REFERENCES AND NOTES

1. Mortality refers to the survivorship curve, which shows proportions of persons who survive to each age. Fertility refers to the number of children a woman has borne at the end of her childbearing. Family limitation refers to a pattern of behavior in which reproducing couples, having reached a certain number of surviving children, act to avoid additional births.

2. Family here will mean "conjugal unit" (husband/father, wife/mother, dependent children, or any two of these three) when referring to numbers of children born and surviving and as the socially understood family unit when discussing childbearing decisions,

3. Ideas about how and why demographic transition occurs must be distinguished from the transitions themselves, unambiguous evidence of which comes from the historical record of the changes in mortality and fertility levels. For a recent discussion of ideas surrounding the demographic transition see S. Szreter, Popul. Dev. Rev. 19, 659 (1993).

4. On the variability of pretransition levels in Europe see A. J. Coale and S. C. Watkins, Eds., *The Decline of Fertility in Europe* (Princeton Univ. Press, Princeton, NJ, 1986).

5. The great Chinese famine of the late 1950s brought total fertility down to 3.3 children per woman. A. J. Coale and S, L. Chen, Papers *of the East-West Population Institute, No. 104* (East-West Center, Honolulu, HI, 1987). The American postwar baby boom brought total fertility up to 3.7 children per woman. N. B. Ryder, in *Demographic Patterns in Developed Societies,* R. W. Hiorns, Ed. (Taylor & Francis, London, 1980).

6. P. T. Ho, *Studies on the Population of China, 1368-1953* (Harvard Univ. Press, Cambridge, MA, 1959).

7. H. D. R. Baker, *Chinese Family and Kinship* (Columbia Univ. Press, New York, 1979).

8. S. B. Hanley and K. Yamamura, *Economic and Demographic Change in Preindustrial Japan 1600-1868* (Princeton Univ. Press, Princeton, NJ, 1977).

9. T. C. Smith, *Nakahara* (Stanford Univ. Press, Stanford, CA, 1977), presents persuasive evidence for one village in which infanticide was used to control the sex composition of surviving children. This is evidently a form of "family limitation," even if not aimed explicitly at limiting family size. CaIdwell, Reddy, and CaIdwell (*42*) show for South India that the practice of abstaining from intercourse after the birth of a child was explicitly aimed at lengthening birth intervals, but that the intention was to benefit the health of the mother and child, not to limit family size. The demographic literature emphasizes the intention to limit family size as a necessary element of "family limitation."

10. Hong Kong and North Korea are not considered here, the former because its experience is similar to that of China, South Korea, and Taiwan, the latter because statistical sources are too limited to allow comparable presentation.

11. Total fertility for a given year is/he average number of children that would be born to an hypothetical group of women on reaching age 50 if these women experienced the age-specific birth rates of the given year.

12. K. Davis, *Popul. Index* **29,** 345 (1963).

13. C. Mosk, *Patriarchy and Fertility: Japan and Sweden, 1880—1960* (Academic Press, New York, 1982).

14. R. W. Hodge and N. Ogawa, *Fertility Change in Contemporary Japan* (Univ. of Chicago Press, Chicago, 1991).

15. I. B. Taeuber, *The Population of Japan* (Princeton Univ. Press, Princeton, NJ, 1958).

16. T. Kuroda, in *Population and Development in Japan* (The Asian Population and Development Association, Tokyo, Japan, 1991), pp. 23-42.

17. *Historical Statistics of Japan* (Japan Statistical Association, Tokyo, Japan, 1987), vol. 1, p. 272, shows prewar total fertility for only six years—1925, 1930, and 1937 to 1940.

18. Births during 1940 to 1947 correspond closely to persons aged 8 to 15 at the 1955 census, taken as of October 1. Fluctuations in the numbers of persons in this age range provide a close analogy to fluctuations of numbers of births during these years. Let *TF(y)* denote total fertility for year *y*, *N(y)* the number of persons enumerated in a subsequent census that would have been born (but for the difference between the census date of 1 October and the end of the calendar year) in year y, and put r(y) = *N(y)/TF(y).* Interpolating between computed values of r(1940) and r(1947) gives interpolated values of *r(y)* and thus values of *TF(y) = N(y)/r(y)* for intervening years, and similarly for earlier periods. Values for 1941 to 1946, 1931 to 1936, 1926 to 1929, and 1921 to 1924 are based on the censuses of 1955, 1947, 1935, and 1930, respectively.

19. Following N. B. Ryder [in R. W. Hiorns, Ed., *Demographic Patterns in Developed Societies* (Taylor & Francis, London, 1980), p. 251, mean numbers of children ever born for women aged 40 to 44 through 75/0 79 at the 1970 census are plotted at the time the cohort reached its mean age of childbearing, taken as 30 years on the basis of mean ages computed as described (*17,* p. 217). The mean number of children born for women aged 40 to 44 at the 1970 census, for example, is plotted at the time of the census less 42.5 to 30 years; in other words, 12.5 years prior to the time of the census. Comparing mean numbers of children ever born to the same cohort as recorded in the 1960 and 1970 censuses indicates a slight downward bias as women age. This might be due either to an association between number of children ever born and probability of survival or to deterioration in the completeness of reporting as women get older. The comparison leads easily to the following set of adjustment factors for mean numbers of children ever born to women aged 50 to 54 through 80 to 84, respectively, at the 1970 census: 1.002 (ages 50-54), 1.012 (ages 55-59), 1.031 (ages 60-64), 1.036 (ages 65-69), 1.054 (ages 70-74), 1.049 (ages 75-79), and 1.067 (ages 80-84). Until recently it was considered that information on children ever born to women of post-reproductive age was unreliable [A. J. Coale and T. J. Trussell, *Popul. Index* 40, 2 (1974), p. 1951]. Recent work has shown that this is not true in general [G. Feeney, *NUPRI Research Paper No. 55* (Nihon University Population Research Institute, Tokyo, Japan, 1990), and *Asian and Pacific Popul. Forum* **5,** 80 (1991)].

20. A. Mason, "HOMES: A household model for economic and social studies", *Papers of the East-West Population Institute, No. 106* (East-West Center, Honolulu, HI, 1987), describes a method for estimating average numbers of surviving children in the absence of a census question. Unpublished estimates received from Mason show

average numbers of surviving children borne to Japanese women are declining approximately linearly from 4.6 for women aged 70-74 to 2.0 for women aged 40-44. The older women were in prime childbearing ages during the early 1930s (relative to younger women, whose prime childbearing years were in the 1960s), and since infant mortality was declining sharply throughout this period (*17*), fertility must have declined even more rapidly.

21. G. W. Barclay, *Colonial Development and Population in Taiwan* (Princeton Univ. Press, Princeton, NJ, 1954).

22. *1992 Taiwan-Fukien Demographic Fact Book Republic of China* (Ministry of the Interior, Taipei, Republic of China, 1993) and preceding annual volumes.

23. T. H. Kwon, in *The Revolution in Asian Fertility*, R. Leete and I. Alam, Eds. (Clarendon Press, Oxford, UK, 1993).

24. 1. H. Kwon, *Demography of Korea: Population* Change *and Its Components 1925-66* (Seoul National Univ. Press, Seoul, Korea, 1977).

25. A. J. Coale, L. J. Cho, and N. Goldman [*Committee on Population and Demography Report No. I* (National Academy of Sciences, Washington, DC, 1980), p. 2] give total fertility for the years 1955 to 1975. N. O. Tsuya and M. K. Choe [*NUPRI Research* Paper Series *No.* 58 (Nihon University Population Research Institute, Tokyo, Japan, 1991), p. 17], continue the series through 1988.

26. A. J. Coale and S. L. Chen, *Basic Data on Fertility in the Provinces of China, 1940-82* (East-West Center, Honolulu, HI, 1987), for years prior to 1973.

27. N. Y. Luther, G. Feeney, W. M. Zhang, *Popul. Stud.* 44, 341 (1990), for 1973 to 1987.

28. G. Feeney and J. H. Yuan, *Popul. Stud.*, in press.

29. The sharp drop circa 1960 reflects the disastrous famine of the late 1950s.

30. G. Feeney, N. Y. Luther, Meng Qingpu, Sun Ying, "Recent fertility trends in China: Results from the 1990 census," International Seminar on China's 1990 Population Census, 19 to 23 October 1992, Beijing (State Statistical Bureau).

31. S. Greenhalgh, C. Z. Zhu, N. Li, *Popul. Dev. Rev.* **20,** 365 (1994).

32. D. Little, *Understanding Peasant China* (Yale Univ. Press, New Haven, CT, 1989).

33. A. A. Buletao and A. 0. Lee, *Determinants of Fertility* in *Developing* Countries (Academic Press, New York, 1983) emphasizes the "supply" and "demand" for children. The validity of this emphasis has been challenged over the past decade, though not specifically in connection with East Asia, by asserting the importance of culture and cultural change as influences on fertility behavior. See, for example, J. Cleland, in *Reproductive Change in Developing* Countries, J. Cleland and J. Hobcraft, Eds. (Oxford Univ. Press, Oxford, UK, 1985), chap. 10, and, for a recent review, C. Hirschman, Annu. Rev. *Sociol.* **20,** 203 (1994). My own view is that the arguments made on both sides of what is sometimes regarded as a heated debate are broadly complementary and that the perceived conflict reflects inadequate empirical evidence.

34. Davis (*12*) seems to have been the first to emphasize the importance of rising numbers of surviving children as a factor in fertility decline. [Increases due to declining mortality may have been augmented by the increases in fertility that may

occur during the early years of the demographic transition. T. Dyson and M. Murphy, *Popul. Dev. Rev.* **11,** 399 (1985).]

35. An *Extract Report on The 1980 Census of Population and Housing, Taiwan-Fukien Area,* Republic *of China* (Census Office of Executive Yuan, Taipei, China, 1982).

36. Unpublished estimates received from A. Mason show an average of 4.7 surviving children per woman for women aged 45 to 69 in 1970 (*20*).

37. The censuses, conducted at five year intervals from 1970 through 1990, provide average numbers of surviving children for women in five-year age groups in Table 2 of the "Fertility" volume for each census. Average numbers of surviving children decline as women age because children die, but comparison between censuses indicates the magnitude of this decline and permits adjustment for it,

38. R. A. Easterlin, in *Historical Studies of Changing* Fertility, C. Tilly, Ed. (Princeton Univ. Press, Princeton, NJ, 1978).

39. J. C. CaIdwell, *Theory of Fertility Decline* (Academic Press, New York, 1982).

40. It is the costs and benefits of given numbers (and sex composition) of surviving children, rather than the costs and benefits "of children" considered individually, that matter. Costs and benefits are to be understood broadly, as possible answers to such questions as "What are the advantages and disadvantages of large families? Of small families?"

41. C. Mosk [*Patriarchy and Fertility in Japan and* Sweden, *1880—1960* (Academic Press, New York, 1983)] provides the basis for much of the following discussion,

42. J. C. CaIdwell, P. H. Reddy, P. Caldwell *[The* Causes *of Demographic Change* (Univ. of Wisconsin Press, Madison, 1988)] provides an invaluable counterpoint.

43. N. O. Tsuya and M. K. Choe, *NUPRI Research Paper Series No.* 58 (Nihon University Population Research Institute, Tokyo, Japan, 1991).

44. A. P. Wolf and C. S. Huang, *Marriage and Adoption* /n *China, 1845-1945* (Stanford Univ. Press, Stanford, CA, 1980).

45. A. Thornton and H. S. Lin, *Social Change and the Family in Taiwan* (Univ. of Chicago Press, Chicago, 1994).

46. This uncertainty over timing suggests that even the closest analysis of relevant time series data is unlikely to yield satisfactory explanations either of why fertility declined or why the declines began when they did. The statistical evidence is necessary both to define the problem end to test alternative explanations, but assessments of causality must also consider evidence on the perceptions and dispositions of family members who did, in fact, adopt family limitation at particular times and for particular reasons.

47. Prevailing and instigating conditions in causal analysis have been discussed (32).

48. T. H. Sun, *Measuring the Effect of Family Planning Programs on fertility,* C. Chandrasekaran and A. I. Hermalin, Eds. (Ordina Editions, Dolhain, Belgium, 1975).

49. The role of family planning programs in fertility decline has been the subject of robust debate for several decades, going back at least to K. Davis, Science **158,** 730(1967) and P. M. Hauser, *Demography* **4**, 1 (1967). See L. H. Pritchelt, *Popul. Dev. Rev.* **20,** 1 (1994), and commentary and response in the same journal, p.3.

50. W. Lavely arid A. Freedman, *Demography* **27,** 3 (1990), provide persuasive evidence that fertility decline in China began in the early 1950s; that it began among the educated and urban elites, as in Europe and other developing societies; but that subsequent rapid declines in both urban arid rural areas were probably due to government policies, Only the latter declines are perceptible at the national level.

51. G. W. Barclay, A. J. Coale, M. A. Stoto, T. J. Trussell, *Popul. Index* **72,** 42 (1976), give data from which it may be calculated that women aged 40 to 44 in 1930 had an average of 3.0 surviving children per woman.

52. *1982 Population Census of China (Results of Com*puter *Tabulation)* (State Statistical Bureau, Beijing, China, 1985), Table 76, shows 4.1 surviving children for women in the same age group at the 1982 census.

53. J. L. Buck [*Land Utilization in China* (Univ. of Nanking, Nanking, China, 1937), pp. 367—370] gives data on family composition indicating 2.2 surviving children per wife, including recently married wives. The average of 5.3 persons per household would imply 3.3 surviving children per woman if households included husband, wife, and children only; but persons classified as head of household, wife, and son or daughter constitute only 69% of household members.

54. J. Bongaarts [in J. Bongaarts, T. K. Burch, and K. W. Wachter, *Family Demography* (Clarendon Press, Oxford, UK, 1987)] gives macrosimulation results for changing levels of surviving children during the demographic transition remarkably similar to those described for the four countries considered here.

55. W. Lavely, Z. V. Xiao, B. H. Li, A. Freedman, *The China Quarterly* **121,** 61(1990).

56. S. H. Potter and J. M. Potter, *China's Peasants* (Cambridge Univ. Press, New York, 1990).

57. V. Smil, *Popul. Dev. Rev.* **12**, 25 (1986); H. Harding, *China's Second Revolution* (The Brookings Institution, Washington, DC, 1987).

58. D. Kelliher, *Peasant Power in China* (Yale Univ. Press, New Haven, CT, 1992).

59. V. Shue, *Peasant China in Transition* (Univ. of California Press, Berkeley, 1980).

60. G. Feeney, in *The Future Population of the World: What Can We Assume Today?,* W. Lutz, Ed. (Earthscan, London, 1994). Even after adjustment for the effect of rising age at marriage, fertility declined at a rate of about 2.3 children per woman per decade between 1970 and 1984.

61. Peng Xizhi, *Demographic Transition in China* (Clarendon Press, Oxford, UK, 1991); H. Yuan Tien, *China's Strategic Demographic Initiative* (Praeger, New York, 1991); J. Banister, *China's Changing Population* (Stanford Univ. Press, Stanford, CA, 1987); P. C. Chen and A. Kols, *Population Reports, Series J., No.* 25 (Population Information Program, Johns Hopkins Univ., Baltimore, MD, 1982).

62. G. Feeney and F. Wang, *Popul. Dev. Rev.* **19,** 61 (1993).

63. A. P. Wolf, *ibid.* **12,** 1 (1986). Wolf notes also the penetration of village society by the national bureaucracy, on which see A. Chan, A. Madsen, J. Unger, *Chen Village* (Univ. of California Press, Berkeley, ed. 2, 1984).

64. J. Banister and S. H. Preston, *Popul. Dev. Rev,* **7,** 1 (1981).

65. S. Greenhalgh, *The China Quarterly* **22**, 191 (1990); *American Ethnologist* **21,** 1 (1994).

66. G. Feeney, X. A. Li, H. W. Vu, J. H. Yuan, L. J. Chen, *Period Parity Progression Measures of Fertility for China and its Provinces: Estimates from the 1990 Census* (East-West Center, Honolulu, HI, 1994).

67. G. Feeney and W. Lutz, in *Future Demographic Trends in Europe and North America: What Can We Assume Today?,* W. Lutz, Ed. (Academic Press, New York, 1991); G. Feeney, F. Wang, M. K. Zhou, B. Y. Xiao, *Popul. Dev.* Rev. **15**, 2 (1989); G. Feeney and J. Y. Yu, *Popul. Stud.* **41**, 1 (1987).

68. S. Greenhalgh, in *Chinese Families in the Post-Mao Era,* D. Davis and S. Harrell, Eds. (Univ. of California Press, Berkeley, 1993).

69. N. Ogawa and A. D. Retherford, *Popul. Dev. Rev,* **19**, 4 (1993).

70. G. W. Skinner, *Journal of Asian Studies* **44** (1985).

71. —, in *The City in Late Imperial China,* G. W. Skinner, Ed. (Stanford Univ. Press, Stanford, CA, 1977); and in T. P. Lyons and V. Nee, *Transformation in South China: Reform and Development in the Post-Mao Era* (Cornell East Asian Program, Ithaca, NY, 1994).

72. I would like to thank M. K. Choe, R. Freedman, K. Hamano, C. Hirschman, D. Lucas, G. McNicoll, A. Mason, Y. Okunishi, G. W. Skinner, W. Feng, S. Westley, and M. Woods for comments and assistance and the Demography Program, Research School of Social Sciences, The Australian National University, where this work was begun on a Visiting Fellowship during the summer of 1994,

Excerpt from
Fertility Decline in East Asia
Page 1518
SCIENCE • VOL. 266 • 2 DECEMBER 1994