Chapter II

THE PREVALENCE METHOD

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This chapter describes and applies a new methodology for estimating the fertility impact of contraception obtained through a family planning programme. This approach is called the "prevalence method" because the principal data required for its application are estimates of the prevalence of contraceptive use at a given point in time. (Contraceptive prevalence is defined here as the proportion of married women currently using contraception.) The development and use of the prevalence method have become feasible in recent years because prevalence data are now routinely available from fertility surveys.[1] In contrast, in the 1960s and early 1970s most countries with family planning programmes relied primarily upon service statistics, such as the number of acceptors, for the purpose of assessing the progress of the programme. Many of the existing methods for evaluating programme impact therefore rely upon acceptor statistics.

It is the objective of the prevalence method to estimate the number of births averted as well as the reduction in the crude birth rate that results from the use of programme contraception. A single application of the procedure produces these estimates for one year, but repeated applications for different years can yield a time-series of births averted or other impact measures.

A. Basic concepts

Before proceeding with a description of the methodology, it is helpful to summarize the basic concepts and variables used in the prevalence procedure:

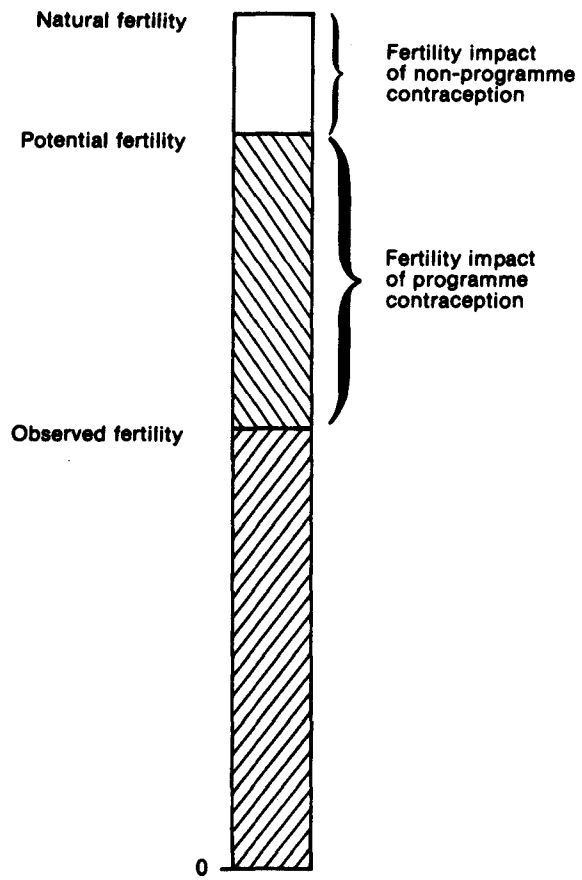
(*a*) *Observed fertility*. This is simply the rate of childbearing measured in the year in which the method is applied. The principal fertility indicator used in this chapter is the age-specific fertility rate expressed in births per 1,000 women in a given age group;

(*b*) *Natural fertility*. This is the level of fertility that would prevail in the absence of contraception (and induced abortion[2]);

(*c*) *Potential fertility (gross[3])*. This is the level of fertility that would prevail in a population if all programme users stopped contracepting. Since there are significant numbers of users of non-programme contraception in most countries, the level of potential fertility will be less than the natural level.

The relationships between these three different types of fertility are summarized in figure III. From them, the following impact measures are obtained:

Figure III. Relationships between observed, potential and natural fertility and the fertility impact of programme and non-programme contraception in a population



(*a*) Fertility impact of programme contraception, which is estimated as the difference between potential and observed fertility;

(*b*) Fertility impact of non-programme contraception, which equals the difference between natural and potential fertility.

Of course, the total impact of all contraception—from both programme and non-programme sources—is given by the difference between natural and observed fertility.

B. Methodology

The procedure for calculating births averted by programme users consists of five parts to obtain, consecu-

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tively, estimates of: (*a*) natural fertility; (*b*) potential fertility; (*c*) fertility impact of programme use; (*d*) births averted; (*e*) birth-rate impact; and (*f*) method-specific results. Each of these steps is described below in some detail. All age-specific fertility variables are measured in births per 1,000 women.

1. *Natural fertility*

The following equation, which relates observed and natural fertility, forms the basis for estimating natural fertility:

$$OFa = NFa \cdot (1 - Ua \cdot Ea/Fa) \quad (1)$$

where a = five-year age groups;

OFa = observed age-specific fertility rate (births per 1,000 women in age group a);

NFa = natural age-specific fertility rate;

Ua = contraceptive prevalence, equal to the proportion of married women currently using contraception in age group a;

Ea = (use-) effectiveness of contraception[4] in age group a;

Fa = proportion of women reported fecund in age group a.

Equation (1) simply states that observed fertility is lower than natural fertility by a proportion $Ua \cdot Ea/Fa$. As expected, this proportion increases with greater prevalence and effectiveness. The parameter Fa is included to take account of the fact that contraceptive use is concentrated among the fecund women. The derivation and testing of equation (1) are discussed elsewhere (Bongaarts and Potter, 1963) and are not covered here.

Rearranging equation (1) yields

$$NFa = OFa/(1 - Ua \cdot Ea/Fa). \quad (2)$$

From this equation, natural fertility can be estimated if estimates of OFa, Ua, Ea and Fa are available for each age group.

In equation (2), the variable Ua measures the prevalence of contraceptive use, including all methods from both programme and non-programme sources; and Ea is the average effectiveness of these methods. The product $Ua \cdot Ea$ in equation (1) can be calculated from method- and sector-specific prevalence data with

$$Ua \cdot Ea = U'a \cdot E'a + U''a \cdot E''a; \quad (3)$$

and

$$U'a \cdot E'a = \Sigma U'ma \cdot E'ma; \quad (4)$$

$$U''a \cdot E''a = \Sigma U''ma \cdot E''ma. \quad (5)$$

where $U'a$ = prevalence of programme contraception in age group a;

$E'a$ = effectiveness of programme contraception in age group a;

$U''a$ = prevalence of non-programme contraception in age group a;

$E''a$ = effectiveness of non-programme contraception in age group a;

$U'ma$, $E'ma$, $U''ma$, $E''ma$ = corresponding method-specific prevalence and effectiveness levels (m = method).

Only four methods are included in applications given below: sterilization ($m = 1$); intra-uterine device (IUD) ($m = 2$); pill ($m = 3$); and other ($m = 4$). Any number of contraceptives can be included, however, by using higher values for m. Furthermore, it is assumed here for simplicity that the use-effectiveness of each method is similar for different age groups and for programme and non-programme contraceptions, i.e., $E'ma = E''ma = Ema = Em$.

2. *Potential fertility*

Potential fertility is lower than natural fertility due to the use of non-programme contraception, so that

$$PFa = NFa(1 - U''a \cdot E''a/Fa). \quad (6)$$

This equation is similar to equation (1) except that now only the fertility-inhibiting effect of non-programme contraception has to be taken into account. The calculation of PFa therefore requires only the values of NFa, $U''a$, $E''a$ and Fa. The product $U''a \cdot E''a$ is estimated from equation (5).

3. *Fertility impact of programme and non-programme contraception*

Once the levels of natural and potential fertility are known, the fertility impact of programme and non-programme contraception is estimated as:

$$FIPa = PFa - OFa; \quad (7)$$

$$FINa = NFa - PFa. \quad (8)$$

That is, $FIPa$, the age-specific fertility impact of programme use, equals the difference between potential and observed fertility; and $FINa$, the age-specific fertility impact of non-programme contraception, equals the difference between natural and potential fertility (see figure III).

4. *Births averted*

Translating the fertility impact measures, $FIPa$ and $FINa$, into numbers of births averted in each sector is accomplished by multiplying by the number of women in the age group to which the calculation is applied:

$$BAPa = FIPa \cdot Wa/1{,}000; \quad (9)$$

$$BANa = FINa \cdot Wa/1{,}000 \quad (10)$$

where $BAPa$ = births averted by programme contraception in age group a;

$BANa$ = births averted by non-programme contraception in age group a;

Wa = number of women in age group a.

5. *Impact of contraception on crude birth rate by sector*

Equations (1)-(10) summarize the essentials of the methodology proposed here for the estimation of age-specific numbers of births averted by sector. From these age-specific results, the aggregate impact on the crude birth rate of progamme and non-programme contraception are obtained from

$$BRIP = 1{,}000 \sum_a BAPa/POP; \quad (11)$$

$$BRIN = 1{,}000 \sum_a BANa/POP \quad (12)$$

where $BRIP$ = reduction in crude birth rate due to use of programme contraception;

$BRIN$ = reduction in crude birth rate due to use of non-programme contraception;

$BAPa$ = births averted by programme contraception in age group a;

$BANa$ = births averted by non-programme contraception in age group a;

POP = total population size.

The calculation of $BRIP$ and $BRIN$ therefore requires that $BAPa$ and $BANa$ shall be calculated (with equations (9) and (10)) for all age groups from 15-19 to 45-49.

6. *Method-specific results*

Since the fertility impact of each method depends directly upon its prevalence and effectiveness, it is clear that in each age group:

$$BAPma = BAPa(U'ma \cdot E'ma)/(U'a \cdot E'a); \quad (13)$$

$$BANma = BANa(U''ma \cdot E''ma)/(U''a \cdot E''a) \quad (14)$$

where $BAPma$ = births averted by programme method m in age group a;

$BANma$ = births averted by non-programme method m in age group a.

The impact on the crude birth rate, by method and sector, is now simply calculated as

$$BRIPm = 1{,}000 \sum_a BAPma/POP; \quad (15)$$

$$BRINm = 1{,}000 \sum_a BANma/POP \quad (16)$$

where $BRIPm$ = reduction in the crude birth rate due to use of programme method m;

$BRINm$ = reduction in the crude birth rate due to use of non-programme method m.

The variables $BAPma$ and $BANma$ are found by applying equations (13) and (14) successively to all age groups from 15-19 to 45-49.

C. Required input data

The following input data are required for an application of the prevalence method in a given year:

(*a*) Contraceptive prevalence (i.e., proportion of married women currently using contraception by age and method for both the programme and non-programme sectors ($U'ma$ and $U''ma$), at the beginning of the year);[5]

(*b*) Observed age-specific fertility rates (OFa);

(*c*) Number of women in each five-year age group from 15-19 to 45-49 (Wa);

(*d*) Use-effectiveness of different contraceptive methods (Ema);

(*e*) Age-specific proportions of fecund women (Fa);

(*f*) Total population size (POP).

The contraceptive prevalence data are usually available from fertility or contraceptive prevalence surveys. Observed age-specific fertility rates and numbers of women by age can be obtained from surveys or other sources. Usually, the most difficult data to obtain are estimates of method-specific effectiveness and proportions reported non-sterile. Fortunately, these two variables tend to vary relatively little among populations and the estimates of fertility impact are not sensitive to small errors in them. The standard values given in tables 5 and 6 can therefore provide good approximations in populations where no direct estimates are available.[6]

Table 5. Standard effectiveness levels of contraceptive methods

Method m	*Contraceptive effectiveness Em*
Sterilization	1.00
Intra-uterine device	0.95
Pill	0.90
Other[a]	0.70

[a] "Other" category refers to traditional methods, such as use of condom, diaphragm, spermicidal agents, rhythm, withdrawal and abstinence. The latest modern methods, such as injectables and subdermal implants, have much higher effectiveness levels (close to 100 per cent) and therefore should not be included with the traditional methods.

Table 6. Standard age-specific proportions reported fecund

Age group a	*Proportion reported fecund Fa*
15-19	0.98
20-24	0.98
25-29	0.97
30-34	0.96
35-39	0.89
40-44	0.75
45-49	0.48

D. Illustrative application

To illustrate the use of the prevalence method, an application example is presented here. In this exercise, a set of hypothetical prevalence data, given in table 7, and age-specific fertility and number of women, given in

Table 7. Contraceptive prevalence levels, by age, method and sector
(*Hypothetical input data*)

Age group a	*Programme contraception U'ma*					*Non-programme contraception U''ma*					*Total Ua*
	Sterilization (1)	*IUD (2)*	*Pill (3)*	*Other (4)*	*Total (5)*	*Sterilization (6)*	*IUD (7)*	*Pill (8)*	*Other (9)*	*Total (10)*	*(11)*
15-19	0	0	0.05	0.05	0.10			0.03	0.02	0.05	0.15
20-24	0	0.1	0.05	0.05	0.20		0.02	0.02	0.01	0.05	0.25
25-29	0	0.1	0.05	0.05	0.20	0.02	0.05	0.02	0.01	0.10	0.30
30-34	0.05	0.1	0.05	0.05	0.25	0.05	0.07	0.02	0.01	0.15	0.40
35-39	0.10	0.1	0.03	0.02	0.25	0.07	0.06	0.01	0.01	0.15	0.40
40-44	0.10	0.05	0.03	0.02	0.20	0.05	0.03	0.01	0.01	0.10	0.30
45-49	0.05	0.05	0.03	0.02	0.15	0.05	0.03	0.01	0.01	0.10	0.25

Source: Fertility survey or contraceptive prevalence survey. *Note:* IUD = intra-uterine device.

table 8, are used. This is the minimum amount of input data that should be assembled before beginning the calculations of fertility impact measures. As already noted, standard levels of effectiveness (table 5) and proportions reported fecund (table 6) can be used.

Once the input data (tables 5-8) are available, the step-by-step application of the prevalence method proceeds as described below.

TABLE 8. OBSERVED AGE-SPECIFIC FERTILITY RATE AND NUMBER OF WOMEN, BY AGE GROUP
(Hypothetical input data)

Age group a	*Observed fertility rate OFa (1)*	*Number of women Wa (thousands) (2)*
15-19	75	250
20-24	200	225
25-29	250	200
30-34	200	175
35-39	150	150
40-44	75	125
45-49	10	100

Source: Vital statistics and census data or derived from sample surveys.

1. *Estimation of age-specific natural fertility rates*

For each age group in the reproductive years, the natural fertility rate is calculated with equation (2). Before using this equation, however, it is necessary to calculate the products *Ua·Ea*, with equations (3), (4) and (5). To accomplish this, the product of prevalence and effectiveness for each method and age group in both the programme and non-programme sectors should be calculated first from the data given in tables 5 and 7. The results, presented in table 9, are obtained by multiplying the age- and method-specific prevalence estimates given in table 7 by the appropriate method-specific effectiveness levels from table 5. The resulting age-specific estimates of *Ua·Ea* given in column (11) of table 9 are now substituted in equation (2), together with the age-specific proportions fecund (from table 6) and the observed age-specific fertility rates (from table 8), to yield the age-specific natural fertility pattern given in the first column of table 10.

2. *Estimation of age-specific potential fertility rates*

Potential fertility rates are calculated with equation (6) by substituting *NFa* (column (1) in table 10), *U"a·E"a* (from column (10) of table 9) and *Fa* (from table 6). The results are presented in column (2) of table 10. As expected, the potential fertility rate in each age group is less than the natural but higher than the observed fertility level.

3. *Estimation of age-specific fertility impact of programme and non-programme contraception*

The age-specific reductions in fertility rates attributable to programme contraception, *FIPa*, are estimated directly from equation (7) by subtracting observed from potential fertility rates. This yields the values of *FIPa* presented in column (3) of table 10. Application of equation (8) produces the estimates of non-programme effects, *FINa*, in column (4) of table 10.

4. *Estimates of births averted*

Age-specific numbers of births averted by programme and non-programme contraception estimated from equations (9) and (10) are presented in table 11. A total of 52,400 births were averted by programme contraception and 27,100 births by non-programme contraception.

5. *Estimation of birth-rate effects*

The reductions in the crude birth rate attributable to either programme or non-programme contraception are now directly obtained by dividing the total number of births averted in each sector by the total population size and multiplying by 1,000 (equations (11) and (12)). With a total population, *POP*, of 6,125,000 persons, the birth-rate effect of programme contraception equals (52,400/6,125,000) × 1,000 = 8.56. Similarly, the birth-rate impact of non-programme contraception equals 4.42. From these sectoral effects, the levels of potential and natural crude birth rates can be calculated if the observed crude birth rate is known. The population in this illustration has a crude birth rate of 29.65.[7] The potential crude birth rate is therefore 29.65 + 8.56 = 38.21, and the natural crude birth rate is 38.21 + 4.42 = 42.63. These results are summarized as follows:

(*a*) Birth-rate impact of programme contraception, *BRIP*: 8.56;

TABLE 9. ESTIMATES OF THE PRODUCT OF CONTRACEPTIVE PREVALENCE AND EFFECTIVENESS, $U \cdot E$, BY AGE, METHOD AND SECTOR

Age group a	*Programme contraception U'ma · Em*					*Non-programme contraception U''ma · Em*					*Total Ua+Ea (11)*
	Sterilization (1)	*IUD (2)*	*Pill (3)*	*Other (4)*	*Total (5)*	*Sterilization (6)*	*IUD (7)*	*Pill (8)*	*Other (9)*	*Total (10)*	
15-19	-	-	0.045	0.035	0.080	-	-	0.027	0.014	0.041	0.121
20-24	-	0.095	0.045	0.035	0.175	-	0.019	0.018	0.007	0.044	0.219
25-29	-	0.095	0.045	0.035	0.175	0.020	0.047	0.018	0.007	0.092	0.267
30-34	0.050	0.095	0.045	0.035	0.225	0.050	0.066	0.018	0.007	0.141	0.366
35-39	0.100	0.095	0.027	0.014	0.236	0.070	0.057	0.009	0.007	0.143	0.379
40-44	0.100	0.047	0.027	0.014	0.188	0.050	0.028	0.009	0.007	0.094	0.282
45-49	0.050	0.047	0.027	0.014	0.138	0.050	0.028	0.009	0.007	0.094	0.232

Source: See formula in text.

Note: IUD = intra-uterine device.

TABLE 10. ESTIMATED AGE-SPECIFIC NATURAL AND POTENTIAL FERTILITY RATES AND AGE-SPECIFIC FERTILITY EFFECTS OF PROGRAMME AND NON-PROGRAMME CONTRACEPTION

(Births per 1,000 women)

Age group *a*	Natural fertility rate *NFa* (1)	Potential fertility rate *PFa* (2)	Fertility effect of contraception: Programme *FIPa* (3)	Fertility effect of contraception: Non-programme *FINa* (4)
15-19	86	82	7	4
20-24	258	246	46	12
25-29	345	312	62	33
30-34	323	276	76	47
35-39	261	219	69	42
40-44	120	105	30	15
45-49	19	15	5	4

Source: Derived with equations (2), (6), (7) and (8).

TABLE 11. ESTIMATED NUMBER OF BIRTHS AVERTED BY PROGRAMME AND NON-PROGRAMME CONTRACEPTION

Age group *a*	Births averted by: Programme contraception *BAPa* (1)	Births averted by: Non-programme contraception *BANa* (2)	Total (3)
15-19	1 750	1 000	2 750
20-24	10 350	2 700	13 050
25-29	12 400	6 600	19 000
30-34	13 300	8 225	21 525
35-39	10 350	6 300	16 650
40-44	3 750	1 875	5 625
45-49	500	400	900
TOTAL	52 400	27 100	79 500

Source: Derived with equations (9) and (10).

(*b*) Birth-rate impact of non-programme contraception, *BRIN*: 4.42;

(*c*) Observed crude birth rate: 29.65;

(*d*) Potential crude birth rate (observed crude birth rate + *BRIP*): 38.21;

(*e*) Natural crude birth rate (observed crude birth rate + *BRIP* + *BRIN*): 42.63.

6. *Estimation of births averted and birth-rate impact by method*

To obtain method-specific results, it is necessary first to calculate births averted by age and method. This is done in table 12. Each cell in this table is calculated from equations (13) or (14) by substituting the estimates of *BAPa* and *BANa* (from table 11) and the products $U'ma \cdot E'ma$ and $U''ma \cdot E''ma$ (from table 9). Summing over all ages in table 12 yields the numbers of births averted by method in each sector, given in the bottom row of this table. Adding sectors yields the total births averted by method. The results are summarized in columns (1)-(3) of table 13. Dividing these numbers of births averted by the total population size (and multiplying by 1,000) produces the effects on the crude birth rate, by method and sector, given in columns (4)-(6) of table 13. The total birth-rate effect of programme contraception is 8.56, of which 1.56 is attributable to sterilization, 3.79 to IUD. 1.85 to the pill and 1.36 to other methods.

TABLE 12. ESTIMATED NUMBER OF BIRTHS AVERTED, BY AGE, METHOD AND SECTOR

Age group *a*	Births averted by programme contraception: Sterilization (1)	IUD (2)	Pill (3)	Other (4)	Total *BAPa* (5)	Births averted by non-programme contraception: Sterilization (6)	IUD (7)	Pill (8)	Other (9)	Total *BANa* (10)	Total (11)
15-19	0	0	984	766	1 750	-	-	659	341	1 000	2 750
20-24	-	5 619	2 661	2 070	10 350	-	1 166	1 105	429	2 700	13 050
25-29	-	6 731	3 189	2 480	12 400	1 435	3 372	1 291	502	6 600	19 000
30-34	2 955	5 616	2 660	2 069	13 300	2 917	3 850	1 050	408	8 225	21 525
35-39	4 386	4 166	1 184	614	10 350	3 084	2 511	397	308	6 300	16 650
40-44	1 995	937	539	279	3 750	997	559	179	140	1 875	5 625
45-49	181	170	98	51	500	213	119	38	30	400	900
TOTAL	9 517	23 239	11 315	8 329	52 400	8 646	11 577	4 719	2 158	27 100	79 500

Source: Derived with equations (9) and (10).

Note: IUD = intra-uterine device.

TABLE 13. ESTIMATED NUMBER OF BIRTHS AVERTED AND EFFECT OF PROGRAMME AND NON-PROGRAMME CONTRACEPTION ON CRUDE BIRTH RATES, BY METHOD

Contraceptive method	Births averted: Programme contraception (1)	Births averted: Non-programme contraception (2)	Births averted: Total (3)	Crude birth rate effect: Programme contraception (4)	Crude birth rate effect: Non-programme contraception (5)	Crude birth rate effect: Total (6)
Sterilization	9 517	8 646	18 163	1.56	1.41	2.97
Intra-uterine device	23 239	11 577	34 816	3.79	1.89	5.68
Pill	11 315	4 719	16 034	1.85	0.77	2.62
Other	8 329	2 158	10 487	1.36	0.35	1.71
TOTAL	52 400	27 100	79 500	8.56	4.42	12.98

Source: Derived with equations (13)-(16).

Conclusion

The preceding overview of the prevalence method indicates that this new approach provides a simple and straightforward alternative to existing methods for estimating the gross fertility impact of programme contraception. In contrast to several of the other procedures, the prevalence method does not require detailed input data on numbers of past acceptors and continuation rates. Instead, estimates of the prevalence of programme and non-programme contraception by age and method are required as principal input data. While such data were rarely available in the past, prevalence estimates are now routinely obtained from national surveys in many developing countries, thus making the application of the prevalence method possible.

Notes

[1] Examples of national sample surveys conducted in large numbers of countries are the World Fertility Survey (WFS) and the Contraceptive Prevalence Survey (CPS).

[2] Natural fertility is defined as fertility in the absence of any deliberate parity-specific birth control practices, such as the use of contraception or induced abortion. In the applications of the prevalence method given here, the term "natural fertility" is used as the fertility prevailing in the absence of contraception. This yields the natural fertility only if there is no induced abortion, but results of the prevalence method are not affected because births averted are calculated only as a result of contraceptive use.

[3] Potential fertility is generally defined as the fertility that would prevail in the absence of a family planning programme. At least two types of potential fertility can be distinguished. Gross potential fertility is the level that would be observed if all programme users stopped contracepting (without substituting). Net potential fertility is the level that would be observed if a programme had never existed. The difference between gross and net fertility is that the latter takes into account substitution and catalytic or spill-over effects of the programme. Further discussion of the definition of potential fertility and its use in various methodologies can be found in Bongaarts (1985).

[4] The use-effectiveness of a contraceptive method equals the proportional reduction in the monthly probability of conception achieved while using the method. A discussion of this and other measures of contraceptive performance (such as failure rate, Pearl rate and continuation rate) is given in Bongaarts and Potter (1983). The measurement of use-effectiveness is difficult and requires special complex surveys. For further details, see Laing (1978 and 1984).

[5] For simplicity, it is assumed here that there is a six-month delay between contraceptive use and its effect on fertility. A nine-month delay would theoretically be preferable, but the error is negligible in practice. In fact, this delay can be ignored altogether in most cases without significant error, unless contraceptive prevalence is changing very rapidly.

[6] These standard patterns of use-effectiveness and reported proportions fecund are proposed in Bongaarts and Potter (1983). For simplicity, method-specific effectiveness levels are assumed to be the same for all age groups in the applications presented in this chapter. Where considered appropriate, an increasing trend with age could be used.

[7] The crude birth rate of the hypothetical population used in this illustration is equal to the observed number of births divided by the total population ($\times$ 1,000):1,000 $\times$ 181,625/6,125,000 = 29.65. The observed total number of births is calculated by summing over all age groups the product of the observed fertility rate, *OFa*, and the number of women, *Wa*, given in table 8.

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