Estimating the Probability of Spontaneous Abortion in the Presence of Induced Abortion and Vice Versa

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Synopsis

An integrated approach to estimate the total number of pregnancies that begin in a population during one calendar year and the probability of spontaneous abortion is described. This includes an indirect estimate of the number of pregnancies that result in spontaneous abortions.

The method simultaneously takes into account the proportion of induced abortions that are censored by spontaneous abortions and vice versa in order to estimate the true annual number of spontaneous and induced abortions for a population. It also estimates the proportion of pregnancies that women intended to allow to continue to a live birth.

The proposed indirect approach derives adjustment factors to make indirect estimates by combining vital statistics information on gestational age at induced abortion (from the 12 States that report to the National Center for Health Statistics) with a life table of spontaneous abortion probabilities. The adjustment factors are applied to data on induced abortions from the Alan Guttmacher Institute Abortion Provider Survey and data on births from U.S. vital statistics.

For the United States in 1980 the probability of a spontaneous abortion is 19 percent, given the presence of induced abortion. Once the effects of spontaneous abortion are discounted, women in 1980 intended to allow 73 percent of their pregnancies to proceed to a live birth. One medical benefit to a population practicing induced abortion is that induced abortions avert some spontaneous abortions, leading to a lower mean gestational duration at the time of spontaneous abortion.

THE PROBABILITY that a pregnancy will end as a spontaneous abortion is measured as the ratio of spontaneous abortions to all pregnancies. All pregnancies include all spontaneous abortions (plus stillbirths), live births, and induced abortions. This measure is problematic because of the uncertainty in the annual number of spontaneous abortions, given that spontaneous abortions are not fully captured in vital registration systems. In addition, for populations in which there is a significant amount of induced abortion, the two types of abortion compete as potential pregnancy outcomes. Some women have induced abortions for pregnancies that would have spontaneously aborted anyway, and some women have spontaneous abortions of pregnancies they had planned to abort. This problem of mutual censorship of outcomes has been described previously in the literature (*1-3*).

In this paper I am proposing an integrated approach to indirect estimation of the annual number of spontaneous abortions in a population and the probability of this outcome. The approach begins with the analytic fiction that all women from the beginning of pregnancy intend either to abort or to have a live birth. I then estimate the total number of pregnancies by designing inflation factors to recover all pregnancies resulting in known outcomes—either induced abortion or live birth. The difference between the estimated total number of pregnancies and the number of known pregnancy outcomes is an indirect estimate of the number of spontaneous abortions. In this way it is possible to estimate the probabilities that a pregnancy will end with one of the three possible outcomes and estimate the "intentionality" of women to abort or to continue the pregnancy.

Pregnancy outcome probabilities have several uses. Abortion and birth probabilities are used as parameters in mathematical models of birth and fecundability (*4,5*) to calculate abortions averted at different contraceptive prevalence levels (*6*), in proximate determinants of fertility models (*7*), and to evaluate the overall mortality and morbidity risk of different contraceptive methods (*8*).

Background

Definitions. What is the most useful definition of the beginning of pregnancy? *Biologically*, conception occurs in the middle of the menstrual cycle, approximately 2 weeks after the first day of the previous menstrual period. In the normal course of pregnancy, the fertilized zygote implants into the uterine lining approximately 1 week later. In the 2 weeks following fertilization, there is an unknown, but large, amount of embryonic loss (*9*). Increased levels of estrogen and progesterone cause amenorrhea in pregnant women (*10*), which women are led to classify as a missed period. Recently developed tests may establish, almost immediately after implantation, the fact that conception has taken place (*11*).

As a *social* event, however, pregnancy may usefully be considered to begin at the first missed menstrual period. The first missed period is the earliest that a woman herself might recognize that she is pregnant. If she has not done so already, she must begin to decide at that point whether she intends the pregnancy to proceed to a live birth, or to marshal financial and personal resources for an induced abortion, if she does not. Gestational age is measured, by medical tradition and convention, in weeks from the first day of the last menstrual period. Pregnancy as a social fact, and for the purposes of this article, begins at the conventional fourth gestational week (28 days since beginning the last menstrual period). The subsequent indirect estimates refer to spontaneous abortions of embryos and fetuses that survive at least until the gestational age of 4 weeks.

The common terms for spontaneous abortion are miscarriage and stillbirth, the latter term usually reserved for an aborted fetus during the third trimester of pregnancy. This article does not distinguish between spontaneous abortion and stillbirth, terming all intra-uterine deaths "spontaneous abortions."

Previous methods of indirect estimation. As discussed previously, estimation of the number of spontaneous abortions is complicated by the practice of induced abortion. Induced abortions avert not only live births, but also spontaneous abortions that would have taken place at a future time in the pregnancy. In addition, some spontaneous abortions preempt a future induced abortion. Spontaneous and induced abortion are therefore competing pregnancy outcomes (*1*).

One approach is to inflate the recorded births and induced abortions to recover all pregnancies including spontaneous abortions. Henshaw and coworkers (*12*) used simple rule-of-thumb multipliers to estimate annual pregnancies. They multiplied reported live births by .20 and induced abortions by .10 and added these two numbers to come up with an estimate of spontaneous abortions. Their procedure assumed that 1.20 conceptions are needed to produce one live birth, and that 1.10 conceptions are needed to produce one abortion. The method described subsequently derives empirical estimates of these multiplicative factors.

Susser (*2*) proposes another rule of thumb to correct spontaneous abortion rates for the presence of induced abortions. He adds half of the induced abortions to the denominator of the spontaneous abortion rate. His method is exact if the gestational duration distributions of induced and spontaneous abortions are the same. Spontaneous abortions, however, happen much earlier in gestation than induced abortions. The method proposed in this paper uses these duration distributions directly, rather than by assumption. Thus it can account for variations in patterns of abortion in terms of the duration of pregnancy by age or across different populations.

Another alternative is to rely on survey reports of miscarriages. Ventura and coworkers took self-reported spontaneous abortions from the 1982 National Survey of Family Growth as their national estimate (*13*). Estimates based on recall are characteristically too low, because women either forget or are not aware of all their spontaneous abortions (*14*).

Other methods recently proposed (*3,15*) use multiple-decrement life tables to inflate the number of spontaneous abortions to account for those censored by induced abortions. The proposed method estimates simultaneously the true probabilities of each of the three possible pregnancy outcomes. Thus it is an integrated approach that also accounts for induced abortions censored by spontaneous, without the assumptions necessitated by a multiple-decrement approach.

Sources of data on births and induced abortion. Data on births and abortions come from several public sources in the United States. State vital statistics agencies register virtually all live births, compiled at the Federal level by the National Center for Health Statistics (NCHS).

Some State health departments also register induced abortions as vital events on "induced termination of pregnancy'' certificates. Completeness of State reporting on induced abortion is highly variable: the median completeness of the State reports is 86 percent, with a range from 49 percent to 100 percent (*16*). To estimate the total number of induced abortions performed in the United States independent of the vital statistics system, the Alan Guttmacher Institute (AGI) has conducted surveys of all abortion providers since 1973 (*17*). Although the AGI provider surveys are as complete as possible, they may be underreported by as much as 6 percent (*13*). The AGI survey does not collect any additional information on abortion patients, such as their age, race, and gestational duration.

As with births, NCHS compiles induced abortion data contributed in a standard format by State health departments. As of 1991, 13 States participate in the Abortion Reporting Area, which account for about 20 percent of the induced abortions in the United States. The standard NCHS form includes demographic data on each patient plus information on the abortion technique employed and gestational age of the fetus. My application uses the by-week distribution of gestational ages from the NCHS data.

Although some States and cities register spontaneous abortions, national counts based on registration do not exist, nor are they likely ever to exist. Much early spontaneous fetal loss occurs in private, either unknown to the woman or without medical care, and thus is impossible to cover with vital registration systems.

A life table of fetal loss may be constructed from prospective data, however, starting from the fourth gestational week. In the next section of the paper I introduce a method to combine a fetal life table from a clinical study (*18*) with vital registration data to estimate the incidence of spontaneous fetal loss. The application section of the paper assesses existing statistical studies of spontaneous abortion, and describes U.S. births and abortion data. The results section of the paper applies the method to estimate the number of pregnancies that began in the United States in 1980 and the probabilities of each of the three pregnancy outcomes.

Methods

A simple way to approach the problem of induced and spontaneous abortion being competing outcomes is to imagine dividing all women into two groups at the time they learn they are pregnant: those who intend to bear the child and those who intend to have an induced abortion. This conceptualization was introduced by Susser, although it is not explicitly incorporated into his methodology (*2*). The first group would go on to bear a child if spontaneous abortion does not prevent it. The second group would have an induced abortion if they do not first have a spontaneous abortion. This section derives multipliers to work backwards from the (known) births and induced abortion outcomes to recover the (unknown) underlying number of pregnancies that ''produced'' them. The difference between total estimated pregnancies and enumerated births and induced abortions is an indirect estimate of the number of spontaneous abortions.

Those who intend births. How many pregnancies are required to ''produce'' a given number of live births? This question has a straightforward answer, given the probability that pregnancies survive to become live births in the absence of induced abortion. This probability is derived from a fetal life table.

The fetal survivor function at gestation week t, denoted $F(t)$, is the associated single decrement l_x function of a fetal life table in which spontaneous abortion and live birth are the only decrements. $F(t)$ is the cumulative probability of a pregnancy surviving to time t, if the only risk is of spontaneous abortion. As stated previously, a conception is not defined as a pregnancy before the fourth gestational week, hence $F(4)$ is equal by definition to 1. By the 44th week of gestation, all pregnancies have terminated as either live births or spontaneous abortions. $F(44)$ is therefore the probability that one of the original pregnancies survives to full term, in the absence of induced abortion. An average value of $F(44)$ for human populations is about .8 live births per pregnancy (*7*).

Using the value of $F(44) = .8$, we can estimate the number of pregnancies required to ''produce'' a specific number of observed births. For example, the number of pregnancies required to produce 100 births is $100 \times 1 \div .8 = 125$. In other words, of 125 women who become pregnant *intending to give birth*, only 100 (or 80 percent) will actually give birth. The multiplier on births to recover all pregnancies represented by those births is denoted $k_b = 1 \div F(44)$. The term k_b is the reciprocal of the probability of each conception surviving to live birth.

Note that in the *absence* of induced abortion (which may characterize a few societies) spontaneous abortions would simply be 125 pregnancies minus 100 live births = 25 spontaneous abortions. Using the previous notation, this would simply be

Glossary of Notation

$F(t)$	The cumulative probability of a pregnancy surviving to time t, if the only risk is from spontaneous abortion.
$F(44)$	The probability that a pregnancy survives to full term in the absence of induced abortion.
k_b	Multiplier on births to recover total pregnancies required to "produce" one birth.
$k_a(t)$	Multiplier on induced abortions to recover total pregnancies required to "produce" one induced abortion in gestational week t.
k_a	Multiplier on induced abortion to recover total pregnancies required to "produce" one induced abortion.
$w(t)$	The proportion of induced abortions that take place at gestational week t.
P_y^b	Pregnancies beginning in year y that end as live births.
P_y^a	Pregnancies beginning in year y that end as induced abortions.
P_y^s	Pregnancies beginning in year y that end as spontaneous abortions.
P_y	Total pregnancies beginning in year y.
I_a	"Abortion intentionality"—the proportion of all pregnancies that would end as induced abortions in the absence of spontaneous abortion.
I_b	"Birth intentionality"—the proportion of all pregnancies that would end as live births in the absence of spontaneous abortion.
$p(A)$	The probability that a pregnancy will end as an induced abortion.
$p(B)$	The probability that a pregnancy will end as a live birth.
$p(S)$	The probability that a pregnancy will end as a spontaneous abortion.

$k_b - 1$ spontaneous abortions per birth, in the absence of induced abortion.

Those who intend abortion. How many pregnancies are required to "produce" a given number of induced abortions, in the presence of spontaneous fetal loss? Because an induced abortion censors spontaneous abortions as well as live births, the answer depends on the gestational age at which the induced abortion occurs. Censoring at a given time implies a truncation of the possibility of observing an event (in this case spontaneous abortion) after that time. An induced abortion represents fewer pregnancies than a live birth because not all aborted pregnancies would have gone on to become live births. Moreover, an induced abortion at an earlier gestational age is more likely to censor a spontaneous abortion than one at a later gestational age.

For example, an induced abortion at the very beginning of the fourth week of pregnancy, when $F(4)=1$, is "produced" by exactly one pregnancy. Suppose, however, an induced abortion takes place at $t=12$ weeks, and the cumulative probability of a spontaneous abortion before $t=12$ is .1; that is, the survivorship function $F(12)=.9$. Hence $1 \div .9$, or 1.111 pregnancies are required to survive from $t=4$ to $t=12$ to produce a single induced abortion at time $t=12$ weeks. In general, the multiplier to recover the number of pregnancies underlying induced abortions at gestation age t depends on the fetal survival function $F(t)$. We let $k_a(t)$ denote the abortion multiplier at week t

$$k_a(t) = 1 \div F(t).$$

To obtain the total pregnancies required to produce some specified number of induced abortions, we take a weighted sum of the $k_a(t)$, weighting each by the proportion of induced abortions $w(t)$ that occur at gestation week t (such that $\sum_t w(t) = 1$):

$$k_a = \sum_t w(t)k_a(t).$$

Substitution of $1 \div F(t)$ for $k_a(t)$ shows that the overall multiplier k_a depends on only the survivor function $F(t)$ and the gestational age distribution $w(t)$

$$k_a = \sum_t (w(t) \div F(t)).$$

Indirect estimate of spontaneous abortion. Together, the births and induced abortions multipliers k_b and k_a yield an estimate of the total number of pregnancies that begin in a calendar year. We denote pregnancies beginning in year y that end as live births by $P_?^b$ and those that end as induced abortions by P_y^a (see box for a glossary of notation). P_y^b is available from vital statistics and P_y^a is available from the AGI provider surveys. Pulling the births and induced abortions multipliers together yields total pregnancies beginning in year y

that were required to "produce" the observed number of live births and induced abortions,

$$P_y = k_b P_y^b + k_a P_y^a$$

Spontaneous abortions that result from pregnancies beginning in year y are the difference between total pregnancies and births plus induced abortions

$$P_y^s = P_y - (P_y^b + P_y^a)$$

P_y^s is the indirect estimate of spontaneous abortions resulting from pregnancies begun in year y.

Substituting for P_y, this equation simplifies to

$$P_y^s = (k_b - 1)P_y^b + (k_a - 1)P_y^a$$

Birth and abortion "intentionality." It is a useful analytic fiction that all women, on learning they are pregnant, formulate an intention either to allow the pregnancy to proceed to a live birth or to have an induced abortion. What procedure will measure this hypothetical intention directly, given that spontaneous abortion can preempt either intended outcome? Taking $k_a P_y^a$ as the number of pregnancies women "intend" to abort, it is possible to define a measure of the propensity of women to terminate pregnancies. It is called abortion intentionality, and is defined as

$$I_a = k_a P_y^a \div P_y$$

Abortion intentionality is the proportion of all pregnancies that would end as induced abortions if spontaneous abortion did not exist. In other words, it is a measure of women's aggregate intentions toward their pregnancies, if their intentions were fully realizable. An analogous measure is birth intentionality

$$I_b = k_b P_y^b \div P_y = 1 - I_a$$

that is the proportion of all pregnancies women intend to allow to go to full term. In the absence of induced abortion, birth intentionality would equal unity, and abortion intentionality would equal zero. The results section of this paper presents abortion and birth intentionalities for the United States in 1980.

Birth or abortion "intentionality" should not be confused with birth intention, which is a classification of the planning status of a birth, nor with contraceptive intent, which is whether contraception is practiced to delay or prevent the next birth.

'Given the option of ending pregnancies voluntarily, American women also avoid a portion of spontaneous abortions formerly suffered. The miscarriages and stillbirths thus averted are of relatively longer gestational durations and more life-threatening, providing a little-documented health benefit for populations practicing abortion.'

It is tempting to reify this measure, but in practice, the decision whether or not to abort a pregnancy is unlikely to be either instantaneous or without reconsideration. A question on the 1982 National Survey of Family Growth asked women a hypothetical question as to what they would do if they were pregnant. The 17 percent who said they would have an induced abortion is about half the proportion who actually do.

Pregnancy outcome probabilities. The probabilities of each of the three possible pregnancy outcomes in a given year is straightforward—just the estimated number of outcomes divided by the sum of all pregnancies beginning in the year. For live births, $p(B) = P_y^b \div P_y$; for induced abortions, $p(A) = P_y^a \div P_y$; and for spontaneous abortions, $p(S) = P_y^s \div P_y$. The three probabilities sum to unity.

Backdating adjustments. To calculate pregnancies conceived in a particular year y, data on births and induced abortions require backdating because many pregnancy terminations occur in the year following conception. Counting from the first missed period ($t = 4$ weeks), duration to a live birth is approximately 8 months. Therefore, pregnancies starting at $t = 4$ during year y that ended as live births did so either in the last 4 months of year y (1/3 of a year) or in the first 8 months (2/3 of a year) of year $y+1$. An approximate direct backdating adjustment for pregnancies beginning in year y that ended as live births is therefore

$$P_y^b = 1/3 \times B_y + 2/3 \times B_{y+1}.$$

An analogous adjustment for induced abortion is as follows: The mean gestational duration to abor-

Table 1. Cumulative probability of fetal survival to duration week t[1], the proportion of induced abortions at week t (N = 295,761), and the pregnancies required to produce one induced abortion at week t, United States, 1980

Week t	Probability of fetal survival to week t F(t)	Proportion of induced abortions at week t w(t)	Pregnancies required to produce one abortion at week t $k_a(t)$
4	[2]1	.0070	1.000
5	.975	.0174	1.026
6	.953	.0827	1.049
7	.934	.1595	1.071
8	.919	.1880	1.088
9	.903	.1595	1.108
10	.884	.1268	1.131
11	.864	.0917	1.157
12	.845	.0545	1.183
13	.832	.0282	1.202
14	.823	.0172	1.215
15	.816	.0117	1.225
16	.811	.0106	1.232
17	.808	.0095	1.238
18	.804	.0096	1.243
19	.802	.0076	1.247
20	.800	.0062	1.250
21	.798	.0040	1.253
22	.797	.0033	1.255
23	.796	.0021	1.256
24	.795	.0014	1.258
25	.794	.0006	1.259
26	.793	.0003	1.260
27	.793	.0002	1.261
28	.792	.0001	1.263
29	.791	.0001	1.264
30	.791	.0001	1.265
31	.790	.0000	1.266
32	.790	.0000	1.266
33	.789	.0000	1.267
34	.789	.0000	1.268
35	.788	.0000	1.269
36	.787	.0000	1.271
37	.786	.0000	1.272
38	.785	.0000	1.273
39	.785	.0000	1.274
40	.784	.0000	1.276
41	.783	.0000	1.277
42	.783	.0000	1.277
43	.782	.0000	1.278
44+	.782	.0000	1.278 (= k_b)

[1] Reference *24*.
[2] $F(4)$ is equal to 1 by definition.

tion in the United States in 1980 was 9.43 weeks (data source subsequently). Again counting from $t = 4$, approximately one-tenth (5.43 ÷ 52 weeks) of the pregnancies begun in a particular year y that end as induced abortions actually terminate during the following year. Pregnancies begun in year y that eventually end as induced abortions are therefore

$$P_y^a = .9 \times A_y + .1 \times A_{y+1}.$$

These backdating adjustments assume that conceptions and either births or abortions occur evenly throughout the year. In the presence of marked seasonality, specific month-by-month backdating adjustments would be indicated. In the subsequent application, one might use the births from September 1980 to August 1981 as the estimate of P_{1980}^b.

An Application: United States, 1980

In this section I discuss data needed to calculate k_a and k_b for the United States in 1980. I first describe sources of the fetal mortality survivor function $F(t)$ for each gestation week t, and then the gestational age distribution of induced abortions $w(t)$. The fetal life table chosen comes from a study by Shapiro and colleagues (*18*). The gestational age distribution $w(t)$ was tabulated from the 1980 NCHS abortion microdata tape.

Studies of spontaneous fetal loss. Reviews of fetal mortality studies discuss their special methodological problems (*7,14,19*). Of the several types of spontaneous abortion studies, including retrospective fertility surveys, Leridon identifies population-based prospective and clinical studies as least biased (*19*). The best population-based prospective studies are the Khanna study in 11 Punjabi villages (*20*) and studies in Matlab Thana, Bangladesh (*21,22*). Spontaneous abortion rates in poor countries however, have limited applicability to the United States in 1980. A prospective study representative of the entire population of a developed country would be ideal for the present purpose. None has yet been published, so we turn to clinical studies.

One potential problem with clinical studies, in contrast to purely prospective studies, is self-selection bias, because medical care is initiated by the woman herself (*14*). Women who contact their physicians especially early in their pregnancies (4 to 8 weeks gestation) may be selected for previous difficulties in carrying a pregnancy—which is a strong predictor of fetal loss. Also, early prenatal medical care may reduce fetal death risks, leading to the opposite selection effect. It is impossible to detect or compensate for selection based on the fetal life table alone.

The two best known clinical studies are French and Bierman's classic Kauai, HI, study (*23*) and the Health Insurance Plan Pregnancy Outcome Study, conducted in New York by Samuel Shapiro and his coworkers (*18,24*). Each project tracked all pregnancies in specified clinical populations. French and Bierman attempted to enroll every pregnancy over a 4-year period on the island of Kauai into their study, using clinical records and many other sources to identify pregnant women. Although French and Bierman use appropriate life table methodology, their sample size is too small to estimate week-to-week changes in fetal mortality, as is needed. It is also quite racially homogeneous, and may not readily apply to the entire United States.

Some of the these problems are redressed by the Health Insurance Plan (HIP) study. Shapiro and coworkers studied the medical records of 11,630 women enrolled in a comprehensive prepaid medical care plan in New York City who became pregnant between March 1958 and March 1960 (*18,24*). Although the HIP enrollees were somewhat better educated, older, and more affluent than the childbearing population of New York City at the time, a variety of ages and racial groups is represented. The sample size is large enough to permit construction of fetal life tables by single gestational week. Table 1 shows Shapiro and coworkers' fetal survival as a function of gestation age t, denoted $F(t)$ (*18*). The cumulative probability of fetal survival from first missed period to birth is $F(44) = .782$, for a spontaneous abortion probability of .218. Cutright discusses and evaluates the validity of Shapiro's study (*25*).

Induced abortion and birth data. The sources for total numbers of abortions performed in the United States in 1980 and 1981 are special surveys of abortion providers conducted by the Alan Guttmacher Institute (*12,17*). Births data are taken from United States Vital Statistics reports for 1980 and 1981 (*26,27*). Table 2 shows the induced abortions and births data used in the analysis. Each number includes pregnancies ending in 1981 that are backdated to conceptions in 1980.

The single-week gestational age at abortion distribution is tabulated from NCHS induced abortion microdata for 1980. The data cover 12 States and contain information on 302,948 induced abortions, of which 295,761 contain valid data on gestational age. Table 1 shows the single-week gestational duration distribution of abortions for the population, under the assumption that these 12 States adequately represent the entire United States. The mean gestational duration is 9.43 weeks, the median is 8.28, and the eighth week is modal.

Results: United States, 1980

Spontaneous abortion indirect estimates. Table 2 shows the results of applying the aforementioned procedure to 1980 United States data. P^b_{1980} represents pregnancies begun in 1980 that resulted in live births in 1980 or 1981. The multiplier k_b recovers pregnancies that result in live birth or spontaneous abortion. The value of $k_b = 1.278$ implies that an average of .278 spontaneous abortions are required to "produce" each live birth. P^a_{1980} is pregnancies begun in 1980 that resulted in induced abortions in 1980 or 1981. The total multiplier for induced abortions, k_a, equals 1.116, implies that .116 spontaneous abortions occur for each induced abortion. P^s_{1980} is the estimated number of pregnancies begun in 1980 that resulted in spontaneous abortions. It is calculated from the formula

Table 2. Live births, induced abortions, and estimated spontaneous abortions that resulted from total pregnancies begun in 1980 in the United States

	Data		*Estimates*	
	Live births	*Induced abortions*	*Spontaneous abortions*	*Total pregnancies*
Symbol[1] . . .	P^b_{1980}	P^a_{1980}	P^s_{1980}	P_{1980}
Number . . .	3,624,993	1,556,235	1,188,960	6,370,188

[1] See glossary and text for definitions.

$$P^s_{1980} = (k_b - 1)P^b_{1980} + (k_a \div 1)P^a_{1980}$$

In 1980, the procedure estimates almost 1.2 million pregnancies resulted in spontaneous abortions.

On tables of contraceptive failure rates "chance" or "hope" is sometimes facetiously included as a very ineffective contraceptive method; we note here that chance is also an ineffective abortifacient.

An empirically-based rule-of-thumb for the procedure of Henshaw and coworkers (*12*) to estimate total pregnancies would be to multiply births by 1.278 rather than 1.20, and induced abortions by 1.116 rather than 1.10. This estimate is adequate in countries and years that are fairly close to the 1980 United States gestational age distribution of induced abortions. If the gestational age distributions are available, k_a and k_b may be readily calculated.

Table 2 shows total estimated pregnancies begun in 1980. The estimate of 6.37 million pregnancies is higher than the Henshaw and coworkers (*12*) estimate of 6.05 million, due to the previously noted differences in adjusting for spontaneous fetal loss. It is also higher than the 5.91 million reported by Ventura and coworkers (*13*). They simply extrapolate from self-reports of spontaneous abortion for the 1982 National Survey of Family Growth, which leads to an underestimate of fetal loss.

Table 3. Estimated pregnancy rates, pregnancy outcome probabilities, and birth and abortion intentionality, United States, 1980

Pregnancy rate[1]		*Pregnancy outcome probabilities*			*Intentionality*[2]	
Estimate	*Henshaw*[3]	*Live birth*	*Induced abortion*	*Spontaneous abortion*	*Birth* (I_b)	*Abortion* (I_a)
120.6	114.0	.569	.244	.187	.727	.273

[1] Per 1,000 women, ages 15–44. [2] See glossary and text for definitions. [3] Reference *12*.

Measures of pregnancy outcomes. Table 3 shows the implications of the new procedure for estimates of the United States pregnancy rate. Under their simple rule of thumb, Henshaw and coworkers (*12*) estimated a pregnancy rate in 1980 of 114 per 1,000 women of reproductive age. The new estimate is about 6 percent higher, or 120.6 per 1,000.

The new technique also makes possible a more refined measure of the extent to which American women resort to induced abortion. The usual measure is the abortion ratio, or abortions to "known" pregnancies, where "known" pregnancies are the sum of recorded induced abortions and live births. For 1980, the ratio was .300. A more refined measure is the probability of induced abortion as a pregnancy outcome, which is .244. Thus, we conclude that American women chose in 1980 to abort closer to one-quarter than one-third of their pregnancies. This conclusion results from correcting for the almost one-fifth of pregnancies that ended as spontaneous abortions.

Yet another measure of the extent to which American women choose abortion is their theoretical intentions in the absence of spontaneous abortion. In a statistical sense, United States women "intended" that 73 percent of their pregnancies proceed to live births in 1980 and 27 percent be aborted. "Intentionality" attempts to measure the propensity of women to seek a particular pregnancy outcome, including women who have a spontaneous abortion that preempts their original intention. In actuality, of course, intentions may not be clearly formed.

Discussion

What does this analysis say about the effects of likely future changes in abortion and pregnancy? Tietze documents the almost universal shift to earlier gestational ages at termination in the years following a country's legalization of induced abortion (*28*). Improved access to abortion services could lower the mean gestational age at abortion in the United States. An earlier induced abortion distribution censors more pregnancies that otherwise would have ended spontaneously; the effects of earlier terminations would be a greater probability of induced abortion as an outcome, lower probability of a spontaneous abortion, and the same probability of live birth.

Consider a country in which abortion takes place at high gestational durations, due to its legal status or for other reasons. Many women who would "intend" to have an induced abortion first have spontaneous abortions. Therefore, as abortion availability grows, and the average gestational duration at induced abortion declines, the number of abortions performed will increase, even if women's intentions stay fixed. Thus, some of the apparent growth in demand for abortions following legalization may be artifactual: medical intervention increasingly preempts spontaneous abortions.

The method relies heavily on the HIP detailed week-to-week fetal life table that is dated and applies only to New York City. Although some might judge this life table as adequate for the United States, it has less relevance for less-developed countries. More prospective studies of spontaneous abortion are needed in these areas. Until more studies are available, the method described in this paper is useful only for rough estimation of the number of spontaneous abortions in a population or perhaps to set a lower bound. In addition, age- and race-specific fetal life tables would allow the estimation of age- and race-specific numbers of pregnancies and probabilities of spontaneous abortion.

In the absence of induced abortion, physiological factors are the sole determinants of whether a conception actually results in a live birth. Given the option of ending pregnancies voluntarily, American women also avoid a portion of spontaneous abortions formerly suffered. The miscarriages and stillbirths thus averted are of relatively longer gestational durations and more life-threatening, providing a little-documented health benefit for populations practicing abortion. All else being equal, the mean gestational duration of spontaneous abortion will be lower in populations practicing induced abortion. Even considering the high level of voluntary termination (24 percent of conceptions are intentionally aborted), the indirect estimates show that nearly the same proportion of conceptions, 19 percent, end spontaneously.

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