and even those of known ineffectiveness have been touted. Predictions that better methods would be available (e.g., Etzioni, 1968) have proven to be premature. The only ways actually available to affect the sex of the next child are through adoption, late abortion after amniocentesis to detect sex, or infanticide—generally impractical or unacceptable approaches.

Even if practical approaches were available, few of those writing on the subject believe there will be any advantages to sex selection. Ethicists and social scientists have worried about imbalanced sex ratios if people were to use techniques to increase the number of boys. Feminists often see the interest in sex selection as evidence of continued sexism and sex selection as the ultimate in sex discrimination.

Because techniques are still impractical, few academics or government researchers take the subject seriously. Public opinion on sex selection probably varies from seeing it as dangerous to considering it trivial or humorous. The topic deserves better consideration, which is the purpose of this volume.

Biologists can better assess the status and prospects of various sex-selection techniques than I can. For the purpose of this discussion, we assume that at least

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one effective and practical method—probably involving artificial insemination or selective abortion—is developed in our lifetime and that it is useful to try to anticipate some of the possible impacts.

This chapter reviews social research on whether parents have strong preferences about the sexes of their offspring in different societies, what preferences are most common, and how they vary by social characteristics or groups. Unless couples have definite sex preferences, the availability of sex-selection techniques will be inconsequential.

We also consider how much appeal sex control might have in developed and developing countries and how the characteristics of the particular techniques might affect their availability, acceptability, and use. Underlying is a concern about whether, on balance, the innovation would be harmful or beneficial, given anticipated patterns of preferences and use.

The chapter argues that sex-selection techniques, even if they become reasonably practical, safe, and effective, would probably be used consistently and correctly by relatively few couples around the world.[1] Furthermore, some of these would be striving for a balanced sex ratio or at least one child of each sex. Although the majority of those using the techniques would probably want a predominance of sons, this would be unlikely to distort the local sex ratios as much as sex-selective migration or wars have already done in many societies. Changes, including slightly lower fertility for users who needed fewer children to achieve their desired sex composition, would be gradual and, we assert, net societal costs would be small. A few couples might have an additional child if they could be quite sure of having a child of the desired sex. On the family level, the results would be modestly positive. The few highly motivated couples successfully using the techniques would benefit from realizing their desires and have more control over their lives. Their children would feel more wanted than those children who know or suspect they were the "wrong" sex. If the available techniques were not perfect, some parents would probably be disappointed, possibly more so than if they had taken their chances with nature. In short, the techniques, although unlikely to accomplish any miracles, would probably not bring any disasters either.

PATTERNS OF PARENTAL SEX PREFERENCES

People are interested in the gender of their children; it is not an uncommon topic of conversation in many cultures. This section reviews research on sex

[1]The birth-control pill is an effective method of birth control, yet many couples use it incorrectly or inconsistently and do not achieve high effectiveness.

preferences for developed (the United States, Europe, and elsewhere) and developing regions of the world.

Developed Countries

The United States

Social scientists have conducted more than thirty studies of Americans' sex preferences about children. Considerably fewer are available from other developed countries. Although the United States studies have used different approaches and samples, the results are quite consistent. A summary of the research appears here; many of the studies are described in Williamson (1976).

Americans rarely want only (or mostly) daughters. (The only exception to this generalization is that girls have often been preferred for adoption [Williamson, 1976, pp. 111–115]). The most popular combinations are: just one boy and one girl, at least one of each sex, and more boys than girls (including a single boy if only one child). Few people are completely indifferent.[2] Those with no children often want a boy first (Westoff and Rindfuss, 1974). Measures that go beyond first preferences uncover more boy preference (Coombs, 1977).

Even those wanting equal numbers of boys and girls usually want them for different reasons: boys to carry on the family name, provide companionship for the husband, and perhaps improve the family's fortune, and girls for more short-term personal satisfactions and as companions for the mother (Arnold and Fawcett, 1975; Hoffman, 1976).

Couples who already have children sometimes recommend their existing sex compositions (Clare and Kiser, 1951; Eckard, 1978; Pohlman, 1967), even though they might have started childbearing with different preferences. This tendency to rationalize[3] somewhat reduces the significance of sex preferences.

Variations in sex preference by social characteristics such as education, race, and religion are small or inconsistent. As Coombs (1977) pointed out, variations in sex preference within countries are much smaller than those between countries. One clear uniformity is that men are more likely than women to prefer boys (Clare and Kiser, 1951; Dahlberg, 1948–1949; Dinitz, Dynes, and Clarke, 1954; Hoffman, 1976; Norman, 1974; Peterson and Peterson, 1973; Strunk,

[2]Pregnant women may be somewhat less willing to express a preference than other women. A 1976 national survey (Eckard, 1978), which included 1657 pregnant women, found that two-fifths (41 percent) professed indifference. Perhaps they wanted to accept whichever sex came and thought that indulging in a sex preference (when nothing could be done about the sex of the coming child) would make acceptance more difficult.

[3]The sexes differ in their responses to existing sex compositions. Men are less likely than women to rationalize having daughters (Clare and Kiser, 1951; Markle, 1974; Wood, 1975).

1947–1948; Uddenberg, Almgren, and Nilsson, 1971). In fact, American (and European) women sometimes report that they want a son mainly to please their husbands (Dahlberg, 1948–1949; Hoffman, 1975; Uddenberg *et al.*, 1971).

Age also appears to be related to boy preference. Younger children prefer their own sex but older girls and boys both prefer sons (Markle and Wait, 1976). In general, college students are more likely to prefer sons than are older adults with children (half of whom typically are girls).

Different measures of sex preference give somewhat different results. Each measure used has its shortcomings. For example, questions about ideal sex compositions among the first several children elicit rationalizations from some parents. Parity progression ratios, the proportion of couples at particular sex and size combinations who go on for more children, have ambiguous interpretations and underestimate the impact of sex preferences on fertility (McClelland, 1979a).

Acknowledging the measurement difficulties, it appears that sex preferences decisively affect the fertility of only a small percentage of American couples. Couples with one child, until recently, have continued childbearing, regardless of the sex of the first. However, those with two children of the same sex are more likely to go on than those with one of each sex (Ben-Porath and Welch, 1972; Bernstein, 1952; Bumpass and Westoff, 1970; Dawes, 1970; Gray, 1972; Gray and Morrison, 1974; Loyd and Gray, 1969; Myers, 1949; Rife and Snyder, 1937; United States Bureau of the Census, 1956; Welch, 1974; Westoff, Potter, and Sagi, 1963; Wood and Bean, 1977). The interpretation of the behavioral pattern alone would be quite ambiguous (because families with different preferences and different subjective probabilities about what sex they might expect to have next might behave the same). But many attitude studies have found the one-of-each-sex preference to be widespread in the United States. This is particularly true for large nonstudent samples (Arnold and Fawcett, 1975; Clare and Kiser, 1951; Westoff and Rindfuss, 1974; Whelpton, Campbell, and Patterson, 1966) and for expressed first preferences. When respondents are asked specifically about odd numbers of children (one, three, etc.), more son preference shows up (Coombs, 1977). In recent years, families with three or more children have been stopping, regardless of sex composition. In other words, number preferences tend to dominate sex preferences for most American couples, except for those with two of the same sex who go on for more (Coombs, 1977). For those with an acceptable sex composition, their preferences may lead them to stop childbearing.

Europe and Elsewhere

The research from other developed countries is so limited and generally out of date that it is difficult to make any firm conclusions. A modest amount of information is available for the United Kingdom, Sweden, Italy, several other

European countries, and Australia. Two Swedish studies (Dahlberg, 1948–1949; Uddenberg *et al.*, 1971) found little evidence of boy preference among women. A college student sample in Belgium (Bollen, 1962) noted considerable boy preference, as did two early studies done in Italy and other European countries (Gini, 1956; Giurovich, 1956). A more recent Hungarian study (Klinger, 1975) found more boy preference than a United States study using a similar approach (Coombs, 1977), and a Belgian study using the same measure (the Coombs scale, described in Coombs, Coombs, and McClelland, 1975) found some girl preference. British research (Peel, 1970) has obtained results similar to those of United States studies. There is some evidence in Europe of the tendency for families with children of only one sex to go on for more (De Wolff and Meerdink, 1957; Thomas, 1951). As in the United States, this pattern is less likely to hold for Catholics.

An Australian study (Young, 1977) also found evidence that families with mixed-sex compositions were less likely to have more children, but the overall effect on family size was small. Women who were older, less educated, more traditional regarding women's roles, and of Southern European background had a stronger desire for children of each sex. But they also wanted more children and probably had less control over family size than more "modern" women with weaker preferences, thus making the relationship between sex preference and fertility a rather fuzzy one.

Given the limited information available, what stands out for the developed countries is the desire for one child of each sex with a secondary preference for boys if the family wants an odd number (one, three, or five) of children. The lack of significant variations (other than sex and age) by social characteristics or group is also notable. Implications of these patterns for the use and impact of sex selection technology are discussed in a later section.

Developing Countries

Sex preferences in developing countries vary widely from the desire for a balanced-sex composition among Filipino women (Coombs, 1977, Stinner and Mader, 1975b) to very strong boy preference among women in North Africa (Eliot, 1968) and men in several Indian states (Lahiri, 1974). The great variety and the lack of information for many countries makes generalization difficult. Researchers have better documented parental preferences in Asia (particularly in India, Korea, Taiwan, the Philippines, and Thailand) than in Latin America or Africa. Research in Korea is especially innovative in the methods used to study boy preference (i.e., in-depth interviews with parents of all-girl families, pregnant women, soothsayers) (Chung, Cha, and Lee, 1974; Ham, 1971).

As in developed countries, son preference is common and typically stronger

for men than women. Parents having large families worry less about sex composition because most will have several of each sex. Problems arise more often for those wanting small or moderate sized families and those living in the better-off developing countries.

Reasons for wanting sons and daughters differ with the emphasis on economic considerations for boys and assistance in the household and babysitting for girls. Even where a balanced number of boys and girls is desired, as in the Philippines, the reasons for desiring boys or girls differ (Bulatao, 1975).

Strong son preference may lead to neglect of girls (Wyon and Gordon, 1971). Women in such countries are not secure in their marriage and family until they produce one or more sons.

Ideal sex ratios—the preferred number of boys divided by girls—go as high as three to five boys to every girl among some Indian men (Lahiri, 1974), suggesting considerable dissatisfaction with the biological sex ratio of approximately 1.05:1. Parents in many countries, including Korea and Táiwan, are concerned about having at least one or two sons; interest in having a daughter ranges from negative to positive.

In some countries, subgroups show different patterns. Although Thais do not generally prefer sons, ethnic Chinese males in Thailand do (Knodel and Prachuabmoh, 1975), as do Muslims in the Philippines (Stinner and Mader, 1975a). Boy preference is also more common in rural areas. Daughter preference has turned up only among several very small societies originally described by anthropologists (see Williamson, 1976) and among roughly a third of women respondents in studies in the Philippines and Bogota, Colombia (Coombs, 1977).

Whether sex preferences affect fertility depends on the extent to which preferences differ from the natural sex ratio and the strength of the preferences, the total number of children desired, and the availability of effective birth control when the desired sex composition is attained. These conditions are generally not met in most African countries where sex preferences are probably weak (compared to Asia), ideal and actual family sizes are still large, and contraceptives are often unavailable. In some countries of Latin America, the above conditions may be met but the data are currently lacking. Son preference probably does affect the fertility of some couples in India and Pakistan and many in Korea and Taiwan (Williamson, 1976). In these countries, couples with sons are more likely to say they want no more children, not proceed to the next child, use contraception, and accept sterilization, in comparison with those of equal parity but no sons.

Although no study is conclusive, the evidence in South Asia and East Asia is that the desire for sons has retarded fertility decline. On the other hand, countries like Singapore and Japan have reached moderately low fertility in spite of son preference. Whether China will be able to hold couples to one child apiece, especially if the one is a girl, remains to be seen. Visitors have reported considerable uncertainty among the Chinese themselves about whether their radical policy will work. Son preference has frequently been mentioned in the Chinese

press as an obstacle to fertility decline in rural areas (Williamson, 1976). Family-planning programs in China, Singapore, and Hong Kong have intermittently tried to combat son preference through media campaigns, such as "Boy or Girl. Stop at Two."

But son preference is not the only culprit. Desires for at least one of each sex (or an equal number of each) may also propel some couples onward, as in the Philippines. Sex preferences may also cause couples to cease childbearing if they are satisfied with the sexes of their children or fear having a child of the "wrong" sex (McClelland, 1979b).

As more countries begin the fertility transition, the problem of attaining the preferred sex composition in a small- to moderate-sized family becomes more salient. But modernization also brings some reduction in the dependence on sons.

BARRIERS TO THE USE OF SEX SELECTION

Previous discussions of the possible appeal of sex-selection techniques have focused on whether people accept the general idea of sex control and approve of specific hypothetical approaches such as a pill. Availability is considered to be no obstacle. For example, an article (Matteson and Terranova, 1977) on the social acceptability of sex selection (among other innovations) began:

> The female will soon have readily available five child conception options which deviate from the usual practice: (a) choose the sex of her unborn child, (b) use artificial insemination (AI) with her mate's sperm, (c) have in-vitro fertilization with her own egg and her mate's sperm, (d) have AI with another man's sperm, or (e) have AI in-vivo with another woman's egg. Of course, options (b) and (d) have been in use the longest and are widely available [p. 225].

We doubt that options (b) and (d) are widely available in the United States and are confident that they are not in the rest of the world. In our view, lack of availability would probably be a more serious obstacle than acceptability of the idea of sex selection, especially in developing countries where sex preferences tend to be the strongest.

Availability

Developed Countries

Modern technology is by no means equally distributed within developed societies. People in countries with especially good health systems, living near large

medical centers, carrying comprehensive health insurance, and who are better educated usually benefit more from medical advances. This is probably even more true for optional (as opposed to lifesaving) procedures, among which sex-selection techniques should be classified. Availability would depend on whether the procedures (e.g., separation of male- and female-bearing sperm, early sex detection, etc.) would be done in ordinary doctors' offices, whether they were well publicized, and whether they were covered by health insurance or public health programs. Because sex selection is often considered a frivolous or trivial problem, it is unlikely that procedures would be covered by insurance or free clinics. Even when the techniques are actually available (as is amniocentesis in many United States medical centers), health staff may discourage their use. For example, some laboratories refuse to do karyotyping (i.e., to identify sex chromosomes) when fetal sex alone is the presenting indication[4] (Fletcher, 1979). Those providing the service would themselves have to publicize its availability because public channels would probably be unwilling to do so.

The techniques would probably be available mainly to the better-educated, higher-income, and urban elite in the United States and other developed countries with strong private health systems. In countries where most people relied on a national health service, the techniques would probably be hard to get.

Developing Countries

To understand the situation in the developing countries (and too many armchair philosophers have applied themselves to this), we might contrast the availability of *sex* control technology with *birth* control technology. Since the 1960s, governments in both developed and developing countries, private organizations, United Nations agencies, the World Bank, and commercial distributors have been trying to increase the availability of birth control. Laws have become generally favorable to birth control and most governments are actively encouraging its spread, being concerned about too-rapid population growth and threats to maternal and child health. Funding has been readily available for commodities (and in many countries, pills, condoms, and IUDs are free or available at very low cost), equipment, training, staff salaries, transportation, educational efforts, seminars, basic and applied research, and publications. Services and counseling are usually free and are increasingly offered in remote areas. Clients can usually choose among several effective and widely tested methods. And although countries differ, availability of birth control has certainly increased remarkably.

[4]For a fascinating discussion of whether doctors should do amniocentesis and selective abortion to select sex see Fletcher (1979), who argues that the Supreme Court decision on abortion gives American women the right to obtain an abortion without regard to their *reasons* for seeking an abortion.

Yet even with all this urgency, legitimacy, effort, and funding, poor people in many countries, remote areas, and city slums still lack services. And even when methods are physically available, couples fear and misunderstand them and exaggerate the side effects and question their effectiveness. Negative rumors abound and methods are often used incorrectly or are discontinued.

The situation with sex control would certainly be less favorable, even if the techniques were similar (e.g., pills, barrier methods). International and national support would be lacking because sex control would probably be seen as less socially desirable than birth control. Public information about the availability of procedures would be practically nonexistent and people would have to rely on private channels. Lack of official support would be crucial in socialist or communistic states.

Depending on the gender selection method, in societies based on a free-enterprise system, some practitioners might make techniques available in private clinics or hospitals in urban areas or, less likely, through commercial distribution (if it were a pill, which is probably the least likely method to be developed). Those holding the strongest boy preferences—men, those with low incomes, rural residents, and those living in North Africa and South Asia—would be furthest from services.

In either developed or developing countries, the techniques would be used by relatively few (compared to innovations like the watch or the bicycle). Candidates would mainly be couples (married or cohabiting) with the woman in the reproductive ages (15–44) who were not sterile, separated or divorced, and who wanted to have more children. (A few single women might also be interested.) In developing countries at least, those not yet having a first child would be unlikely to use the technology since sex composition is usually not a serious consideration until later in childbearing. First births are less subject to planning of any kind and are often sought as proof of fertility, regardless of the child's sex.

Only couples with definite and *agreed-upon*[5] sex preferences who had not already fulfilled their preferred sex composition (and had not rationalized their existing composition) would presumably be interested in sex control. Some potentially interested couples would be unaware that a technique had been developed, and if they were informed they might run into the availability problems mentioned earlier. The methods might not be acceptable (see the following discussion), especially if they required artificial insemination or selective abortion. Not all eligible couples would actually get around to trying a method, even if available; if the method required sustained motivation and discipline (pills, barrier methods, timing of intercourse), fewer still would continue the method and use it correctly. Not all women would conceive while using the method,

[5]Because husbands are usually more obsessed with having boys than wives are, there might be conflict over whether to have a boy or a girl.

especially if they were older. For those who did conceive, not all would give birth to a surviving infant. Finally, the technique would probably not work in all cases. For a description of a sex-selection clinic in Singapore using the Rorvik and Shettles (1970) rhythm and douching approach, which encountered most of these problems as well as ones not mentioned (for example, language differences between the counsellors and clients), see Williamson, Lean, and Vengadasalam (1978).

Although availability would certainly depend on the method, even the simplest, cheapest, safest, and most effective method would probably be unavailable to all but only a small urban elite in the richer developing countries.

Acceptability

For sex selection to become widespread, sufficient numbers of couples would have to approve both of the general idea of sex control and of one or more specific methods. The second aspect would probably be more of a constraint. Different techniques would have different barriers to use. Methods requiring selective abortion would encounter legal barriers in some countries, relatively high cost, unavailability in rural areas, some health risks, and emotional and ethical objections. Sperm-separation techniques would require the husband's cooperation and would probably be available only in clinics with laboratories. Methods in which couples have intercourse at particular times of the ovulation cycle require cooperation of both spouses, discipline, sustained motivation, and thorough education in the method (Whelan, 1977). On the positive side, the monetary costs of timing techniques would be low. Unfortunately for its users, the effectiveness of this approach is by no means assured and there are competing theories about the best timing. If pills and barrier methods were developed, they would presumably have most of the advantages of the present family-planning methods, particularly the need for sustained motivation. Methods would need long-term testing to assure that the children born using them would be normal.

Developed Countries

Because effective methods are not yet practical, it is difficult to predict how people would respond. When the methods are available, acceptance might increase as people become accustomed to being able to influence the sex of offspring; there could be a decrease in popularity if people became afraid of negative side effects. In order to improve predictions, several researchers in the

United States (but not elsewhere, to our knowledge[6]) have asked respondents about general attitudes toward sex selection and about specific methods. A 1969 study (Markle and Nam, 1971) of 283 students in three Florida colleges found that a quarter (26 percent) approved of sex control for themselves. More (46 percent) approved of others using the technique. Three-fifths (62 percent) approved in the situation of having had only children of one sex. Largey (1972) interviewed 126 married couples in Buffalo, New York, and found that 65 percent approved of sex control. However, only a small number (10) of the 58 couples not yet having children agreed among themselves on both the desirability of using sex control and the sex to be preferred. An analysis (Westoff and Rindfuss, 1974) of data from a 1970 national probability sample of 5981 currently married women found that 39 percent of the women approved of sex control. Five more recent studies have found even more widespread approval, possibly indicating more familiarity with the possibility. Rosenzweig and Adelman (1976) found that 60 percent of respondents in their study of 47 graduate-level-educated couples approved of sex control, particularly to get a balance of boys and girls. A larger study by the same authors (Adelman and Rosenzweig, 1978) obtained similar results from high-school-educated (65 percent approval) and college-educated (56 percent approval) couples. A college-student study (Hartley, 1981) with 2138 respondents from five colleges in northern California found approval by two-thirds (66 percent). However, two-fifths (44 percent) of the sample felt that sex-determination research should have relatively low priority and 10 percent felt it should have high priority. Another college-student study (Matteson and Terranova, 1977) found variable support among 45 undergraduate women when respondents were asked about use of sex control themselves but considerable support for use by others. Another study (Rodgers, 1979) of 222 University of North Carolina undergraduates found that 65 percent said they would use sex selection on certain conditions—depending on the technique and the sexes of previous children.

Because the samples are not directly comparable, we cannot say whether there has been increased approval over time. However, it is clear that there is sufficient general support for the technology to make it of interest.

When asked about different approaches, couples tend to approve of methods involving a pill or barrier method or timing of intercourse but not artificial insemination or selective abortion (Adelman and Rosenzweig, 1978; Markle and Nam, 1971). Hence, the nature of the method would probably be a deciding factor in its use.

[6]The fact that most of the social research on sex selection has been done in the United States suggests that the interest of Americans is higher than people in other developed countries, perhaps combined with a greater propensity of Americans to do research on connections between technology and society.

Developing Countries

Acceptability in developing countries is much more difficult to assess, given their diversity and the complete lack of research. It is clear that many parents have definite sex preferences, most often wanting boys. However, couples wanting large families would have little need for sex control. The common belief in some developing countries that one cannot limit family size and that birth control methods are ineffective might also lead to a skepticism about sex-control technology. People often fear innovations and see them as unnatural. In countries such as Korea, Taiwan, China, Hong Kong, and Singapore, where parents are having moderate to small families, have strong sex preferences, and where abortion is already common, methods involving early selective abortion might be acceptable. Artificial insemination would probably be less popular. People might have some of the same fears about a sex-control pill as they have about a birth-control pill.

Although sex preferences are often stronger and more extreme in developing countries, skepticism about modern technology is usually greater as well. Hence, overall acceptability might be about the same as in the developed countries. But availability of methods would certainly be much less in developing countries.

IMPACT OF SEX SELECTION ON SOCIETY AND THE FAMILY

Developed Countries

Given the likely restraints on availability and the fact that not all theoretically eligible couples would be sufficiently keen on sex selection and willing to use the techniques, if available, we feel that sex selection in the developed countries would be used mainly by a small elite of higher-income, urban, and well-informed couples who had strong sex preferences (usually for one of each sex) and were willing to undergo the inconveniences, risks, and uncertainties of sex selection. Here we assume that the methods available will be extensions of ones already being investigated, such as sperm separation and artificial insemination or sex detection and selective abortion, rather than a very cheap, effective, and convenient pill, which seems unlikely to be developed.

Because of the small numbers of couples involved and their probable use of sex selection to get a child of the opposite sex after having one child, or to have a firstborn (or only) son, sex selection would not have a noticeable societal effect. The desire to have a firstborn son might diminish if effective sex control were

available because parents could be assured that they could have a boy among the first two, even if the first were a girl (Adelman and Rosenzweig, 1978).

Effects would mainly accrue to the elite families involved. There might be greater acceptance of the children born. But because boys and girls have increasingly similar opportunities, the outcome for the family would not be dramatic. (And, of course, even if the children were of the desired sex, they might not turn out as the parents desired. Think of the parents whose child, as an adult, decided to have a sex-change operation!) A few births might be averted as more two-child families were of mixed sex and those parents could stop childbearing, and a few families might be tempted to go on if they were reasonably sure of the outcome. Some women might feel less worry about producing a son desired by the husband and might feel they had a little more control over their lives. Some children might feel they were especially wanted, and fewer than is the case now might feel that their sex was a disappointment to parents or grandparents. On the other hand, parents not succeeding with the technique might be quite disappointed.

In short, the small number of elite families might be a little better off and the majority would be either unaffected or somewhat frustrated that the techniques were not available to them also.

Developing Countries

Given the even more severe limits on availability in developing countries, the proportion of the population affected by the technology would be even smaller. The urban population makes up a smaller proportion of the total in developing (as opposed to developed) countries. And this urban population has less extreme sex preferences. Nevertheless, the absolute numbers affected might be greater than in the developed countries (given a suitable technology). But even so, the sex ratio would be unlikely to be affected. The sex ratios of these urban users would be high (i.e., more boys than girls), but might not be noticed in cities with already unbalanced sex ratios. In fact, some cities have more female in-migrants than males (Manila, Bangkok, Seoul, several in Latin America). On the positive side, some births would be averted. But given the tremendous growth in cities in developing countries, these trends would probably be scarcely noticed. The effects on families would be similar to the developed countries—smaller family size for some and possibly larger families for a few others, more security for women who could be sure of producing desired sons, more acceptance of the children born, and more control over the family's fate.

In societies where son preference is very strong and women have little security in marriage or in their husband's family until they have produced sons, sex

selection could considerably improve their situation. This is ironic, because sex selection is sometimes seen (e.g., Powledge, 1981) as the height of sexism. But the sexism is being directed, in the case where sons are preferred, toward preventing unwanted daughters. If the method involved selection, then these daughters would never have existed. Their not being born might improve the lot of those already alive (the mother and other daughters already born). A study by Welch (1974) found a hint of support for this idea in data from Bangladesh where girls had a higher survival rate if they were born into families with more boys than girls than into ones with more girls than boys.

Perhaps we should consider ourselves fortunate that sex selection is not yet practical. It gives us time to try to equalize the value put on boys and girls so that when sex control is more available it will prove to be superfluous.

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8

Legal Aspects of Prenatal Sex Selection*

V. JEFFERY EVANS

INTRODUCTION

The debate about prenatal sex selection has developed rapidly from the rather speculative exercises that characterized the discussion of this subject in the late 1960s (Evans and Serow, 1970). The issue has become part of the serious public debate about the use of emerging medical technology to influence the size, structure, and quality of the population. In fact, an experiment to enable parents to choose the sex of their children was attempted in Singapore during the years 1975–1977 (Williamson, 1978), and the advent of this effort and increasing public interest in sex selection have elevated the issue to a position of greater importance and visibility.

Although it is generally agreed that there is still no practical way to implement sex selection for the general population, medical technology has progressed to the point where it is possible to accomplish it on a highly selective individual basis and where the emerging medical techniques show sufficient promise to stimulate serious public discussion concerning their future utilization. The issue has ripened sufficiently to consider the legal aspects of using sex-selection tech-

*This reflects the opinions of the author and does not necessarily reflect the policy or the opinions of the National Institute of Child Health and Human Development.

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nology. This chapter presents a discussion of the legal problems that may be associated with the use of this emerging technology. It attempts to identify situations in which legal issues could arise and to extend existing legal doctrine to suggest possible resolutions of these issues.

Legal issues involved in prenatal sex selection could arise in two different yet related contexts. In the first scenario, sex selection would be seen as a factor in achieving quantitative control over the population. From an individual point of view, this would arise out of a desire to control the sex composition of the family in terms of the overall number of male and female children and also in controlling the order in which male and female children are born. From the point of view of society, sex selection could be desired as an inducement to achieve smaller family sizes and ultimately a reduction of population growth. One could speculate that couples would seek to achieve a certain number of male and female offspring and would continue to have children until that number is reached. This implies that families will be larger than desired and that a number of extraneous, wrong-sex births will be produced en route to achieving the desired number of male and female offspring. Allowing the use of sex-selection technology would presumably reduce the number of extraneous births and therefore contribute to smaller overall family size. In the second scenario, sex selection would be seen as a way of achieving control over the quality of the population. Individuals would desire to use the technology to either avoid sex-linked negative traits or to allow the family to optimize family investment patterns that depend upon the sex of the offspring. In these cases, the family's desire for control over the sex composition of children might be very great. From a public standpoint, sex selection could be desired to minimize the incidence of negative sex-linked traits and perhaps to enrich the age–sex structure of the population for economic, social, or political purposes.

The desires to control both the quantity and quality of the population combine to give two dimensions to the context of the legal analysis of sex selection. These dimensions are interrelated, but the analysis can be quite different depending on which dimension is emphasized. Within these two dimensions, private citizens could view sex selection much differently than government. Also, governments and legal systems vary greatly depending upon their cultural heritage and level of socioeconomic development. Public policy and law regarding sex selection could be torn by disagreement and vacillation if opposing viewpoints emphasize different dimensions of the issue.

If the sex trait is regarded as only one of a class of genetic traits that can be selected or avoided, then the sex selection issue becomes the vanguard of the genetic engineering debate. The present discussion only concerns the legality of the methods that would allow parents to choose the sex of their children before birth. This chapter confines itself to a narrow issue of sex selection, but the legal

principles governing it may be applicable to the broader problem of genetic engineering.

There are a variety of techniques of various reputations that may permit prenatal sex selection. None of the techniques is theoretically foolproof—sometimes the wrong sex is selected and some techniques may involve risk to the fetus and the mother. There are four that merit discussion. First is the so-called Shettles regime (Rorvik and Shettles, 1970), which involves manipulation of the environment and timing of coitus. The second involves selective insemination. This is a two-step procedure by which, first, the sperm is separated into two pools, one pool bearing the male trait and the other bearing the female trait. The second stage involves artificial insemination by sperm from the desired pool. These two techniques can be jointly discussed as selective fertilization. The third technique is selective implantation. This technique is as yet only a speculative possibility and would involve the fertilization of the egg(s) *in vitro* and then the selective transfer of an embryo to the mother. The decision to transfer the embryo would be conditioned on determining its sex and then transferring the embryo with the correct sex. The last technique is selective abortion. This is also a two-step process in which the sex of the fetus is determined and then abortion is implemented if the fetus is not of the desired sex.

The Shettles technique is a six-step procedure that recommends when and how to perform coitus in order to maximize the probability of producing a boy or girl.[1] A recent evaluation of a sex-selection clinic set up on the basis of Shettles regime in Singapore indicates that the technique is unsuccessful, at least as it was operationalized in Singapore (Williamson, Lean, and Vengadasalam, 1978).

Selective fertilization is a technique of sex selection that has been successfully applied in commercial livestock operations. Sex selection is accomplished by artificial insemination after sperm has been separated into andro and gyno sperm pools. The technique is dependent on the feasibility of separating the sperm into pools and has not been clinically proven in human populations, although some investigators have been successful in separating human sperm into sex-specific pools (Steeno, Adimoelja, and Steeno, 1975) or at least male-dense sperm fractions (Ericsson, Langevin, and Nishino, 1973). Should it be medically practical and safe to separate sperm into pools that are homogeneous with respect to sex trait, it might be possible to use artificial insemination from the appropriate sperm pool to produce offspring of the desired sex.

Selective implantation is a sex-selection technique that would involve fertilizing the egg(s) *in vitro* and transferring the embryo bearing the desired sex trait to

[1]An alternate, similar approach has been described in Guerrero (1975). These techniques involve recommendations regarding coital position, douches, orgasm, and timing of intercourse in relation to ovulation in order to produce the desired sex.

the womb. Possibly more than one egg could be fertilized and the resultant embryos tested for the desired trait in order to choose the embryo that would be transferred into the womb. Alternatively, one egg might be fertilized selectively to insure that the resultant embryo would have the desired sex trait. The embryo would then be transferred to the womb of either the mother or surrogate mother and carried to term naturally. Sex selection has not been successfully combined with *in vitro* fertilization and embryo transfer in humans, but it should be pointed out that *in vitro* fertilization and embryo transfer have been successfully performed in many animal populations and have been accomplished several times in humans. Given the significant number of infertile women who would be candidates for using *in vitro* fertilization and embryo transfer as a remedy for infertility, it is possible that *in vitro* fertilization may become a generally available medical procedure. If this should happen, then it might be possible to combine some form of sex-selection procedure to accomplish not only the goal of childbearing but also the goal of bearing a child of the desired sex.

Selective abortion is a feasible method of prenatal sex selection that depends on detecting the sex of the fetus as early in the pregnancy as possible, and then aborting the fetus if it is of the undesired sex. Since the 1960s it has been possible to gather cells shed from the fetus, which can be tested for various genetic traits including sex. The procedure is known as transabdominal amniocentesis. It is performed by tapping the amniotic cavity containing the fluid and the fetus. The tap produces cells from the fetus, which can then be cultured and tested for a number of genetic traits. If there is no contamination from the mother's cells or from other fetuses in the case of multiple pregnancies, then the test results can be known during the second trimester of pregnancy (MacIntyre, 1973). A consensus development exercise conducted by the National Institute of Child Health and Human Development concluded that midtrimester amniocentesis is both accurate and safe (United States Department of Health, Education, and Welfare, 1979). As laboratory facilities for performing amniocentesis expand in the United States, the procedure will probably become widespread in the detection of selected hereditary diseases. It will also produce information on the sex of the fetus. It is uncertain how many couples would resort to selective abortion solely for the purposes of sex selection. Procedures for providing them the capability of determining the sex of the fetus in time to effect the selective abortion will probably become increasingly accessible.

This chapter is organized to identify the legal issues surrounding sex selection and to suggest a legal analysis of possible ways of dealing with these issues. First, a conceptual foundation for a legal analysis of sex selection is developed. A number of paradigms are examined for their potential contribution to development of a coherent framework to support legal analysis in this area. The legal issues attendant to the use of the various techniques of prenatal sex selection already discussed are identified. The analysis of current law follows. This analy-

s.; draws heavily on the legal traditions of the United States but also attempts international comparisons. Last, trends in the law are identified to determine how the law might be extended to cover the various issues involved in sex selection. This section again draws heavily on the American experience, and the United States is compared to selected countries.

CONCEPTUAL FOUNDATION FOR THE LEGAL ANALYSIS OF SEX SELECTION

On what basis can a legal analysis of sex selection be performed? To answer that question, we must examine why society would regulate the decision making of its members. In search of an answer to this question, several conceptual paradigms are examined; it is hoped that one or an amalgamation of several paradigms will provide a foundation facilitating a legal analysis of the complicated issues surrounding prenatal sex selection.

The Economic Paradigm

Economic considerations frequently enter into legal analysis. It is therefore useful to examine an economic paradigm that may possibly be used to address the issues of sex selection. A commonly used approach is cost–benefit analysis. Each individual is seen as making decisions based upon the expected benefits and costs attendant to the decision. Similarly, society makes decisions on the basis of the benefits and costs accruing to its choices. A problem arises when individuals and society must make a decision about the same thing. In these cases, private cost–benefit calculations can deviate considerably from social cost–benefit analyses. Laws are sometimes enacted to balance these opposing considerations. Situations of this sort often develop because private decisions produce effects on individuals not immediately involved in the decision. These externalities can accumulate to produce a positive or negative effect on society; in the event that they are significant, society has an interest in inducing or compelling individuals to modify their decisions by doing more or of refraining from some activity. If the individual decision results in an activity that has a higher social benefit-to-cost ratio than private benefit-to-cost ratio, it is in society's interest to have individuals do more of that activity than they would be expected to do if they only considered their own situations. If the social benefit-to-cost ratio is less than the private, the reverse result obtains and society has an interest in curtailing the

individuals' activities. When the discrepancy between private and social cost–benefit calculations is sufficient to warrant governmental action, law may be developed either to change the parameters used by individuals in making those decisions so that resulting decisions are compatible with the social good, or to regulate individual activity so that individuals are forced to conform to the socially desirable conduct. For example, the state may require an individual to attend formal schooling to a greater extent than that person desires or may prohibit economic activity destructive to the environment.

Sex selection is a private decision that can produce significant externalities. The externalities touch every single member of the family, the offspring, and society in general. It certainly affects the texture of the relationship between parents and their offspring. In societies where sex roles are well defined, children born as a result of sex selection will have the course of their lives materially affected by that decision. Moreover, if sex selection materially alters the sex–age structure, the general socioeconomic welfare of society could be significantly affected. It is easy to imagine situations in which the externalities accruing to sex-selection decisions would accumulate sufficiently to warrant social intervention, and depending on the situation, the intervention might be oriented toward encouraging sex selection of a given type or curtailing sex selection in general or of a specific type. In order to develop law suitable for such intervention, rules must evolve to identify those situations in which externalities are so considerable as to warrant social intervention and to develop a framework that will balance private versus social considerations equitably.

In analyzing the benefits and costs of sex selection one must always look for what is gained or lost, quantitatively and qualitatively, by enabling parents to choose the sex of their children. Quantitative aspects of the decision involve overall family size and the number and parity of each sex. Qualitative aspects involve physical characteristics of the offspring and family investment strategies with respect to children of each sex. Becker and Lewis (1975) postulate that quantity–quality tradeoffs with respect to childbearing are natural concomitants of rising incomes and rising costs of child care. One might expect an increasing incidence of sex selection in societies characterized by increasing family incomes and costs of childrearing. In other words, the substitution of child quality for child quantity could be expected in these situations. One could also view childbearing as an investment process. In these cases, parents will invest in raising children, hoping for some form of return either to themselves or to society in the future. It is quite possible that the rates of return would vary considerably with respect to the gender of the offspring and the number of children in the family. The rates of return would vary according to the overall state of economic development and the cultural setting in which sex roles are defined. Depending on the level of socioeconomic development and the institutional context, it is quite likely that quality versus quantity tradeoffs in childbearing decisions would vary

markedly among cultures. One must conclude that if the economic paradigm has relevance to childbearing, then child quality versus quantity tradeoffs are natural parts of the decision process involving childbearing and should be factored into every public and private consideration regarding fertility, including sex selection.

The Ethical Paradigm

Ethical considerations of sex selection tend to follow the economic paradigm very closely. The ethical paradigm is heavily influenced by the competing desires to protect both individual rights and collective rights. In balancing the rights of the affected parties involved in a sex-selection decision, it is constructive to sort out the interested parties, the decision maker(s), and the circumstances impinging on the sex-selection decision.

The affected parties to the decision regarding prenatal sex selection include: (a) parents, (b) present and future children, (c) close kin to the family, and (d) society at large. Issues like sex selection involve a clash of interests and, as such, it is imperative to determine a hierarchy of rights that will determine the outcome of the decision process. This really reduces to the question of identifying the decision maker(s). Once the decision-making unit is identified, it is then necessary to develop rules to protect the interest of other individuals and society in general. These rules must specify when these related interests must be recognized and how these interests will be factored into the decision process.

Rules of law must evolve to identify the decision maker(s) involved in sex selection and to determine how all of the competing interests will be balanced in the decision process. These legal structures must balance the competing individual interests of protecting social integrity, and they must be developed within the existing cultural traditions of society. For example, in the Anglo-American legal tradition there is a tendency to give a primacy to individual rights and impinge on individual decision making only when necessary to protect key social institutions or to protect society from outcomes of the decision process that might accumulate to the significant detriment of society. In regard to sex selection, it is possible that severe sex-ratio imbalances could occur that would force social institutions like marriage and the family to adapt in unusual ways. Also, the use of technology to produce sex selection could possibly spin off into more general applications of positive and negative eugenics that significantly alter the structure of society in either a positive or negative way. In the Anglo-American tradition, individuals would be given freedom to choose the sex of their children subject to the rules developed to provide for the protection of outside individual interests and the societal concerns mentioned previously. In contrast to this approach

would be the socialist tradition, which would reverse the priority of rights and develop rules governing sex selection that would best suit the interest of society subject to the needs of the individuals involved. For example, in an article on population control in the People's Republic of China, Deputy Prime Minister Chen Muhua outlined why the control of population growth was absolutely necessary to accomplish the modernization and development of China. Also, Chen took great pains to couch the control of population growth as "an objective demand of the socialist system [Population Council, 1979, p. 724]." China has revealed targets for population that would produce zero population growth by the end of the century. In order to do this, they are attempting to eliminate large families and to popularize the one-child family. Individuals are expected to subordinate their interests consciously to the overall goal of controlling population growth by adopting one-child families (Population Council, 1979, p. 730). Interestingly, a severe barrier to this policy is the problem of son preference existing among the masses. China is now faced with the problem of either dissuading the masses of son preference or of providing technology to allow couples to achieve this preference.

The economic and ethical paradigms can be combined to form the conceptual basis of a legal analysis of the problem of sex selection. Applications of these paradigms are expressed differently in the various legal traditions that exist in the world. Nevertheless, it is useful to approach legal problems from the standpoint of the two paradigms in order to give the discussion a logical consistency and to facilitate the comparative analyses of different legal traditions.

LEGAL ISSUES

A myriad of legal issues arises out of the three major categories of sex-selection technology (i.e., selective fertilization, selective implantation, and selective abortion). The constellation of issues attendant to each category contains many similarities, but there are enough differences to warrant separate treatment of the issues involved with each technique. In this section, the complex typology of issues surrounding each of the three categories of technology is traced so the reader may assess the diverse contingencies that any legal system must address. It is first assumed that the prevailing population policy of society is gender-neutral. In other words, society does not explicitly prohibit or compel prenatal sex selection. In this type of legal environment, issues tend to arise out of the doctor–patient relationship or conflicts among parties affected by the prenatal sex-selection decision.

In a gender-neutral legal environment, questions regarding the extent to which

government may prohibit or compel prenatal sex selection are not relevant. However, it is important to regulate the scope and conduct surrounding the relationship between the attending physician and the patient. In so doing, it is important to determine the rights and duties of each party to the transaction between doctor and patient, to determine when and under what circumstances the cessation of that relationship may occur, to determine what the standard of medical care is in each circumstance, to develop rules regarding breach of the duty to provide proper care, and, last, to determine the extent to which the physician must act as a counselor to ensure that the patient is properly educated concerning the ramifications of the prospective treatment. In addition, the law must develop rules to identify the decision maker regarding sex selection. The law must then also develop rules to determine the factors that the decision maker must take into account. Finally, rules must be developed to take into consideration the effects on family members, the prospective children, and society in general.

Selective Fertilization

The legal issues attached to the use of selective fertilization technology can involve the use of either the Shettles regime or some form of artificial insemination. Because we are assuming in this section that there is no formal governmental policy to compel or prohibit sex selection, the legal issues would arise between the individual actors in the sex-selection process. The actors would represent three distinct interests. The first interest is that of the decision-making unit governing the sex-selection process. This unit might involve only one person, for example the mother, or it could involve a group of people, for instance the couple or the family. The second interest is represented by those individuals who would give access to the medical techniques necessary for achieving sex selection. These representatives could be an individual doctor or an entire medical team. The third interest is something of a residual category. It includes individuals who are instrumental in the process of sex selection but who are not medical specialists and individuals outside of the decision-making unit who are affected by the act of sex selection. For want of a better phrase, let us refer to this collection of diverse individuals as the third-party interest. This triumvirate of interests challenges the law to develop rules to identify the members of each class of interest, to evolve rules of law regulating the interaction among multiple parties, if any, involved in each interest group, and to define how the interest groups may interact with one another. The three spheres of interest must act cooperatively to achieve sex selection, and the law must therefore be structured to facilitate cooperative behavior and to discourage breaches of any agreement

that may ensue. Also, the interaction among these interests might impinge on the personal rights of some of the parties involved and certainly would give rise to a set of duties and obligations among the parties, which must be enforced in order to avoid doing personal harm to one or more of the parties involved in the process.

The Shettles Regime

Turning our attention to the issues arising out of the use of Shettles regime, let us first examine the parties who are logical candidates to occupy the three interlocking spheres of interest. Because the use of this technology necessarily implies a complicated, cooperative pattern of conduct between the parents, the decision-making unit would seem to involve both the male and the female. The decision-making unit could easily be expanded to include the family, but it is difficult to imagine how it could be smaller than the couple in question. Representatives of the medical community could be numerous and varied (e.g., a clinic setting involving both medical and paramedical personnel). On the other hand, this interest could be represented by only one individual (e.g., an individual physician or a paramedic). Indeed, because the technique is essentially a do-it-yourself regime, parents could practice this technique without any contact with the medical community. Legal issues would arise in the certification of personnel capable of providing the information, counseling, and related medical services, and in sorting out the relationships among the diverse types of individuals constituting a medical team. The third-party interest could be negligible; it could contain the immediate family that would be affected by the various outcomes in sex selection; it could be quite numerous, reflecting the interests of society at large and perhaps even prospective progeny. The law will find this sphere of interest particularly difficult to define because of the many possibilities involved. The choice of representatives for the third-party interest will undoubtedly be determined by the prevailing public policy regarding population growth and the family. If the prevailing policy is antinatalist, then the interest of the prospective progeny in the family may be relatively unrepresented. On the other hand, if the traditional interests of the family are being promoted by the state, the impact on the family may also be considered within this sphere. In this case, it is possible to imagine a clash between anti- and pronatalist policy, and some compromise position would necessarily evolve to strike a balance between two partially competing policies. Also involved, and possibly the object of public policy protection, is the interest of the prospective progeny. Depending on the culture and the relative stage of economic development, gender may make a material difference in the course and quality of life. This is especially true if the practice

of sex selection significantly altered the sex ratio so that the sexes were materially unbalanced within any cohort. If public policy attempts to acknowledge all of these interests, then it must develop rules of law to delineate hierarchies of priority among these interests and also minimal guarantees to provide for the protection of less-favored parties within this group.

Once the representatives of the various interest groups have been ascertained, the law must develop rules governing the interaction between the spheres of interest. In this regard, a number of thorny legal issues arise. Consider the relationship between the decision-making unit and the medical community. Because the role of the medical community in executing the Shettles regime is primarily that of counselor, it is difficult to determine exactly when medical treatment begins and when it ends. This is particularly important in legal traditions that give legal redress to patients who have been abandoned by their physicians. The issue of abandonment (Wyatt, 1980) involves the question of whether the medical team has provided appropriately sustained levels of supervision over the course of the treatment and whether the team has notified the patients that it is terminating treatment if and when that does occur. If it is difficult to ascertain when a particular form of treatment has begun, it will be equally difficult to determine when it has ended and how it was conducted during its course. A hypothetical case may clarify this issue. Suppose that a couple has read about the Shettles regime in the popular literature and asks their physician his opinion of the efficacy of the technique. Also suppose that the physician responds positively about the technique. Does this constitute the beginning of a doctor–patient relationship? If so, what level of effort should the doctor take to follow up on the actual practices of his patients? When is the relationship terminated, and how, if at all, should the physician communicate his intention to terminate the treatment to his patients.

If the parents seek out a medical clinic to provide counseling and diagnostic services such as the clinic involved in the Singapore experiment, the definition of the doctor–patient relationship is less problematic. However, it gives rise to another legal issue: To what extent does a clinic or practitioner specializing in this type of service guarantee results (Wyatt, 1980)? This could be a problem particularly in those cases in which the state is attempting to promote the sex-selection technique, as in the Singapore experiment. The provision of medical services could be accompanied by a great deal of rhetoric indulging in claims of efficacy that may not be realized by the patient. The clinic (or physician) might attempt to stretch the truth in order to build enthusiasm and discipline in patients. In this case, the clinic (or physician) might place itself in the position of guaranteeing the success of the treatment. This would give rise to the issue of whether or not the clinic (or physician) has made a contractual commitment to its clients that would give rise to a breach of contract action should the wrong sex be produced.

Also, because of the unproven nature of the technique, this type of conduct could give rise to questions regarding fraud in the inducement of patients to engage the clinic's (or physician's) services.

The law would necessarily be required to develop rules to acknowledge when a contractual relationship existed between the medical community and patients involved in this kind of effort, and also to describe the remedies available to the parties for any breach of that contract. In light of the scientific controversy surrounding the efficacy of the Shettles regime, a related issue of fraud might also attach itself to these contractual issues.

If a breach of contractual relationship and/or fraud is found, the question of damages quickly arises (Reilly, 1981; Wyatt, 1980). How would parents be damaged by a breach of contract involving the Shettles regime? Certainly, the outcome could be at variance with their expectations. For instance, a girl might be produced when a boy was desired. How does one quantify the monetary value of this disappointment? A related claim may involve an unwanted increase in the size of one's family. For instance, if a couple had decided not to have any more children except a girl, they might argue that they were burdened with an additional unwanted dependent if a boy resulted from the treatment. In order to impute a monetary value for these types of damages, one must necessarily compute the benefits and costs attendant to an addition to the family for each sex, and these costs and benefits would necessarily be subjective from the point of view of the parents in question. This could result in a complicated, if not impossible, requirement of proof. What about the disappointment, anxiety, and wasted effort that the parents experienced in cases where the wrong sex is produced in their offspring? The existence of a doctor–patient relationship gives rise to rights and duties in each of the parties, and a failure to perform adequately one's duty resulting in harm to someone else could give rise to legal action. In this case, the law would have to recognize under which circumstances rights and duties would arise in the doctor–patient relationship regarding the Shettles regime and also quantify the damages to the parents in terms of disappointment, waste of effort, and maybe even the effects of this disappointment on the development of the offspring in question. To what extent is a couple damaged if the wrong sex is produced? To what extent will consequential damages be awarded for the mental anguish to the parents, to the child born with the wrong sex, and to the family if, for instance, a greater family size results from the failure to produce the right sexual portfolio? It would be extremely difficult to estimate concrete damages in any of these cases. There is also the question of punitive damages. Punitive damages could easily be awarded in cases involving wrongdoing by the physician such as malpractice or the failure to provide proper information to effect informed consent in his patients. A more difficult question is whether punitive damages would be awarded in those cases in which a breach of a contractual arrangement to produce the desired sex is alleged.

A closely related legal issue is the quantum of information required to be transmitted from the physician to the patients. In the United States tradition this requirement is referred to as *informed consent*. A physician attempting to help patients in the proper use of the Shettles regime might be required to advise them as to the risks of failure and any side effects that might result from the treatment and to provide accurate medical information concerning the proper utilization of the Shettles technique. The physician not providing this quantum of information might be held to have breached a duty owed to the patients and thereby be found guilty of doing harm to them. Using the United States example, that physician would be found negligent in the performance of the duty to provide informed consent to patients. Of course, if found guilty of doing harm to patients, the legal system would be challenged to quantify the degree of harm and to provide a remedy to make the patients whole again. In the United States tradition of law, this would result in payment of a sum of money from the physician to the patients representing the degree of harm done to them because of the physician's negligence. In other legal traditions, the grounds for recovery and the amounts of recovery may be prescribed by statute, and if practice were found to be at variance with the dictates of the statute, then the physician would automatically be liable for damages or be punished in some criminal context (Reilly, 1981; Wyatt, 1980).

In sum, there are a variety of grounds by which a physician could be held legally accountable to patients for advising them to use the Shettles regime for sex selection. A physician could be found guilty of breaching a contract to provide the couple with the correct sexual portfolio of their children. Alternatively, a physician could be found guilty of a failure to follow up to help patients successfully follow the rigors of the regime. Last, a physician could be found guilty of negligence. In this case of negligence, it must be proven that the duty of care expected of a physician in providing advice was violated regarding the Shettles regime. This would almost always involve closely aligned issues involving informed consent because the bulk of the treatment consists of advice, and the advice must be such as to allow the patient to make an informed decision regarding the treatment to meet the burden of the doctrine of informed consent. Damages arising out of any of these actions would be difficult to prove concretely. Legal rules would evolve to accommodate allegations of actual or consequential damages arising out of the birth of a child with the wrong sex. It is possible to foresee punitive damages being awarded in the case of the Shettles regime because of the suspect nature of the treatment and the unruly nature of the doctor–patient relationship involved in practicing the Shettles regime that could easily produce situations that would be very embarrassing to the physician in retrospect.

Legal issues may also arise in clashes between the interests of parents and the interests of third parties, however broadly defined. One of the most problematic

issues involves the rights of the offspring. If, for instance, parents who choose to have a girl are effective in implementing that choice, does the resulting female offspring have redress should she have preferred to not have been born at all rather than born female? If the legal system determined that the offspring was wronged by the decisions of its parents, it would be quite complicated to formulate an accurate estimate of damages attributable to being born the wrong sex. This issue is related to an even more perplexing problem—whether the offspring can seek redress against the medical community for either providing insufficient or wrong information to their parents resulting in an unfavorable gender selection for that person. In the latter case, the offspring may argue that, for instance, she was born a girl when her parents intended her to be a boy and that has resulted in damages to her because of negligence on the part of the medical community. A related issue could involve an allegation by the child that the physician failed to advise the parents about the long-run implications of choosing the sex portfolio of their family and of dealing with any mistaken sex. This latter issue could place a severe burden on physicians in that members of the medical community would be forced to anticipate all of the problems and all of the developmental disabilities that could result from disappointment with the gender outcome of any particular birth.

Other issues could arise between the third-party interest and the medical community. For example, the state could require the doctor to represent the state's position on prenatal sex selection to the parents, and this would conceivably involve the doctor in a conflict of interest in those cases where the choice of the parents is at variance with the policy of the state. A hierarchy of laws must be established in those cases to inform the physician and the patients of their respective roles in given situations.

Artificial Insemination

The legal issues arising out of the use of artificial insemination as a selective fertilization technique to effect sex selection are slightly more varied and complex than issues arising out of the use of the Shettles regime. The legal issues and rules governing the doctor–patient relationship in regard to whether the physician is acting as a guarantor of the technique and whether the physician has abandoned the doctor–patient relationship improperly are similar to those discussed with respect to the Shettles regime. Issues involving negligence and informed consent are sufficiently different from those in the Shettles regime to warrant continued discussion. Also, issues involving parentage must be discussed because of the novel possibilities presented by artificial insemination.

Because artificial insemination involves both doctor–patient counseling and

some rather complicated procedures on the part of the physician, the possibility of malpractice suits on grounds of negligence is increased. It is likely that issues involving informed consent would be intermingled with issues involving negligence, as is the case in many malpractice suits. If the fetus is damaged by the procedure or if the wrong sex is produced, then issues involving the extent to which the physician provided the patient with sufficient knowledge to make an intelligent choice concerning the procedure can arise and compound the legal difficulties of the physician. Sex selection achieved through artificial insemination presents many opportunities for doing damage to the fetus, and very little is known about the likelihood of these occurrences. It would therefore be prudent for the physician to provide extensive information concerning the steps in the procedure and the possible outcomes, for better or for worse, involved in each step. It is especially important that the possibility of producing the wrong sex be discussed at length. This is because the physician would wish to establish that he is not a guarantor of the success of the procedure and to foreclose the possibility that informed consent issues would be blended with concerns about the actual conduct of the procedure to form a negligence action.

Sex selection through artificial insemination involves the cooperation of more than one person and, therefore, the law must develop rules to determine how much information each interested party is entitled to regarding the procedure and to what extent their individual desires will control the process. Various combinations of four potential classes of people can emerge to form the decision-making unit regarding artificial insemination. The members of the decision-making unit must be provided with adequate information to be able to make an informed judgment regarding the procedure. The classes of potential people who could be involved in the decision include: (a) the mother (the woman who would raise the child), (b) the father (the man who would raise the child), (c) a surrogate mother (a woman who would be inseminated and give birth to the child in place of the mother), and (d) a surrogate father (a man who would donate sperm in place of the father).

The law must evolve rules determining who will make decisions regarding initiating the procedure, who will make decisions regarding the disposition of the sperm before insemination, who will make decisions regarding the actual fertilization, and who will make decisions regarding prenatal care and the actual delivery of the child. It is possible that the decision-making unit could change during the process. For example, the man donating the sperm could be the decision maker regarding the disposition of the sperm before fertilization, the couple charged with raising the child could make decisions regarding fertilization, and the woman bearing the child, be it mother or surrogate mother, could be entrusted with making decisions regarding prenatal care and delivery. Other combinations could obtain depending on the controlling legal system. This

means that legal rules governing this type of procedure must necessarily be quite complex and almost certainly be very confusing to the physicians attempting to implement the procedure.

When the child is born, questions of parentage become complex. In the simplest case, where the natural mother and father actually contributed the biological material and carried the pregnancy to term, parentage is clear. However, in the case in which a surrogate father has donated sperm, the parentage question could change. For instance, is the child born under these circumstances to be considered an adopted child of a natural father or his real child? Does the surrogate father have any rights at all regarding the child? Another interesting question arises in the case of the natural mother who is not married and intends to raise the child as a single parent. Does the man contributing the sperm have any fatherhood rights at all? If the legal system does recognize rights for male sperm donors, does the woman have any power to contract with that man to modify his rights before the insemination takes place? The case of the surrogate mother is an even more complex example. In this case, the law must develop rules to determine the extent to which it will recognize contractual arrangements between the mother and father and the surrogate mother regarding the time and place of fertilization, prenatal care during pregnancy, rights to terminate the pregnancy, conditions governing delivery, and parentage of the child once it is born.

Once the child is born to a surrogate mother, is the child to be considered the natural child of the surrogate mother which is then adopted by the mother and father contracting for her services, or is the child considered to be the natural child automatically of the woman (or couple) contracting for the birth? Another interesting question is whether the mother (or couple) contracting for the birth can refuse to accept the child if the child is defective or of the wrong sex. A more complicated question is whether a father can contract with a surrogate mother to produce a child without the involvement of the mother (the woman who will actually raise the child, presumably the wife of the father). If one adds a surrogate father to the question of a surrogate mother, then the legal questions become complicated indeed. This is because the decision-making unit swells to its largest size both in regard to the processes under which the child is produced and the eventual parentage of that child.

Any legal system will have to contemplate all of these diverse contingencies and develop a logical, systematic hierarchy of rules to define the decision-making unit, to determine what rights arise during the various stages of the process, and to determine how the parties may contract among themselves to tailor the rights and obligations involved in the process to their particular needs. Also, if sex selection via artificial insemination is to be controlled through a multiparty contractual relationship, the law must contemplate what remedies will be available to the parties involved in case of breach of contract (e.g., specific performance or damages) and whether the child will be recognized as a third-

party beneficiary under the contracting scheme. Moreover, if the child is recognized as a third-party beneficiary to the contract, the law must determine if the child will have any remedies against the parties to the contract in the case of breach of contract. Otherwise, the issues arising out of disputes between the third-party interest and the other interests are similar to those of the Shettles regime discussed previously.

Selective Implantation

Sex selection achieved through selective implantation raises many of the same issues already discussed regarding sex selection through selective fertilization. The issues of the physician acting as guarantor of the process and of abandonment of treatment by the physician are identical to those discussed above. Similarly, questions of negligence and informed consent are identical to those discussed above. However, because selective implantation involves fertilization *in vitro* (rather than fertilization *in vivo* as in the case of selective fertilization discussed earlier), a number of new issues arise; discussion of them follows. It is helpful to divide the issues involved in selective implantation into three cases. Each case represents a slightly different variation in sex-selection technique. In each case, the analysis of the issues is complicated by thorny questions involving the makeup of the decision-making unit. This is because not only can the decision-making unit become much larger than those previously discussed but also the process involves more steps and potentially a longer period of time than selective fertilization *in vivo*. Particular attention will be paid to these questions in the discussion of each case.

Selective Implantation with Testing for Sex

In the first case, a single egg donated from the mother is fertilized *in vitro* by sperm donated from the father. The resulting embryo would then be tested for the sex characteristic and implanted in the mother if the embryo possessed the desired sex trait. This procedure is not possible under present technology because the diagnostic test would result in the destruction of the embryo. For the sake of completeness, and on the chance that a suitable diagnostic test will become available sometime in the future, it is useful to examine the legal issues arising out of such a procedure. Certainly, such a diagnostic test would involve some risk to the embryo. This is because it would probably invade the embryo in some way. Such handling of an embryo in the early stages of its development would involve many possibilities of accidents and also may affect the long-term devel-

opment of the resulting child in ways not easy to anticipate. This leads to a discussion of two other related technological issues. First is the problem of how long to allow the embryo to develop *in vitro* before the diagnostic test is performed, and second is the problem of delaying the development of the embryo by freezing. Presumably, the more developed the embryo, the easier it will be to obtain material to be used as a test. On the other hand, the longer the embryo is allowed to develop, the more problems in transferring the embryo back into the mother are likely to develop. Moreover, once material is separated from the embryo, it may take some time to culture the material to develop a mass sufficiently large to test for the sex trait and other genetic characteristics. Decisions must be made as to how to test, when to test, and when to re-implant the embryo. It may prove beneficial to arrest the development of the embryo through freezing to allow the test material to mature to a proper mass or to allow the mother's cycle to be restarted so that the embryo can be transferred at an optimal time in the menstrual cycle. Freezing the embryo involves immediate risks to the embryo and also introduces the problem of the length of time before implantation.

All of these steps involve some risk to the embryo that must be explained to the prospective parents so that conditions of informed consent are met. The law will be hard pressed to develop rules for defining the quantum of information that must be delivered to the decision-making unit and defining the rights and obligations of the parties to the decision.

Determination of the decision-making unit regarding selective implantation is of prime importance because this issue permeates all of the other legal issues arising with respect to the technique and may be the prime focus in developing legal rules for resolving these issues. Its determination is made difficult because it could swell to subsume all of the other interests mentioned in the previous analysis, and primary responsibility for making decisions could shift among the members of the unit during different stages of the process. Because the technique involves cooperation of both the natural mother and father in donating biological material to achieve fertilization, both actors are prime candidates for inclusion in the decision-making unit. Their cooperation is absolutely necessary to achieve the first step in the process—fertilization. The cooperation of medical specialists is also necessary to achieve fertilization. The physician must gather biological material from both parents and create the conditions facilitating fertilization *in vitro*. Because absolute control of the process is transferred to the physician while creating the conditions surrounding fertilization, it is possible to imagine the inclusion of the physician in the decision-making unit, at least for some point in the process. The decision-making unit could grow even larger if a surrogate mother is utilized. This is because the surrogate mother would have control over the process for the length of time she carries the child. Similarly, a surrogate father could be used to donate sperm; because his cooperation is at least a

necessary condition for the process, his interest may be included in the decision-making unit, at least for some portion of the process.

What about the embryo itself? The decision to include the embryo in the decision-making unit is more difficult here than in the case of selective fertilization because the embryo would exist as an independent entity outside of the mother's body for a measurable period of time. The matter is made even more difficult because the possibility of freezing the embryo for extended periods of time would also extend the period of time that the embryo exists as a distinct, independent entity. Also, the possibility exists that the embryo will contain the wrong-sex trait and would therefore not be implanted. If the embryo is unwanted and yet still continues to exist as an independent entity outside the body of the mother and if, in addition, it is possible to preserve the embryo through freezing for extended periods of time, does the embryo have a right to be included in the decision regarding its future? At this time, it is unknown whether it is possible to freeze a human embryo and, if so, how long the embryo could be maintained in a frozen state. However, it potentially could be done for many years. The life of a frozen embryo could presumably even extend beyond the lives of the natural parents. In any event, the embryo could be brought to term by a surrogate mother at any time. If the natural parents are unwilling to bring the fetus to term, or if they die and the embryo lives on in a frozen state, the possibility of adoption arises. This means that the fetus would have many possible parents and, in this case, representatives of the state may be included in the decision-making unit to effect the adoption. Prime candidates for adopting an embryo so situated would be family members of the natural parent. Grandparents, uncles, aunts, and even members of future generations are potential family members and may wish to adopt the embryo into their families. In many legal traditions, the kinship ties of these family members might give the family representation in the decision-making process.

As this analysis suggests, the decision-making unit could swell to an enormous size and subsume many conflicting interests within it. The unit can become so large and unruly that any legal tradition would have trouble developing rules to define the boundaries of the unit and rules for regulating the decision process if the decision unit contained more than one interest. The possible way of handling this matter is to develop different legal rules for each stage in the process. If the structure of the decision-making unit shifts during the process, it is possible that some actors and interests would be involved in decisions regarding one stage but not another. Moreover, because the process splits into conditional branches depending on the implantation decision, it is possible that actors and interests would come into play contingent on the outcome of this particular decision. Do the actors and interests that are included in the decision-making unit at latter stages of the process have a right to be kept informed of the progress of the

process in earlier stages and do they have a right to advise or consent to decisions made in the earlier stages? To develop a feel for the issues that could arise out of these considerations, it is useful to examine each stage of the decision process in terms of the possible structure of the decision-making unit and in terms of the rights of interests involved in future stages of the process.

The first stage involves the collection of biological material from the mother and father and seemingly would involve primarily their decision to donate the material. The decision-making unit would logically embrace them alone. Cooperation of medical specialists is necessary in gathering the material, but it is possible to confine the interests of the medical community into a separate sphere and treat the interaction between the physician and the parents as a traditional doctor–patient relationship. Must the parents inform the physician that they may reject the implantation on the basis of sexual characteristic of the embryo and must they inform the state and other potential interests in the decision tree already outlined? An interesting related issue is whether any of the parties that could be included in the decision-making unit at later stages in the process can veto the process or have a right to drop out of the process from the beginning. For example, the physician might wish to terminate the relationship if it appears possible that the parents would refuse implantation on the basis of the sexual characteristics of the embryo. One might well argue that the physician has a right to be informed as much as the parents concerning the future possibility of this occurrence and also has the right to abandon treatment if future prospects of the process are unacceptable. Similarly, the state representing the third-party interest may have a legitimate interest in being informed at the beginning of a process that potentially could involve it in some form of an adoption proceeding contingent on the decision to implant. The state may also have a legitimate role in insuring that full information regarding the present and future status of the fetus be developed and transmitted to the essential parties of the subsequent stages in the progress. The rationale for this might be that potential adopting parents may wish to have information in addition to the sexual characteristics of the fetus, particularly information regarding the possibility of any genetic defect or deficiency in the embryo. The state may also wish the natural parents themselves to be fully informed of these matters on the grounds that it is good health policy to have parents fully informed about the condition of their potential offspring and, possibly, that it is good public policy to have decisions regarding implantation based on the most complete information available rather than on the sex characteristic of the embryo alone. A counterargument to the proposition that the state and other interested parties to the decision should be made aware of the possibility of sex selection through selective implantation at the time that the biological material is donated is that, at this stage, selective implantation is only a possibility and it may be premature to put such a burden on the parents and/or the physician in charge of the procedure.

The second stage of the process involves the actual fertilization of the egg. At this stage, the material is now distinct and separate from the bodies of the parents and has combined to form a distinct biological entity—the embryo. Moreover, the fate of the embryo is in the hands of the medical community. This gives rise to a number of compelling legal issues. First, when—if ever—does the ownership of the biological material pass from the donors to the collective decision-making unit, and does the ownership of the biological material ever pass on to the medical personnel? For example, does the physician alone have decision-making power and ownership of the biological material as it is entered into the *in vitro* fertilization process and, assuming that fertilization is completed, does the physician have any control over the excess material? Will the physician's interest be kept distinct from the decision-making unit at the time of fertilization, or will the physician's interest be merged into the decision-making unit once an embryo is produced *in vitro?* The argument for including medical personnel in the decision-making unit is that they now have total control of the process and, as such, they should be vested with power to make critical decisions. An argument against including them in the decision-making unit is that they are still performing under the traditional umbrella of the doctor–patient relationship and are rendering a service to patients who should be vested with the primary decision-making authority governing the process.

At the time of fertilization, the process changes from a mere possibility of selective implantation into concrete reality. As long as the embryo lives, it is certain that a decision must be made. This again raises the question of the right to information by interested third parties who may be involved in subsequent stages of the decision process. The right of the physician to know the intentions of prospective parents gains greater importance. At this point, it is necessary that the parents notify the physician that they wish to have the embryo tested for genetic traits, and it is conceivable that the law might require the parents to inform the physician regarding their intentions of using the information derived by these tests in deciding whether to accept implantation or not. Also, it is an interesting question whether the parents can request information on the sex trait alone or whether the physician or the state can compel them to learn the maximum amount of information possible concerning the genetic makeup of the potential offspring. At this point, it becomes more difficult for the physician to terminate treatment if he or she finds the prospect of selective implantation solely for sex-selection purposes to be displeasing. This is because the physician now has a live embryo completely under his or her care and if he or she totally abandons treatment, the embryo will surely be destroyed. The law might require the physician to maintain the embryo until suitable substitute medical treatment can be found. Also, the law might require that the information be given not only to the parents but also to representatives of the state and possibly other interested parties who might be involved in the decision process. This may merely involve

notification that the process has begun or could involve the transmission of all or part of the technical information derived from the process. The burden could be placed on either the parents or the physician or on both to provide this information. Depending on the degree of information required, it could place quite a strain on the doctor–patient relationship especially if the physician is required to notify the state if his or her patients have indicated how they will use information derived to make decisions regarding implantation. Arguments in favor of compelling that information be provided to interested parties about the process become stronger because the existence of an embryo means that what was only a potentiality has now become a reality, and many legal traditions may attach concrete rights and obligations to future interests at this point.

The third stage in the process involves testing the embryo for the sex characteristic and, possibly, the preservation of the embryo if it is to be stored through freezing for any length of time. This stage raises many of the same issues as the fertilization stage but differs from it in requiring that a number of important decisions be made that will have implications for the rest of the decision process and the eventual outcome. The first decision is when and how to test the embryo for the sex characteristic. This is mere speculation, as no suitable test now exists. However, it is conceivable that one or more types of tests may become available for determining the sex characteristic. If there were multiple tests available, they might have varying degrees of accuracy in determining the sex trait and might provide varying degrees of information about the genetic makeup of the embryo in addition to the sex characteristic. Performance of the test would involve medical science to a high degree, but it might also involve other interests. For example, there may be alternative methodologies available for determining sex characteristics that would yield varying degrees of ancillary information about other genetic traits. The issue arises as to how much information the decision-making unit should have and this, of course, affects the choice of testing methodology. For the reasons already discussed, public policy may demand that complete information concerning the genetic characteristics of the embryo be developed, and this might conflict with the desire of the parents who, for example, may only wish to know the sex characteristic. It is conceivable that laws could be developed that would limit decision-making in this regard and compel the development and disclosure of complete information about the process.

Another decision point is reached if there is a choice of techniques for implanting the embryo. For example, one technique might implant immediately; another technique may require that the embryo be frozen for a period of time. In choosing one technique over another, one obviously must grapple with the varying conditions of risk of each methodology. A related concern is the access to information about the tests. If the embryo is to be implanted as soon as the test results are known and without delaying its development through freezing, there is obviously very little time to waste in making the decision. This is an obvious constraint on

the ability of interested third parties and the state to provide advice and perhaps consent to the process. If, on the other hand, a technique is chosen that would freeze the embryo for an extended period of time, the length of time to make a decision after the test results are known becomes quite attenuated. This would afford much opportunity for third-party intervention into the decision process. It is conceivable that legal issues could arise that would compel the choice of one technique or another depending on how many parties are to have access to the information and how many parties will make up the decision unit governing the future course of the process. A related issue is pertinent to the physicians's continued participation in the process. If the embryo is not to be frozen, then once fertilization has been accomplished, there is very little time for the physician to terminate the treatment if he or she discovers that the decision to implant would be controlled by the sex characteristic of the embryo and objects to that choice on moral grounds. On the other hand, if the embryo is frozen, there will be ample opportunity for the physician to weigh future cooperation in the process if he or she disagrees with the decision of the parents. In sum, if there is a choice of techniques, the exercise of that choice could greatly affect the operation of the law, and, conversely, if the operation of the law could be affected by the choice of technique, the law may build in constraints and incentives for adopting one technique over another.

The fourth stage in the process is a critical point at which the possible outcomes branch off into several directions. This is a stage when the decision to implant the embryo is made. If it is determined that the embryo carries the correct-sex trait, the decision might be made to implant the embryo. On the other hand, if the embryo does not have the desired-sex trait, or if sex-linked genetic characteristics or other genetic considerations dictate, the embryo may not be implanted. If the embryo is successfully implanted in the mother, then the process is set in one definite direction. On the other hand, if the decision not to implant the embryo is made, it is possible for the process to move in the direction of destroying the embryo or of preserving it for some possible future use. At this stage, the process can go into three distinct directions, each with different legal implications. This is the most important stage in the process and for that reason it is the point at which the decision-making unit could swell to its largest size and become the most difficult to manage in a legal sense. At this point, the law might absolutely define the members of the decision-making unit and methods of decision making. The legal possibilities for resolving these questions are too numerous to mention, but it is clear that this will be the most difficult stage at which to develop a legal doctrine that will be manageable in a practical sense.

If the decision is made to transfer the embryo to the mother because it has the desired sexual trait, the legal issues are reduced to a much more manageable dimension. The decision-making unit could be as small as one person—the mother. This would turn on the theory that she is now totally in control of the

process and the fate of the fetus is now intermingled with her own fate. The issue becomes slightly more complicated if a surrogate mother is introduced, but the issues are the same as those discussed in the section on selective fertilization. In this case, the decision-making unit could remain just the woman or could be modified to include the interests of the natural parents or, alternatively, the law could merely allow for some sort of contractual relationship relating the surrogate mother to the natural parents.

If the decision is made not to transfer the embryo to the mother, then the disposition of the embryo must be decided. Conceivably, the embryo could be destroyed, or the embryo could be preserved through freezing for some future use. With respect to this latter choice, the natural parents may decide to use the embryo for some future implantation. This would become important if the parents wanted to not only choose the composition of their family but also the order of the children who bore specific traits. For example, a childless couple may wish to have a boy first and a girl second, and the embryo produced bore the female sex trait. In this case, the parents might wish to preserve the female embryo, and try for a male embryo to be implanted as the firstborn. The female embryo would then be preserved until some period after the male offspring was born. This raises only one legal issue: Who controls the fate of the female embryo while it lies in storage awaiting a future implantation? The choice of the decision-making unit and the rules governing the decision process are similar to those governing the basic decision of whether to implant or not. Another possible outcome of this decision is that the parents would abandon all claims to the embryo but it would lie in a state of preservation awaiting adoption sometime in the future. This might occur if the couple had moral objections to destroying the embryo or if there were some legal constraints to its destruction. However, this does raise some novel and considerable issues. Most notable is who controls the fate of the frozen embryo regarding when, if ever, it is to be implanted. The law might develop making it impossible for parents to give up their rights to an embryo and, in that case, the parents might be forced to look after it personally or through some sort of trust arrangement. On the other hand, the law might position the state, or the physician acting for her- or himself or as a proxy for the state, as the prominent figure in the decision-making unit regarding the preservation and future implantation of the embryo. The law might also give the natural parents notification, advice, and/or consent privileges in future determinations regarding the embryo. Presumably, the law would draw heavily on the existing principles governing adoption in these cases, but it would differ because the possibility would always remain that the natural parents would change their minds and wish to use the preserved fetus.

If the decision is made to destroy the embryo rather than to implant it, two possible variations with different legal outcomes could arise. First, the decision-making unit, however defined, could affirmatively decide to destroy the fetus. In

this case, the legal issues are similar to those involved in abortion; they are treated in the section on selective abortion. The second variation of this case would arise if parents simply abandon all rights to the embryo and turn it over to the physician's control. Can parents voluntarily dismiss themselves from the decision responsibility? Would then the decision unit shrink to that of the relevant physician? Would the state or family of the parents or both be given a chance to include themselves in the decision responsibility if they desire or, alternatively, would it be mandated that the state or the family take responsibility for an abandoned embryo? In resolving these legal issues, the law might borrow from existing procedures for handling abandoned children or caring for orphans. These principles must be modified to account for the fact that the embryo is simply not a child and must rely on some other human being to give it birth and, also, that the natural parents are known and have made a decision regarding not a child but a piece of biological material that has the potentiality to be a child. However the law is designed to treat this contingency, it must nevertheless identify some decision maker vested with the responsibility of either terminating or prolonging the preservation of the embryo or finding a surrogate mother and surrogate parents for the embryo. All of this might put the physician in an awkward position. The physician could be treated as a trustee of the state, or the embryo could be treated as the physician's property to be disposed of as he or she wishes, or perhaps the state could intervene and take the matter completely out of the doctor's hands. In any event, the physician will be torn by considerations of morality, emotion, peer pressure, and law.

Sex Determined in the Fertilization Process

In the second case of selective implantation, a single egg is gathered from the mother and fertilized by a process designed to produce an embryo of a given sex. The embryo is then transferred into the mother or is preserved through freezing for a time and then transferred into the mother. In this case, there would be no necessity to test for the sex characteristic because the process of fertilization would be designed to produce the desired sex. The process might involve separating sperm into pools bearing the male and female traits and then fertilizing the egg with sperm selected from the pool of choice. Alternatively, the process of fertilization could be mimicked, but altered surgically to produce a male or a female clone of an existing individual.[2] Another possibility, which is discussed only for the sake of completeness and which is only at this point a wild speculation, would be that an egg could be fertilized by another egg to produce a female

[2]This might be performed along the lines that John Gordon pioneered in cloning frogs by surgically transferring a nucleus from one cell into an egg.

offspring containing characteristics of the two females donating the eggs. This case involves all of the legal issues discussed in stage one save those peculiar to this stage at which the embryo would be tested for the sex trait. In addition, several new problems arise that again may challenge the law to adapt in unusual ways.

If the fertilizing sperm is divided into two separate pools specific to a particular genetic trait, then many of the issues involving the risk to the sperm from such a separation technique and the risk of producing the wrong outcome are merged with the issues already discussed particular to selective implantation. In a sense, the issues of selective fertilization are merged with the issues of selective implantation. No new legal issues arise. However, two already legally complicated situations merge to form an even more legally complicated situation.

If the sex of the embryo is determined by surgically altering an egg to produce a clone of an existing or previously existing human being, then several completely new legal issues arise. For example, suppose a couple wishes to have a female offspring just like a favorite female relative—in effect, an exact clone of that person. Further, the cloned embryo may have been preserved by freezing for some time allowing for the cloning of an individual who has died. The parentage issue becomes complicated depending on whether the definition of parent entails donation of biological material, giving birth to the baby, and/or raising the child. The embryo could have a single parent if the mother were cloning herself. Alternatively, it could have two natural parents if the father were cloning himself. The situation becomes complicated if someone other than the natural parents is cloned. For instance, if another female is cloned, then presumably the embryo could have a father and two mothers. Alternatively, if another male is cloned, then the embryo could have a mother and two fathers. These issues of parentage are similar to the ones previously discussed under selective fertilization and again result in a merger of two sets of complicated issues.

Fertilization of Multiple Eggs

In the last case of selective implantation, the situation differs from the first two cases in only one important way. Multiple eggs are fertilized *in vitro*. The one or ones bearing the correct sex trait are transferred to the mother, raising the question concerning the fate of any excess embryos. This case brings to play all of those issues previously encountered in cases one and two. However, it complicates the degree of difficulty in deciding what to do with any excess embryos because there could be several embryos left over instead of just one. Moreover, the parties would anticipate the emergence of this issue from the very beginning of the treatment almost guaranteeing that there will be excess embryos at the end of the treatment. The same options for dealing with excess embryos are available

as in case two. But the decision is made more complicated because of the existence of multiple excess embryos. Because this case would generate many more potential excess embryos than would the technology in case two, the public interest may be given greater sway in determining the outcome of decisions regarding excess embryos and perhaps even regulating the process from the beginning.

Selective Abortion

Selective abortion is the last type of sex selection method that will be discussed. This technique involves testing for the sex trait of the fetus *in vivo* and then aborting the fetus if it bears the wrong sex trait. Given the present state of technology, this technique is the only one that is feasible. Use of the technique is highly controversial because it depends upon an abortion for achieving sex selection.

Determination of membership in the various spheres of interest involved in sex selection through selective abortion is a simpler task than that involved in selective implantation. The technique requires a high degree of medical expertise and there is little possibility that the physician would be drawn into the decision-making process because of the possibility that a live embryo may revert to the doctor's control; therefore, the interests of the medical community are sharply distinct from those of the decision-making unit, and the relationship between the two spheres of interest is strictly that of the traditional doctor–patient relationship. Working within the context of the traditional doctor–patient relationship, members of the medical community should be vigilant to provide the proper quantum of information and counseling to satisfy the demands of informed consent and should be careful not to act as a guarantor of the technique because there is a small but real possibility that the test to determine the sex trait of the fetus may be in error. To shoulder adequately the burden of informed consent, the physician and other members of the medical community should detail the risk to the fetus that any diagnostic test might involve and should also outline the various possibilities that the wrong-sex trait will be encountered necessitating an abortion. Perhaps the most difficult issue confronting the medical community is whether it is permissible to terminate treatment because the physician disagrees with the motivation of the parents. Does the physician have the right to refuse treatment if a diagnostic test like amniocentesis is requested to ascertain only the sex of the fetus, and does the physician have a right to refuse treatment if an abortion is requested only on the basis that the fetus bears the wrong-sex trait? Suppose, for example, a physician accepts a woman as his or her patient and determines that the patient is pregnant. The doctor then accepts responsibility for

caring for the pregnancy. At some later point, the patient requests a diagnostic test such as amniocentesis. Does the physician have a duty to inquire as to her motivation for the test or is the doctor's responsibility merely to make sure that she is fully aware of the implications of having the test? Suppose further the physician learns that she wishes to have the test for purposes of sex selection. Can the physician refuse to do the test? Does the doctor then have the right to terminate the doctor–patient relationship? This hypothetical situation raises many of the issues previously discussed concerning abandonment. A similar set of issues relates to the decision to terminate a pregnancy solely on the basis that the fetus bears the wrong-sex trait. The options available to the medical specialists are to terminate the doctor–patient relationship, to refuse to do part of the treatment, to refer the patient to another specialist who will perform the objectionable parts of the treatment, or simply to perform the treatment. If a physician elects to refuse all or part of the treatment, then the doctor should be careful to explain the decision fully to the patients and to see that they are adequately referred to another source of treatment. To do otherwise would risk the possibility of issues of abandonment and that the physician would be held accountable for leaving the patient out on a limb. These issues become particularly troublesome if the patient refuses to reveal her motivation for requesting a diagnostic test or if her motivations are revealed rather late in the process. The longer the treatment progresses, the more awkward it is for the physician to withdraw if the physician is kept in the dark until relatively late stages in the pregnancy. In light of this, does the physician have the right to demand that a client inform the doctor of her motivations, and does the physician have the right to refuse treatment if the patient will not reveal the full substance of her thinking on this matter? In any event, although it is a simple matter to distinguish between members of the medical community and the decision-making unit, electing abortion to accomplish prenatal sex selection raises a number of complicated issues relevant to the conduct of business between the two spheres of interest that may warrant legal attention.

Gender-Biased Legal Environments

Thus far, the discussion of legal issues has been confined to those that might arise in a gender-neutral legal environment. However, it is conceivable that the legal environment could be biased to encourage or discourage the use of sex-selection technology. Furthermore, it is possible that an environment designed to encourage the use of sex-selection technology might also be biased in favor of a particular sex. The case of Singapore discussed earlier involved a situation in which sex selection was generally encouraged. The legal issues arising in such

environments are similar to the ones previously discussed but, in addition, new legal issues are raised because the state will actively intervene either directly or indirectly to affect the private decision-making process regarding the use of technology generally and the outcome of the decision in particular. Reasons for the creation of a non-gender-neutral legal environment might be rooted in an interplay between the economic and ethical paradigms mentioned earlier or derived from ancillary policies that affect the use of particular forms of the technology. At this point, only the issues attendant to the use of government power to influence the decision-making policy will be discussed.

Direct intervention by the government could take the form of a criminal statute. For example, it could be made a crime to utilize sex-selection technology and the statute might be directed at the mother, the couple, or the physician. In fact, it could be directed at all three major parties to the decision-making process. The statute might embody fines and/or jail sentences. The use of this form of governmental intervention is most obvious in environments wishing to prohibit the use of sex-selection. However, criminal law could be fashioned to encourage the use of the technology by perhaps mandating the development of gender-specific information about the fetus and attaching penalties for the failure to develop the information. Another form of direct government intervention to encourage sex selection would be to allow the government to issue an order (e.g., an injunction) compelling the use of a technology for, perhaps, a specific outcome. In this case, a representative of the state could petition the government to compel a particular outcome and the government may be empowered to force the woman and/or the physician to perform specific tasks leading to the desired outcome.

The government could use indirect means for influencing the use of sex selection. The government could set up a system of taxes or subsidies to create a non-gender-neutral legal environment but still allow a wide latitude of individual decision making subject to these constraints. The government might also set up a regulatory scheme that would limit access to various forms of the technology dependent on the goals of the patient. In this latter case, the agency would position itself as the watchdog of the third-party interest and would intervene at some point in the process to affect the outcome of the decision-making process either actively or passively. The agency might take the form of a committee of physicians delegated government responsibilities or assume a more formal bureaucratic configuration. Alternatively, the third-party interest might be represented by the court or a governmental agency. No matter what approach government takes, however, the legal issues will undoubtedly involve the choice of the party(s) targeted for regulation and the conditions that trigger the existence and timing of governmental interference with private decision making. Also, issues will arise involving the type and magnitude of the penalty–incentive scheme utilized by the government to regulate behavior regarding sex selection.

ANALYSIS OF CURRENT LAW

The previous section outlined the legal issues arising out of the use of the three classes of sex-selection technology; this section attempts to identify applicable rules of law and to suggest how these rules might be applied to resolve the issues. The application of United States law is discussed first and then brief international comparisons are attempted.

In the United States tradition of jurisprudence, there are a number of sources of law that could be applied directly or by analogy to the problems involved in sex selection. The first is common law. The courts have articulated principles of common law within the context of tort and contract law, and some of these principles may be applicable to solutions of the issues raised above. The second source can be found in the statutes enacted by state and local governments attempting to regulate, sometimes with criminal sanctions, activities related to issues of sex selection. A last source of law can be found in the federal and state constitutions. Constitutional law is most important because it sets the overall tone of the legal environment and provides a backbone of legal principle upon which all of the other sources of law can build and grow.

Contract Law

In the area of sex selection, the application of contract law is the simplest body of law with which to work. The contract generally involves an exchange of promises that can be enforced through the courts. A creation of a contractual obligation begins when both buyer and seller come to a meeting of the minds concerning the exchange of promises or other valuable considerations. The parties should be clear as to the exact substance of the bargain and should come to an agreement at the same point in time. Properly done, the contract will then become enforceable by a court either in the form of awarding damages for a breach of contract to make the injured party whole or of mandating "specific performance" that would, in effect, compel the breaching party to fulfill its end of the bargain. The contract may be made for the benefit of a nonparty, which is known as a third-party beneficiary. Properly done, the contract will allow a third-party beneficiary to enforce his or her rights under the contract in a court of law. Courts will generally attempt to award damages for a breach of contract. They will rely on the remedy of specific performance only in unique situations where there is no other remedy. Also, the courts will not allow the remedy of specific performance in those cases in which granting the remedy would conflict with a constitutional principle or some other important element of public policy.

Tort Law

The United States concept of a tort is much more applicable to sex selection than contract law. A tort is a civil wrong resulting from an act or an omission that injures the legally protected interest of another, causing harm for which the court will grant a remedy.[3] The most applicable tort in matters involving sex selection is negligence. Negligence exists when someone fails to perform at a legally established level of conduct, causing injury and harm in situations for which courts will allow a cause of action.[4] The injured party must not have done anything that would disable himself or herself from bringing an action for such an invasion.[5] Closely, often inseparably, related to the notion of negligence is the concept of informed consent. Informed consent, when combined with the concept of negligence, can create a duty in the attending physician to provide enough information to allow parents to function adequately as informed, knowing decision makers concerning their reproductive choices (Capron, 1980, pp. 85–86; Reilly, 1981).

There is considerable controversy concerning to whom the duty of providing accurate, timely reproductive information is owed. Does the physician owe this duty to the parents, the child, or to both? There is a fast-developing body of law that seems to be articulating a cause of action for the parents and, perhaps, the subject child against the attending physician for a failure to provide detailed and timely information and subsequent services to allow parents the latitude of decision making necessary to intervene or abort the pregnancy (Capron, 1980; Reilly, 1981; Shaw, 1980; Sorenson and Swazey, 1980). Although every state recognizes a cause of action in negligence for medical malpractice with respect to performing at a legally defined standard of care in rendering direct medical services, only a few courts have recognized a duty to provide genetic information to allow parents the opportunity to choose not to conceive or, alternatively, to choose not to carry a pregnancy to term (Reilly, 1981; Shaw, 1980). However, several prestigious state courts of appeal have allowed suits for preconception negligence and prenatal torts (Shaw, 1980). It is uncertain how many other state courts will adopt a recognition of the right to sue an attending physician for the failure to provide sufficient information concerning the genetic disposition of the fetus to the parents in order to allow them the ability to make reproductive decisions concerning the conception or termination of a pregnancy. It is equally uncertain how far the boundaries of this tort will extend in the case of sex selection. Most probably, the principles would be applied in cases in which sex-linked genetic disorders are at issue, but it is unlikely that courts will allow a

[3]Restatement, Second, Torts, Sections 6 and 7.
[4]Restatement, Second, Torts, Sections 281 and 282.
[5]Restatement, Second, Torts, Section 281.

cause of action and/or damages in the case of the production of a wrong sex. This is because most courts still adhere to the doctrine that the birth of a child, especially a healthy child, is such an exceptional blessing that suits concerning the characteristics of the child are largely irrelevant and so speculative as to preclude award for any "damages" resulting from the lack of existence of a specified set of characteristics. However, the courts that have allowed suits for prenatal torts have generally adopted a new doctrine in which something akin to a cost–benefit analysis is employed. These courts have allowed for damages to the parents, and in some cases to the child, because the lack of or incorrect information provided to the parents precluded the possibility of weighing the costs and benefits accruing to the birth of the child in question and, thereby, produced a situation in which they were forced to bear a child with the wrong set of characteristics. Most of these suits have involved the existence of a genetic deformity, and it is very unclear whether or not these courts would extend the doctrine to allow for damages due to disappointment concerning the sexual characteristics of healthy offspring (Capron, 1980; Reilly, 1981; Shaw, 1980; Wyatt, 1980).

Constitutional Law

Many of the legal issues associated with sex selection concern determining who the decision maker(s) is at various stages of the process and, also, determining when the decision maker may elect abortion as a means for implementing a sex-selection strategy. Resolution of these issues requires an examination of the United States Constitution. In 1965, the United States Supreme Court found that the logical implications of six amendments to the United States Constitution—the First, the Third, the Fourth, the Fifth, the Ninth, and the Fourteenth—combine to imply a constitutional right of privacy that insulated the marital relationship from interference by the state in the form of laws prohibiting the practice of birth control.[6] Because the successful practice of birth control depended upon cooperation with medical interests, the Court also extended the zone of protection of the privacy principle to the individual physician and clinic that were instrumental in providing family planning information. In so doing, the Court created a protective zone of privacy surrounding the married couple in their pursuit of reproductive choice and extended the protection of this principle to necessary parties from the health community. The role of privacy has been further refined in the subsequent cases of *Roe* v. *Wade*[7] and *Doe* v. *Bolton*.[8] *Roe*

[6]*Griswold v. Connecticut*, 38 U.S. 479.
[7]410 U.S. 113.
[8]410 U.S. 179.

and *Doe* combined to form the constitutional cornerstone of the legal principles that govern many of the issues raised by prenatal sex selection. In this light, it is instructive to review the rationale of these cases in some detail to discover what the current state of the law is and to postulate how it may be further extended and/or modified.

Three critical points stand out in *Roe* and *Doe*. First, the state may not enter into the abortion decision until the end of the first trimester of pregnancy. During that period of time, the abortion decision is a medical matter left to the pregnant women and her attending physician. Second, it is clear that the physician and patient form a team to make the abortion decision such that any protection that extends to the patient also extends to the physician. Last, after the viability of the fetus is established, the state may enter the abortion decision to protect the potentiality of human life except where an abortion is necessary for the preservation of the life and health of the mother (Walbert and Butler, 1973, pp. 349–350). It is worth noting that the point of viability as was presumed in *Roe* and *Doe* might not necessarily coincide with the beginning of the third trimester. In an examination of the ancient traditions of common law to determine the point of viability, the estimate of 16–18 weeks of pregnancy emerges (Walbert and Butler, 1973, p. 326). An alternative and more current estimate fixes the point of viability between 20 to 28 weeks. Arguably, then, the point of viability might occur during the second trimester of pregnancy. Legislation and litigation have tried to fix the point of viability at various times and the Court has held that the underlying rationale of any statute establishing the point of viability must be at a point at which the fetus has the potential for a meaningful, rather than merely temporary, survival (Glantz, 1980).

Because a pregnant woman carries with her the potentiality of human life, the Court was unwilling to leave her absolutely isolated in the exercise of the privacy principle (Walbert and Butler, 1973, p. 345). The right of privacy, then, is quite qualified. It leaves the door ajar for reconsideration of *Roe* and *Doe* any time medical technology changes regarding viability, the health of the mother, or the potentiality of human life. One might also argue that these types of changes inject new interests into the considerations that the state may weigh in passing laws regulating this type of behavior. The doctrine of *Roe* and *Doe* condenses to the proposition that, given the biomedical technology existing at the time of the decision, a mother and her physician can be protected from state influence in the abortion decision up to the point of viability, after which they are unprotected. After that point, only the preservation of the life or health of the mother will be an interest sufficiently important to preclude state action in regulating their decision-making power regarding abortion. It might be fairly implied that change in biomedical knowledge or a major modification of the interests involved in *Roe* and *Doe* could precipitate a change in this doctrine.

The development of the privacy principle as it applies to abortion has evolved

such that the court will entertain exceptions to the privacy principle as it was applied in *Roe* and *Doe* and, also, will allow some avenues of access to the principle to be modified substantially.

An exception has been seemingly carved out of *Roe* and *Doe* in the special circumstances of a minor who wishes to obtain an abortion. In *Belotti* v. *Baird*,[9] the Supreme Court implied that states could pass statutes to require parental consultation and consent to abortions performed on their minor children. However, the Court went on to require that mature minors—that is, those capable of giving informed, knowing consent—could petition the courts or administrative agencies to allow an abortion without obtaining parental consent and notification. Moreover, immature minors would be given the option of going to court and having the court act in place of the parents to issue an order that would be in their best interests. In deciding *Belotti*, the Court has opened the door still wider to the possibility that the woman's decision-making power, as guaranteed by *Roe*, might be modified in exceptional cases to include notification of other interested parties or the third party as represented by the court, and might possibly be subjected to consent requirements of those interests. Future litigation will determine the scope and importance of this exception, but it does give some indication as to the trend in the development of this body of law.

Another body of litigation has developed that focuses on the avenues by which a pregnant woman can gain access to abortion.[10] These cases involve restrictions on the federal funding of abortion through Medicaid. It is now established that the federal government is not required to pay for abortions. Further, the policy of excluding payment for abortion services from Medicaid was held to be constitutionally permissible because it was an indirect, rather than a direct, method of government action that clashed with the privacy principle. The Supreme Court outlined the substance of its approach in the case of *Maher* v. *Roe*[11] by concluding that a Connecticut statute that prohibited Medicaid for abortions that were not medically necessary, but also allowed Medicaid payments for medical services incident to childbirth, was constitutional. The Court wrote:

> An indigent woman who desires an abortion suffers no disadvantage as a consequence of Connecticut's decision to fund childbirth; she continues as before to be dependent on private services for the service she desires. The state may have made childbirth a more attractive alternative, thereby influencing the woman's decision, but it has imposed no restriction on access to abortions that was not already there. The indigency that may make it difficult—and in some cases, perhaps, impossible—for some women to have abortions is neither created nor in any way affected by the Connecticut regulation.[12]

[9]*Belotti* v. *Baird*, 428 U.S. 132.

[10]*Harris* v. *McRae*, U.S. Supreme Court Opinion 79-1268; *Williams* v. *Zbarez*, Supreme Court Opinion 79-4.

[11]432 U.S. 464.

[12]*Maher* v. *Roe*, 432 U.S. at 474.

The Court elaborated on *Maher* in *Harris* v. *McRae*[13] in finding the Hyde amendment to the Social Security Act, which severely restricted the availability of Medicaid funds for funding abortions, is constitutional. In *Harris*, the Court wrote:

> But regardless of whether the freedom of a woman to choose to terminate her pregnancy for health reasons lies at the core or the periphery of the due process liberty recognized in *Roe* v. *Wade*, it simply does not follow that a woman's freedom of choice carries with it a constitutional entitlement to the final resources to avail herself of the full range of protected choices. The reason why was explained in *Maher* v. *Roe:* Although the government may not place obstacles in the path of a woman's exercise of her freedom of choice, it need not remove those not of its own creation. Indigency falls in the latter category. . . . Although Congress has opted to subsidize medically necessary services generally, but not certain medically necessary abortions, the fact remains that the Hyde amendment leaves an indigent woman with at least the same range of choice in deciding whether to obtain a medically necessary abortion as she would have had if Congress had chosen to subsidize no health care costs at all.[14]

These developments in the constitutional foundations of the right of privacy as it applies to abortion cases indicate that the principle is a qualified right that has exceptions (as in the case of a minor seeking abortion) and also indicate that access to the exercise of the principle can be modified by indirect governmental intervention (as in the case of Medicaid funding for abortion). The combination of these two developments creates an uncertain legal environment regarding the extent to which the right of privacy will be further excepted and modified. Would a case involving sex selection trigger more exceptions and modifications? This issue is dealt with later; under current applications of the privacy principle, it might seem that the use of selected abortion and related techniques for the purposes of sex selection might run into some legal difficulty. For example, using the literal "black letter" law of *Roe* v. *Wade*, one might conclude that the state may not regulate this matter before the point of fetal viability. On the other hand, there is nothing that would compel the attending physician to cooperate in such a matter, aside from his customary duties to provide competent medical service. If the selective abortion is before the point of viability (arguably 20–28 weeks in the pregnancy), then the protective provisions of the *Roe* v. *Wade* rule could possibly cover the operation. Techniques using amniocentesis as the diagnostic method are on somewhat shaky ground because they usually force the abortion to take place during the second trimester of pregnancy, which places it in or near the uncertain zone of viability. A physician could weigh the factors of viability of the fetus, the interests of society, and the psychophysical health of the mother and, perhaps, other factors in coming to a conclusion involving a second-trimester abortion. This might result in a restriction on the use of selective abortion for purposes of prenatal sex selection.

[13]U.S. Supreme Court Opinion 79-1268.

[14]*Harris* v. *McRae*, U.S. Supreme Court Opinion 79-1268, at 17.

Using the reasoning of *Roe*, one might encounter difficulty in securing privacy protection for these cases because the question of viability is still unsettled in the law and because of the rather tentative relation of sex selection to the mother's health. All of this suggests that the protection of *Roe* v. *Wade* with respect to actions before the sixth month of pregnancy may vanish in any particular application of the principle. At this point, all of this is conjecture and only further litigation before the Supreme Court can really settle the issue.

One other constitutional consideration remains. This is the issue of whether the constitution would permit anything other than a gender-neutral legal environment. All state laws are bound by the general provisions of the Fourteenth Amendment requiring the equal protection of the law to all persons covered by it.[15] The sense of the equal protection clause requirement is that laws cannot discriminate on the basis of sex unless the state has a good reason for so doing. The state must have a compelling reason for discriminating against certain types of individuals, most notably minority groups. Sex selection raises the issue of whether the state can induce the population either directly or indirectly to favor the reproduction of male and female offspring. There has been considerable debate concerning whether gender is a classification so suspect in the eyes of the Constitution that states must have a compelling interest in overpowering the protections of the Fourteenth Amendment. The Supreme Court seems to have settled at a position that gender is something of an intermediate consideration in which the states have a good reason for something short of compelling, but something more than just a rational, motive for discriminating in the law on the basis of gender. Therefore, if the states could demonstrate that there is a good reason for favoring production of one sex over another, then they might be allowed to pass laws that directly or indirectly affect the decision making of parents regarding the gender of their offspring. One might also see the use of the *Maher* and *Harris* logic, which would indicate that indirect influences might be permissible as long as parents were left with the discretion to choose the gender of their offspring. However, this issue is very unclear and must be litigated for an exact determination of the issue. The issue is very unsettled because of the uncertain status of the once defeated Equal Rights Amendment to the Constitution, which, if reintroduced and passed by the Congress and ratified by the states, would seemingly preclude anything but a gender-neutral legal environment for the country.

Application of Legal Principles

We have examined the sources of United States law and distilled a few legal principles that could be applied to some of the issues of sex selection. It is now

[15]U.S. Constitution, Amendment 14, Section 1.

worthwhile to reexamine the legal issues raised previously in light of these rules in an attempt to draw some conclusion as to the probable disposition of these issues in the United States. Analysis will be limited to issues as they would be settled under the legal principles that are now in effect. As noted earlier, there are definite trends in some of the legal doctrines that may evolve new rules and precipitate new conclusions in the future. The effect of these trends are considered in the last section of this chapter.

The issues will be treated in the order in which they were discussed in the third section of this chapter. Some cannot be resolved under existing legal principles and are ignored. The first issue is whether the overall legal environment is gender-neutral. As we have seen, it is unclear whether the equal protection clause of the Fourteenth Amendment would allow the government to influence prenatal sex selection issues either directly or indirectly. It is possible that the Court would require that the government demonstrate "compelling" state interest in support of a direct governmental intervention into private decision making regarding prenatal sex selection. This is because it would invade not only the general guarantees of the equal protection clause available to all persons but, also, it would invade the interests protected by the privacy principle as it has been articulated through the *Griswold–Roe–Doe* trilogy. It is very difficult to demonstrate a compelling state interest in any circumstances; to do this the government might reach into the rationale of the economic and ethical paradigms sketched in the second section of this paper. However, it is difficult to imagine a sufficiently strong case arising out of these paradigms to justify such an invasion of protected interests. It may be possible to fashion a system of indirect incentives or disincentives using the logic of *Harris,* discussed earlier, to create a scheme that would favor the production of one sex or another in the offspring. However, using the logic of *Harris,* the government would be careful to establish that the full range of discretion was still left with the decision maker. The present legal environment in the United States is gender-neutral and the important questions in an immediate sense seem to be more oriented toward determining whether sex selection, per se, will be allowed at the private level than toward whether the government will try to intervene to produce an outcome in favor of a specific gender.

The next group of issues focuses on the actors populating the various interests involved in the sex-selection decision process. The actors making up the decision-making unit can vary according to the context of the situation. In those situations in which cooperation is required between the couple to accomplish, for instance, general goals of contraception, the decision-making unit is comprised of the couple; it is the couple who is protected by the zone of privacy, using the logic of *Griswold,* and who cannot be directly influenced by governmental pressure except in conditions representing a compelling state interest. On the other hand, if the technique involves abortion, then the logic of *Roe* would be applied to define the decision-making unit as primarily a woman in consultation

with her attending physician(s). In this case, there is a potential problem of a conflict between the physician and the woman over access to information necessary to the implementation of the selective abortion decision for the purposes of sex selection. Many physicians do not consider this information of crucial medical importance in cases involving the healthy fetus and the law will not compel them to provide the information as long as it is done within the context of their standard medical practice. However, medical practice in this regard varies considerably in the medical community; given the increasing tendency to practice defensive medicine, physicians may feel inclined to provide the information lest they overlook some negative sex-linked medical outcome. We have seen that there are exceptions to this rule such as the case of minors who might be compelled to consult or obtain consent of parents in the sequelae of *Belotti*, discussed earlier, or, in the alternative, present their case to a court, which will first decide if they are mature enough to make a decision, and in the case that they are found lacking in maturity, will act in their best interest.

This leads directly into a discussion of who generally populates the third-party interest. As we have already seen in the discussion of the cases, the interest of the fetus grows during the progress of the pregnancy to where it may be protected by the state at the point of viability. Certainly at the point of viability the fetus is a recognized third-party interest. We have also seen under *Belotti* that the parents of a minor or, in the alternative, the court or one of its agencies may also populate the third-party interest in special cases. Many of the issues involved in prenatal sex selection are sufficiently complex to tempt the court to interject some spokesperson for the third-party interest into the process. Under present conditions of law in this area, it is probably premature to predict how a court might do that although we can certainly say that the situation would be very tempting to many jurists.

Of the two options available for sex selection by means of selective fertilization, the Shettles regime raises the simplest issues. The decision-making unit seems to be the couple and would be protected in the pursuit of this technique because the locus of the activity is the marriage bed, falling under the umbrella of protection erected by *Griswold* v. *Connecticut*. *Griswold* has established that this type of intimate behavior is shielded from the direct scrutiny of the state. The only forces strong enough to overwhelm this might possibly be either the pressure of social imbalances caused by radically imbalanced sex ratios or the possibility of widespread genetic disease arising out of sex selection. Even in these cases, it is probable that our society would use indirect means such as tax incentives or genetic counseling to remedy these situations rather than direct legal sanctions. The interest of the medical community is hard to define because of the rather vague nature of the medical assistance in support of this technique. The third-party interest is probably populated only by the family and prospective children who have only a future interest in the matter. In the absence of a

wholesale calamity resulting from this technique, third-party interest is likely to be unrepresented in the process.

Interesting legal issues do arise out of the patient–physician relationship. Considering the highly debatable efficacy of the Shettles regime, representatives of the medical interest should be very careful not to make claims of efficacy so exaggerated as to be fraudulent. Moreover, the medical community should be quite clear about when they are starting a medical relationship with a patient and when it ends, and should be absolutely certain that they do not guarantee efficacy of the approach. This is important because United States law does recognize that a contract exists between doctor and patient and, although it is highly regulated by the norms of the medical profession, the contract could be voided by charge of fraud; a breach of contract could be alleged in case of abandonment or if the wrong sex is produced and the physician was found to have given an expressed warranty that the technique would work. However, these are not problems peculiar to the use of the Shettles regime; they permeate all of the entire technology. However, because of the slippery nature of the doctor–patient relationship in this area, the consequences of these issues are the most serious for the use of Shettles regime.

If a breach of contract is found, the question of damages will soon follow. Under traditional contract law, breachers are liable for the actual and reasonably foreseeable consequential damages ensuing the breach. This is subject to the reciprocal duty of the other party to mitigate the damages caused by the breach. Normally, questions involving emotional stress and punitive damages are not part of a contract action and, therefore, the actual calculation of damages due to the production of the wrong gender becomes very difficult to quantify. For this reason, breach of contract actions are only a remote possibility. In any event, the normal relationship between the physician and patient is that of a fiduciary relationship subject to the normal practice of the profession in the community. A breach of the standard of care, so defined, is usually litigated under tort rather than contract law. In the United States tradition, damages arising under torts can be more encompassing than those coming out of a contract action.

An ancillary issue in tort law is whether any action could arise between the prospective child and the parents. Can a child sue his or her parents in tort because the child was born with an unwanted and, therefore, a disadvantaged gender? This is a theoretical possibility that has arisen because of the confusion generated by the "wrongful life" litigation mentioned earlier (see, generally, Capron, 1980; Reilly, 1981; Shaw, 1980). This type of legal possibility seems awkward conceptually and the practical difficulties involved in calculating damages make this a remote possibility in United States jurisprudence.

The second option for achieving sex selection through selective fertilization involves the use of artificial insemination. All of the same issues involved in the Shettles regime are present in matters involving artificial insemination. Howev-

er, the danger of malpractice suits (tort actions) on grounds of negligence is increased because of the more complex technology involved. This, of course, places an increased burden of informed consent on the attending physician. The determination of the decision maker is much more complex, however. Because the locus of the technology is not the marriage bed, the logic of *Griswold* would be seemingly inappropriate. The logic of *Roe* would seem to apply instead because it really reduces to an intimate form of cooperation between the attending physician and the woman with only indirect assistance from a donor male. A complicating factor is introduced by the possibility of a surrogate mother, in which case primary decision making under *Roe* would be given to her until birth. There have been attempts to modify this result by elaborate contractual relationships between the various parties. However, it is questionable whether a court would order specific performance; rather, it would more likely resort to the award of damages for any breach of contractual relationship. For example, a man and woman might contract with a surrogate mother and surrogate father to produce a child that would be adopted by them. The decision maker throughout the pregnancy would be the surrogate mother; if she decided to violate the terms of the contract, which might include provisions regarding prenatal care and eventual adoption, it is unlikely that the court would compel her to perform the provisions of the contract but would, rather, award damages to compensate the disappointed parties.

If artificial insemination is accomplished using the natural mother but with sperm donated from a surrogate father, questions of parentage and adultery arise. In most states, affirmative steps still must be taken to legitimate the offspring if the sperm comes from someone other than the father (Katz, 1980). Similarly, the act of artificial insemination is still technically considered adultery under many domestic relation codes (Katz, 1980). However, the modern trend is to regard resulting children as legitimate and as being conceived in a nonadulterous environment. It is probable that most states will adopt the modern trend either through case law or statutory intervention. However, it is still technically possible that these issues could arise in many states (Katz, 1980).

All these issues are germane to the technology of artificial insemination generally. The use of this technology for sex selection complicates matters still further because it adds still one more element to the process that could go awry. Issues rising out of this type of situation could tempt many courts to award damages for the production of the wrong sex if cases of gross negligence were discovered. Also, if surrogate parents are used in contractual relationships that are established between the parties, a breach of the contract by either party on account of sex will dearly test the courts' ability to estimate damages. Moreover, if the parents refuse to accept delivery of a wrong-sex child, the courts might be tempted to compel specific performance. There is no case law in the United States tradition to establish how any one court would treat these matters, but it

does not take much of an extension of present legal doctrine to reach these conclusions.

There is another ancillary issue arising out of the use of artificial insemination. This is because elaborate contractual relationships may be established between the parties that may give a third-party interest to the fetus. In other words, depending on how the contract is construed and constructed, the contract might treat the prospective fetus as a third-party beneficiary. This might give a cause of action for breach of contract to a prospective child if, in fact, any damage is done to it, in general, or if the wrong sex is produced, in particular. The actual resolution of these issues would depend on the precise wording of the contractual relationship existing between the parties.

The issues arising out of the use of selective implantation to achieve sex selection are, in many cases, similar to those raised by selective fertilization using artificial insemination. The remaining new issues were grouped together in a discussion of three different cases involving *in vitro* fertilization and resulting embryo transfer to the mother. In the simplest scenario, in which a single egg is fertilized with the intention of transferring it to the mother, the most difficult issue discussed is the problem of determining which actors populate the decision-making unit. An examination of United States constitutional law relevant to the issue is of very limited usefulness because the precedents have dealt with activities that were reasonably concrete and relatively easy to circumscribe. In the case of *Griswold,* the umbrella of constitutional protection enveloped the marriage bed, the actors occupying it, and the members of the medical community providing the necessary means of contraception. In the case of *Roe,* protection enveloped the woman and her physician because of the highly personal ramifications attendant to an abortion decision. Selective implantation, however, involves multiple activities, the locus of which occurs far from the marriage bed and does not involve the woman's body until relatively late in the process. Also, the resulting embryo does not meet the criteria of viability, as it was anticipated in *Roe,* until much later in its development and after it has been transferred to the mother. The immediate product of an *in vitro* fertilization, then, does not seem to represent a viable human life that would be subject to the protection of the state under the logic of *Roe* (Katz, 1980). For these reasons, it is difficult to imagine existing constitutional principles to be easily applied to the process of selective implantation until relatively late in the process when the embryo is transferred into the body of the mother.

How may we determine the actors in the decision-making unit before the time of embryo transfer? How may we resolve all of the legal questions outlined here that would arise before the time of embryo transfer? Absent specific statutory or governmental regulation, these matters would be treated as private concerns subject to existing principles of contract and tort law. The only way that the parties and the physician could be even reasonably certain of the decision makers

and the possible outcomes during the many decision points that could occur in the selective implantation process would be to negotiate an agreement allocating responsibility and anticipating outcomes during the complicated process. This would become a contract and the problem would reduce to the considerations of damages and specific performance.

This type of arrangement would place the medical interests in a very pressured environment. Not only would they be the hub of the very complex contractual agreement, but also they would be subject to tort liability for negligence or, perhaps, an intentional tort if they intentionally disrupted the process causing harm to one or more of the parties. Consider the case of *Del Zio* v. *Columbia–Presbyterian Medical Center* (Katz, 1980, pp. 359–361) in which the Del Zios were awarded a large sum of money in compensation for the intentional tort of emotional distress committed by the hospital's staff when an *in vitro* fertilization process involving them was interrupted with the resulting biological products of the process destroyed. In effect, the court found the medical interests involved in the process guilty of knowingly and intentionally inflicting emotional distress on the Del Zios by depriving them of the right of fertilizing an embryo *in vitro* and transferring that embryo into Mrs. Del Zio. In so doing, the court recognized the private right of the parties to engage in this type of activity and gave them a remedy for those who would willfully disrupt it. It may be possible to bring another type of civil action against anyone who willfully interrupts an *in vitro* fertilization process. This would be under an action for wrongful death, which is available in some form or another in every state (Katz, 1980, p. 359). The possibility of the medical interest incurring liability through breach of contract or some form of tort as a result of terminating a selective implantation process places the physician in a very precarious situation from which the doctor cannot easily be extracted once the process has begun.

It is even more difficult to find principles of law applicable to the fact setting of the second case. Even though the decision tree is significantly streamlined by the production of a single embryo having the desired sex trait, the same fundamental issues still obtain. In addition, the possibility of cloning to produce this outcome raises issues so complex that existing principles of law seem to be totally inadequate to cover the situation. It has been suggested that such cloning would create a situation in which the offspring would be saddled with a genotype of a previously existing human being. This might create a form of slavery that could be called genetic bondage. This situation could become so stifling to the United States principles of individuality and freedom of personal development that it could run into prohibitions emanating from the Constitution's Thirteenth Amendment, which prohibits all forms of slavery (Pizzulli, 1974, pp. 507–525). No legal precedent has been established using this particular theory. A considerable void, then, exists of law applicable to the special issues presented by case

two. In the third case of selective implantation, an extremely troubling set of issues arises in addition to all of the others emanating from the first two cases. This situation involved multiple embryos, some of which may not be transferred to the mother. Again, there is an absence of applicable law to answer the issues raised. It is possible, however, that government intervention will be created in some form because the existence of leftover embryos brings so many significant parties into the third-party interest that the situation might make a compelling case sufficiently strong to overwhelm the privacy principle.

In counterpoint to the relative lack of law applicable to the exigencies of selective implantation, the issues arising out of selective abortion can be handled by a relatively straightforward application of existing law. One of the major problems of selective abortion is that information regarding the sexual characteristic is generated relatively late in the term of the pregnancy; those wishing to use this information to effect a selective abortion for purposes of sex selection will find that they will be attempting abortion at approximately the point of viability of the fetus. The present state of the law provides just enough flexibility to allow this type of procedure. However, if the concept of viability is ever fixed at a time earlier than the 24th week of pregnancy, states could pass statutes regulating or prohibiting some of these abortions.

The possibility of misdiagnosis of sex leads to the twin possibilities that the wrong sex will be born or the right sex will be aborted. In either case, there will be ample physical evidence that an error was made and if the physician has not adequately discharged the obligations to the patient in terms of informed consent and adherence to community standards of medical practice, the physician could be liable for a malpractice suit (Milunsky, 1980, pp. 65–67). Also, even though a physician certainly has the right to withdraw from a case in which the patient sought selective abortion to accomplish sex selection, the doctor should be careful to withdraw in such a way that the patient is not disadvantaged, lest the physician be held accountable for abandonment.

The real legal battleground regarding selective abortion is likely to occur over access to the technology producing fetal sex determination and access to information by the patient once the determination is made. Diagnostic procedures are expensive and, because of the high price, not every patient will be able to use them. Using the logic of *Harris,* it is possible for the government to refuse to subsidize these types of tests or in some other way indirectly affect the environment in which the decision is made. Even after the diagnostic test has been performed, the physician has no duty to provide the information on fetal sex unless there exists the danger of some sex-linked malady. It is possible that standards of medical practice, in general, or state governments, in particular, could intervene to clarify the conduct of physicians in these cases without unconstitutionally impinging on the right of the mother as outlined in *Roe*.

International Perspective

Until this point, the discussion has centered on how the law in the United States would treat the many issues arising out of sex-selection technologies. It is useful to examine some of these issues from an international perspective. We have seen that the only feasible and reliable method of sex selection is accomplished through selective abortion. This, in turn, depends upon access to expensive technology and the option of effecting an abortion to prevent the wrong sex from being produced. International information on the availability and restrictions on diagnostic techniques like amniocentesis are too limited to allow any formal comment. However, information on the status of abortion in many countries is not so limited. The following discussion examines the legal environment in the world to determine how many countries might possibly give the option to parents to practice selective abortion for the purpose of sex selection.

Using Henry David's survey of the legal status of abortion in 140 countries, it is possible to narrow down the field to a manageable subset of candidates that might allow abortions for sex-selection purposes. David reported 20 countries allowing elective abortions (David, 1981, Table 1). It should be noted that in David's scheme of classifying abortion statutes, the United States falls into the elective abortion category. Countries comparable to the United States included Austria, Bulgaria, the People's Republic of China, Cuba, Denmark, Finland, France, the German Democratic Republic, Hungary, Israel, Italy, Norway, Romania, Singapore, Sweden, Tunisia, the Union of Soviet Socialist Republics, Vietnam, and Yugoslavia (David, 1981, Table 1). However, it should be noted that 8 of these countries constrain selective abortion in such a way that it would be difficult to implement the present technologies involving amniocentesis. A typical restriction would be that elective abortion is only available until the third month of pregnancy. David (1981, p. 20) reported an additional 15 countries allowing abortion for sociomedical reasons, which he defined as "threatening the social–medical well-being or socioeconomic life situation of the woman and/or her family." This is a category subject to wide interpretation and, depending on how a gender is perceived in the particular cultural setting of the country in question, sex selection might be allowed. Even then, there are countries with restrictions that would make present technology difficult to use, such as only allowing these reasons to justify an abortion within the first three months of pregnancy. Countries, then, that allow sociomedical abortions without these constraining restrictions are: Australia, Cyprus, Hong Kong, Iceland, India, Iran (although the effect of the recent revolution has not been determined), Japan, the People's Democratic Republic of Korea, Switzerland, and Zambia (David, 1981, Table 1).

Because the cultural setting enveloping the legal environment is crucial to

interpreting these statutes, it is very useful to examine some of these cultural settings in detail. A brief discussion of some of the most populous countries, in addition to the United States, with respect to how selective abortion might be treated in those cultures follows.

Union of Soviet Socialist Republics

There are several strands of law in the Union of Soviet Socialist Republics that deserve careful attention and provide clues as to the possibility of using selective abortion to achieve prenatal sex selection. These strands include laws governing abortion, laws controlling the status of women, and laws governing family relationships. Since 1955, abortions have been available on demand if done by qualified personnel in approved medical facilities (Lee, 1973). This policy is articulated in official decrees carrying the force of legislative authority. However, if the pregnancy exceeds 12 weeks, special permission is required (Lee, 1973). Seemingly, the granting of permission to obtain an abortion in these circumstances will depend very heavily on the medical aspects of the proposed operation. Two major points stand out in this legislation. First, abortion can be easily obtained. Second, the locus of abortion is in authorized medical facilities and available for a very small fee. Medical facilities are highly subsidized by the central government and, presumably, other types of diagnostic techniques, such as amniocentesis, could be made available through these institutions. Given that the technology could be made available, it seems that Soviet law does not present an insurmountable barrier to the exercise of technological options to produce prenatal sex selection.

A second important strand in Soviet law concerns the general status of women and whether the overall legal environment is gender-biased. Since the Russian Revolution there has been a concerted effort to treat the sexes equally in the eyes of the law, especially in the area of work and family environments. Part of this is due to the necessity of using large quantities of female labor to build a modern labor force after World War II (Grzybowski, 1971). Another reason is an attempt to implement a new social structure that deemphasizes private sex and familial differentiation in roles and, at the same time, emphasizes the role of the state in providing for care of children and other dependent members of the family. These policies can be seen by examining general marriage and divorce laws, which enable total freedom of choice of both men and women in entering into or dissolving a marriage. Since 1944, divorce laws have been toughened to some extent and are now granted only by courts for good reasons (Grzybowski, 1971, p. 283). However, these reforms were aimed more at strengthening the family as a unit rather than in subordinating the status of women.

This brings us to the third strand of law, which concerns family relations. A

series of reforms begun in 1968 was designed to strengthen the family's role as a basic building block of society, reversing the trend to undermine the family as a social unit that was previously in force after the Russian Revolution. Salient characteristics of the reform policy include a gender-neutral definition of parental responsibilities of child support (Grzybowski, 1971, p. 284). These strands combine to create an overall gender-neutral environment in which there are no institutional attempts to favor the production of any particular sex of child. If technological barriers can be overcome and sex-selection technology made generally available in the Soviet Union, the present legal and institutional structure does not seem to be a constraining factor.

People's Republic of China

In contrast to the approach of examining legislative decree taken with respect to the Soviet Union, one must examine party action and its effect on private, social networks in the People's Republic of China. Understanding the operation of Chinese law is always most difficult for Western analysts, especially those in the Anglo-American tradition. This is because Chinese law operates in an opposite way from that of the West. Rather than have courts discover and formalize principles that govern private interactions in the form of court opinions, which is a large part of the United States tradition, Chinese law starts with general notions of party policy, which are given meaning through an informal sociopolitical network.

Modern Chinese law must be understood against the background of ancient Chinese custom. The central concept of ancient tradition is the cult of ancestor worship, in which it was absolutely necessary to provide male heirs in order to continue the line of one's ancestors and provide a proper level of worship (Luk, 1977). In this tradition, parents were given extraordinary powers over their offspring. In fact, a fetus did not become a complete person until birth, which contributed to a legal environment that provided light penalties for abortion and then only to protect the mother's interest (Luk, 1977). When the Communist Party took power in 1949, induced abortion was initially prohibited following a Western-oriented tradition. However, this policy was reversed in the 1950s and there is evidence that abortion is now generally available on demand (Lee, 1973, p. F2). Because of the constraints of medical facilities available, abortions are encouraged as early as possible, many times in informal settings by "barefoot" doctors or midwives. The lack of facilities and the preference for early abortion would seem to be a factor greatly constraining to the use of selective abortion for prenatal sex selection. However, there does not seem to be any formal impediment to using abortion for those purposes.

A new population policy, officially adopted on a national basis in 1981, fea-

tures a strong incentive system aimed at producing small, preferably one-child, families. Party leaders have acknowledged that ancient traditional practices favoring large families and male children still persist in rural areas and clash with the policy goals of the party. Party officials have announced steps to overcome these ancient traditions. The steps operate informally through the local leadership, have the force of law, are attempting to create a gender-neutral environment in which there is equal pay for equal work regardless of sex and in which families not producing male offspring are not put at an economic or social disadvantage (Population Council, 1981). This is partly a legal attempt to eradicate the effects of male preference existing in a large portion of the population. Given the difficulty of overcoming these ancient traditions, it would seem that the legal environment would embrace technology that would allow families to realize their son preference and still maintain small families. However, in the absence of this type of technology, the legal environment in China is moving quickly to dampen the social and economic incentives attendant to the sex preferences of rural populations that also contribute to large families. The general principles of this approach were articulated by the marriage law of 1980, which attempted to give a gender-neutral content to the laws regulating marriage, divorce, and the obligations between parents and children (Population Council, 1981).

India

The legal environment of India has been greatly affected by contrasting socioreligious traditions. As a result, the code of law is necessarily flexible. For instance, in the area of marriage and divorce, different bodies of law pertain to different religious groups and are patterned after ancient religious custom. The law governing abortion has been codified in a rather constraining manner but official explanations attached to the text of the law create an enormous amount of flexibility (Lee, 1973). The prevailing law governing abortion went into effect in 1972 and allows abortion in two major cases: (a) if the pregnancy would threaten the life of the woman or cause physical or mental injury to her or (b) if the resulting child would suffer from physical or mental abnormality so as to be seriously handicapped (Lee, 1973, p. F4). However, explanations attached to these clauses indicate that if the pregnancy had been caused by the failure of any device or method used for contraceptive purposes, then it is presumed that a resulting unwanted pregnancy would involve great injury to the mental health of the woman and thereby abortion would be allowed under the code. Given the practical difficulties involved in proving that a pregnancy was not caused by contraceptive failure, it would seem that abortion on demand would be readily available. The code does provide time limits, however. Abortions after 20 weeks

are not permitted. Abortions of pregnancies not exceeding 12 weeks are permitted if a medical practitioner has formed a good-faith opinion that one of the two exceptions apply to the woman's case. In cases of pregnancies of more than 12 weeks and less than 20 weeks in duration, a prerequisite to obtaining an abortion is that two registered medical practitioners form the same good-faith opinion. Thus, it can be seen that the flexibility provided by the Indian code would allow the use of abortion to accomplish sex selection if it were requested before the 20th week of the pregnancy and if the woman could convince two medical practitioners that the pregnancy resulted from contraceptive failure or the fetus was at risk of having some physical or mental abnormality.

The legal situation regarding domestic relations law in India is quite varied. There are separate bodies of law for each of the major religious groups, the Hindus and Muslims. In the Hindu tradition, the dominant purpose of marriage had been traditionally to produce male offspring who were necessary to perform the funeral rights for the well-being of ancestors. Also under Hindu law the family line could only be perpetuated through males. The Hindu Marriage Act of 1955 has changed some of the elements of the tradition, mainly to make Hindu marriage more like a contract than a sacrament. Moreover, reforms of the laws have greatly elevated the status of Hindu women. Although their status has been so elevated as to render the legal environment of the Hindus completely gender-neutral, son preference still is indirectly encouraged. Family law for the Muslim community in India is largely uncodified and is greatly influenced by local custom. The status of Muslim women is very much lower than that of Hindu women, creating conditions conducive to the bearing of male children. In fact, one writer has urgently advised reform of Muslim practices to modify practices such as "unilateral right of husbands to divorce their wives at will or on grounds of failure to bear children or to bear a child of a particular sex [Agrawal, 1980, p. 45]." It would seem that the overall legal environment still admits of a decided male gender preference and abortion laws allow opportunity for parents to use selective abortion for sex selection.

Indonesia

The dominant religion in Indonesia is Islam and the legal traditions tend to reflect these religious values. At present, Indonesia has cautiously entered into a family planning program, but abortion is strictly forbidden (Sodhy, Metcalf, and Wallach, 1980). Laws relating to the family environment favor the male as was the case in India (El-Kammash, 1971). This produces a strong incentive to produce male offspring and a patrilineal and patrilocal family. Islamic law provides conflicting prescriptions concerning family planning generally (El-Kam-

mash, 1971) and would probably make it very difficult to practice sex selection even if abortion were available.

LEGAL TRENDS

In which directions are the legal winds blowing in the United States? How might any trends in the law involve issues like sex selection? The overall gender orientation of United States law is still governed primarily by the equal protection guarantees of the Fourteenth Amendment of the United States Constitution. This would allow direct gender distinctions in the law only for very good reasons. For example, the principle permits separate treatment of the sexes in such matters as a military draft and in occupations with obvious and specific gender requirements. Indirect governmental influences on society that may create a gender-biased environment might be permitted under the logic of *Harris* v. *McRae*, discussed earlier. In these cases, society would merely be expressing a general policy preference through a system of incentives and/or disincentives that would alter the context in which individual decision making would take place. Ratification of the Equal Rights Amendment to the Constitution could have a very constraining effect on both direct and indirect gender biases in the law. Amendment XXVII, proposed by Congress on March 22, 1972, reads as follows:

> Section 1. Equality of rights under the law shall not be denied or abridged by the United States or by any state on account of sex.
>
> Section 2. The Congress shall have the power to enforce, by appropriate legislation, the provisions of this article.
>
> Section 3. This Amendment shall take effect two years after the date of ratification [Babcock, Freedman, Norton, and Ross, 1975, p. 129].

The Amendment failed to receive the necessary ratification by three-quarters of the states but will almost certainly be passed by the Congress and put before the states again. Regardless of the status of the Amendment, a number of states have enacted amendments to their state constitutions similar to the proposed Equal Rights Amendment and a number of other states have begun work on the reform of sex-discriminatory laws by means of legislative reform (Babcock *et al.*, 1975, pp. 184–190). These movements, however, are running into considerable opposition from those who feel that attempts to eradicate sex distinctions in the law undermine the traditional bases of society. At this point, it is uncertain whether the trend to neutralize gender distinctions in the law, which was appar-

ent in the 1960s and 1970s, will be fully realized or will instead be overcome by a countertrend to preserve traditional sex distinctions in the law.

There are other changes impinging on the issue of sex selection, the most apparent of which are the changes that would affect the ability to produce sex selection through abortion. Congress may attempt to modify the law of abortion through legislative enactment and/or constitutional amendment. Ideas are now percolating that would define the fetus as a person for purposes of the law at the time of conception. If this is accomplished, then the use of selective abortion would probably be forbidden because the fetus would be given rights equal to those of the mother at the time of conception. This change would also impinge very greatly on selective implantation techniques. Certainly, those situations in which there might be any danger that an embryo would not be implanted in the mother would place the medical community in such a precarious position that it is doubtful that any of these procedures would be attempted. This is because the physicians would be no longer merely in possession of biological material but, instead, would be responsible for the lives of the embryos entrusted to their care. Moreover, it might tempt courts to allow the suits of children against their parents for actions resulting in injury to them during the time of gestation resulting from parental negligence or intentional interference with the genetic structure of development of the fetus. In other words, if the fetus were given equal rights under the law with that of its parents, could not it object under the law to overt attempts to manipulate its genetic structure resulting in a less-than-favorable outcome in the eyes of the child? Could a child complain of being born a disadvantaged sex? All of this is, of course, quite speculative but, should these trends take hold in the law, it might provide a legislative or constitutional foothold for considerable judicial expansion in the area of prenatal torts.

There may also be attempts to transfer the locus of the determination of abortion-related law from the courts to the federal Congress and state legislatures. If this were to occur, then the whole issue of sex-selection technology would be a matter of federal and/or state regulation. In addition, access to ancillary technologies necessary for the accomplishment of sex selection would be a matter of legislative scrutiny. It is also possible that the courts could determine on their own initiative that the privacy principle is too brittle to be stretched adequately to cover the many exigencies involved in the sex-selection problem. For example, sex selection through selective abortion usually means that the abortion would occur during the second trimester of pregnancy, when state regulations designed to preserve the mother's health are permissible as long as they are not needlessly restrictive on her decision making. It is possible that a court could reason that abortion to produce a certain type of offspring is sufficiently dangerous to the mother's health (in addition to raising issues of state interest not previously anticipated) that it would be permissible for states to regulate and even proscribe this type of activity. After all, *Roe* and *Doe* were

decided with given assumptions about the state of medical technology; the novel consideration discussed in the sections concerning the economic and moral paradigms, combined with the emerging technology involved in sex selection, might lead the Supreme Court to conclude that the state of medical knowledge has changed so sufficiently that these cases would fall outside of *Roe*. The Court might therefore be tempted to transfer the responsibility for regulating this behavior into the legislative forums, which have a much better ability to gather and weigh evidence on the diverse ramifications of these matters than do the courts. Remember, the Court always insisted that a woman was not isolated in her privacy; the interest of the state and the interest of the father and perhaps the family regarding the genetic structure of the family may count more in a sex-selective abortion decision than in *Roe* because the focus of the abortion is on selecting a child with preferred sexual characteristics rather than protecting the mother from a danger to her health. It is difficult to predict the exact course of legal development in the sex-selective abortion area, but it is clear that the problem is more complex, in ethical, economic, social and medical terms, than the situation in *Roe* and, therefore, any sex-selection case might be distinguished from *Roe*. It is possible that the law-giving by the Court will be much more pragmatic than the rather ideological approach in *Roe*.

If the locus of the legal debate concerning sex selection were transferred from the courts to the federal and state legislatures, how might those bodies react? Certainly, they would weigh the considerations outlined in the economic and moral paradigms above against the backdrop of public opinion relevant to the technology involved. Already, Congress has acknowledged the advisability of stimulating private, voluntary genetic testing and counseling programs (Motulsky, 1980, p. 243), and some individual states have become quite aggressive in adopting genetic screening programs (Holtzman, 1980, pp. 247–254). These initiatives are oriented toward the negative genetic consequences of human reproduction, and it is uncertain how far any government would go to promote positive eugenics by legislative means. In regard to sex selection accomplished through selective abortion, legislation at any level of government would probably be greatly influenced by public opinion regarding the issue of abortion. Blake and Del Pinal (1981) argue that there is essentially no national consensus on abortion as judged from historical examination of national opinion surveys that have questions on this topic. They argue that "although out-and-out negativism towards legal abortion is rare, so is support for basic planks in the pro-choice platform [Blake and Del Pinal, 1981, p. 318]." Against the backdrop of this political situation, it is likely that laws would be enacted that would legalize abortion in certain circumstances but regulate access to and conduct of abortion to a considerable degree. It is too speculative at this point to predict what might happen if matters relating to sex selection were to be determined, together with abortion, generally by federal or state legislatures. However, if it is permitted at

all, it is quite likely that matters relating to the scope and composition of the decision-making unit, especially the inclusion of the spouse, and access to necessary technology would be the subjects of intense state scrutiny.

Internationally, the trend seems to be toward broadening laws to allow abortion in an increasing number of cases. The International Planned Parenthood Federation (Paxman, 1980, pp. 48–49) reports that since 1967 10 countries—Austria, Denmark, France, the Democratic Republic of Germany, Norway, Singapore, Sweden, Tunisia, the United States, and parts of Yugoslavia—have relaxed their laws to allow for abortion on request (usually in the first trimester). Two countries, Hungary and Bulgaria, have taken steps to limit abortion on demand since 1967. Even in these countries, some abortion on demand is permitted in certain circumstances usually dictated by the marital and parity status of the woman in question (Paxman, 1980, p. 50). It should be noted that women in some of these circumstances might also desire abortion to achieve sex selection. For example, consider the case of a Bulgarian woman with two daughters who wishes to have one more child and also wishes that child to be a son. Assuming that prenatal diagnostic technology is available, she might be able to use selective abortion on request to accomplish sex selection of a son. There is also a coincident trend to merge the practice of abortion with other aspects of overall family planning and to make it available as soon as possible at the lowest possible cost. This trend could easily expand to include genetic counseling and diagnostic services under the umbrella of family planning and, perhaps, accommodate some desire for prenatal sex selection.

To date, only one country, Singapore, has attempted to combine sex selection with family planning programs using the Shettles technique. The technique proved faulty and the experiment was abandoned. However, the existence of son preference in many countries, especially those countries with very high rates of natural increase, could induce governments to engage in wholesale campaigns to dissuade the populace of their gender preferences (as in the case of China) or to try providing technological accommodation to their desires. The technique for accomplishing sex selection through selective abortion is still quite limited in terms of popular access, and other techniques, such as selective implantation, are not yet feasible. As the technology develops, however, public policy and law will be forced to deal with the matter of sex selection. Countries embodying a gender-neutral legal environment may actually move to restrict access to the technology. Countries with high rates of natural increase and distinct gender preferences may take the opposite tack and make the technology generally available. Countries with low or negative rates of natural increase may adopt strategies involving a pronatalist policy coupled with aggressive approaches to increase the status of women to maximize female economic contributions. This strategy may be very amenable to the process of sex selection and may even produce female-gender-biased environments. This is because the state would

have a natural interest in using all technology available to maximize the qualitative aspects of its population and, if coupled with a pronatalist point of view, could result in a strategy to maximize the number of females produced, which might in turn increase the number of expected future births.

In the United States, the law is struggling to develop the appropriate legal forms of action and principles to cope with the fast-developing technology that could be applied for sex-selection purposes. At present, existing bodies of civil and criminal law are inadequate to cope with many contingencies discussed in this chapter. In addition, the constitutional principle of privacy that regulates the interface between the government and individuals in matters regarding the control and termination of pregnancy seems to be a very brittle concept when one attempts to apply it to the problems of sex selection. It may, in fact, be so brittle that it will break and result in sex selection being treated as an exceptional case or, perhaps, precipitate a wholesale rethinking of the privacy principle. However, all of this must remain speculation until actual cases are litigated that will force the law to speak directly to the issue.

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9

Toward A Moral Policy For Sex Choice

TABITHA M. POWLEDGE

BACKGROUND

Etzioni published his seminal article on sex choice in 1968, a long time ago by the standards of science. Perhaps that is one reason why those who cite it often forget that the article was not about sex choice so much as it was about the difficulties of predicting the consequences of, and devising policies for, technologies with the potential for having major impact on human social arrangements. Etzioni's declared intention was to trigger further discussion, and he certainly did, although the percentage of it that has been either illuminating or useful is minuscule. The most public of these discussions, especially the how-to books for potential parents and articles in the so-called women's magazines, have, in presenting their readers with methods—however dubious—for choosing children's sexes, begged the question of whether parents *ought to* seek control of their children's sexes. Serious discussions have been rare, and even they have been descriptive far more often than normative.

There is a sound technological reason for this: The effective ways of choosing are different from what had been envisioned in the 1960s. They are complex, expensive, and inconvenient. Prenatal diagnosis, the method currently most feasible, requires abortion if the fetus is the ''wrong'' sex (and late abortion at that). A simple, safe, cheap technology, one likely to be widely used, is nowhere

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on the horizon. As long as great numbers of people are not trying to choose the sexes of their children, hard decisions about policy do not seem urgent.

But a second factor has also contributed to the sluggish pace of serious discussion, a factor part moral, part psychological. This factor is the inability of thoughtful students of the subject to translate their immediate, almost visceral, usually negative reaction to the idea of sex choice into sensible arguments and policy choices that are not in irresolvable conflict with other important social principles and the policies flowing from *them*. This chapter attempts both argument and policy proposals.

MORAL DIMENSIONS OF SEX CHOICE

As befits this postutilitarian age, most discussion has continued to be tied, in the Etzioni tradition, to the anticipated social consequences of sex choice.

Arguments from "Good" Consequences

Not all commentators have viewed the possibilities with alarm. Indeed, there are several that would be desirable, particularly were they guaranteed instead of speculative. An important goal of birth control practices can be said to be "every child a wanted child." Sex choice could extend that goal not only by providing a child when its parents feel ready, but also by providing the particular kind of child they feel ready to have. Parents, the argument goes, will feel content and so inevitably will the wanted child. A pretty picture, if it were certain to work out that way. Alas, parental expectations based on children's sexes are already in place at birth (if not long before), feeding fantasies, closing off choices, resulting in disappointments and worse when those expectations are frustrated—as to some degree are *all* parental expectations. Parents who went to some time, trouble, and expense to achieve a son would likely be crestfallen if he became a ballet dancer, even a Baryshnikov. And the more the child departs (as does every child) from the platonic idea of the child that exists in the parents' heads, the more of a disappointment, the more unwanted, he or she will be. One could almost argue that deliberate satisfaction of parental desire in the matter of sex would be wrong because it would lead inevitably to frustration and disappointment, and to the child being less wanted than one who entered the world not so burdened with the preceding generation's daydreams.

We can also dismiss the reciprocal argument, that sex choice would be good

because it would satisfy parental desires. Satisfying parental requests for sex choice would not satisfy their desires, because their desires are not really for a girl or a boy, but for a child that will carry out certain acts its parents believe will make them content: continuing the family business, becoming a doctor, winning at Wimbledon. It is the acts that are important, not the sex of the actor, and that matters only because cultural expectations associate particular deeds with one sex or the other.

If it is difficult to base an argument for sex choice on family values, more compelling arguments can be based on benefits flowing from possible alterations in the sex ratio. They, too, need not necessarily be bad. One of those that has begun to seem important to me, as I contemplate male mortality statistics, is loneliness. In 1970, there were only 72 men for every hundred women over 65; that makes my own prospects for survival in good health for some decades considerably less intriguing than they might be. I offer this argument partly to lighten what otherwise has been a debate of leaden solemnity, but I do not mean it frivolously. Human beings are social animals, and most of them are heterosexual. Loneliness, emotional and physical, is always dispiriting and can even engender pathology. The question is whether a massive alteration in the sex ratio at birth in favor of males that insures more of them in the later decades of life is an appropriate solution. One answer is that this great disparity in the sex ratio at older ages appears to be a function of economics and culture. It is a statistic of the more-developed world. Elsewhere, women still die in childbirth, young. (The grave of an old man, surrounded by the earlier tombstones of several of his young wives and children, is a common sight in New England churchyards. We forget how far we have come in 200 or 300 years.) Or girls and women can be subject to a kind of systematic (possibly sometimes unconscious) slow early extermination from chronic malnutrition simply by being less favored than boys and men, a practice common not only in the past (Wells, 1975) but today as well. Something like the reverse of that process appears to be going on in the more developed world. Better nutrition and safer deliveries are saving women, but a phenomenon not much more concretely defined than that wretched word *lifestyle* is killing men. The sensible solution consists not in making more men in order to assure the supply, but rather in keeping the ones already here from sickening and dying. That should be a popular program with men as well.

The final consequentialist argument for sex choice is serious, compelling, even powerful. And it is difficult to refute. It is the argument made by the biologist John Postgate in a 1973 article, an argument more recently taken up by Clare Boothe Luce (1978). They argue that the rate of population increase in the Third World could be slowed more rapidly and effectively if people could be guaranteed not just the number but also the sexes of their children. In some less-developed countries, nurturing a certain number of sons to adulthood is a couple's best chance for a secure old age. In places where infant mortality is high

and female children are perceived as a drain on family resources, Postgate asserted, the drive to overproduce sons, partly for status and partly to assure that some will be around to provide care a generation hence, contends powerfully and often successfully with any natural (and other economic) inclination to limit family size. A *Man Child Pill*—his name for a cheap, safe, convenient (and, of course, so far unavailable) technology for getting sons—would, he believed, solve this problem in both direct and secondary ways: first by its immediate effects on family size, and then by the greatly reduced number of women in subsequent generations—the rate-limiting factor in population growth being the number of available uteruses.

Postgate made a plausible case. It has not been given much attention and research support, perhaps not so much on its merits as because the idea that the planet needs fewer people has come to be regarded in many quarters as not only unfashionable, but even reactionary and racist. Postgate's was a gloomy enthusiasm, however; although he thought the strategy would work, he also thought social arrangements resulting from what would surely be a major alteration in the sex ratio in favor of men would be unpleasant, particularly for women. He was, however, willing to undergo them (or rather, to have women undergo them) for the sake of the larger long-term social good he believed would accrue from reduced population growth.

Without referring to Postgate, Luce made exactly the same argument, although she was most interested in the secondary effects; she argued (1978, p. 826) that "if the world birth rate were only one female baby per *two* women, world population, instead of doubling, as it is now doing every 34 years, would *un*double every 35 years." Although she is a well-known conservative (and her proposal appeared in *National Review*), she has feminist credentials as well. These credentials may bear some relation to her beliefs about the social outcomes, which differ from Postgate's. She envisioned polyandry, or the possibility that women, being rare and therefore very desirable, "might be able, for the first time in history, to dictate their own terms for the improvement of their living conditions and status" [p. 827]. Whether one views that outcome as desirable could well depend on one's sex.

Arguments from "Bad" Consequences

The evils in Postgate's scenario—chief among them that women, being in short supply, will be kept in a kind of perpetual purdah and permitted few freedoms—are typical of the kind of outcomes that critics of possible sex choice techniques envision, and constitute their reasons for opposing those techniques. All commentators are certain that any shift will favor males; the preference

studies (however inadequate) and ordinary observation bear them out. The only argument is about the size of the shift, and what will follow from it. Etzioni's guesses about the social outcomes were related to known statistical differences in the social behavior of men and women. He thus foresaw more crime and male homosexuality, and less "culture" and churchgoing. He also speculated on subtle effects of a larger male population on what might be called social tone and style, hypothesizing that a boisterous, strident, locker-room atmosphere would be loosed in the land.

A curious feature of the talk about changes in the sex ratio is that the sex ratio is spoken of as if it were a single invariable relationship, frozen in demographic amber. In fact, it is age-specific and varies sharply according to the dictates not only of biology, but also of culture. It works against males in wartime. But current sex-choice techniques likely to be used mostly against females are simply a new kind of female infanticide, an ancient practice. Indeed, we have considerable historical experience of differential alteration of the sex ratio. On the other hand, I have argued elsewhere (Powledge, 1981) that, given the fact that we do not have a clear idea of its evolutionary significance or function (including the significance or function of its plasticity), we ought to be cautious about deliberately alterating the sex ratio.

Westoff and Rindfuss (1974) believe that sex-choice technology, at least in the developed world, will result in an eventual ratio much as it is today, although they also believe there may be a period of short-term oscillations in the ratio. They think the oscillations will eventually dampen out, but cannot predict how long the process will take. Resulting social dislocations—erratic, constantly changing demands on social institutions, for instance—might persist over a fairly long time, perhaps several generations.

From the standpoint of the more-developed countries, their most disturbing speculation concerns how a sex-choice technology is likely to affect birth order patterns. If it is widely used to achieve the storybook two-child family (a boy first, a girl second), then a pernicious pattern already present in these countries—anxious, overachieving men and passive, accommodating women—might be substantially reinforced, because those personality patterns also tend to be characteristic of, respectively, first- and secondborns. In addition, such family planning might have an important effect on the sex ratio, because a certain percentage of couples originally hoping, for example, for two-child sex-balanced families will actually stop with one, through infertility or perhaps divorce.

The dangers analysts foresee in sex ratio alteration and rigid birth order patterns are concrete, if speculative. But the worst consequence might be a subtle one—the perpetuation of sexual stereotypes. As I pointed out earlier, the only reason people want a child of a particular sex in the first place is because of beliefs they have about qualities such a child will possess. Whether biology dictates *any* sex role characteristic continues to be a matter for debate. But it is

simply no longer debatable that many attributes of sex roles quite recently thought innate are actually learned, imposed by the culture. If we believe that human beings ought to be as free as possible to develop uniquely appropriate selves, then we must regard with dismay anything that stereotypes and unnecessarily constrains that development. The argument applies no matter which sex is the chosen one.

A corollary argument addresses the position of women specifically. No one disputes that males are and will be preferred; thus, how can we doubt that expressing male preference in a concrete act of conception can do anything but reinforce and serve as continuing justification for the preference? The process is unbreakably circular. To pick a male is to declare males more valuable and females less so, which in turn perpetuates the preference.

This observation is thematically related to my final set of arguments against sex choice.

Arguments from Justice

If the process is circular, it is also something of a zero-sum game. To prefer males is, unavoidably, to denigrate females.

The dominant thread of this century's politics is surely the pursuit of social justice. Such a theme ought to be embraced particularly by Americans, whose nation itself is founded on a philosophical, possibly romantic, yet morally admirable ideal that people ought to be regarded as equally valuable no matter what their surface differences. Beginning with the religious toleration sought by many early immigrants, the list of those surface differences that citizens are by law specifically enjoined to ignore range from the no-longer-applicable, such as previous condition of servitude, to the newest claims to just treatment made by the handicapped.

But this country is also familiar with the social conflict and policy dilemmas engendered when the moral claims of such groups conflict with each other. Sex choice is a fine example, because to restrict it is to restrict reproductive freedom, and many hold this freedom to be a kind of absolute principle. However, while an important one, it is really subsidiary to the egalitarian one, which must take precedence when the two are in conflict. In fact, reproductive freedom is not so much a principle as it is a procedural step, a facilitator, one way of helping achieve the ultimate goal of equal treatment. So we can ignore or abandon it when it works against that ultimate goal.

Therefore, we should embargo sex choice in any form because it abrogates the principle that people (in this case the sexes) should be regarded as equally valuable. Fletcher (Chapter 10, this volume) bases his argument on freedom with

fairness. I reverse his emphasis, underscoring fairness. It is painfully obvious that freedoms for one group often result in injustice to another. A moral policy should always seek to enhance freedom, which is important and desirable, but when the two conflict, fairness must come first—if only to insure that freedom will be equally available to all.

POLICY FOR SEX CHOICE

That tidy abstract theorizing, however, founders on the rock of a practical problem: In the real world reproductive freedom is not just *a* procedural facilitator of the equal treatment principle, it is the foundation supporting the principle, at least as far as equality of the sexes is concerned. To give a simple and concrete example: Improvements in the position of women depend on women being able to obtain abortions without needing to justify their decisions to anyone but themselves. Restrictions retard that goal. There are bad reasons for obtaining abortions, and sex choice is certainly one of them. But I do not believe I, or the state, has any business imposing that view on other women—nor do I wish to provide to others a precedent for intervening in *my* reproductive decisions. I do not want to promulgate laws against abortion for sex choice because I do not want to encourage the generation of lists of officially forbidden or approved reasons for abortion. This is particularly urgent given contemporary abortion politics in the United States.

I am arguing that, to preserve what improvements in their lot women have achieved, society should seek no legal restrictions on reproductive freedom, even on a technology that will be used selectively against females. I recognize its irony, but view this position as part of the price of furthering the goal of equal treatment, much as the toleration of political views of which I disapprove is part of the price of free speech.

I have been distressed to realize that often opposition to sex choice, particularly among women, is based solely on the fact that it is likely to be used selectively against women. Some women would approve of sex choice if they thought they could control it and use it selectively to produce females. Therefore, let me emphasize that my position is not a woman-centered one, but rather one based on the principle of equality. I oppose sex choice no matter what sex is chosen.

I have been talking largely about abortion policy for sex choice, which illustrates a curious fact. It is possible to discuss the ethics of sex choice in the abstract, without reference to specific methods of achieving the desired sex. My arguments can be applied to both pre- and postconception methods. But policy

discussions are more directly linked to methods. One simple and obvious reason is that the method will determine the rate of use, and the higher the rate of use, the more urgent the policy decision becomes.

That accounts for the calm and measured tone of most of the chapters in this volume. It is difficult to get exercised about something so uncommon as sex choice is now when the list of severe and pervasive problems confronting the planet is so long. Nevertheless, I am not convinced that we can safely ignore the subject until somebody actually develops the Man Child Pill. Williamson (Chapter 7, this volume) quite correctly points out how wrong were those who prognosticated almost a generation ago that such methods were just around the corner. But I do not share her optimism that this will always be the case. The march of technology's most predictable feature is its unpredictability. In addition, of course, policy itself can have an important effect on the development of technology. It is to some extent within our power to determine whether more sex-choice methods are developed at all.

Yet another reason to look more closely at the subject is that sex choice is a paradigm, a type case, for policy decisions about genetic engineering in general. This field as a whole (in contrast to sex choice) is undeniably moving much more rapidly than anyone predicted even in the late 1970s. Although it will begin with attempts to eliminate disease, it may move quite quickly on to the ability to select some of our offspring's other attributes. Given the awesomeness of such a step in human evolution, no thoughtful reflection on such subjects, no matter how tentative and preliminary, can be really premature.

Because I expect that process to take a long time, I am eager to see it begin. Therefore, I will conclude by describing some policy areas besides abortion that should be explored, and by making some further policy proposals. Although I do not make them ad hoc or casually, neither am I wedded to them. They are intended as first cuts at complex problems, to provide a basis for reflection, argument, and further refinement—in short, to carry forward the process Etzioni began in the 1960s.

Research is the area ripest for policymaking, because research decisions made today will shape the technology policy of decades and even generations hence. I have two kinds of research in mind here: research into the technology itself and research into how it might be used.

Let me begin with the latter, and with a proposal that will no doubt be controversial among other contributors to this volume, if not elsewhere. We should fund no more preference studies. As McClelland (Chapter 2, this volume) makes quite clear, methodological problems render them all deficient, and that is reason enough to spend the money on something else. But even should all such problems be resolved, preference studies would still be pointless, for two reasons. The first is that they tell us something we already know: People prefer males—hardly a novel insight. The second is that they are unable to help us

toward the two kinds of information we need to guide policy. One is whether people will translate those preferences into action and really *use* a sex-choice technology. The other is what the social consequences are likely to be if they do use it. As I have already observed, for most people a moral assessment of the technology will depend on its results, and those are (and can only be) wholly speculative. Take, for example, disagreements over the status of the sexes in a post–Man Child Pill world. As a woman and a feminist, naturally I find the polyandrous Luce scenario appealing, but history (if not paranoia) inclines me to believe that the Postgate view of things—the revival of purdah—is the more likely one. But in fact, all three of us are guessing. Preference studies cannot help us refine those guesses into something more substantial, so why do them?

Having invited the wrath of the social scientists, let me do the same for the biological ones. We should fund no more research targeted either at the sexing of fetuses or at enhancing chances of conception of one sex over the other. The former is usually rationalized on grounds of its usefulness in eliminating X-linked disease, which affects only males, but that rationalization cannot withstand careful scrutiny. First, dealing with X-linked disease by sexing and aborting male fetuses is morally opprobrious because half those fetuses will be normal. Research should instead be directed toward prenatal diagnosis specific to the disease, not the sex, as is currently the case with the X-linked disease hemophilia. Second, for those X-linked disorders not yet directly detectable, there already exist several methods of sexing a fetus; more are not needed. To the argument that early, safer methods would be useful, I would reply that the earlier and safer they are, the more likely they are to be used for sex choice. In fact, if there is a major increase in sex choice imminent, I expect it to come not from a breakthrough in preconception technology, but as a result of developments in first trimester prenatal diagnosis, now in the research stage. (See Gosden, Mitchell, Gosden, Rodeck and Morsman, 1982.)

Preconception methods are sometimes also rationalized as an aid in eliminating X-linked disease, but the justification is a puny one, and could not, of course, justify research on a Man Child Pill. This entire chapter is an argument against their far more likely use. People who believe that a Man Child Pill would have an important impact on population growth will of course disagree and assert that such research is urgent. But even were I convinced that Postgate's scenario was an accurate prediction, I would still argue that we should not use research dollars to perpetuate social systems that decree only men can earn enough to take care of their aging parents.

Eliminating targeted research is one thing, and it might (indeed, I hope it would) slow down the proliferation of this technology. On the other hand, a major advance could come by accident, out of a different line of investigation undertaken for an unrelated reason, as often happens in science. Controls in this case would have to be post hoc, imposed on application rather than research and

tailored specifically to the particular sex choice method. Because we do not know exactly what those methods will be, we cannot anticipate clearly how we might control them, but some broad problems with controls are already apparent. For example, if timing-of-coitus methods were more effective, even if we had no moral qualms about invading the marital bedroom, I still cannot imagine how, as a practical matter, we might impose controls. Strictures would be unenforceable. Elaborate technology, by contrast, is easier to regulate.

Regulation of sex-choice technology is at the moment in the hands of the medical profession, and is therefore riddled with the usual inconsistencies and a certain respect for free enterprise. Amniocentesis is, by and large, not done for sex choice (although exceptions are occasionally made, particularly if a woman successfully blackmails the doctor by convincing him she really will get an abortion if he cannot tell her the fetus is of the "right" sex). On the other hand, scientists claim to be enabling couples only to conceive males by using the fractionated semen of each husband to inseminate his wife (Beernink and Ericsson, 1982). Amniocentesis has historically been withheld from women who want sex choice on grounds that it is a scarce technological resource that should not be used for frivolous purposes. This cannot be the real objection, however, because it applies equally well to the sperm-separation method to which there has been no professional objection. We are left to infer that in the case of amniocentesis the real objection is to abortion. For medical practitionors (and I am sure for many other people as well), if the technique involves abortion, it is not acceptable; if it does not, it is. In medicine, sex choice with abortion and sex choice without it are seen as morally discontinuous states, with one in need of regulation and one not. For me (and I trust I am not alone) they are on a moral continuum and medicine is an inappropriate (and ineffective!) locus of moral control. But I have no practical suggestions about how to change that as long as the technology involved can be—however vaguely—defined as medical. Indeed, I would not be surprised, if the hypothetical Man Child Pill ever does arrive, to see it made available only by prescription. A good analogy is cosmetic surgery, which can sometimes be life saving, though it is usually done for reasons of social pressure and vanity. Because the line between them is difficult to draw (is the movie star who gets a lift simply narcissistic or is he really protecting his livelihood?) and the methodology comes out of medicine, the whole field is defined as medical, although no disease is involved.

When lines *are* drawn in these fuzzy areas, it is by third-party payers. Perhaps that will also be the case with medical varieties of sex-choice technology: The fee schedule might include amniocentesis for X-linked disorders, but not for sex only. I need hardly say that I strongly oppose including any form of sex choice in the list of those medical procedures supported out of tax funds, although I recognize that this shuts out the poor, leaving others free to seek it if they can pay

for it. In that case, we can always express moral disapproval in the way we do for other activities we believe cannot be suppressed, like liquor, gambling, and tobacco: Tax it, perhaps heavily.

It is unlikely that many, perhaps any, of these proposals will come to pass. I am not naive enough to believe that the equal treatment argument will be very persuasive. Equal treatment (not just of the sexes, but of people in general) is an unpopular cause today, and the liberalism underlying it an object of derision, considered old-fashioned and impractical.

The best hope for discouraging sex choice lies in arguing that its consequences will be socially disruptive. But the consensus is otherwise. Analysts believe either that unpleasant consequences will be few, or that sex choice will bring benefits and (as Postgate and Luce say) perhaps even save the planet. We forget, when the Westoff and Rindfuss study is cited, that these authors cautioned that their conclusions might not hold in the developing countries, where male preference is probably stronger than in the United States, or if there were a major increase in one-child families in the developed countries, as is already a trend in Europe. When one adds to the belief that sex choice may not be so bad after all the economic interests in providing methods of sex choice, medical and otherwise, and the self-absorption of the parents who would use it, the forces conspiring to promote sex choice seem formidable.

A FINAL WORD

We have not faced up to the fact that sex choice is eugenics in all the opprobrious senses of that word. We have been deceived, partly by Nazi history and partly by devisors of fiction like Aldous Huxley, into believing that eugenic ideas will be imposed by governments. We simply do not see that attempts by individual couples to achieve particular kinds of children are no different, except that the one is imposed by state power and the other appears voluntary. I have argued elsewhere (Powledge, 1984) that not all eugenics ideas are intrinsically evil. But when eugenics *is* evil, does its evil reside solely in whether the state promulgates it? Are all attempts at eugenics acceptable if they are individual and voluntary? With sex choice, we seem perilously close to answering those questions "yes." There is no little irony—and a bitter lesson of sorts—in the discovery that those who have feared a recurrence of the sordid eugenics history born early in the century may have been directing their vigilance at the wrong quarter. It is not the hypothetical actions of governments that should fill them with trepidation, but those of the people themselves.

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10

Ethics and Public Policy: Should Sex Choice Be Discouraged?*

JOHN C. FLETCHER

INTRODUCTION

Foucault (1978), the historian of sexuality, uses the terms *bio-power* and *bio-politics* to describe the onset of public controls over the human body in populations of seventeenth and eighteenth century Western European nations. The steady increase of public and individual control over life and its elements led to a qualitative difference between earlier ages and modernity depicted by Foucault as follows:

> For millennia, man remained what he was for Aristotle: a living animal with the additional capacity for a political existence; modern man is an animal whose politics places his existence as a living being in question [p. 142].

One of the most difficult and complex societal issues bearing on Foucault's thesis is the emerging possibility that an effective method or set of techniques could introduce control in parental choice of the sex of children.

*This reflects the opinions of the author and does not necessarily reflect the policy or the opinions of the National Institutes of Health.

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There are three methods by which some parents and physicians have attempted to increase the chances of having a child of the preferred sex; (a) timing of intercourse and/or pre- and postcoital douching, (b) selective abortion following amniocentesis, and (c) techniques to separate X- and Y-bearing sperm followed by artificial insemination. Extensive reviews of the efficacy of these techniques (Rinehart, 1975; Williamson, 1978) show them to be objectionable, difficult, or unreliable. These methods do not promise to be rapidly diffused for use in the United States or any other society. Physicians do not counsel couples at risk for a sex-linked disease to consider sex determination at conception by any method but counsel them to be aware that amniocentesis can identify the sex at 16–18 weeks of gestation.

Although the state of the art of sex selection is in its infancy, existing research does point toward the possibility that society will face real choices about the desirability of widespread use of sex choice in family planning. A report by Dmowski, Gaynor, Rao, Lawrence and Scommegna (1979) indicated partial success in the use of albumin gradients for X and Y sperm separation for clinical use to select males. Herzenberg, Bianchi, Schroeder, and colleagues (1979) reported that fetal cells potentially usable for prenatal diagnosis were sorted from maternal blood samples taken as early as 15 weeks of gestation. The latter discovery has considerable significance for earlier screening of the fetus. More research will likely open new doors to *sex choice* (i.e., the selection of the gender of a child before its birth). Policy makers are in a fortunate interim with time to reflect soberly on some of the implications of sex choice for various societies and their moral and cultural traditions and, further, to reflect on the problem of attempting to guide or direct the diffusion of sex-choice technology.

Callahan (1980) described a shift in the young field of bioethics from a focus on moral problems that confront the physician and patient as individuals to social–ethical problems that confront the entire society and call for some form of resolution in public policy. This chapter is especially intended for policy makers in the health sciences and groups in which decisions are made about whether to encourage research that may lead to sex choice.

The strategy of the argument is based on a rule-utilitarian approach to ethical conflicts. The approach is described following a brief account of the rise of a prevailing voluntaristic ethos with respect to sexuality and reproduction. The major claim of the argument is that this ethos provides a common-ground moral policy in relation to which several diverse moral traditions can contend and coexist. The predominant ethos is guided especially by moral principles of freedom and fairness. Finally, the positive and negative consequences of guiding decisions about sex choice in family planning by these principles are evaluated, as far as existing evidence and experience can take us. The public policy ques-

tions cluster around one theme: Should sex choice be discouraged as a social practice?

MORAL POLICY IN SEXUALITY AND REPRODUCTION

The term *moral policy* is used here, following Callahan (1970), to mean the way a particular community chooses to order the moral rules about a particular area of social life. The term *community* includes a wide variety of human groups and collectivities. A moral policy contains a guide to conduct, or a *prescription* as Hare (1977) defined the term, that is itself a response to the claims of one or more moral principles. Within the policy there will be a bias toward firmness or looseness of the rules and attention to the hierarchy of rules. Moral policies relate the moral experience of human communities to moral judgments in the unfolding problems of everyday life. An example is in the prevailing moral policy on euthanasia (J. C. Fletcher, 1982). The first feature is the basic prescription that guides the policy—it is wrong to kill an innocent person, even though that person is suffering and asks for death in the name of mercy. There is a general moral rule against the killing of persons that functions throughout societies. Baier (1965) describes the exceptions that are part of the rule: killing an enemy in war, capital punishment, accidental killing (the suicide-bent person steps in front of one's car), and, as Baier (p. 99) interestingly puts it, "possibly mercy killing." The second feature of the policy is an affirmative stance toward allowing an individual to die when evidence shows death is imminent and attempts to prolong life would increase suffering.

A moral policy contains the basic prescription or guide to conduct in a form that can be communicated when the need arises to express it. Need arises when there are cases to be considered, when features of the policy are being questioned, and when others need to know what the policy is. Education of persons in professions is a typical occasion for communicating moral policy. What do we want physicians in their education to know about moral policy with respect to sexuality and reproduction? What would we want them to know about moral policy regarding sex choice in particular? At a minimum, one would want them to know the basic conduct guidelines most cherished by the society, the moral rules pertaining to this conduct, the degree of strictness of the rules, the possibility of exceptions, and the leading arguments that challenge the prevailing moral policy. For consensus on moral policy one looks to authoritative writings

on ethics, crucial legal decisions and legislative and policy expressions of the ethical legal background.

Freedom with Fairness

Discerning the moral policies actually at work in the society is the requisite first step in a rule-utilitarian approach to analysis of a conflict about the ethics of changing a social practice that affects all members of the society. Rather than estimating the benefits or harms that might flow from doing or refraining from certain acts, such as sex choice, one estimates the positive or negative consequences of continuing to follow the moral guides that society uses to structure choices about the acts. What is the content of moral policy in sexuality and reproduction? Since the seventeenth century, in Western nations and increasingly in other societies, these activities have been defined as voluntaristic social practices that respond largely to the claims of moral principles like freedom and fairness. Freedom is defined both negatively and positively. On the one hand it is freedom from external restriction, harm, and the disabling of voluntaristic activity. On the other hand, freedom is self-realization and the satisfaction of basic needs. Fairness is defined as impartial and equal treatment of those who participate in voluntaristic activities and as the obligation to live up to certain standards expected of all who participate in the activity. These two principles have so interacted with the various family, legal, and moral traditions of a pluralistic society that a unifying tradition itself can be described, functioning as one of freedom *with* fairness.

The discussion will touch both upon the development of marriage and family institutions that structure and regulate sexuality and reproduction and upon several major innovations in the control of reproduction, such as contraception, abortion, sterilization, prenatal diagnosis, and *in vitro* fertilization (IVF). Historically, significant changes in human conduct in marriage and family life preceded technological innovations in reproductive control. To some extent, the values that emerged from four centuries of cultural change in marriage and family life, conditioned by the Industrial Revolution, prepared the way for many to accept reproductive technologies.

Marriage and Family

Stone's (1975) historical research on the threshold of the rise of the nuclear family in sixteenth-century England shows that, prior to industrialization, forces at work through the Protestant Reformation and the rise of the modern state led to

consequences for the family in England that in succeeding centuries have been noted in virtually every modern nation (Goode, 1963), although the routes of change and transmission of these changes have been diverse and complex. Specifically, kinship declined as the main organizing force of the society, the state assumed many of the social and economic functions that extended relatives had once borne, emphasis increased on the affection and companionship that bound the conjugal pair, and the conjugal family became increasingly the seat of moral authority in family matters, rather than extrinsic religious authorities. To be sure, the authority of the husband–father was supreme in this period, reinforced by propaganda from a favorable monarch and state. However, patriarchical authority itself began to change with the spread of concepts of individual choice and egalitarianism as espoused by Locke and others, resulting in an eighteenth-century ideal of marriage chosen for love and companionship rather than the traditional patriarchically arranged marriage for commercial or inheritance considerations. The less fortunate classes had long enjoyed the "opportunity" of companionate, self-chosen marriages. It remained for the nineteenth century thinkers, especially the philosophers Marx and Mill, to mount a full-scale attack on the cultural and economic subjugation of women to men.

The modern conjugal family based on egalitarian considerations is an ideal type to which many exceptions may be found by examination of actual behavior. For example, parents are ideally not supposed to interfere with a grown child's marriage choice, but many in fact do so. Yet one may safely claim that after four centuries of development, a moral policy does exist designed to guide decisions about marriage and family relationships. The freedom of the individual to choose his or her own marriage partner, to pursue the self-fulfillment possible through marriage, and even to dissolve the marriage, is increasingly urged upon members of the society. The principle of fairness is relevant to the resolution of conflicts of interests between women and men, as well as those between children and their parents. Rothman and Rothman (1980) have commented on a growing awareness of children's rights in contrast to women's rights in family disputes.

Further, the institutions of marriage and family have been increasingly defined within a so-called private sphere of social existence (Berger and Kellner, 1964), perceived as apart from immediate control of economic and political institutions. Within this private sphere it is believed that individual choice and autonomy can be protected and exercised. The reasons for the development of the private sphere are deeply related to the history of industrialization. The relationship between the concept of privacy utilized by the Supreme Court in decisions related to contraception, abortion, and procreation and the historical development of a concept of a private sphere is extremely significant. The idea of a private sphere can also be understood as a product of secularization in that with the reduction of influence of official religious guidance of individual choices,

there needed to be an equivalent social definition of limits to political, social, and ecclesiastical interference with individual pursuit of happiness.

Sexuality

London (1978) and Farley (1978) have traced the steady growth in sexual freedom in almost every segment of the society, as well as the growth in a positive emphasis on sexuality in written expressions of ethics, including religious ethics. The principle of freedom has probably been subject to abuse in this rapid development, because the major moral problem currently facing the society in sexual behavior is the limits of the permissible. The principle of fairness can be seen at work in the development of legal and social protection for homosexuals who struggle against attempts to change their expression of sexuality. So much documentation exists of the extension of these two principles in the area of sexual behavior (Hunt, 1975) that no further comment is needed here.

Application of Reproductive Technologies and Interventions

Public and private contraceptive educational programs have grown steadily in recent decades. The success of such programs can be partly measured by the fact that since 1970 (The Alan Guttmacher Institute, 1979) contraceptive use by poor women in the United States increased to the point where there is virtually no difference in rate of use by poor and nonpoor women. Federally subsidized contraceptive services were extended to over 4 million poor women through family planning programs, and the majority of women who obtained abortions reimbursed by Medicaid received contraceptive education and left the abortion agency with a contraceptive. These services were originally authorized by Congress in 1970 in Title X of the Public Health Services Act (Section 1007), which underscored the voluntary nature of the program:

> The acceptance by any individual of family planning services for family planning or population growth information (including education materials) provided through financial assistance under this Title (whether by grant or contract) *shall be voluntary* and shall not be a prerequisite to eligibility for or receipt of any other services or assistance from, or to participation in, any other program of the entity or individual that provided such service of information [42. United States Code 300a-5].

Two decisions of the Supreme Court on contraception also reflect the voluntaristic ethos based on the freedom principle. In *Griswold* v. *Connecticut* (1965, p. 485), a state law banning the use of contraceptives was held unconstitutional on the basis that the law in question "had a maximum destructive impact upon

the marital relationship.'' Further, the privacy of the marital relationship was seen as protected by the Bill of Rights. The decision in *Eisenstadt* v. *Baird* (1972) struck down a Massachusetts law banning distribution of contraceptives to the unmarried. The Court (pp. 435, 453) held that contraception was a fundamental right, because ''it is the right of the *individual,* married or single, to be free from unwarranted government intrusion into matters so fundamentally affecting a person as the decision whether to bear or beget a child [italics added].''

From the time the Supreme Court declared a Texas antiabortion law unconstitutional in *Roe* v. *Wade* (1973, pp. 113, 154) on the basis that ''the right of personal privacy includes the abortion decision,'' about 6 million women obtained legal abortions through 1979. The annual number of legal abortions increased in 1977 to 1.3 million, more than 600,000 more procedures than were done in 1973. In 1978 nearly one-third of all abortions were obtained by women under 20 years of age, and childless women accounted for more than half (53 percent) of all women obtaining abortions (United States Department of Health, Education, and Welfare, 1979a). Abortion on request is available to most women if a physician agrees with their reasoning. The woman's freedom to decide for abortion has been extended and protected. On the other hand, in the interest of fairness, the Court (pp. 115, 154) stated that the right to abortion was not ''unqualified and must be considered against important state interests in regulation.'' The Court also stipulated that physicians should be involved in abortion decisions and that physicians have the right to refuse to perform abortions.

Abortion policy in both private and public sectors of medicine has been applied with an emphasis on the voluntary nature of the request. There is no evidence in the United States of overt social and economic policy favoring abortion in the name of population control as there is in China (Engelhardt, 1980). Further, a Supreme Court decision upholding the right of Congress to limit federal funds for abortion to protect the life of the mother reflects an appeal to the principle of fairness by those who feel that the legitimate interest of the state in the protection of life was undercut by an unlimited approach to abortion (*Williams* et al. v. *Zbaraz* et al., 1980).

Involuntary sterilization of males and females was done in the past in many states in the United States for eugenic and economic reasons (Giannella, 1973), but in the latter half of this century, a strong trend in moral and legal policy toward voluntary sterilization became evident. Friedman (1978) noted that then-binding Supreme Court and appellate court decisions sustained the state's power to compel sterilization of ''mental incompetents,'' but that a federal court in *Relf* v. *Weinberger* (1974) held that any sterilization made possible by federal funds could be done only with the voluntary consent of the individual. It followed that no mentally incompetent person could meet this standard. After an appeal, the Department of Health, Education, and Welfare adapted its policy to express a federal standard of voluntariness. As of 1980, rules of the Department of Health

and Human Services to cover payment for sterilizations funded under federal auspices have required not only written informed consent of the individual but a 30-day waiting period between signing the consent form and the surgical procedure. The purpose of the waiting period has been to avoid coercion and decision making in the stress of labor. These rules have applied only to a person above the age of 21 years who is competent to consent and who is not institutionalized. There is a report that the waiting period has not been respected by physicians in some states (Kurtz, 1980). An official audit of 11 state records by the Office of the Inspector General has been done to document the extent of noncompliance, but this material is still unpublished and unsummarized.

Voluntary sterilization for reasons of contraception or health increased more than threefold between 1970 and 1978. In 1978, 670,000 women were sterilized, but in 1981 it was estimated that this number had decreased to 464,000 (Association for Voluntary Sterilization, 1982). 424,000 men were sterilized by vasectomy in 1981, as compared with 461,000 in 1978. The reasons for decline in numbers were probably (a) fewer eligible persons in the total pool, (b) increased costs of the procedure, and (c) increased losses of insurance coverage and eligibility.

This brief sketch indicates a dual movement toward increased voluntary sterilization and increased efforts to protect those whose rights may be easily abused because of their incompetence.

Prenatal diagnosis of disease or malformation in the fetus *in utero* was applied to as many as 40,000 pregnancies in the United States by 1978 (United States Department of Health, Education, and Welfare, 1979b). In 1978 alone, 15,000 of these procedures were done, indicating a recent rapid increase. In the earliest use of amniocentesis, prior to the knowledge of its safety and efficacy, some investigators (Fuchs, 1971; Littlefield, 1970) argued that parents who were not willing to accept abortion should not be allowed to obtain amniocentesis, because bearing the unknown risks could be justified only by abortion when a diagnosis was positive. Because studies of the safety and technical accuracy of amniocentesis have firmly established that the possibilities of fetal death and technical error are each less than 1 percent, this early restriction has been relaxed. There is no published evidence of coercion of women whose pregnancies are seriously at risk for genetic disease to obtain personal diagnosis. Callahan (1973) expressed concern that social and economic pressures would force at-risk parents to use amniocentesis, but these consequences have not materialized. The transactions between genetically at-risk individuals and genetic counselors take place within a situation overwhelmingly defined as voluntaristic by counselors and clients themselves (Sorenson and Culbert, 1979). Some moral and legal critics have reflected on the benefits of a law that would make the knowing transmission of genetic defects a crime (J. F. Fletcher, 1974; Shaw, 1973), but there has been no legislative activity in this area.

Over 100 infants had been born by 1983 to previously infertile mothers due to achievement of human IVF of recovered ova and implantation in the uterus, some in the United States. No federally funded research on human IVF has been allowed in the United States because of a moratorium imposed by the Secretary of the Department of Health, Education, and Welfare (DHEW) in 1975. Mastroianni (1978) provided an extensive list of scientific and therapeutic benefits that could emerge from research on human IVF. On being asked for guidance on whether federal funds should be expended for research on IVF, the Ethics Advisory Board (1979) to the DHEW secretary recommended that federal support be limited to studies of the safety and efficacy of IVF and embryo transfer of gametes derived from lawfully married couples. As of 1983, no regulations had been issued pending approval of the secretary of the Department of Health and Human Services.

A precedent for the IVF recommendation of the Ethics Advisory Board was the recommendation on fetal research from an earlier national body (National Commission for the Protection of Human Subjects in Biomedical and Behavioral Research, 1975) that subsequently became a regulation of the DHEW (Code of Federal Regulations, 1978). Research that promises to benefit a particular fetus is permitted so long as the risks are minimal and the information cannot be obtained by other means. Thus the scope of freedom of research into fertilization, gestation, and the obstacles to reproduction is limited and balanced by the extension of the principle of fairness to the interests of the fetus that will not directly benefit from such research.

In summary, an overarching moral policy has developed that protects the freedom of parents and physicians to apply knowledge gained from research and technology to intervene to avoid or achieve reproduction, even while treating with fairness those who would not themselves, on moral grounds, use such freedom. On the practical level, this policy has been enacted by allowing knowledge and technology to be diffused through a public filter of individual choice. Persons who want to practice contraception may do so; those who do not are not extrinsically punished. Persons who are at risk for genetic disease are counseled but are not prohibited from reproduction. Abortion decisions are overwhelmingly the choice of the woman. Mentally retarded persons are given sex education and equipped with contraception in some instances. It is increasingly considered blameworthy to sterilize another person involuntarily. The injunctions of the moral policy as it bears upon reproduction are twofold: "I will respect your freedom to choose to avoid or achieve reproduction with or without technological intervention, if you will respect my freedom to do likewise. Further, I will work for a society in which neither of us will suffer harm or punishment because of the differences that exist when freedom is cherished." This moral policy provides a common ground upon which differing moral policies can coexist, as long as each community assents to the principles inherent in the policy. A strong similarity

exists between the function of this moral policy and the dynamics of religious toleration. An inevitable result of tolerance of different moral policies is that acts that some consider to be morally abhorrent coexist alongside renunciations of those acts. The frequency and intensity of moral abhorrence increases with the variety of sexual and reproductive choices. The range of moral policies is indeed wide. On the one hand, official Roman Catholic teaching is that the unity of the procreative sphere and the sphere of marital love is created by God and should not be disrupted except to avoid a greater and unavoidable evil. On the other hand, there are emergent moral claims of homosexual communities for protection of the freedom of expression of a form of sexual love that not only separates procreative from marital love between male and female but also allows for a choice against each. Within these poles of divergent practices are several religiously or culturally inspired visions of moral responsibility that reflect the rich diversity of peoples who have added their cultures to the United States.

The most serious challenge to the existing moral policy has been the effort for a constitutional amendment limiting freedom in abortion decisions. McCormick (1980, p. 41) outlined a proposal for an amendment premised upon the difference in abortion if "the alternative is tragedy" (incest, rape, impaired physical health of the mother, genetic disease in the fetus) or abortion for "mere inconvenience." As yet, however, the moral policy of freedom with fairness, with its emphasis on individual choice, remains essentially uncompromised as the way the society reconciles a wide diversity of values, attitudes, and beliefs in sexuality and reproduction. Even those who criticize the prevailing moral policy as "excessive individualism and autonomy: the freedom-to-be-let-alone-to-do-my-own-thing syndrome [McCormick, 1980, p. 43]" draw upon the freedom and fairness that the policy makes available to all. There is freedom for a variety of moral policies and there are no unfair disincentives or economic reprisals against those whose moral traditions oppose the modern tendency to separate sexual love and reproduction. The limits of freedom begin when harm is inflicted on all by its unlimited expression. The question before us is whether the freedom to practice sex selection is such a case.

Rule-Utilitarian Approach

The reader is now asked to examine two claims that have been successfully advanced in the name of human reason. The first is that we should adopt the overriding principle that we should do what is required by moral rules. Baier (1965, p. 91) describes this step as adopting the "moral point of view." Rule utilitarianism is based primarily on a concept of unity in diversity, in that one wills to act in a way that will best serve to harmonize the interests of all of those

diverse others who will be affected by the action proposed. Further, one decides that the most reliable way to act in the long run is by submitting self-interest to the test of following moral rules by assessing the consequences of following the rules in the classes of cases in dispute. The theory is utilitarian in that it estimates the value of actions by reference to their consequences, but the actions are not divorced from the obligation to follow moral rules.

I hold with Gert (1973) that there are no independent moral rules concerning sexual behavior to which all rational persons would agree. Rape is immoral because it involves brutalizing and victimizing another person and inflicting pain and depriving of freedom, not because it is a sexual activity. In short, rape is immoral because it violates moral rules that apply to all forms of behavior. Sexual behavior should not be singled out as a special category for its own moral rules. The moral policy of freedom with fairness is the way the society calls attention to the two moral rules that might most frequently be violated in sexuality and reproduction: (a) Do not cause loss of freedom or opportunity, and (b) Do not be unfair. The benefits that emerge from technologies to control reproduction can only be recognized as morally justified benefits if persons are not coerced to use them. Coercion deprives one of freedom and opportunity. Coercion is also unfair because sexuality and reproduction are defined as voluntaristic activities. The opportunity to control reproduction and express sexuality must not be coercively blocked because these moral rules would be broken. It further follows that those who, on moral grounds, choose not to use technology to avoid or achieve reproduction must not be treated unfairly or deprived of opportunity in the society because of their position.

Rule utilitarianism is concerned primarily with precise calculations of the consequences of faithfully following moral rules and the policies that the rules inspire. This theory does not ask "What would be the consequences if doctor A responded to patient B's request for sex choice in this particular situation?" Looking at the consequences of acts while referring to moral rules as rules of thumb or maxims is the main characteristic of *act utilitarianism,* perhaps best described by Joseph F. Fletcher (1966). In my view, the possibility for fallacy and self-interested reasoning are significantly reduced if the problem is approached through this question: "What would be the consequences if doctor A and all others in the physician's situation followed the moral rules applicable in this society for this request and others like it?" The reason for caution about situation ethics is that because of self-interest none of us sees the situation as adequately as we ought. We need the help of rules that have gradually been tested and adopted. What appears in the short run to be in our best interests often in the long run proves to be mistaken. Additionally, an ethical method based on assessment of consequences for individual situations is not adequate for a larger social–ethical issue, such as sex choice.

In this view, the place of moral rules is obviously very important. To para-

phrase Baier (1965), to be moral means to reason in a way that overrules the reasons of self-interest in those cases where if everyone followed self-interest significant harm would come to everyone involved. Rule utilitarianism holds that we should consider first the consequences that follow from applying the moral practices of the community to the decisions at hand. If it can be shown that consistently following this moral policy leads to reprehensible amounts of pain, avoidable suffering, deprivation, or long-term social upheaval, we are obliged to reassess the ordering of the moral rules and recommend a change in practice. No moral policy is inviolable, and no moral rule is beyond criticism. We should judge moral policy by the consequences of consistently and faithfully observing it.

This observation brings out the second claim, which is that we have the freedom to decide to alter the force and applicability of moral rules by generating exceptions that become part of the rule. We have the freedom to change loyalties. This freedom may be expressed by the individual who criticizes a prevailing moral policy and recommends a change in practice. Lorber (1973), a British neurosurgeon, acted in this spirit about selection of infants for treatment of open neural tube defects after 15 years' experiences with aggressive surgery. Or an individual may conscientiously object to following a moral policy and openly violate the policy while accepting the moral and legal consequences. Dr. Hermann Sander did so in 1949 when he dictated into the hospital records that he injected air into the vein of a cancer patient on the verge of death. He was tried and later acquitted of the offense (Russell, 1975).

There are also examples of whole groups in societies acting upon their freedom to change loyalties. The applications of moral rules are affected by historical, technological, and cultural change. For example, it was sufficient for many years that the conscience of the individual investigator was the only moral resource to protect human subjects in research. In the mid 1960s, however, a combination of increasingly potent research tools and rising popular expectations to participate in decisions that affect the quality of life resulted in a modified moral policy that now requires peer review of research proposals, written informed consent, and strong emphasis upon individual conscience (Frankel, 1976). The priorities expressed through moral policy differ in time and circumstance. Moral rules and their expressions are human products, or products of cultural evolution, and thus are subject to the qualities of openness and change that characterize everything human.

When we face the question of whether sex choice should be encouraged or discouraged, we are brought up against the dual nature of morality. Wisdom from the past and awareness of our fallibility makes the objective side of morality necessary. No human being is good enough to answer the question apart from guidance by the moral rules. On the other hand, pressure from the future and its possibilities makes the subjective side of morality necessary. No moral rule and

its application is inviolate in the sense of being unrelated to the consequences that flow from consistent attempts to follow it. An adequate ethical analysis must hold these two sides together.

CONSEQUENCES OF FREEDOM WITH FAIRNESS IN SEX CHOICE

What are the likely positive and negative consequences of loyalty to the policy of freedom with fairness applied to sex choice? Three ranges of possibility are discussed: (a) sex choice by amniocentesis and midtrimester abortion, (b) sex choice by fetal sexing and first-trimester abortion, and (c) sex choice by methods that avoid abortion.

Amniocentesis and Midtrimester Abortion for Sex Choice

In a 1979 article, I revised a long-held position favoring prohibition of amniocentesis for sex choice. I argued that it was inconsistent for physicians who hold the view that the best abortion policy is the one that protects the autonomy of women to withhold amniocentesis for sex identification mainly because they object that an abortion may follow. The argument does not advocate the use of amniocentesis for sex choice; it protects the freedom of a woman to request abortion for sex choice and allows the participation of physicians in the interest of fairness. The article portrayed a physician confronted with a request from parents who were genuinely informed about risks, had multiple children of the same gender, and who wanted one child of the opposite sex with the final pregnancy. If the same physician defends the right of women to obtain abortion for any other unwanted pregnancies, he or she could not (in my view) reconcile the refusal of amniocentesis on the grounds of objection to abortion. Consistency in abortion policy was the main thrust of the argument.

Subsequent critical responses to the article (Adamek, 1980; Childress, 1980) claimed that the argument was weak in two respects: (a) insufficient attention was given to the Supreme Court's stipulation (*Doe* v. *Bolton,* 1973; *Roe* v. *Wade,* 1973) that physicians should participate in abortion decisions, and (b) there was overreliance on legal rather than moral reasoning, in that an argument from consistency did not count as heavily as an appeal to an ethical principle such as fairness. Another shortcoming was the lack of perspective on the long-range possibilities of sex choice. These weaknesses are conceded and invite

further discussion of the social–ethical issues of amniocentesis and abortion for sex choice.

What are the negative consequences of following the policy of freedom with fairness in requests for amniocentesis for sex choice? Writers who have published their concerns about the issue or who defend prohibition of amniocentesis for sex choice point to three negative consequences if prohibition is relaxed: (a) an excessive drain on an important medical resource at the expense of parents who are medically at risk (Milunsky, 1977), (b) precedent setting for wider use of sex choice that will increase sexual discrimination (Lenzer, 1980), and (c) if the numbers of persons using abortion for sex choice rose sharply, there would follow a strengthening of the antiabortion position leading to the overturn of legal abortion (Kazazian, 1980). Each of these potential consequences will be explored.

Frequency of Amniocentesis for Sex Choice

By 1978 over 40,000 amniocenteses had been done for medical indication, and the figure probably increased by 20,000 in 1979 (United States Department of Health, Education, and Welfare, 1979b). How many amniocenteses for sex choice not involving sex-linked disease have been done in the United States? No empirical study of this question has been done. An informal estimate is that the total number ever done in the approximately 125 recognized prenatal diagnosis centers between 1970 and 1983 does not exceed 50. This estimate is based on personal communication with active centers, news reports on the issue (Cohn, 1979), and two surveys of attitudes of genetic counselors (Fraser and Pressor, 1977; Sorenson, 1975). Sorenson found that only 1 percent of a sample of 448 counselors would accede to a request for sex choice amniocentesis. Fraser and Pressor found 21 percent of a sample of 149 counselors open to a request or willing to refer the request, a definite increase in acceptance of the idea but no reliable indication of actual practice. The number of amniocenteses done in the belief that maternal age was over 35 years when age was falsified is unknown. Physicians do not routinely ask for birth certificates. At any rate, no reports of sharp increases in requests for sex choice alone exist in the medical literature. Kazazian (1980, p. 18) wrote that 6 months after the Prenatal Diagnostic Clinic of the Johns Hopkins Hospital changed its policy from refusal of counseling to couples with a sex-choice request to offering counseling, there had been only "one serious request for sex selection by a couple otherwise at low risk for prenatally detectable disease." Kazazian's report is significant because the policy change was openly discussed in the center with cooperating physicians in the area and the final policy decision was widely reported. His conclusion is that couples who want to select sex by means of midtrimester abortion are uncommon

in American society. An empirical case that present use of amniocentesis for sex choice is now a drain on medical resources on a national or local scale cannot be made.

A Precedent for the Future?

Is sex choice by amniocentesis a precedent for wider practice of sex choice by simpler, safer means? An empirical answer to this question lies partly in the motivation of parents who now request amniocentesis for this purpose. Their motivation is notably different from the desire to balance gender in a two-child family or the sequential birth planning that likely would dominate future use of sex choice. The parents who continue to request amniocentesis for sex choice after being discouraged by accurate counseling are willing to accept the risks of amniocentesis and midtrimester abortion. The usual medical risk–benefit ratio does not work here, because the benefit to be gained (preferred sex) reflects an emotional or social need that is difficult to measure against the risk to the woman's life and health and the slight risk that the preferred fetus will die as a result of testing. The risk of fetal death from amniocentesis is less than 1 percent, according to controlled studies in the United States and Canada (NICHD, 1976; Simpson, Dallaire, Miller, Siminovitch, and Hamerton, 1976). The risk of death to the woman from abortion rises with gestational age. Abortion in the first trimester is seven times less likely to cause maternal death than childbirth. After 16 weeks' gestation, however, the risk of death from abortion is greater than from childbirth, or close to 20 deaths in 100,000. The risks of complications such as infection, embolic events, and hemorrhage are also greater with late abortions (Cates and Tietze, 1978). Further, there is an unknown risk of insult to other members of the family by abortion for sex choice.

What could explain the acceptance of these risks? Two characteristics have been identified in medical reports: (a) emotional suffering and despair following multiple births of the same gender and (b) strong male preference in new immigrants or graduate students from Asian nations.

Dove and Blow (1979) reported that a 30-year-old married Englishwoman (an only child) pregnant for the sixth time (para 3 + 3) threatened to kill both herself and the child of this pregnancy if the child was another daughter. Physicians offered amniocentesis on the condition of the mother's accepting psychotherapy. She accepted and amniocentesis identified a female fetus. The mother's request for abortion was refused. Psychiatric support was accepted both before and after delivery of the child. When the authors questioned the mother's ability to care for her children of either sex now and in the future, they investigated and found that "she is an exemplary wife and mother [p. 1399]."

Kazazian (1980, p. 18) wrote that in 8 years at Johns Hopkins "nearly all" of

the couples seeking amniocentesis for sex choice were of Asian extraction, "frequently Indian, and they desire a male after one or more female children." Williamson's review of sex preference (1976) shows that boy preference is highest among women in rural Egypt, Algeria, and Tunisia, and among men in India. The reasons reflect the inequality of sex roles, religious beliefs, and the dependence upon sons in support of the elderly. When persons from these backgrounds immigrate or study in the United States, they may seek amniocentesis to fulfill expectations derived from another culture before they have an opportunity to adopt different expectations of their future.

Anxiety and desperation in parents must in most cases be extremely high to prompt a request for amniocentesis for sex choice. Stress may also explain the parents' choice to confront physicians with an ultimatum to abort if the procedure is refused. Physicians in this bind feel morally blackmailed. Kazazian (1980, p. 18) believed the previously mentioned couple offered amniocentesis at Johns Hopkins would "terminate the pregnancy without sex selection," and he noted that "they had terminated another pregnancy for other reasons." Physicians like Kazazian now prefer (in my view, on sound ethical grounds) to attempt to save the life of a fetus, as long as these crises of gender remain the rarest exception to the approved medical reasons for amniocentesis and do not compromise requests by at-risk individuals. Male or female preference is not now so strong in American society, unless exacerbated by special circumstances, to be a compelling motivation for many couples to ask for amniocentesis for sex choice. Counseling will be an effective means to discourage most requests. A few parents, however, will persist. What then? When ethical beliefs are premised largely on balancing the aggregate consequences of good against those that are harmful, rather than on only judging the intrinsic rightness or wrongness of an act, there are ethnical reasons for meeting the request to avoid certain harms. Before the physician's choice can be fully explored, however, the question of precedent must be addressed. Does providing amniocentesis set a moral precedent that will inevitably lead to wider use of sex choice?

My negative answer rests on three points. First, because a few desperate parents now seek help through amniocentesis it does not follow that parents motivated by family planning considerations will use sex selection widely. The answer to why future parents may or may not desire sex choice is exceedingly complex.

Second, a precedent to restrict contemporary abortion policy entails a higher risk of compromise to the ideal of equality between men and women than does taking a risk that the few sex-choice abortions done under this policy can be contained, without setting a moral precedent that sex choice by abortion is good practice. If a prohibition of amniocentesis for sex choice were truly to be made effective in public life, legislation and strict administrative controls are required. Abortion for sex choice, to be prohibited effectively, would have to be made a

crime punishable by law. An examination of this alternative quickly reveals a large amount of misplaced concern. The prevention of harm to society's quest for equality that would come by renewed interference with physician–patient abortion decisions far outweighs the small amount of good that could be done by preventing a very small number of abortions for sex choice. Further, any new legal prohibition of sex-choice abortion or amniocentesis begs the question of why the moral policy of freedom with fairness ought not to be restricted at other points, especially when harm and suffering flow from loyalty to these principles. Does it make sense to restrict the freedom of these few parents when many parents can knowingly reproduce with a high risk of transmitting lethal genes to their children and future generations? A scapegoating process may have occurred with parents who now request sex-choice amniocentesis. Why has so much attention been given by the media to this issue? Why is their motivation to abortion especially "more cold-blooded and contrived [Stenchever, 1972, p. 408]" than the motivation to abort for economic or social reasons? If one would not now trade an intact abortion policy based on freedom with fairness for the effective prohibition of sex choice as currently practiced, he or she will permit the latter under present conditions but not further, for reasons that are discussed subsequently.

Third, although a conceptual precedent is undeniably set by a small number of amniocenteses for sex choice, nothing prevents us or our descendants from altering the moral policy of freedom with fairness if evidence persuades that greater harm than good will flow from following it without reservation. Human beings are free to change their loyalties concerning moral policy. The moral uncertainty that cannot be erased from agreeing to present decisions for sex choice is largely connected to visions of sex discrimination, genetic engineering, and social catastrophes that could gradually emerge from wide-scale sex choice (Etzioni, 1968).

Backlash by Antiabortion Movement

Is there a substantial reason to oppose a precedent of abortion for sex choice because of the power of the antiabortion movement? Kazazian (1980, p. 18), concerned that legal abortion itself is in "a precarious state," wrote that the "wholesale acceptance" of abortion for sex choice could lead to a dismantling of legal abortion. Compliance with the requests of a few parents initially could escalate and strengthen antiabortion groups and perhaps deprive at-risk couples of prenatal diagnosis. There are two separate questions here: (a) Has the antiabortion movement seriously hampered the provision of genetic services? (b) If abortions for sex choice increase, will existing abortion policy be changed and genetic services be reduced or prohibited?

Genetic services include screening carriers and newborns, genetic counseling, prenatal diagnosis, education and research on the cause of genetic disease, and potential therapies. In the 1970s there was been steady growth in the provision of these services, public and political support for them, and increased increments of economic support. Public contributions to the March of Dimes Birth Defects Foundation, the source of most of the initial funds in the United States for genetic services from 1970 to 1977, increased from $24 to $57 million in that period (Salisbury and Russell, 1978). Contributions in 1978 and 1979, a period of controversy about the foundation's policy in funding genetic services, still managed to increase from $62 million to almost $63 million (March of Dimes, 1979). The foundation granted $2.5 million to genetic services in 1978. The National Genetic Disease Act, passed by Congress in 1975, was not funded in the first 2 years. A new version of this bill, enlarging the number of diseases to which genetic services were to apply, passed in 1978 by votes of 82:4 in the Senate and 343:27 in the House. Table 1 illustrates federal funding for genetic services.

Abortion for genetic indications was not among the permissible reasons authorized for expenditure of Medicaid funds for abortion by the 1975 Hyde amendment. No attempt was made to add a provision for abortion to legislation on genetic diseases, probably reflecting the power of antiabortion forces in Congress to prevent easy passage.

The future rate of growth in genetic services depends largely on federal and state appropriations (Reilly, 1978). There were no reports during the 1970s of harassment of particular prenatal diagnosis programs or prevention of at-risk couples from services by antiabortion groups. To the contrary, surveys in these years show widespread acceptance of abortion when prenatal diagnosis shows evidence of genetic disease. McIntosh and Alston (1977) reported results of a survey in 1975 of Catholics and Protestants showing that the majority accept abortion when the health of the child or mother is involved, but show less approval when the reason is economic. Table 2 illustrates the growth in Catholic acceptance compared to a 1962 Gallup poll.

A Harris poll (Policy Research Incorporated, 1977) used a United States

TABLE 1

Federal Support for Genetic Services (million of dollars)[a]

	1976	*1977*	*1978*	*1979*	*1980*	*1981*
Authorization	30	30	30	17.5	21.5	26
Appropriation	0	0	4	4	8	16.4[b]

[a]Source: Genetic Disease Services Branch, Bureau of Community Health Services, Health Services Administration.

[b]This figure includes funds for sickle-cell disease and hemophilia screening previously appropriated.

TABLE 2

Acceptance of Abortion under Three Conditions by Religion, 1962 and 1975 (in percent)[a]

Years of study	*Health of mother*		*Condition of child*		*Money*	
	Protestant	*Catholic*	*Protestant*	*Catholic*	*Protestant*	*Catholic*
1962	90	61	73	39	16	11
1975	93	86	86	77	54	44

[a]Whites only (McIntosh and Alston, 1977).

probability sample of 1679 male and female adults, finding that 80 percent of the sample supported access for women to genetic services. Only 21 percent were opposed to abortion if the fetus were defective to a degree requiring "life-long care." Doherty and Roghmann (1979) surveyed married women between 30 and 45 years of age in the Rochester, New York area and found that in a sample of 1616 only 15 percent opposed abortion for genetic disease.

Although there is no sign that the antiabortion movement has prevented the growth of genetic services, there is evidence that activities and morale in the March of Dimes organization (which does not endorse amniocentesis for fetal sex determination) have been negatively affected by opposition and distortion of facts through the media as a result of antiabortion group pressure. Organized in some 900 local chapters for fund raising and support of local projects, the organization long enjoyed strong Catholic support at local and national levels (Williams, 1973). Schoolchildren and their parents participate in marches and walk-a-thons to stimulate support and funds. In the mid 1970s, attempts in a few Catholic dioceses to boycott these activities were partially successful, even though official ecclesiastical approval from the National Conference of Catholic Bishops was never withdrawn.

The most serious controversy in the history of the March of Dimes indirectly reflects the power of antiabortion groups. On December 7, 1977, Dr. Arthur Salisbury, then vice-president of the March of Dimes, in testimony of the National Genetic Disease Act at the National Institutes of Health referred to the fact that foundation policy was to fund for no more than 5 years in any new area. Between 1971 and 1978, 82 genetic services programs had been funded for 5-year periods. His point was that it was timely for the federal government to enter an area that the foundation could not support alone. This message was quickly reported in the medical press (Drug Research Reports, 1978; Mullan, 1978) as a recent decision by the foundation, resulting from pressure by antiabortion groups, to halt all funding to genetic services. National television news programs shortly reported to this effect. Leaders of antiabortion groups were quoted in the press in a manner that lent credibility to the belief that their power turned the

foundation from funding genetic services (Associated Press, 1978). Soon it was widely believed that the March of Dimes had renounced genetic services out of fear of the antiabortion movement. Concerted efforts by foundation officials to correct this interpretation and to pledge continued support to genetic services began in March 1978 (Rensberger, 1978) and continued. During this period the foundation was strongly criticized by supporters of genetic services who believed the incorrect message.

According to interviews with foundation officials, the lasting result of the controversy is damage to the morale of an exceptional voluntary organization committed to high ideals. When volunteers and staff who are unused to the stress of public conflict are cast into the role of wrongdoers by antiabortion groups, a residue of self-doubt and defensiveness can continue to cast a pall over new and continued activities. Some potential for serious harm to the provision of genetic services does appear to be present if sufficient cause were available to antiabortion groups. Increase in the use of amniocentesis and abortion for sex choice could provide a cause.

In summary, the moral policy of freedom with fairness should continue to guide the rare request for amniocentesis for sex choice following full disclosure of risks. If physicians counsel accurately on sex choice requests, they will counsel discouragingly. The moral justification for (rarely) providing amniocentesis for sex choice lies in (a) the obligation to relieve severe emotional suffering, (b) the possibility of saving the life of a fetus, (c) measuring up to a standard to fairness in providing information to the parents or woman within the legal boundaries of abortion policy, and (d) the prevention of harm to society's respect for the autonomy and privacy of the woman in the abortion decision. These conclusions rest mainly on an assumption that contemporary requests for amniocentesis are rare, desperate, and of a character that do not precipitate a real trend to sex choice in family planning. The ethical risk that policy makers take in not prohibiting sex choice by amniocentesis is that the few procedures that have been done will be cited as a precedent when new techniques make sex choice safer, simpler, and apparently desirable in the framework of individual choice. To these future possibilities the remainder of the argument is devoted.

ETHICS, PUBLIC POLICY, AND THE FUTURE OF SEX CHOICE

Policy makers and citizens participate in a stream of events in which safer, efficient abortion-free methods of sex choice may emerge. The effort to avoid a sex-linked disease by sex selection is a possible site of discovery. There are other

potential sites in the total system of research discoveries. In terms of health policy, this type of sex-choice technology is distantly downstream and should not have a prominent place on the contemporary agenda. However, there are two public policy issues with respect to sex choice that are significant and require time, study, and further discussion to resolve. The first is the potential for an increase in requests for sex choice by amniocentesis for fetal sexing at an earlier gestational age. Second, how should policy makers and citizens evaluate the ethical dimension of their decisions to support research that may make sex selection more likely? The remainder of the chapter explores these issues.

Genetic Services, Abortion Policy, and Sex Choice

Without accurate data on the frequency of requests for amniocentesis for sex choice, the number of requests actually met, and the number of abortions obtained for this purpose, there is no reliable base line from which to consider how physicians should ethically be prepared to meet a potential increase in requests. For this reason alone, a careful study should be done of the incidence and dynamics of contemporary use of amniocentesis for sex choice.

There are reasons to expect a significant increase in requests for amniocentesis generally. Further, there are reasons to expect an increase in requests for sex choice.

Tables 3 and 4 illustrate the projection of age-specific births in the United States from 1978 to 1988 and the projection of utilization of amniocentesis with rates ranging from 3.6 percent (the approximate national compliance rate in 1975 to 1976) to 50 percent (United States Department of Health, Education, and Welfare, 1979b). Maternal age is the most prevalent indication for prenatal diagnosis, and the number of at-risk pregnancies is projected to increase significantly in the over-35 age group of pregnant women from 1978 to 1988. Because this fact is more appreciated by physicians and women themselves, there will be an increased demand for genetic services. Added to the effect of aging in the pregnant population is a second trend of postponement of pregnancy to later in life (United States Bureau of the Census, 1977). Thus there will be more older women at genetic risk who are also in a position to learn the sex of the fetus.

Has there been an increase of perceived need in younger American parents to know the sex of the fetus prenatally? Reliable data do not exist to answer this specific question. Aspects of two studies are suggestive. Sell, Roghmann, and Doherty (1978) found in a sample of 1616 women in the Rochester, New York area that the greater the knowledge about prenatal screening, the greater the readiness to use abortion to reduce birth defects. They also found that 7 percent approved abortion for unwanted sex identified before birth. Hartley and

TABLE 3

Projected Age-Specific Births in the United States, 1978–1988[a]

Year	Maternal age 30–34	35–39	40–44	>44	Cumulative ≥35	Cumulative ≥30
1978	398,611	113,548	23,766	1,845	139,159	537,770
1979	410,932	116,341	23,653	1,811	141,805	552,737
1980	448,619	123,180	24,548	1,782	149,510	598,129
1981	487,977	137,471	26,473	1,786	165,730	653,707
1982	495,399	138,418	26,546	1,790	166,754	662,153
1983	507,465	143,227	27,948	1,808	172,983	680,448
1984	518,811	151,090	29,025	1,838	181,953	700,764
1985	532,472	158,799	29,843	1,877	190,519	722,991
1986	544,257	166,681	30,242	1,912	198,835	743,092
1987	556,599	166,038	32,532	1,978	200,548	757,147
1988	566,457	168,923	33,538	2,057	204,518	770,975
Percent change in annual levels comparing 1978 with 1988						
Increase	42.1	48.8	41.1	11.5	47.0	43.4
Absolute change in annual levels comparing 1978 with 1988						
Increase	167,846	55,375	9,772	212	65,359	233,205

[a]Source: United States Department of Health, Education, and Welfare, 1979b.

TABLE 4

Projected Amniocentesis for Advanced Maternal Age by Utilization, 1979–1988[a]

Year	Women ≥ 35 utilization 3.6%[b]	15%	35%	50%	Women ≥ 30 utilization 3.6%	15%	35%	50%
1979	5,105	21,271	49,632	70,903	19,899	82,911	193,458	276,369
1980	5,382	22,427	52,329	74,755	21,533	89,719	209,345	299,065
1981	5,966	24,860	58,006	82,865	23,533	98,056	228,797	326,854
1982	6,003	25,013	58,364	83,377	23,838	99,323	231,754	331,077
1983	6,227	25,947	60,544	86,492	24,496	102,067	238,157	340,224
1984	6,550	27,293	63,684	90,977	25,228	105,115	245,267	350,382
1985	6,859	28,578	66,682	95,260	26,028	108,449	253,047	361,496
1986	7,158	29,825	69,592	99,418	26,751	111,464	260,082	371,546
1987	7,220	30,082	70,192	100,274	27,257	113,572	265,001	378,574
1988	7,363	30,678	71,581	102,259	27,755	115,646	269,841	385,488

[a]Source: United States Department of Health, Education, and Welfare, 1979b.
[b]Approximate utilization rate, 1975–1976.

Pietraczyk (1979) sampled 2138 respondents of college age in northern California. Almost half agreed that they might want to use sex-selection methods if such were available; 65 percent agreed with the statement that such methods should be available to all parents if it were technologically possible (18.5 percent strongly agreed, 25.0 percent agreed, and 22.4 percent agreed somewhat). Most significantly, the respondents assigned priorities to sex selection with regard to ongoing biomedical research: High priority, 9.7 percent; moderate priority, 27.5 percent; low priority, 44.5 percent; no opinion, 4.5 percent, and prohibit, 13.5 percent. These priority preferences suggest a modest degree of interest in sex choice. These local findings should be understood against more reliably and widely collected data in the 1970 and 1975 National Fertility Studies (NFS). In 1970 a survey of 6752 ever-married women under 45 years of age showed that 37.2 percent approved of sex preselection and 47.8 disapproved (Westoff and Rindfuss, 1974). In the 1975 NFS, a subsample of 2,361 of these women were reinterviewed. The proportion approving was 37.5 percent, but the disapproving increased to 59.1 percent (Pebley and Westoff, 1982). The study authors concluded that the number of those who switched positions was greater in the group that changed from approval to disapproval. The questions asked whether they approved or disapproved of sex preselection, not if *they* would use it or about preference as to various methods.

A reason to expect an increase of interest in sex choice is the trend towards small family size. Smaller family size means fewer lifetime pregnancies and an enhanced desire of some couples for a balanced family or, if only one child is planned, to have a child of the desired gender.

Other reasons to be aware of potential increased requests for sex choice are developments of techniques for much earlier prenatal diagnosis. Physicians in the Soviet Union (Kazy, Rozovsky, and Bakharev, 1982) reported that chorion biopsy was performed in 165 cases between 6 and 12 weeks of pregnancy. The chorionic sac is the outermost fetal membrane. It is multilayered, and on the maternal surface it possesses villi that are bathed by maternal blood. Fetal cells are also found on the villi. Two groups of women requesting abortion were biopsied immediately prior to or 5–10 days prior to abortion. Biopsy was carried out in 26 women to determine fetal sex in suspected X-linked disorders. Diagnosis was correct in all cases. The authors state that no cases of infection or amniotic sac disruptions were seen in this experiment. (The article contains no mention of the informed consent of the subjects.)

Another technique, more difficult and experimental, is fluorescence cell-sorting (Porreco, Sarkar, and Jones, 1980), which will identify fetal cells obtained from maternal blood in the first trimester of pregnancy, perhaps as early as 8–10 weeks. Small amounts of fetal blood appear in the mother's circulation from the second month of pregnancy. It has not been possible (to date) to culture fetal cells obtained by this method. If it were possible, and the procedure were

efficient and less costly, amniocentesis for prenatal diagnosis may be bypassed and its risks eliminated.

How should policy makers and physicians prepare themselves for increased requests for sex choice, should they occur? Further, how can they do so and keep faith with the moral policy of freedom with fairness?

The foremost ethical consideration is adequate provision of services to women whose pregnancies are at risk by standards of medical indication. The fairness issue is starkly raised when a request for amniocentesis for sex choice competes for scarce resources with a request on the chance of a neural tube defect or a life-threatening disease. By extrapolation from reports from states (United States Department of Health, Education, and Welfare, 1979b), one can estimate that genetic services are offered in only 10 percent of 150,000–200,000 annual at-risk pregnancies. The number of affected parents seeking genetic services will increase. The harm that could come to these persons by acceptance of any increase in sex-choice requests cannot be justified by moral reasons. If parents seeking the pleasure of selecting the sex of offspring inflict harm on parents seeking to avoid suffering, these parents and physicians who help them will have violated a moral rule. In the vast number of cases in the United States of the gender issue in childbirth, there is no permanent suffering. The face of medicine should always be turned, when there is a choice to be made, toward the relief of suffering.

The second consideration is to meet a need for clear statements of policy on the sex-choice issue. This issue needs to be addressed in the light of day. Each center and physician providing genetic services should address this issue in a larger policy statement describing the approach taken to the typical ethical issues that arise in genetic counseling and prenatal diagnosis. The Report of an International Workshop (1980) on prenatal diagnosis, reflecting consensus of active genetics centers in Europe, Canada, and the United States on current medical, ethical, and social issues, recommended that each center develop a policy statement on its approach to ethical issues. These issues include controversial indications for amniocentesis (maternal anxiety, sex choice), disclosure of disputable genetic information (XYY chromosome), disclosure of sex of fetus, disclosure of risks to possibly affected relatives, and abortion. The report attempted to bridge wide differences between medical traditions that are paternalistic and those that favor a high degree of patient autonomy. Consequently, the report did not favor one approach to these ethical issues but stressed the importance of an articulated, coherent policy that could be shared by those working in the center and from which counseling could be offered. The report (Report of an International Workshop, 1980, p. 16) stated that "determination of fetal sex for social reasons alone should *not* be considered a medical reason nor an indication for prenatal diagnosis."

The policy options on amniocentesis for sex choice are (a) restriction only to

cases of sex-linked disease; (b) limitation to requests based on emotional indications and referred by a psychiatrist; (c) limitation to requests agreed to by the physician following counseling, provided no medically indicated cases are compromised; or (d) the free choice of the woman following counseling.

If the near future brings an expected rapid increase in requests for genetic services, a center that presently operates on the second or third option would find it untenable to grant virtually any requests for sex choice. Counseling with couples who make requests for sex choice alone would be better supported by written policy statements that backed up a refusal based on fairness to those in greater need. If a center works for the first option, couples who request sex choice for social reasons alone should be offered counseling. A genetic history can be taken, providing knowledge where there was possibly none. Also, because these requests at times reflect emotional and marital difficulty, proper referral can follow counseling. Probably no existing center operates from the fourth option, because the requirements of fairness would be vitiated by making no distinction between sex-choice requests and medically indicated requests.

A third consideration is based on the ethical imperative to avoid the harm that would come to women, infants, and the future of applied human genetics by any increased use of abortion for routine sex choice. The United States had a legal abortion ratio in 1977 of 400 to every 1000 live births (Forrest, Sullivan, and Tietze, 1979). If every couple who desired a sexually balanced two-child family with a boy-first, girl-second birth order used abortion to achieve the result, at least one abortion for each of the two births must be assumed. Such a choice could potentially add 1000 abortions to the 400 that exist, resulting in a ratio of 1400 abortions to every 1000 live births. This ratio obtained in Hungary in 1964 (Klinger and Szabady, 1978). Likewise, if every couple used abortion only to select sex of the second child, at least one abortion per two births is assumed. This approach adds 500 abortions to the ratio, or 900 abortions for each 1000 live births, approximately the prevailing rate in Bulgaria in 1976. Kobrin and Potter, whose work on the probabilistic outcomes of abortion for sex choice appears in this volume, clearly demonstrate the high number of abortions required to achieve either sequential or compositional goals. The examination of a moral issue must have within it the universalistic question of what would happen if everyone acted in this way.

Levin and colleagues (Levin, Schoenbaum, Monson, Stubblefield, and Ryan, 1980) reported on a study of the relationship of prior induced abortion and pregnancy loss. They compared prior pregnancy histories of 240 women who had a pregnancy loss up to 28 weeks gestation and 1072 women delivering at term. Women who stated in interviews that they had had two or more previous induced abortions had a two to three times greater risk of first trimester spontaneous abortion and loss between 14–19 and 20–27 weeks. Not one prior induced abortion was found to be associated with the risks of later pregnancy

loss. This report must be received in the context of ongoing efforts to study the use of induced abortion and its consequences.

Three other studies (Moriyama and Hirokawa, 1966; Richardson and Dixon, 1976; WHO Task Force on Sequelae of Abortion, 1979) found a significant relationship among previous induced abortion, pregnancy losses in the first and middle trimester, low birth weight, and preterm deliveries. Other studies (Daling and Emanuel, 1977; Kline, Stein, and Susser, 1978; Van der Slikke and Treffers, 1978) found no association between prior abortion and these consequences. Repeated studies need to be done to resolve these questions. However, it is reasonable to assume that until the questions are fully answered, couples with sex-choice requests could be correctly counseled about the possible risks to subsequent pregnancies through use of abortion. Using abortion more than once could diminish their chances of having a safe pregnancy and optimally healthy infant, albeit with the desired sex. An additional caution in the event of earlier fetal sexing is that any delay in obtaining abortion after the eighth week of gestation is associated with significantly higher maternal morbidity (Cates, Schulz, Grimes, and Tyler, 1977).

The technology of fetal sexing is now in the hands of physicians who deliver genetic services. These physicians will jealously guard against any increased use of their services for sex choice because of the potential harm that could come to the field of applied human genetics. Their orientation is medical (Milunsky, 1973). Prenatal diagnosis is presented as life saving because of the 96.5 percent rate of negative diagnosis and the previous lack of an alternative to abortion or childlessness for at-risk parents. Any use of abortion for routine sex choice violates this orientation, especially because a threshold of treatment for some genetic diseases and malformations is being attained in the field of fetoscopy (Golbus, 1980). Some defects can be corrected after delivery, including narrowings or absence of part of the gastrointestinal tract, small spina bifidas, and abnormalities of the face and head. Other malformations, detected earlier, can require induced premature delivery for early treatment; these include hydrocephalus, urinary tract obstruction causing hydronephrosis, and bowel gangrene resulting from intestinal malrotation. If the fetus is allowed to continue *in utero*, these conditions grow worse. In cases of conjoined twins or a large hydrocephalus, detectable by sonography, preparation can be made for cesarean delivery. A third type of birth defect involves a deficiency in the fetus that can be treated *in utero*. Intrauterine transfusion can be used to treat red blood cell deficiency. Massive doses of vitamin B_{12} to the mother have been used to treat a fetal enzyme defect responsive to this vitamin. Suggestions to treat congenital hypothyroidism and growth retardation through infusion of thyroid and nutrients have been made, along with consideration of intrauterine surgery, guided by fetoscopy or sonography, for defects that interfere with fetal organ development. As the fetal candidates for therapy grow, the ethical contrast of routine sexing

and abortion for sex choice alone will be too stark to hold together in the conscience of physicians. Further, they would not be willing to risk progress in therapy and continued diagnosis for genetic diseases by controversy about sex choice.

In conclusion, policy makers can rely on the imperative to avoid the harms of increased abortion and the vigilance of the present generation of developers of fetal diagnosis and treatment to curb any potential increase in sex choice by contemporary methods of fetal sexing.

The Future of Sex Choice

Other authors (Largey, 1978; Steinbacher, 1980; Williamson, 1976) including those in this volume, have made a reconnaissance of the future of sex choice from scientific, sociological, and demographic perspectives. The discussion largely is concerned with forecasts of consequences. The positive and negative consequences that emerge in the debate are arranged in Table 5 as factors that encourage or discourage sex choice as a social practice.

With the exception of attempts to avoid sex-linked disease, none of these envisioned consequences has yet occurred. We can do no more than account for them figuratively in current policy considerations. The future of sex choice depends first on technical success, because it requires a safe, reliable technique that avoids abortion. If success is achieved, should it be used? Simply because it can be done is no rational or moral reason why it should be done.

If a method with these characteristics were to emerge, the use of sex choice

TABLE 5

Positive and Negative Consequences

Positive	*Negative*
1. Avoidance of sex-linked disease	1. Mainly the rich will benefit
2. Girls will especially feel wanted	2. Wherever a strong boy preference, girls will be present in fewer numbers
3. Balance two-child family	3. Concentration of first- and second-born characteristics in boys or girls
4. Enhance happiness in families	4. Imbalance of sex ratio and social dislocation
5. Reduce population in less-developed nations	5. Precedent for genetic engineering, eugenics
6. Enhance family planning	6. Increase conflict between sexes
7. Increase human control over genetics	7. Possibility of abuse by totalitarian state

would partly depend on the relative strength of sex preference in family planning and the acceptability of sex choice to the growing feminist movement. However, the future of sex choice also depends on the shape of the moral policy of freedom and fairness that structures social practices in sexuality and reproduction in older, more developed nations. Were the moral policy to be substantially changed by attempts to reduce negative or enhance positive consequences of technological events in areas other than sex choice, the future of sex choice would be influenced accordingly. Because the potential consequences of sex choice are so indeterminate, an approach is taken here that provides policy makers with substantial analogues to the sex-choice issue. By examination of the ethical dimension of the impacts of other technologies, policy makers will be able to compare and contrast what their responses may be to the possible impacts of sex choice.

Health policy also faces decisions in funding research on contraception, recombinant gene experiments, genetic screening methods, and experimental genetic therapies in animals that may be copied in humans. What if these technical problems were mostly or completely resolved? What tests would be posed for the continuity and stability of the moral policy of freedom with fairness? The strategy of the argument is to construct three tests posed by technological success. Each involves demonstrably serious consequences. If the moral policy can be envisioned to function without substantial revision in these tests, the probability is that it can be trusted to function in the challenges of sex choice.

The state-of-society assumptions that underlie the argument pertain only to the United States.

1. There will be a continued decline in fertility resulting in a desired family size of between one and two children (Council on Environmental Quality, 1980).
2. There will be steady progress scientifically and medically that will lead to
    a. Virtually perfect and inexpensive contraception for males and females
    b. *In vitro* fertilization and embryo transfer for involuntary infertility
    c. Mapping of deleterious genes
    d. Ability to support the developing embryo *ex utero* for therapeutic research
    e. Continued success in rescue and support of low-birth weight infants
    f. Diagnosis of disease in the fetus by methods virtually that are risk free to the mother
    g. Increases in postnatal treatment of genetic disease
    h. Methods of determining sex of embryo prior to fertilization.
3. There will be a substantial increase in the number of pregnant women using prenatal diagnosis, available genetic therapies, and termination of pregnancies with untreatable disease.

4. There will be substantial success in effective tests for screening carriers of recessive genes (cystic fibrosis) and persons at risk for later onset of disease (cancer, heart disease, diabetes, and Huntington's disease).

A Test of a Perfect Contraceptive

A perfect mode of contraception must include the following characteristics:

1. Effectiveness of 100 percent (no pregnancies would ensue)
2. Total reversibility (pregnancies would ensue on cessation of contraception)
3. Absence of serious side effects
4. Minimal minor side effects
5. Usage separated from sex act and genital contact
6. Over-the-counter and mass distribution availability
7. Usability by males and females.

Assuming that the state of the art of contraception included or approximated most of these characteristics, it follows that some degree of social pressure would mount to change the voluntaristic ethos that presently functions. Examples of such pressure, on a spectrum from low to high, could include

1. Physicians prescribing contraception to at-risk patients as standard medical practice
2. Legal tests of the right of public transit systems to refuse to display posters paid for by family planning groups that depicted a pregnant woman with the slogan No Excuse If You Did Not Plan It
3. Proposals to tie proof of mandatory contraceptive education to annual renewals of budgets for public school systems
4. Proposals to amend legislation for family planning programs to require that women receiving state-subsidized contraception comply with regular appointments to verify use
5. Proposals to administer contraception without requirement for consent in institutions for the retarded, prisons, and social welfare programs
6. Proposals to withhold reimbursement for maternal care and childbirth in high-risk populations where contraception was not used.

Would any or all of these efforts succeed? One can envision many physicians prescribing contraception for spacing following childbirth and for high-risk adolescent groups, but controversy would continue about whether prescription should be standard medical practice. Religious beliefs alone would be one source of opposition. A legal test of a right to refuse to display procontraceptive posters seems quite plausible. The test would involve the questions of First Amendment rights and whether public transit vehicles or stations are a public forum for these

rights. *Carey* v. *Population Services International* (1977) invalidated a New York law prohibiting distribution of contraception to minors and the advertisement of contraceptives. If the same constitutional standards were being applied to new cases involving noninterference in the fundamental privacy of reproductive decisions, each of the proposals of legislative or budget actions would undoubtedly be held unconstitutional, even if they passed legislatures. Although proponents could show that great economic savings would result from one or more proposals, it is doubtful that the appearance of a perfect contraceptive would alter the legal or moral framework that presently structures reproduction. It would be a simple matter to show that concentration of the power to control this aspect of reproductive behavior of the state would bring more harm to the relationships among the individual, the family, and the state than the good that would be done by increasing the number of persons who were contraceptively protected from unplanned pregnancies. A price in individual freedom would be paid that would not be interpreted as beneficial, assuming that social, political, and economic institutions were intact and functioning with the values that had traditionally structured them. Efforts would be concentrated on education and the risks of freedom of choice would be taken, especially in a nation that was not threatened by a great increase in the fertility rate.

A Test to Abortion Policy

To envision this test, we assume both the success in contraception just described and great progress in therapy for genetic disease *in vitro* in the embryo, *in utero,* and postnatally. Further, diseases like beta-thalassemia, sickle-cell disease, and Tay–Sachs disease can actually be cured with only 2–3 percent risk of partial success and minimal complications that are not inherited in subsequent generations. Sonography and fetoscopy are safe means of identifying fetal problems *in utero* that can be surgically or medically corrected after birth. The combination of these successes will create some social pressure to change the abortion policy.

First, it will be argued that because there is no excuse for an unplanned pregnancy, society allows faulty moral examples by providing abortion in cases of willful refusal to use contraception. Abortion on request should not, in this view, reward the irresponsible. As a public measure to reinforce the need for contraceptive vigilance, these irresponsible persons should be punished by the denial of the right to abortion. Some way of knowing who was contraceptively at fault must be assumed, and it is likely that such knowledge could only be obtained from persons who were dependent publicly on subsidized medical care. Again, the poor would be the most vulnerable.

The second feature of the test will follow from a claim that it is unethical and

should be illegal to abort a fetus that can be cured of a genetic disease. Proponents will point to significant public funds spent for research that led to therapy and argue that the interest of the state in the protection of life requires that the purpose of these expenditures be carried out. Yet, some parents may decide not to accept even small risks of failure or partial success and request abortion of a fetus that is a candidate for therapy. Should these parents continue to have the right to abortion even though therapy is available? The attending physician may conscientiously refuse to perform such an abortion, but should these parents be able to obtain a legal abortion by a physician for this reason? A proposal will emerge to change abortion policy by making an exception for fetal disease about which there is medical consensus that it is treatable. One can envision a version of this test applied in the developing policy on abortion reimbursed by Medicaid as determined by the United States Congress. If prenatal diagnosis is reimbursed for indigent women whose pregnancies are at risk, it follows that proposals will be made to require treatment (rather than allow abortion) for treatable disease.

Will these successes lead to change of the voluntaristic approach to abortion decisions? The consequences of denial of abortion to those who either refused to use contraception or were noncompliant include increasing the number of unwanted children with subsequent risks to their security and self-esteem (Dytrych, Matejcek, Schuller, David, and Friedman, 1978), interference in the freedom of women, concentration of power in those not directly affected by the decision, and precedent for greater state interference in other areas of reproduction. It is difficult to imagine that this punitive step would succeed.

The ethical dilemma in remaining loyal to abortion policy when therapy for genetic disease is available is more difficult. Those who generally oppose abortion for genetic disease (Kass, 1973) have a high ideal ground on which to stand, but the means to relieve suffering are not available to approximate the ideal. In historical perspective, abortion for genetic disease is a compromise in the ethics of relief of suffering. One can morally choose to relieve parental suffering because it is praiseworthy to avoid disaster if knowledge is available. Yet, from the perspective of a planned pregnancy that is aborted only because therapy is lacking, there is a moral imperative to seek the means to relieve suffering. If the means became available through research into the causes and cures of genetic disease, the highest ideals could be fully pursued with the affected fetus. The morality of abortion in any era, however, rests on the issue of whether the interests of the fetus may ever override the interests of the woman. Advancing technology will favorably affect consideration of fetal interests because the fetus can be objectified and even treated at an earlier gestational age.

Success in therapy from fertilization through midtrimester will create strong pressure to alter abortion policy. But what if a woman refused to give consent for intrauterine therapy of the fetus in the fifteenth gestational week and requested abortion on the grounds that even the slightest risk of failure was unacceptable?

If one would not be willing to coerce any woman to continue to delivery of an unwanted pregnancy when she is carrying a fetus that could not otherwise be supported, one would argue for a continuity of abortion policy. What if neonatal intensive care had progressed to the point at which physicians could attempt the same therapy at 21 to 24 weeks gestation in the hospital after cesarean delivery? Would abortion policy change by removing the abortion decision from the woman in the case of a treatable fetus that required the mother to carry it for a few more weeks? Could a "fetal advocate" be appointed by the court? If one would not coerce a competent adult to accept a medical procedure, one would not alter abortion. On the other side of the dilemma, however, women who chose to proceed to delivery with an affected fetus when therapy had probably failed should not be coerced into abortion. Presumably each woman would know the potential consequences and alternatives prior to consenting to prenatal therapy. It is ethical to treat the fetus, to be sure. It will also continue to be ethical to respect a woman's right to abortion even if the fetus is treatable, although the increasing ability of medicine to rescue the fetus at an earlier age will be the occasion of many conflicts. The future will see prenatal diagnosticians increasingly separate themselves from abortion for treatable disease. Presumably other physicians not previously involved would meet the abortion request.

Physicians and parents must continue to have the freedom both to terminate and to continue pregnancies, including those begun with therapeutic measures. The moral policy would and should continue to guide abortion decisions even as these were exacerbated by success in fetal therapy.

If artificial means were available to support a fetus through a therapeutic trial and the mother's physical life and health were not a consideration, abortion decisions would not be relevant to therapy. Some parents may request that support be withdrawn with the same dynamics as now frequently occur in the neonatal setting. It is an open question as to whether the same bonds would develop from parent to child in a new prenatal setting where the fetus is separate from the biological mother from fertilization. Careful thought must be given to the responsibility of physicians to protect the life of the fetus in case parents decide to withdraw themselves from a therapeutic trial at any stage of gestation. Parents are not entitled to the death of a fetus in any moral sense, but are only entitled to have their interests separated from the life of the fetus. In an era when fetal life can be supported artificially, there will be great conflict about physicians' obligations to use these measures to support fetuses that will be otherwise destroyed by abortion. The resource issue will bear upon the controversy, because available equipment will undoubtedly be used for fetuses wanted by parents willing to accept significant degrees of illness in future children. Just as no parent today has an absolute right to control physician decisions in neonatal care, the same ethical and legal framework will extend to prenatal care. The potential conflicts are significant and will require careful study and preparation. The

period of most significant conflict will be in the necessary stage of learning to do therapy in the fetus and the earlier prerequisite to learn enough about fetal development to have a knowledge base to succeed in therapy.

A Test of Screening for Genetic and Multifactorial Disease

In the event of great technical success in screening for carriers of recessive genes, persons at risk for later onset of genetic disease (Huntington's disease), and multifactorial disease (cancer, heart disease, diabetes), will more strenuous public health measures be taken that will amount to a change of the moral policy that respects the freedom of persons to marry and reproduce? Ingle (1973, p. 139) proposed "selective population control" that entails surveillance of at-risk populations and proscription of the right to reproduce for some. One of the consequences of continued progress in screening will be more proposals to require extensive screening prior to legal marriage and, further, to make the knowing transmission of deleterious genes a punishable crime.

Under similar economic and social conditions, states would probably not choose mandatory screening prior to marriage but rather would concentrate on educating and informing couples about opportunities for screening. If other middle institutions between the family and the state became more involved in voluntary screening for health reasons, the purposes of screening could be pursued without the dangers of reduction of freedom of the individual by the state. For example, clergy officiated at 80 percent of all first marriages and 60 percent of all remarriages in 1976, a total of 2.5 million marriages (United States Department of Health, Education, and Welfare, 1979c). Most seminary-educated clergy require some form of premarital counseling. If a significant number of clergy insisted on testing the mutual concern of couples by requesting that they complete a family health history and consult a genetically informed physician prior to a second meeting, much information could be obtained that would avoid potential disasters. All forms of genetic screening are voluntary today and probably will remain so even when more diseases and carrier states can be detected.

If states would not make screening mandatory prior to marriage, the more to avoid interference with the decision to marry, it is even more unlikely that laws punishing the knowing transmission of lethal or deleterious genes would be enacted. Memories of the early eugenic influences on legal measures would be stirred and renounced. Parents themselves, especially those who increasingly postpone childbearing until later years, will be more concerned with the health and quality of life of their children. An arresting fact, however, is that the most extensive study of genetic counseling yet done (Sorenson, Swazey, and Scotch, 1980) indicates that childbearing increases following counseling of parents for

genetic problems. Further, the willingness to risk childbearing increases in parents at risk for diseases that are not treatable. Presumably, the experience of counseling reduces the fear of taking risks of having affected children. One could not predicate that a requirement of genetic counseling prior to marriage of an at-risk couple could result in prevention of disease. At any rate, the policy of freedom with fairness entails allowing harm in subsequent generations to protect the right of many to enjoy choice in reproduction.

Implications for Sex Choice

The previous arguments claimed that despite technical success, moral and legal policy should not be altered to allow: (a) contraception, albeit perfect, to be forced upon unwilling persons; (b) the denial of abortion to reinforce contraceptive vigilance; (c) the denial of abortion to insure saving lives of affected fetuses treatable *in utero;* (d) the requirement of genetic or other medical screening tests to gain access to the enjoyment of individual rights; or (e) the punishment of those who knowingly transmit preventable genetic disease. Indisputably, good could be done if aggressive steps were taken to maximize technical success. More scarce resources could be saved, fetal lives salvaged, disease prevented, and public health strengthened. However, within the framework of moral policy in reproduction, these benefits would be sabotaged by harms to freedom and fairness in public life inflicted by coercive measures.

Let us now assume that an effective sex-choice technique were developed in a sequence that followed the three successes and their impacts described earlier. In light of the decision not to alter the moral policy of freedom with fairness in these events, even to maximize the good that could be done, what are the implications of these prior decisions for moral policy in reproduction as it affects preconceptive sex choice? If we should restrain compulsion and coercion in these three tests, even though it is certain that good could be done, it follows that we should restrain compulsion and coercion to use or not to use sex choice, especially when the question of harm resulting from either choice is so debatable. If a technique were available, what moral rules would be violated by a choice to use it? No deaths would occur and no pain be inflicted. What moral rules would be violated by a choice not to use it? Some would argue that the moral rule not to inflict pain and harm would be violated if the woman were at risk to transmit a sex-linked disease having a 50 percent chance of being transmitted to a male by her choice not to use sex selection. This appeal to the moral rules is debatable, however, because the moral status of the fetus is debatable. One can grant the argument real significance when the fetus is apart from the mother, but as long as her life, health, and freedom are inextricably involved in the pregnancy, society as presently constituted should not override her right not to use a sex-choice technique. If one would not deny a woman's freedom not to use sex choice in the belief that

doing so would incur a greater societal risk than the probable risk of disease, how could one then deny a woman's freedom to use sex choice to balance or plan the gender of her family? The desire to balance or plan the gender of children in itself can hardly be understood as a "disease" that will bring harm to society, but there are risks involved in providing the technology to act on the desire.

Just here is where the basic social–ethical issue turns. There are two risks to society and its institutions from disseminating the technology to make sex-choice decisions. First, the unharmful desire to plan or balance children in a family could result in harm to the ideal of equality between males and females if there are significant increases in first-born males and decreases in second-born females. Steinbacher (1980, p. 28) appropriately asks, "Will the second-class status of women in the world be confirmed by choice?" Male preference is still dominant in most societies to a greater or lesser degree, but it is by no means clear that male preference is indelible (Williamson, 1976). From the perspective of social justice, however, the interests of women in sharing equally in the benefits and responsibilities of citizenship and leadership could be damaged by a long-term trend of sex selection of first-born males.

A second risk is a precedent for a reintroduction of some of the ideas of positive eugenics, defined historically by Ludmerer (1978, p. 458) as "the striving to increase wanted traits in the population by urging 'worthy' parenthood." This dimension can be seen at work in the argument that sex choice would make children, especially girls, feel especially wanted. Williamson (1978, p. 28) refers to the benefit of wantedness in girls, citing the thought of Margaret Mead, in the context of a future method of sex selection that would be "foolproof and universally feasible." The context for the argument is the hope that sex choice would be one locus among many for a countervailing trend to the historic prejudice against females, mistreatment of female infants, and prevailing ignorance about the male's contribution to the outcome of gender. Presumably, a female would, in light of these facts, keenly experience wantedness. Presumably, parents who impressed these facts on their female children would be "worthy" in the sense of deserving praise. Although the original intent of these sentiments reflects an admirable desire for justice, those who advance them should evaluate their potential to serve as a precedent for reintroduction of lapsed eugenic proposals such as Muller's (1963, p. 260) to increase the traits of "creativity, wisdom, brotherliness, loving-kindness, perceptivity, expressivity, joy of life, fortitude, vigor longevity," and so on. To be sure, Muller argued for methods of artificial breeding to insure that people not miss the "golden chance" that their children approximate such goals; however, sex choice would not necessarily depend on the deep freezing of ova, cloning, or other methods cited in Muller's rapture (p. 261), concluded by the words "man is already so marvellous that he deserves all our efforts to improve him further." But if today's "worthy" parents argue for sex choice on the basis of making children feel "wanted," others may use the same reasoning to argue for eugenic selection for

intelligence and other traits. How children in the future will actually feel as a result of being chosen by a method of sex selection is an open question. They could feel subtly harmed, controlled, or invidiously different from other children not so conceived. Conceivably these children could display dominating tendencies because they believe themselves to be superior. The point is that the argument from wantedness is vulnerable to comparison with eugenic arguments that reflect the inordinate desire of one generation to instill its concepts of ethics and virtue in succeeding generations, thus depriving them of some of their freedom to find their own way in the world.

Sufficient social harms from these and other effects of sex choice may accumulate in the future to warrant decisions to restrict the technology only to sex-linked disease or other medically indicated purposes. Prior to having evidence that such harm exists, however, there is no reason to prevent an extension of freedom and fairness to the first decisions about sex choice.

In summary, policy makers and citizens should prepare for a series of conflicts in which they will be strongly pressed to reorder the rules that have applied to the interactions of science, medicine, the family, and the individual. One of these conflicts will involve the question of whether it is in the best interests of society to make available a method of selecting the sex of children. Arguments will be made that these decisions are too important and too threatening to be left to the ordinary individual. Policy makers should avoid options having any element of coercion to use or not to use this technology. Those who argue to the contrary have the burden of proof to show what alternative social arrangements could better harmonize the diverse interests that contend in conflicts about reproduction and sexuality. The mills of a democratic society, strongly powered by concepts of freedom and fairness, are probably sufficient to grind and resolve the problems under review here.

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AGE, TIME, AND FERTILITY
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By MARY B. BRECKENRIDGE
With an appendix by JOHN W. TUKEY

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This volume models change in the age pattern of fertility. It responds to a specific need in making fertility comparisons across time and place—the need for a summary measure of change that conveys more information about the dynamics of change than total fertility rates alone can give. The modeling process is based on Tukey's exploratory data analysis (EDA) methods. This approach has proved very effective in other fields in detecting underlying patterns, even in flawed data. The success reported here in modeling overall and marital fertility in long time-sequences is the result of the data-guiding and flexibility of EDA in combination with robust, resistant methods of parameter estimation. As applied in this monograph, the process also introduces two-stage demographic modeling, a further innovation that is placed in the larger perspective of "modeling" in the appendix by John Tukey.

Modeling is carried out for two centuries of Swedish age-specific overall fertility rates and seven decades of marital fertility rates in both cross-sectional and cohort perspective. The general applicability of these findings is then illustrated with fertility sequences for the 25 counties of Sweden, with a six-decade sequence of United States data, and with recent data for other countries. While the primary contribution of the work is to the modeling of demographic change in time sequence rather than to the study of Swedish history, the work provides some new insights into Swedish marriage and fertility experience across two centuries and makes informative new use of 85 years of eighteenth and nineteenth century data that have previously been subjected to little analysis.

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