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RAPID FERTILITY DECLINE IN IRAN: ANALYSIS OF INTERMEDIATE VARIABLES

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Summary. The remarkable decline in fertility in Iran, which saw the total fertility rate fall from 7 children per woman in 1986 to 2 in 2000, has received only limited analysis in the demographic literature. Using the 2000 Iran Demographic and Health Survey and Bongaarts' age-specific fertility model, this paper examines the role of the major proximate determinants of fertility in bringing about the rapid decrease in fertility in Iran. The analysis indicates that contraception had the largest effect on fertility, accounting for 61% of the reduction in fertility from its theoretical maximum. The fertility-inhibiting effect of marriage patterns accounted for an additional 31% reduction, and was most important among the young. Further analysis of contraceptive behaviour suggests that the current period fertility rate of 2·0 children per woman is an outcome of a synchronization of delaying and spacing of births among younger women with stopping of childbearing among women in the middle and late reproductive ages. The policy implications of the results are discussed.

Introduction

In contrast to other Middle Eastern countries, Iran has experienced a dramatic change in its period fertility rates during the last three decades. The total fertility rate, which was 6·07 children per woman in 1976, rose to 7·0 in 1986, and then declined rapidly to 5·3 in 1988 and 2·0 in 2000 (Statistical Centre of Iran, 2000, pp. 57–58; Ministry of Health and Medical Education, 2000, p. 48). The decline in fertility by more than three children per woman in just over one decade has made Iran a case of interest for neighbouring countries with high fertility, where population policies have been in place for many years but fertility remains high. Therefore, it is of great importance for other developing countries with high fertility, particularly the Islamic nations, to know what factors have been responsible for such a rapid fertility decline in Iran.

The few recent studies of Iranian fertility that have been undertaken have linked the decline to various aspects of the country's social and economic development (Erfani, 2005). In particular, the economic hardship associated with the 1980–88 war between Iran and Iraq, and the shift in the population policies from pro- to anti-natalist in the late 1980s, have been viewed as especially significant (Mirzaie, 1999; Abbasi-Shavazi *et al*., 2002). Other studies have placed great emphasis on the role of the 1989 family planning programme (Aghajanian & Mehryar, 1999), though empirical analysis of its effects is limited. Despite widespread agreement on the broader social and economic factors associated with the Iranian fertility decline, little work has been undertaken on how these factors have influenced the proximate determinants of fertility among recent Iranian cohorts. The availability of data from the first Iran Demographic and Health Survey (IDHS), conducted in 2000, allows us to fill this gap and to improve our understanding of the causes of fertility decline in Iran. Doing so may yield important lessons for other countries in the region and may also lead to further improvement in the national family planning and health programme.

Data

This study takes advantage of data drawn from the 2000 Iran Demographic and Health Survey. The survey was conducted by the Ministry of Health and Medical Education during October 2000, in collaboration with the Statistical Centre of Iran. It is a single-stage disproportionate stratified-cluster survey, where the sample was stratified by province and place of residence (urban–rural) within each province. Thus, the population was divided into 57 strata, including 28 rural and 29 urban strata. Based on the sampling frame generated by the 1996 census, 200 households were selected in each stratum using a systematic random sampling method. Assuming each of these selected households is the head of a cluster, nine more households adjacent to the selected household were included. Therefore, a sample size of 114,000 households was expected. Interviewers were asked to select one informant to complete a household questionnaire and, if an ever-married woman aged 10–49 was present, to select an eligible respondent to complete the woman's questionnaire. Investigators succeeded in contacting 113,957 households, and household questionnaires were completed for 111,627 households, yielding a response rate of 97·7% (Ministry of Health and Medical Education, 2000, pp. 5, 10). Within the 111,627 households, the interviewers conducted complete interviews with 90,740 ever-married women aged 10–49, of which 87,248 women were married at the time of the survey. These 87,248 women in union are the focus of this study. The sampling weights provided by the Statistical Centre of Iran (Ministry of Health and Medical Education, 2000, pp. 138–139) will be used in all the analyses in this study so as to obtain representative estimates from the disproportionate sample. The external and internal evaluation of the quality of the survey showed significant reliability and validity (Ministry of Health and Medical Education, 2000, pp. 120–130), and this was attributed to the professional supervision conducted directly during the process of data collection.

The survey is not as comprehensive as the standard Demographic and Health Surveys in terms of the number of variables, but it contains a wide range of data on the socio-demographic characteristics of household members, the hygiene and welfare facilities in households, fertility and reproductive health, breast-feeding, contraceptive use, and child health and welfare. Access to data for the current study has been made possible by the Ministry of Health and Medical Education of Iran.

Model

The analysis of direct and indirect determinants of human fertility was initiated by the classic work of Davis & Blake (1956), who defined a set of direct fertility determinants through which structural and environmental factors influence the observed fertility of a population. Their long list of 'intermediate variables' or 'direct determinants' of fertility was modified by Bongaarts and labelled 'proximate determinants' of fertility. Bongaarts (1978, 1982; Bongaarts & Potter, 1983) suggested the following set of intermediate variables responsible for variation in fertility levels: female proportion married, contraceptive use and effectiveness, prevalence of induced abortion, duration of postpartum infecundability, fecundability, spontaneous intrauterine mortality (spontaneous abortion), prevalence of sterility, and duration of the fertile period. The last four variables, which are biological determinants, are recognized as much less important sources of variation in fertility because even large variations in them create only slight changes in overall fertility. Therefore, he considered them as secondary factors and showed that variations in the first four variables, the proportion married, contraception, induced abortion, and postpartum infecundability, are the most important in the analysis of fertility levels and differentials. Thus, these four proximate determinants were considered as principal 'inhibitors of fertility'. In his model, the maximum level of fertility, called the total fecundity rate (TF), decreases as a result of an increased age at first marriage and marital dissolution, contraception, induced abortion and postpartum infecundability produced by breast-feeding and postpartum abstinence. Following his approach, these variables are used to measure the fertility-inhibiting effect of each of these four proximate variables and of the combination of them on the fertility level of Iran in 2000.

Bongaarts (1978) developed four indices to quantify the fertility-inhibiting effect of the principal proximate determinants: C_m = index of proportion married, C_c = index of contraception, C_a = index of induced abortion and C_i = index of postpartum infecundability. The value of each index ranges between 0 and 1, where zero denotes a complete fertility-inhibiting effect and unity means no fertility-inhibiting effect. The complement of the value of a given index, therefore, is the proportionate reduction in fertility due to the inhibiting effect of that proximate variable. The actual level of fertility in a population, as measured by total fertility rate (TFR), is then a multiplicative function of the four indexes and the total fecundity rate (TF) such that $\text{TFR} = C_m \times C_c \times C_a \times C_i \times \text{TF}$. If all women of reproductive age are married (i.e. $C_m = 1$), the total fertility rate will be equal to the total marital fertility rate (TMFR) so that $\text{TMFR} = C_c \times C_a \times C_i \times \text{TF}$. If the practice of contraception and induced abortion are also removed (i.e. C_c and $C_a = 1$), fertility will be equal to the total natural marital fertility rate (TNMFR) so that $\text{TNMFR} = C_i \times \text{TF}$. Finally, if there is no inhibiting effect of lactation (i.e. $C_i = 1$), fertility will reach the theoretical maximum level, which Bongaarts estimated to fall between 13 and 17 children per woman, with an average of 15·3. The observed fertility rate (TFR), therefore, is lower than the maximum (TF) due to inhibiting effects of non-marriage, contraceptive use, induced abortion and lactational infecundability.

As Bongaarts & Potter (1983) suggested, the four indices can be estimated by either an 'aggregate' fertility model or an 'age-specific' model. Contrary to the aggregate model, the age-specific models provide us with weighted indices and measures. They also provide age-specific measures of fertility and the proximate determinants that allow us to examine variation in fertility behaviours and in the proximate determinants among women in different reproductive age groups. As a result, the use of age-specific fertility models was preferred in the current study. After describing the details of the calculation of the indexes, age-specific estimates of the proportion married, contraception and postpartum infecundability will be computed. Unfortunately, no direct information on the practice of abortion is available from the survey. Abortion is deemed illegal in Iran and no questions on the practice of abortion were included in the questionnaire. Thus, in the analysis, the authors will tentatively assume that abortion is not practised and so the value of the index of induced abortion will be set to one in the model. The implication of making this assumption will be discussed later in this paper. Once the individual indexes have been calculated, the multiplicative effects of the proximate variables on the fertility level of Iran in 2000 will be examined. Finally, the relative contributions of the proximate variables to the recent fertility level in Iran will be discussed and the policy implications of the findings will be examined.

Results

Index of proportion married C_m

The index of proportion married is calculated as the weighted average of the age-specific proportions married, $m(a)$, with the weights given by the age-specific marital fertility rates, $g(a)$. The value of C_m is the proportion by which TFR is smaller than TMFR due to the proportion of women of childbearing age who are not married and is computed as:

$$C_m = \frac{\text{TFR}}{\text{TMFR}} = \frac{\sum m(a) \times g(a)}{\sum g(a)}.$$

The index takes the value of 1 when all women in the reproductive age categories are married and 0 when no women are married. Bongaarts found that for countries with a TFR greater than 5 the value of C_m is typically greater than 0·65, while a C_m less than 0·65 is characteristic of countries with a total fertility rate less than 5 (Bongaarts, 1978, p. 109).

The above equation is based on the assumption that women in marital unions are continuously exposed to the risk of conception. However, the prevalence of ‘seasonal’ and ‘absolute’ spousal separations among certain sub-groups of Iranian married women violates this assumption. Seasonal separations, which refer to separation of married couples for less than 12 months in a year, are common in certain provinces of Iran and are mainly attributed to the migration of husbands from rural to urban areas to work in construction, or to internal migration of male nomads to graze their animals in rich pastures. Seasonal separations are more common among women who are in the middle or late reproductive ages. In contrast, absolute separations, which refer to separations of married couples for the whole 12 months of a year, are mostly seen among young women who are legally married but have not yet started living with their spouses due to certain socioeconomic and cultural reasons, such as studying in high school or university or the lack of housing and basic furniture required for starting a new common life. In the survey, women who reported they were not living with their spouses in the 12-month period before the interview were recorded as 'married', though they were not cohabiting and hence were not at the risk of conception. In effect, the extensive spousal separation is a key factor of low age-specific natural fecundability (Bongaarts & Potters, 1983). Following Hill (1985) and Millman & Potter (1984), this study, therefore, adds a multiplicative factor, $k(a)$, to the numerator of the original Bongaarts's equation in order to obtain an adjusted age-specific proportion married, $m(a)$, without *effective* spousal separations:

$$C_m = \frac{\mathrm{TFR}}{\mathrm{TMFR}} = \frac{\sum[m(a) \times k(a)] \times g(a)}{\sum g(a)},$$

where $k(a)$ is the age-specific proportion of marriage time that married couples lived together. The values of $k(a)$ adjust $m(a)$ for effective spousal separations, referring to those separations which are not overlapped with use of effective contraceptives, postpartum amenorrhoea, infecundity and pregnancy. Thus, the values of $k(a)$ are computed among married women who are not pregnant, infecund or amenorrhoeic, and who do not use effective contraceptives. In this study, effective contraceptives include sterilization, vasectomy, IUD, Norplant and DMPA, which are not coitus-dependent and may be used even in the absence of the spouse, and coitus-dependent contraceptives, namely coitus interruptus, condom, safe period and foam, and pills, which will probably not be used during periods of separation. The value of $k(a)$ rages from 0 to 1, where 0 and 1 mean that the couples spent respectively 0 and 100% of their marriage time living together during the last 12 months before the interview. The details of computation of $k(a)$ are shown in the Appendix.

In this study, the age-specific marital fertility rates, $g(a)$, are obtained by dividing the age-specific fertility rate, $f(a)$, by the adjusted proportion of currently married women, $m(a)k(a)$, in each 5-year age group. Bongaarts, however, has suggested that application of this procedure for the age group 15–19 can produce inaccurate results as small errors in the proportion married for this age group can produce large errors in g(15–19), the incidence of premarital conception is not negligible, and the married women in the age group 15–19 are mostly 18 or 19 years old and unrepresentative of the entire age group. As a solution to these problems, he proposed that the age-specific marital fertility rate, $g(a)$, for the age group 15–19 be estimated at 0·75 times g(20–24) (Bongaarts, 1978, p. 130). In the Iranian case, this reduces the estimated value of g(15–19) from 0·278 to 0·170. The details of the calculation of the index of marriage C_m are presented in Table 1 and show that the observed total fertility rate (TFR) for Iran in 2000 is 1·98, the observed total marital fertility rate (TMFR) is estimated to be 3·71, and the estimated value of the index of marriage is 0·533.

Index of contraception C_c

The index of contraception, C_c, depends on the prevalence of contraception, the extent of use and the effectiveness of contraception. In the absence of contraception

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Table 1. Calculation of index of marriage, C_m, Iran 2000

Age group	Age-specific fertility rate (ASFR) $f(a)$	Proportion of currently married women aged 15–49 $m(a)$	Proportion of marriage time lived together in last 12 months $k(a)$	Age-specific marital fertility rate (ASMFR) $g(a)=f(a)/[m(a)k(a)]$	Index of marriage $C_m(a)=f(a)/g(a)$
15–19	0·0269	0·1586	0·6099	0·1697[a]	0·1917
20–24	0·0989	0·5286	0·8267	0·2263	0·5286
25–29	0·1228	0·7852	0·9223	0·1696	0·7852
30–34	0·0871	0·8771	0·9391	0·1057	0·8771
35–39	0·0435	0·9108	0·9404	0·0508	0·9100
40–44	0·0141	0·9038	0·9359	0·0167	0·9038
45–49	0·0031	0·8875	0·9336	0·0037	0·8857
Total	0·396			0·7425	

TFR = 5 × ΣASFR = 5 × 0·396 = 1·98

TMFR = 5 × ΣASMFR = 5 × 0·7425 = 3·713

C_m = TFR/TMFR = 1·98/3·713 = 0·533

Note: the value of g(15–19) was calculated as 0·75 × g(20–24).

Source: the values of $f(a)$ and $m(a)$ were computed by the first author from the women's and households' weighted data of the 2000 IDHS. The values of $f(a)$ were calculated based on the births that occurred in a 12-month period before the survey.

Table 2. Proportion of married women currently using contraception by age and method, $u(a,m)$; Iran, 2000

Age group	TL	Vasectomy	IUD	Norplant	DMPA	OCP	Condom	Coitus inter-ruptus	Safe period	Other methods	Total
15–19	0·001	0·000	0·044	0·002	0·009	0·148	0·050	0·128	0·001	0·000	0·383
20–24	0·003	0·003	0·108	0·006	0·030	0·222	0·059	0·174	0·003	0·000	0·610
25–29	0·037	0·010	0·134	0·007	0·038	0·254	0·070	0·192	0·003	0·000	0·745
30–34	0·163	0·030	0·112	0·006	0·034	0·211	0·070	0·186	0·004	0·000	0·818
35–39	0·304	0·055	0·069	0·005	0·029	0·162	0·058	0·176	0·004	0·000	0·863
40–44	0·363	0·047	0·045	0·002	0·023	0·131	0·048	0·166	0·006	0·001	0·832
45–49	0·314	0·033	0·022	0·003	0·014	0·087	0·043	0·157	0·006	0·001	0·680
Total	0·171	0·027	0·085	0·005	0·028	0·184	0·059	0·174	0·004	0·001	0·738

TL=tubal legation; IUD=intrauterine device; DMPA=depot medroxyprogesterone acetate (injection); OCP=oral contraceptive pill; other methods=spermicidal gel, cap, diaphragm, emergency ('morning after') pill, post-coital washing of the vagina, and certain herbal medicines (Ministry of Health and Medical Education, 2000, pp. 153–154).
Source: the values of $u(a,m)$ were computed by the first author from the weighted data of the IDHS.

C_c equals 1, and 0 if all fecund women use 100% effective contraception. In the latter scenario, the fertility-inhibiting effect of contraception is complete, and hence TMFR equals 0. When the average proportion of married women currently using contraception (u) and the average contraceptive use-effectiveness (e) are known, the aggregate index C_c can be estimated as $C_c = 1 - (1{\cdot}08 \times u \times e)$. Based on this aggregate function, the age-specific index of contraception, C_c, is estimated by the formula proposed by Bongaarts (1982, p. 114) and modified slightly by Singh and her colleagues (Singh *et al.*, 1985, p. 133) as follows:

$$C_c = \frac{\mathrm{TMFR}}{\mathrm{TNMFR}} = \frac{\sum \mathrm{tnmfr}(a) \times C_c(a)}{\sum \mathrm{tnmfr}(a)} = \frac{\sum \mathrm{tnmfr}(a) \times \{1 - [u(a,m) \times e(a,m)]/s(a)\}}{\sum \mathrm{tnmfr}(a)},$$

where: tnmfr(a)=the age-specific schedule of natural marital fertility rates, obtained from $g(a)/C_c(a)$; $u(a,m)$=age-specific proportions of currently married, non-pregnant, and non-amenorrhoeic women currently using different contraceptive methods; $e(a,m)$=age-specific effectiveness weights for different contraceptive methods; $s(a)$=age-specific proportions of married women who are fecund. The values of $u(a,m)$ are shown in Table 2.

As suggested by Bongaarts & Potter (1983, pp. 65–66), this study uses the cumulative failure rate to compute the use-effectiveness of contraceptive methods. The cumulative failure rate is the proportion of women who become accidentally pregnant within a given time (e.g. a year) from the beginning of a period of contraceptive use. It is measured by a single-decrement life table in which the confounding effects of

Table 3. Estimated contraceptive use-effectiveness by age and methods, $e(a,m)$, Iran 2000

Age group	TL	Vasectomy	IUD	Norplant	DMPA	OCP	Condom	Coitus interruptus	Safe period	Other methods
15–19	1	1	0·993	0·993	0·993	0·933	0·924	0·841	0·791	0·833
20–24	1	1	0·993	0·993	0·993	0·933	0·924	0·841	0·791	0·833
25–29	1	1	0·990	0·990	0·990	0·945	0·920	0·880	0·791	0·833
30–34	1	1	0·998	0·998	0·998	0·941	0·935	0·917	0·791	0·833
35–39	1	1	0·998	0·998	0·998	0·941	0·935	0·917	0·791	0·833
40–44	1	1	0·998	0·998	0·998	0·941	0·935	0·917	0·791	0·833
45–49	1	1	0·998	0·998	0·998	0·941	0·935	0·917	0·791	0·833
Total	1	1	0·994	0·994	0·994	0·939	0·926	0·876	0·791	0·833

Note: The average value of $e(a,m)$ for all women aged 15–49 and for all methods was computed as 0·922.
Source: The values of $e(a,m)$ were calculated by the first author from the 12-month gross failure rates taken from Enünlü & Güçiz Doğan (1996, pp. 50–55), except the figures for tubal ligation and vasectomy, which were taken directly from Bongaarts (1978, p. 112).

discontinuation for reasons other than pregnancy are eliminated and considered as censored observations, so that the (gross) failure rate refers to the experience of a group of women who continuously use contraception except if a pregnancy intervenes. In effect, the one-year 'gross' failure rate is analogous to the ${}_1q_0$ value in the standard mortality life table. This procedure is applied to compute age-specific use-effectiveness for different contraceptive methods, $e(a,m)$, by the formula proposed by Bongaarts & Potter (1983, p. 75):

$$e(a,m)=1-\frac{F(a,m)}{[(12\times f_n)\times(1-0.5\times F(a,m))]},$$

where f_n is the natural fecundability rate, suggested as 0·14 for all reproductive ages from 22 to 45 (Bongaarts & Potter, 1983, p. 69), and $F(a,m)$ are age-specific observed 12-month gross failure rates for different contraceptive methods. As there are no proper data available in the survey for computing gross failure rates, the age-specific 12-month gross failure rates of the Turkish population, drawn from the 1993 Turkey Demographic and Health Survey (Enünlü & Güçiz Doğan, 1996, pp. 50–55), are used in the above equation and the results are shown in Table 3. The Turkish data were selected because the authors judged Turkey to be the most similar population to that of Iran for which such data were available. While the use of these data may introduce an unknown element of inaccuracy into the analysis, this is the best solution available to this study.

The calculation of the index of contraception is depicted in Table 4. Infecudity is usually measured either subjectively, where women declare themselves to be infecund

Table 4. Calculation of index of contraception, C_c, Iran 2000

Age group	$h(a)$	$s(a)$	$h(a)/s(a)$	$C_c(a)$	tnmfr(a)	tnmfr(a)×$C_c(a)$
15–19	0·348	0·97	0·359	0·641	0·265	0·170
20–24	0·559	0·97	0·576	0·424	0·534	0·226
25–29	0·700	0·96	0·729	0·271	0·626	0·170
30–34	0·782	0·96	0·815	0·185	0·571	0·106
35–39	0·833	0·95	0·877	0·123	0·413	0·051
40–44	0·806	0·91	0·886	0·114	0·146	0·017
45–49	0·658	0·77	0·855	0·145	0·026	0·004
Total	0·68	0·93			2·581	0·744

C_c=0·744/2·581=0·288.
Note: $h(a)=u(a)e(a,m)$; $s(a)$=age-specific proportion of fecund women; tnmfr(a)=age-specific total natural marital fertility rate.
Source: all were calculated by the first author from the data given in Tables 1, 2 and 3.

due to non-contraceptive reasons, or objectively, where data on infecundity due to any cause for a five-year duration are used to recognize an infecund woman (Stover, 1998; Rutstein & Shah, 2004). This study follows the first method, as there are no proper data available for implementing the objective method suggested by Stover (1998, pp. 258–260). Therefore, the values of the age-specific proportions fecund, $s(a)$, are the complement of the age-specific proportions of currently married women who report not using a contraceptive due to being menopausal, infertile (primary or secondary) or having had a hysterectomy or an oophorectomy. As a first step in calculating the index of contraception, the values of $h(a)=\Sigma u(a,m)\times e(a,m)$ are computed, using the data given in Tables 2–3. For instance, the value of $h(a)$ for age group 15–19 is computed as follows: $h(15–19)=(0{\cdot}001\times1{\cdot}0)+(0{\cdot}044\times0{\cdot}993)+(0{\cdot}002\times0{\cdot}993)+(0{\cdot}009\times0{\cdot}993)+(0{\cdot}148\times0{\cdot}933)+(0{\cdot}050\times0{\cdot}924)+(0{\cdot}128\times0{\cdot}841)+(0{\cdot}001\times0{\cdot}791)=0{\cdot}348$. Then, the values of $C_c(a)$ are computed as the complement of $h(a)/s(a)$. Finally, having the values of age-specific natural marital fertility, tnmfr(a), the index of contraception, C_c, is calculated as 0·288 for Iran.

Index of postpartum infecundability C_i

The fertility-inhibiting effect of lactation operates through delaying the next conception and hence increasing the length of birth intervals and reducing natural fertility. The lactational fertility-inhibiting effect is estimated by comparing average birth-interval lengths in the presence and absence of lactation. Bongaarts (1978, p. 115) decomposed the birth interval into four components:

(1) *Infecundable interval*: instantly follows a birth. It is measured from birth to the first postpartum menses, since the return of menses is closely coincident with the return of ovulation. Its value ranges from 1·5 months, in the absence of lactation, up to 24 months, in the presence of prolonged lactation.

(2) *Waiting time to conception*: starts at the first ovulation following birth and ends with a conception. The population averages for waiting time to conception range from a low of about 5 months to high values that only rarely exceed 10 months, with typical values around 7·5 months.
(3) *Spontaneous abortion*: when a conception does not end in a live birth, the duration of a shortened pregnancy and another waiting time to conception are added to the birth interval. On average 2 months are added to the birth interval for spontaneous abortion.
(4) *Gestation:* a nine-month gestation period which ends in a live birth.

The duration of a birth interval *without* lactation, therefore, is estimated to be 20 months (=1·5+7·5+2+9), and *with* lactation is 18·5 months (=7·5+2+9) plus the average duration of the infecundable period. The aggregate index of lactational infecundability, C_i, is computed by the ratio of the average birth intervals without and with lactation, i.e. $C_i=20/18{\cdot}5+i$, where i is the average duration (in months) of infecundability from birth to the first postpartum ovulation (menses). Given $\text{TNMFR}=C_i\times\text{TF}$, C_i equals unity means that in the absence of lactation i is equal to 1·5 months, and hence TNMFR equals TF. Thus, as the lactation period lengthens, C_i declines.

Singh and her colleagues (Singh *et al.*, 1985, p. 133) proposed a modified formula to compute the index of postpartum infecundability when age-specific mean durations of postpartum amenorrhoea are available. It can be written as:

$$C_i=\frac{\text{TNMFR}}{\text{TF}}=\frac{\sum \text{tf}(a)\times C_i(a)}{\sum \text{tf}(a)}=\frac{\sum \text{tf}(a)\times[p(a)/(q(a)+i(a))]}{\sum \text{tf}(a)}.$$

where tf(a) are age-specific total fecundity rates, computed as tnmfr(a)/$C_i(a)$; both $C_i(a)=p(a)/(q(a)+i(a))$ and $i(a)$ are age-specific measures of the indices and mean durations of postpartum infecundability respectively; $p(a)$ represents the length of the birth interval in months without the effect of lactational postpartum amenorrhoea, while $q(a)$ stands for the length of the birth interval in months without the effects of lactational and non-lactational postpartum amenorrhoea. In other words, $q(a)$ can be defined as $p(a)$ minus the infecundable interval (i.e. 1·5 months). The values of these two symbols, derived from the estimates of mean waiting times to conception calculated by Hobcraft & Little (1984), show the variation in waiting time to conception (and fetal mortality as well) with age.

Age-specific mean durations of postpartum amenorrhoea, $i(a)$, are estimated for Iran using the data drawn from two questions given in the survey. Those women who had their last birth during a two-year period before the survey were asked whether their menstruation resumed since they gave birth to their last child, and if this was the case, they were asked how many months it took. Both women with resumed menstruation and those who were still breast-feeding and for whom menstruation had not resumed by the time of the interview (right-censored cases), were included in the computation of $i(a)$. Nevertheless, those women whose menstruation had not resumed by the time of survey and who were using contraception were excluded from the analysis in order to avoid overlapping fertility-inhibiting effects of postpartum infecundability and contraceptive use. The Kaplan-Meier survival analysis procedure

Table 5. Calculation of index of postpartum infecundability, C_i, Iran 2000

Age group	$p(a)$	$q(a)$	$i(a)$	$q(a)+i(a)$	$C_i(a)$	tnmfr(a)	tf(a)
15–19	18·5	17	3·74	20·74	0·892	0·265	0·297
20–24	17	15·5	4·35	19·85	0·856	0·534	0·624
25–29	20	18·5	4·81	23·31	0·858	0·626	0·730
30–34	20	18·5	5·39	23·89	0·837	0·571	0·682
35–39	23	21·5	5·96	27·46	0·838	0·413	0·493
40–44	38	36·5	6·45	42·95	0·885	0·146	0·165
45–49	94	92·5	7·29	99·79	0·942	0·026	0·028
Total	230·5	220	4·84			2·581	3·019

TNMFR = 5 × Σtnmfr = 5 × 2·581 = 12·91.
TF = 5 × Σtf = 5 × 3·019 = 15·09.
C_i = TNMFR/TF = 2·581/3·019 = 0·855.
Notes: $p(a)$ = age-specific birth intervals in months without lactational infecundability; $q(a)$ = age-specific birth intervals in months without lactational and non-lactational infecundability; tf(a) = age-specific total fecundity rates, computed as tnmfr(a)/$C_i(a)$; $C_i(a) = p(a)/[q(a) + i(a)]$.
Source: the values of $i(a)$ are weighted mean duration of postpartum amenorrhoea, estimated by the first author from the weighted data of the IDHS, but the values of $p(a)$ and $q(a)$ were taken directly from Singh *et al.* (1985, p. 134). Other measures were calculated by the first author.

was used to estimate the mean survival time to the resumption of menstruation after the delivery of a woman's last birth so as to incorporate the 6·5% censored cases in the computation of $i(a)$ as well. As a result, the mean duration of postpartum amenorrhoea for Iran as a whole is estimated to be 4·84 months. As expected, Table 5 shows that the mean duration of postpartum amenorrhoea monotonically increases with the age of women. Using the values of $i(a)$, $p(a)$ and $q(a)$, the index of C_i and total fecundity rate (TF) for Iran are estimated as 0·855 and 15·09 children per woman respectively. The details of the calculation of the index of postpartum infecundability and TF are presented in Table 5.

The estimated TF for Iran falls within the range from 13 to 17, identified by Bongaarts, and it is a little lower than the average of 15·3 that he estimated (Bongaarts, 1978). This could be due either to the omission of important proximate determinants from the model or to measurement errors related to the determinants. Induced abortion, which is one of the four principal proximate determinants, was omitted from our model due to data restrictions. Although induced abortion is illegal and strictly prohibited in Iran, there are strong indications that abortion is indeed practised by some proportion of women (Singh *et al.*, 1997; Jahanfar *et al.*, 2003; Zare & Dastouri, 2004; Fallahian & Mohammad-Zadeh, 2005; Nojomi *et al.*, 2006). In addition, spontaneous abortion (fetal loss) is the other determinant that has not been included in the model. The effect of spontaneous abortions is difficult to estimate, though unlikely to have a major impact. Regarding potential measurement errors, one must recall that contraceptive use-effectiveness was estimated using data from Turkey.

While the situation of the two populations is similar and significant inaccuracy would not be expected to result from the use of the Turkish data, the potential effect of this limitation cannot be ruled out. The authors believe, however, that the lack of information on abortion and the assumption that abortion is not practised in Iran is the most likely source of the slightly low estimate of TF.

Multiplicative effects of proximate determinants

As explained above, the Bongaarts model ($TFR = C_m \times C_c \times C_i \times C_a \times TF$) is a multiplicative fertility model, measuring the proportionate fertility-inhibiting effects of the four proximate determinants. Lacking data on abortion (and thus assuming that $C_a = 1{\cdot}0$), below the total fertility rate of Iran is presented as the outcome of the three indices times the total fecundity rate:

$$TFR = C_m \times C_c \times C_i \times C_a \times TF$$
$$= 0{\cdot}533 \times 0{\cdot}288 \times 0{\cdot}855 \times 1{\cdot}00 \times 15{\cdot}09$$
$$= 1{\cdot}98$$

As expected, this is the observed total fertility rate of Iran in 2000. An estimated maximum of 15·09 children per woman, in the absence of the fertility-inhibiting effects of the three proximate variables, falls to almost two children, in the presence of the inhibiting effects. In other words, the reduction from total fecundity to the total fertility rate indicates that proportions married, contraception and postpartum infecundability are the most important proximate determinants of fertility in Iran. It is clearly seen that contraception has the largest inhibiting effect on fertility (0·288); it is followed by the effect of marital age structure (0·533). The fertility-inhibiting effect of postpartum infecundability (0·855) is small compared with the other two indexes. To quantify more precisely the relative importance of the fertility-inhibiting effect of each index, logarithms are taken from the three indexes:

$$\log(C_m \times C_c \times C_i)$$
$$= \log C_m + \log C_c + \log C_i$$
$$= \log 0{\cdot}533 + \log 0{\cdot}288 + \log 0{\cdot}855$$
$$= -0{\cdot}273 - 0{\cdot}541 - 0{\cdot}068 = -0{\cdot}882.$$

The results reveal that 61·3% (=0·541/0·882) of the combined inhibiting effects of these proximate determinants on the total fertility rate is accounted for by the use of contraception. That is, contraceptive prevalence has contributed to the rapid decline in the recent period fertility rate in Iran much more than the other two proximate variables. The marital age structure of the Iranian population is the next in importance, responsible for 31% of the reduction in the total fecundity rate (=0·273/0·882). The fertility-inhibiting effect of marriage is most influential among young women aged 15–29 who delay marriage (see Fig. 1). In contrast to the fertility-inhibiting effects of contraception and marriage, postpartum infecundability has a small effect (7·7%), which is almost identical for women in all reproductive age groups. Figure 1 presents a graphic view of the effects of the three proximate determinants and demonstrates that the reduction of fertility from the theoretical maximum levels (ASF) to the observed levels (ASFR) is primarily due to the extensive use of contraceptives. The rapid decline in the Iranian period fertility rates that occurred over the last decade, thus, can be attributed mainly to a sharp increase in

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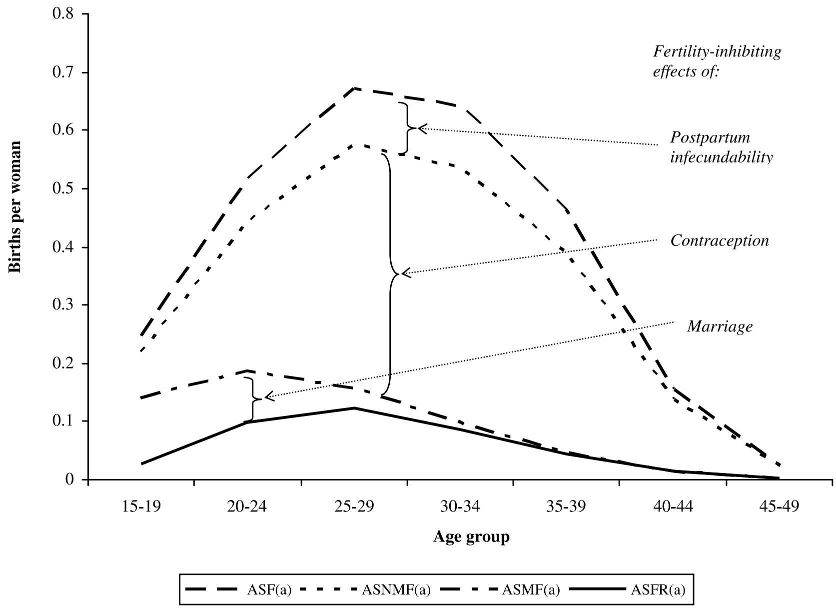

Fig. 1. Estimated age-specific fecundity rate, ASF(a), natural marital fertility rate, ASNMF(a), marital fertility rate, ASMF(a), and observed fertility rate, ASFR(a), among currently married women, Iran, 2000. Source: Tables 1, 4 and 5.

deliberate marital fertility control. Time series data support this conclusion. For instance, vital demographic and health data registered by more than 16,000 health houses, covering all rural households over the last decade, show that the rural prevalence rate of modern contraceptives increased from 43·7% in 1993 to 59·5% in 1996 and 66·2% in 2003. Concurrently, the rural period total fertility rate declined from 3·9 children per woman in 1993 to 2·6 in 1996 and 2·0 in 2003 (Naghavi *et al.*, 2005, p. 75).

The total fertility rate of 1·98 children observed for the whole of Iran in 2000 can be seen as the outcome of a synchronization of 'delaying and spacing' of births, mostly among young cohorts of married women, with the 'stopping' of childbearing, mainly among women in the mid or late reproductive ages who had already attained high parities. Spacing of births among Iranian couples is usually carried out by delaying marriage and using traditional and reversible modern contraceptive methods. Entry into marriage is the only legally and socially acceptable pathway to both the initiation of sexual activity and childbearing in Iran. A delay in marriage, therefore, would play a key role in constraining fertility. Figure 1 clearly shows the significant reduction in marital fertility among women under age 30 that is due to postponement of marriage and spousal separation of young married women. The prevalence of reversible and traditional methods among the young cohorts of married women allows them to space their first or successive births (see Table 2).

The situation among women who wish to stop childbearing is more complicated. More than half (58%) of currently married women who use contraceptives reported that they want no more children in the future (data not shown here). This study considers these women as birth stoppers. Contrary to a general expectation that birth stoppers usually use very effective or irreversible contraceptive methods such as sterilization or IUD, half of those who indicated they desired no more children use oral contraceptives, withdrawal, condoms and other temporary, reversible methods (see Fig. 2b). For some, this may reflect uncertainty about their situation; some may prefer to keep open the possibility of a future birth. For others, cultural understandings about different forms of birth control may be important. Fears surrounding the side-effects of sterilization for men and women are not unknown, while men, in particular, may fear the stigma attached to sterilization. The other salient feature of birth-stopping behaviour in Iran is the existence of strong socio-demographic differentials in the type of contraceptives used by the stoppers. As Fig. 2a shows, contraceptive use varies by women's level of education: 51·3% of women with 12+ years of schooling do not use female contraceptives, but rely on their husbands to control childbearing by using coitus interruptus, condoms or undergoing vasectomy. In contrast, 83% of women with no schooling use female sterilization, pills, IUD or other female-related modern methods. Similarly, the prevalence of male-related contraceptives is greater among urban stoppers than among rural stoppers. As a result of the greater prevalence of less effective methods (i.e. coitus interruptus and condoms) among educated and urban women, it is these women who face an increased risk of unwanted pregnancies.

Proximate determinants of fertility transition in Iran

The Bongaarts fertility model can also be used to examine typical patterns of change in fertility levels and in the key proximate determinants over the course of the transition from natural to controlled fertility (Bongaarts & Potter, 1983, pp. 103–106). When a population is moving from natural to controlled fertility, there is an increase in deliberate marital fertility control (contraception, induced abortion) along with change in marriage patterns and postpartum infecundability. As a consequence, natural marital fertility, marital fertility and total fertility levels change significantly. Bongaarts and Potter analysed 31 contemporary populations at different stages of the fertility transition to obtain a sketch of a typical 'synthetic transition' from a high-fertility schedule (seen mostly in developing countries) to a low-fertility schedule (seen mostly in developed countries). They divided populations into four groups based on the total fertility rate (Bongaarts & Potter, 1983, p. 104): Phase I with TFR over 6, Phase II with TFR in the range of 4·5 to 6, Phase III with TFR ranging from 3·0 to 4·5, and Phase IV with TFR less than 3·0 children per woman. The populations in Phase I have a 'natural' fertility schedule, whereas populations in Phase IV are at the end of fertility transition. Bongaarts and Potter calculated estimates of the proximate determinants and the measures of fertility for each of the four transition phases using data from 31 developing and developed countries.

In Table 6, the relevant measures calculated for Iran using the 2000 IDHS are compared with those obtained by Bongaarts and Potter in order to explore Iran's current situation in relation to the fertility transition model. The results show that the observed total fertility rate of Iran is very close to that of developed countries in

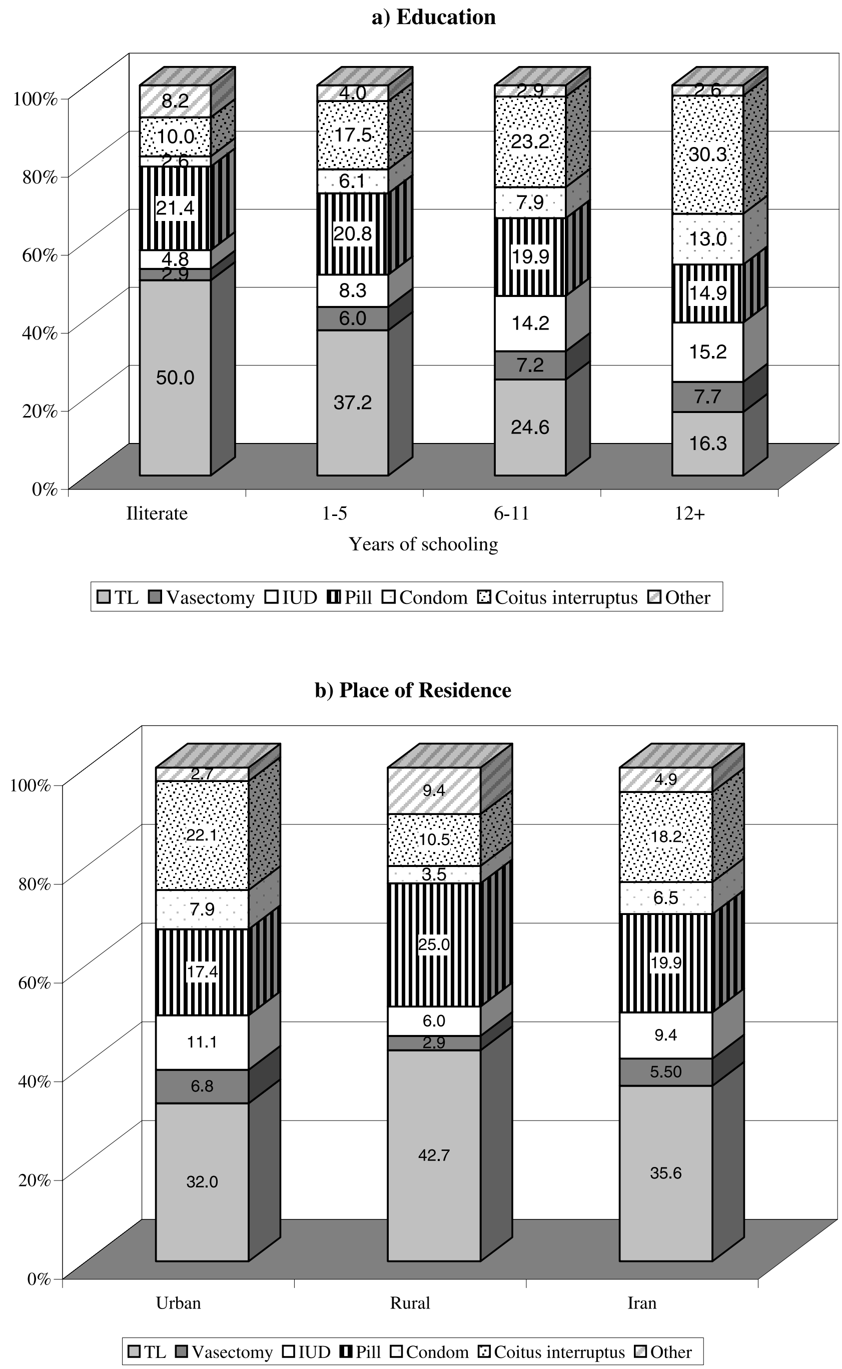

Fig. 2. Type of contraceptive method used by currently married women aged 15–49, who want no more children in the future, by years of schooling and place of residence, Iran 2000 IDHS. Source: calculated by the first author using the weighted data of the 2000 IDHS.

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Table 6. Measures and indexes of three proximate determinants and fertility rates, Iran, 2000, compared with those of four phases of synthetic transition

Index	Phases				
	I (Developing Countries)	II	III	IV (Developed Countries)	Iran 2000
Prevalence of contraceptive use (*u*)	0·10	0·35	0·40	0·69	0·74
Use-effectiveness of contraception (*e*)	0·85	0·85	0·86	0·94	0·92
Postpartum infecundability (*i*)	12·90	7·60	8·50	3·00	4·84
Index of marriage (C_m)	0·780	0·627	0·551	0·550	0·533
Index of contraception (C_c)	0·912	0·682	0·630	0·301	0·288
Index of postpartum infecundability (C_i)	0·649	0·780	0·763	0·930	0·855
Combined inhibiting effects	0·460	0·330	0·260	0·150	0·131
Total fertility rate (TFR)	7·03	5·03	3·88	2·06	1·98
Total marital fertility rate (TMFR)	9·08	8·08	7·05	3·80	3·71
Total natural marital fertility rate (TNMFR)	9·93	11·93	11·67	14·23	12·91

Source: Bongaarts & Potter (1983, pp. 104–105); the results for Iran, 2000, as presented in this study.

Phase IV (1·98 against 2·06), which have completed the fertility transition. The three indices of the proximate determinants for Iran show a striking similarity with the typical situation in developed societies. The combined inhibiting effect of the three principal proximate determinants of Iran is 12·7% stronger than that of the developed countries (0·131 against 0·15). This small gap is primarily due to differences observed between the corresponding indices of contraception (C_c) and postpartum infecundability or amenorrhoea (C_i) between Iran and developed countries. Although the measure of use-effectiveness (*e*) of Iran is 2·1% lower than that of developed countries, the contraceptive prevalence rate of Iran is 6·8% higher. In addition, the mean duration of postpartum amenorrhoea in Iran is 61% greater than that of developed countries.

The index of marriage, C_m, for Iran is also slightly lower than that for developed countries. Nevertheless, the relative importance of the proximate determinants in Iran is identical to that of developed countries. That is, contraception has the largest inhibiting effect on potential fertility followed by marriage patterns and postpartum infecundability. By contrast, postpartum infecundability has the greatest fertility-inhibiting effect for the populations of developing countries.

Finally, it should be noted that though the *period* fertility rate of Iran is similar to those observed in the developed countries, *cohort* fertility patterns are undoubtedly quite different. Women who were near the end of their childbearing period at the time of the survey were attempting (quite successfully) to stop childbearing, but they had typically experienced more than five children (Erfani, 2006, p. 135). Younger women, on the other hand, were attempting to delay births. While they will almost certainly give birth to significantly fewer children in their childbearing years than previous cohorts, it is too early to conclude that the completed fertility rate for these younger cohorts will be at or below the replacement level.

Discussion and Conclusion

The objective of this study was to examine current fertility patterns in Iran, a country that has experienced a remarkably rapid fertility decline which saw the total fertility rate decline from approximately 7·0 in 1986 to just 1·98 in 2000. Using data from the most recent national survey, the 2000 Iran Demographic and Health Survey, the empirical analysis focused on the relative contributions of the three most important proximate determinants of fertility: the proportion married, use of contraception and postpartum infecundability. The findings show that contraception is by far the strongest inhibitor of fertility in Iran, particularly among older cohorts of women who are using more effective and permanent methods. The fertility-inhibiting effect of contraception (61·3%) is much greater than that of marriage and lactational infecundability. The contribution of marital structure in inhibiting the potential fertility in Iran (31%), while smaller than that of contraception, is significantly greater than lactational infecundability. Postpartum infecundability reduces potential fertility in Iran by only 7·7%. These findings point to the major role played by the joint family planning and health programme, which has been described as a prompt 'responding to a nation's needs' (Roudi-Fahimi, 2002). This is generally understood to mean that the programme responded to significantly increased demand for fertility reduction produced by the rapid socioeconomic change that followed the 1979 revolution.

As remarkable as Iran's rapid fertility decline has been, the analysis in this paper has identified several features of the current Iranian situation that distinguishes the country's situation from that found in most highly developed societies with low fertility rates. First, the current low period TFR is the product of quite different patterns of fertility across cohorts. Women near the end of their childbearing years in 2000 will have high completed fertility. In their later childbearing years they have quickly adopted contraception in order to stop further childbearing. By contrast, younger women are delaying the beginning of childbearing. It remains to be seen whether their completed fertility will be close to the current period TFR of 1·98. One reason for caution is found in the data on contraceptive practice. The average level of use-effectiveness of contraceptives for Iran is lower than is typically found in the developed countries. This is mainly due to the fact that coitus interruptus, with low use-effectiveness, is the second most common method among Iranian couples. Thus, there is scope for significant unwanted fertility in Iran and younger couples who are relying on such methods may exceed their desired level of fertility. Why so many couples opt to use such methods is an important topic for further research.

These findings point to a strong tendency among the younger generation to delay marriage. High levels of unemployment and growing participation in post-secondary education undoubtedly contribute to this trend. Nevertheless, marriage has long been nearly universal in Iran and it seems reasonable to expect that most women in Iran will eventually marry. This pattern of delayed marriage has reduced fertility at younger ages for Iran's baby boomers, who were born during the first decade after the 1979 Islamic revolution. It remains to be seen what the impact on fertility rates will be when these women eventually marry.

Finally, it was also found that the fertility-inhibiting effect of postpartum infecundability is more similar to the pattern found in semi-developed countries. This is so because breast-feeding is universally practised in Iran. This is particularly true in tribal and rural areas, where prolonged breast-feeding is common. In addition, current health policy in Iran favours prolonged lactation so as to improve both the health condition of children and the widening of birth intervals. In support of this policy employed women who breast-feed are permitted to leave their office for an hour daily to breast-feed their children. In addition, the training programmes conducted in the health houses across the country, as well as the messages broadcast by the mass-media, have been propagating the slogan of the health programme: 'at least six months breast-feeding'. Thus, in an environment which supports long breast-feeding, it is unlikely that the mean duration of postpartum amenorrhoea will decrease further in the near future.

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Appendix

In a question in the survey, women were asked 'How many months out of the past twelve has husband spent in household?' The complement of the responses to this question would be duration of spousal separations in months, which are shown in Table A1 by age group of married women who were not pregnant, infecund, amenorrhoeic and did not use effective contraceptives.

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Table A1. Frequency distribution of married women who were not pregnant, infecund, amenorrhoeic and did not use effective contraceptives by duration of spousal separation in months and age groups, 2000 IDHS

	Months of separation													
Age group	0	1	2	3	4	5	6	7	8	9	10	11	12	Total
15–19	2480	71	50	31	42	24	68	17	39	33	48	32	1533	4468
20–24	8971	240	176	121	93	75	246	44	96	107	100	84	1450	11,803
25–29	11828	402	207	146	105	104	278	86	115	97	91	42	448	13,949
30–34	10421	303	182	124	119	65	234	35	74	75	69	44	235	11,980
35–39	7741	184	112	79	51	29	182	32	54	61	72	44	149	8790
40–44	6209	160	77	94	42	14	152	36	50	68	52	31	134	7119
45–49	4303	67	40	23	22	18	73	17	17	28	24	7	182	4821
Total	51953	1427	844	618	474	329	1233	267	445	469	456	284	4131	62,930

Note: figures are weighted.
Source: all values were computed by the first author, using the weighted data from the 2000 IDHS.

Table A2. Computation of age-specific proportion of marriage time lived together, $k(a)$, among married women who were not pregnant, infecund or amenorrhoeic, and did not use effective contraceptives, 2000 IDHS

Age	Months of separation														$r(a)$=Sum/	$k(a)$=
group	0	1	2	3	4	5	6	7	8	9	10	11	12	Sum	(Total × 12)	$1 - r(a)$
15–19	0	71	100	93	168	120	408	119	312	297	480	352	18,396	20,916	0·3901	0·6099
20–24	0	240	352	363	372	375	1476	308	768	963	1000	924	17,400	24,541	0·1733	0·8267
25–29	0	402	414	438	420	520	1668	602	920	873	910	462	5376	13,005	0·0777	0·9223
30–34	0	303	364	372	476	325	1404	245	592	675	690	484	2820	8750	0·0609	0·9391
35–39	0	184	224	237	204	145	1092	224	432	549	720	484	1788	6283	0·0596	0·9404
40–44	0	160	154	282	168	70	912	252	400	612	520	341	1608	5479	0·0641	0·9359
45–49	0	67	80	69	88	90	438	119	136	252	240	77	2184	3840	0·0664	0·9336

Source: All values were computed by the first author, based on figures in Table A1.

As shown in Table A2, $k(a)$ is the proportion of marriage time lived together that is simply the complement of proportion of marriage time spent separated, $r(a)$. The values of $r(a)$ for each age group are found by producing a table similar to Table A2. The figure in each cell of Table A2, except the last two columns, is the product of number of women in the corresponding cell in Table A1 times its corresponding month of separation (measured in person months). The value of $r(a)$ for each age group is found by dividing the *sum* of each row in Table A2 by the product of *total* number of women in that row, taken from Table A1, times 12 months.

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