The Impact of Legal Abortion: Redefining the Maternal Mortality Rate

LEWIS H. ROHT, MD, ROGER SHERWIN, MD, and MAUREEN M. HENDERSON, MD

INDUCED ABORTION is associated with several clinical and demographic measures. Recent reports have demonstrated the relative safety of early surgical termination of pregnancy (*1–3*) as well as the relationship between legal abortion and a decline in birth rates and fertility indices (*4,5*). New York City data suggest that out-of-wedlock births may also be decreased, and Evrard (*6*) has further suggested that widespread use of abortion may affect the maternal and perinatal mortality rates.

In this paper we will examine the effect of varying utilization of induced abortion on the maternal mortality rate and the relationship between nonviable conceptions and the measurement of maternal risk. We will attempt to show the limitations of the traditional maternal mortality rate as a measure for describing or comparing maternal risks for different cohorts. Alternative methods of measurement will be discussed.

The traditional maternal mortality rate is expressed as the ratio of the number of maternal deaths (numerator) to the live births (denominator) in a defined population per unit of time. It seems likely that the rationale for the traditional measure stems from the fact that live births were the most readily obtainable quantity useful for measuring maternal risk. In addition, we might speculate that it is derived from a notion of a cost to benefit ratio—the cost in maternal deaths for the benefit of a given number of live births, that is, the cost of successful reproduction.

When the large majority of known pregnancies ended in live births, the traditional maternal mortality rate (TMMR) represented an adequate measure of pregnancy risk which was useful for both descriptive and comparative purposes. Because conceptions ending in spontaneous or induced abortion were difficult to ascertain, their relationship to the maternal mortality rate could not be fully appreciated. The legalization of induced abortion has resulted in a substantial increase in knowledge concerning the incidence of

Dr. Roht is an assistant professor in the department of epidemiology and population studies, University of Texas at Houston, School of Public Health. Dr. Sherwin is an associate professor and Dr. Henderson is professor and chairperson in the department of social and preventive medicine, University of Maryland, Baltimore. Tearsheet requests to Lewis H. Roht, MD, University of Texas at Houston, School of Public Health, P.O. Box 20186, Astrodome Station, Houston, Tex. 77025.

nonviable conceptions. Because it is currently possible to identify many of these heretofore unknown pregnancies, it is important to determine the ways in which they might affect the maternal mortality rate. Understanding of the way in which this rate is affected would permit one to consider how the measurement of maternal risk might be redefined in order to reflect current knowledge.

As defined, the traditional maternal mortality rate is not a true proportional rate of the type $a \div (a+b)$ but, in fact, is a ratio, $a \div b$. It is important to note this distinction because deaths attributed to complications of induced or spontaneous abortions, ectopic pregnancies, or stillbirths enter the numerator, although the conceptions from which these deaths occur are excluded from the denominator. It is apparent, therefore, that the risk associated with conception and all of its possible terminations is not actually being measured by the TMMR because the denominator does not fully represent those at risk of death from all conceptions. Risk measured against a denominator of live births (the TMMR) is misleading because a substantial proportion of maternal mortality results from stillbirths and abortions as well as live deliveries. The contribution of induced abortions alone was estimated to account for 38 percent of maternal deaths in New York City between 1960–71 (*2*). Since live births represent only a portion of the total conceptions, the traditional maternal mortality rate inevitably overestimates the risk attributable to conception, which is referred to in the subsequent discussion as the actual maternal mortality rate (AMMR). It will be shown that the extent of this overestimate, that is, the difference between the TMMR and AMMR, depends upon the proportion of nonviable conceptions.

Comparison of TMMR and AMMR

The effect of excluding nonviable conceptions from the denominator of the traditional maternal mortality rate results in an overestimate, indicated as the "percent overestimate" of the actual maternal risk as shown in tables 1 and 2. New York City (*2,7*) and Japan (*8*), where large numbers of abortions and good statistical reporting systems exist, reveal differences between the actual and the traditional rates ranging from 12 to 78 percent. Since considerable underreporting of nonviable conceptions is likely, the percent overestimate should be interpreted as representing the minimum estimate of difference between the TMMR and AMMR.

The data in tables 1 and 2 show that induced abortion, because of its frequency, makes a larger contribution to the difference between the actual and traditional rates than do other types of known fetal loss. The ratio of stillbirths to live births has remained fairly constant over time and can be ignored as a major explanation of variations in the difference. These findings are particularly well

Table 1. Maternal mortality estimates, New York City residents, 1968–71

Item	1968	1969	1970	1971
	Number			
Maternal deaths	66	77	68	37
Total known conceptions	159,981	164,231	192,355	216,011
Live births	141,920	146,221	149,192	131,970
Stillbirths	17,394	17,112	[1] 23,711	[2] 17,000
Induced abortions:				
Legal	608	850	19,349	67,032
Illegal [3]	59	48	103	9
	Rate per 10,000			
TMMR (maternal deaths ÷ live births)	4.7	5.3	4.6	2.8
Maternal deaths ÷ live and stillbirths	4.1	4.7	3.9	2.5
AMMR (maternal deaths ÷ total known conceptions)	4.1	4.7	3.5	1.7
Percent overestimate (TMMR − AMMR ÷ AMMR)	12.8	12.3	28.9	63.7

[1] Increase may be due to inclusion of some induced abortions.

[2] Authors' estimate of stillbirths. Accurate data not available because of overlap in reporting stillbirths and induced abortions since July 1970.

[3] Most illegal abortions are unreported. Tietze (*9*) has estimated the incidence to be at least 50,000 per year before July 1970.

SOURCE: of data in table, references 2, 7.

NOTE: TMMR = traditional maternal mortality rate, AMMR = actual maternal mortality rate.

Table 2. Maternal mortality estimates, Japan, 1950–67

Item	1950	1955	1960	1965	1966	1967
	Number					
Maternal deaths	4,117	3,095	2,097	1,597	1,266	1,351
Total known conceptions	3,043,592	3,084,100	2,848,578	2,828,562	2,317,600	2,831,752
Live births	2,337,507	1,730,692	1,606,041	1,823,697	1,360,974	1,934,958
Stillbirths	216,974	183,265	179,281	161,617	148,248	149,304
Induced abortions: legal	489,111	1,170,143	1,063,256	843,248	808,378	747,490
	Rate per 10,000					
TMMR (maternal deaths ÷ live births)	17.6	17.9	13.1	8.8	9.3	7.0
Maternal deaths ÷ live and stillbirths	16.1	16.2	11.7	8.0	8.4	6.5
AMMR (maternal deaths ÷ total known conceptions)	13.5	10.0	7.4	5.6	5.5	4.8
Percent overestimate (TMMR — AMMR ÷ AMMR)	30.2	78.1	77.4	55.3	70.3	45.8

SOURCE: of data in table, reference 8.

NOTE: TMMR = traditional maternal mortality rate, AMMR = actual maternal morality rate.

illustrated by the New York City data (table 1), which show a marked increase in differences between the actual and traditional maternal mortality rates before and after the introduction of the liberal abortion law in July 1970. The apparent increase in fertility in 1970 and 1971 may be attributed to two factors, decrease in illegal abortions and the availability of legal abortions. Registration of legal abortions has shed light on the current patterns of abortion utilization and has enabled Tietze (*9*), on the basis of current age-specific fertility rates, to conclude that at least 50,000 illegal abortions may have occurred annually in New York City before the introduction of the liberal abortion law. Most of these would be replaced by legal abortions, which are now being reported. It is also probable that the widespread utilization of legal abortions may result in their acceptance by women who might not have sought illegal abortions before July 1970.

Table 2 describes fertility in Japan between 1950 and 1967. Since 1955 the number of reported abortions has declined, which is reflected in the decreasing percent difference between the TMMR and AMMR. The low number of Japanese births in 1966 is presumably due to the traditional belief that girls born in the "Year of the Fiery Horse" do not make good wives. Many families apparently avoided childbirth to preclude the expected difficulty of marrying off daughters born in that year. The fact that induced abortions did not increase appreciably in 1966 may indicate the extent to which induced abortions are not reported in Japan.

The relationship between the TMMR and AMMR may be derived as follows:

$$TMMR = d \div y$$
$$AMMR = d \div (y + z)$$

where

$TMMR$ = maternal deaths ÷ live births per year
$AMMR$ = maternal deaths ÷ total conceptions per year
z = number of nonviable conceptions per year
y = number of live births per year
d = number of maternal deaths per year

then

$$TMMR \div AMMR = (d \div y) \div [d \div (y + z)]$$
$$TMMR \div AMMR = (y + z) \div y$$
$$TMMR \div AMMR = 1 + (z \div y)$$

The effect of exclusion of nonviable pregnancies on estimates of maternal mortality is evident from the last equation, since it is clear that the difference between the TMMR and AMMR depends only on the ratio of nonviable pregnancies to the total live births ($z \div y$). The larger the term ($z \div y$), the greater the difference between the traditional measure and the actual rate observed when conceptions are used to define those at maternal risk. The exclusion of 10 percent of the nonviable pregnancies from the traditional measure, therefore, will result in an overestimation of 10 percent; exclusion of 20 percent, an overestimation of 20 percent, and so forth, relative to the actual rate. We have shown the theoretical limitations of the TMMR, and in the following discus-

sion we will show that legal abortion may cause the TMMR to react in unpredictable ways, thereby addressing the question of whether or not the TMMR may be readily interpreted and should be retained as a useful comparative measure.

Legal Abortion and the TMMR

Interpretation of the measurement of maternal risk is made difficult because an increase in early surgical abortions can affect the numbers of maternal deaths and live births in several ways.

1. For a given conception cohort, each abortion reduces the denominator of the TMMR because of the mutually exclusive nature of abortion and live birth. When large numbers of legal abortions occur, fewer women are exposed to the risks of death from delivery and the puerperium, but more are subject to the risk of the abortion procedure. The relationship is not, however, a simple 1:1 exchange (that is, one abortion averts one live birth) since a woman who aborts a pregnancy is quickly at risk of again becoming pregnant. For demographic purposes, more than one abortion is needed to avert one birth (*10*).

2. In actual practice there is replacement of most (but not all) illegal terminations by legal abortions (*5,9,11*), and in some circumstances a demand for additional abortions may occur owing to the facility with which legal abortions can be obtained (*9*).

As a result of this fluid situation, the TMMR could show a decrease, an increase, or be unchanged, depending upon the numbers and associated "case-fatality" of legal compared with illegal abortions and of deliveries occurring under different hypothetical circumstances. These possibilities may be illustrated by assuming that population size, conception rate, and the risk of delivery remain constant and that all maternal deaths result from legal or illegal abortion (early pregnancy deaths) or delivery (late pregnancy deaths). Spontaneous abortion and stillbirth rates are also assumed constant, but for ease of presentation they are excluded from consideration since they account for a relatively small and constant proportion of maternal deaths over time. The relationship between the TMMR, abortion, and delivery can be represented mathematically.

$$TMMR = (dd + dla + dia) \div n$$

where

dd = deaths from live deliveries
dla = deaths from legal abortions
dia = deaths from illegal abortions
n = number of live deliveries

The deaths from legal and illegal abortions may be combined into a single term (da), representing deaths from all abortions, and the above expression rewritten as

$$TMMR = (dd + da) \div n$$
$$TMMR = (dd \div n) + (da \div n)$$

which is the risk of delivery ($dd \div n$) plus the ratio of abortion deaths to deliveries ($da \div n$).

The relationship between the TMMR and legal abortion can now be seen more clearly. If we assume that risk of delivery ($dd \div n$) remains constant, variation in the TMMR results from change in the ratio ($da \div n$). If legal abortions merely replace previously illegal abortions and if the risk of legal abortion is less than that of illegal abortion, the number of abortion deaths (the numerator) will decrease. Since the number of deliveries is unchanged, the TMMR will fall.

Consider, however, the hypothetical situation in which legal abortion becomes available in the absence of preexisting illegal abortion. Even if the mortality from legal abortion is low, the deaths attributable to it will increase from zero and the number of live births will fall, resulting in an increase of the TMMR despite the generally accepted safety of early abortion (provided that those women undergoing abortion represent a random sample of the pregnant women and not a selected group carrying a higher than average risk at the time of delivery). By increasing the propor-

Table 3. Comparison of traditional and actual maternal mortality under hypothetical conditions before and after legalization of abortion

Item	Before	After
Maternal death rate per 10,000 live births	5	5
Abortion death rate per 10,000 abortions	10	1
Number of live births	100,000	50,000
Number of delivery deaths	50	25
Number of abortions	10,000	60,000
Number of abortion deaths	10	6

NOTE: Following are rates per 100,000 for the traditional maternal mortality rate (TMMR) and the actual maternal mortality rate (AMMR).

Rates per 100,000 before legalization:

$TMMR = 50 + 10 \div 100{,}000 = 60$
$AMMR = 50 + 10 \div 100{,}000 + 10{,}000 = 55$

Rates per 100,000 after legalization:

$TMMR = 25 + 6 \div 50{,}000 = 62$
$AMMR = 25 + 6 \div 50{,}000 + 60{,}000 = 28$

Table 4. Maternal deaths by cause, New York City residents, 1966–71

Cause of maternal death	1966	1967	1968	1969	1970[1]	1971
Abortion	31	20	21	24	22	9
Ectopic pregnancy	2	7	8	5	11	4
Delivery, puerperal, toxemia, other	47	49	37	48	35	24
Total	80	76	66	77	68	37

[1] Legal abortion from July 1, 1970. SOURCE: reference 7.

Table 5. Legal abortions to women ages 10-49 by color, New York City residents, 1970–72

Age group (years)	Female population, 1970		Legal abortions, 1970–72		Ratio per 1,000 resident women	
	White	Nonwhite	White	Nonwhite	White	Nonwhite
10–14	211,777	96,014	186	696	0.9	7.2
15–19	219,834	84,755	7,850	10,894	35.7	128.5
20–34	668,452	251,114	36,484	45,586	54.6	181.5
35–49	553,928	189,584	5,526	5,834	10.0	30.8
Not stated	.....	.....	661	992	...	....
Total	1,653,991	621,467	50,707	64,002	30.7	103.0

SOURCE: reference 7.

tion of pregnancies terminating in abortion, the ratio $(da \div n)$ of the TMMR can increase to a theoretical maximum approaching infinity as the number of live births approaches zero in a given period of time. A high TMMR could occur despite a low case fatality ratio for legal abortions.

Now consider the case where a small number of illegal abortions carrying a high mortality are replaced by a large number of legal abortions with a relatively low mortality. Hypothetical yet plausible values for variables affecting the TMMR again result in an increase in the TMMR, even when the overall number of maternal deaths is falling (table 3).

Finally, if consideration is given to situations in which fertility is not held constant, one alternative result is that the ready availability of abortion may cause a decrease in either overall utilization or the effective utilization of contraceptive methods, resulting in the abortion of many pregnancies without altering the number of deliveries. Here also, one might see an increase in the TMMR, since abortion deaths would increase relative to the unchanged number of deliveries. Space limitations preclude a complete discussion of additional situations which could be proposed to show the limitations of the TMMR.

Through the mechanisms just discussed, large numbers of legal abortions could alter the traditional maternal mortality rate even if no changes occurred in such important variables as the quality of prenatal care or medical treatment at delivery. The further possibility that the TMMR has the potential to change unpredictably indicates that it is of limited usefulness as an index of risk. Although a decline in the TMMR has usually followed the legalization of induced abortion, it should not be expected that a decrease will occur invariably. Public health workers who must interpret the TMMR cannot be certain what risks they are measuring, since the ratio or mixture of abortions and live births will be determined by differences in local reproductive practices.

The amount and direction of expected change in the TMMR is also likely to be influenced by selective factors in abortion utilization. Following the legalization of abortion in 1970, New York City experienced a rapid fall in births and maternal deaths (tables 1 and 4). The TMMR fell to a record low level (table 1) partly because of the fall in abortion deaths (table 4). The differences in abortion utilization by white and nonwhite women (table 5) suggest that selective factors do play a role in the reduction of the TMMR. Women at high risk of delivery or puerperal complications and those at high risk of complications from illegal abortion may be among those especially likely to seek an abortion.

A second important but unknown factor relates to the demographic effect resulting from women

who obtain abortions outside their home State. These abortions may affect both the maternal deaths and live births in the home State, depending upon the incidence of the practice. The implications for TMMR can only be conjectural at present, since little is known concerning abortions of nonresidents.

Redefining Maternal Risk

The interpretation of the TMMR is dependent upon knowledge of (*a*) the proportion of pregnancies ending in abortion as opposed to delivery and (*b*) the relative mortality associated with those two mutually exclusive pregnancy outcomes. From inspection of the AMMR, it is apparent that its interpretation is similarly dependent upon knowledge of *a* and *b*. Although total conceptions would appear to be the ideal denominator of exposure to risk, this number does not relate specifically to those risks attributable either to abortion or delivery. Nonspecificity is a major liability in view of the complexity of interpreting maternal risk when abortion is legal. Since different cohorts would have variable proportions of abortions and deliveries, the AMMR (like the TMMR) would not be a legitimate tool for making cohort comparisons or statements about the quality of medical care in different places or at different times.

The problem can be resolved if maternal risk is estimated for each of three component periods of pregnancy, as defined by the widely accepted trimester intervals of gestation. Risks for each trimester would be the maternal deaths during the relevant trimester in relation to either of the following two methods:

1. All pregnant women at the start of that trimester; that is, applying the principle of life table analysis, or

2. The terminating events in that trimester; that is, termination mortality rates. Overall terminations would comprise the total of induced and spontaneous abortions, ectopic pregnancies, stillbirths, and deliveries of live infants. A more sensitive and desirable refinement would be the mortality rate for each specific type of pregnancy outcome, analogous to the case-fatality ratio.

Formulas for calculating maternal risk for both methods are given in table 6. Numerators are identical for both, but different denominators are used for the first and second trimester. Rates would coincide in the third trimester because all pregnancies continuing to that period terminate in delivery (some being stillbirths); thus the denominators are identical.

Both the life table and termination mortality rate methods would be advantageous because each would provide numerators and denominators at several stages of pregnancy, thereby allowing more analytic flexibility than either the TMMR or AMMR. Determination of risk, using the proposed methods, requires the registration of all recognized conceptions, a time-consuming and costly procedure. However, the indices thus generated would be more sensitive to real changes in maternal risk and medical care because of the separation of earlier terminations from later deliveries. Registration of all conceptions would also provide relevant data concerning such important causes of fetal loss as spontaneous abortion and ectopic pregnancy, and it would contribute greatly to the understanding of the reproductive process. As new o. increased services for legal abortions become available, registration of these terminations will surely be necessary to monitor the clinical safety and demographic impact of this procedure. Many States have or are currently developing a reporting system for legal abortions.

Table 6. Estimators of maternal risk by trimester of pregnancy—life table method compared with the termination mortality rate

Period	Life table method[1]	Termination mortality rate
1st trimester	Maternal deaths ÷ total known conceptions	Maternal deaths ÷ 1st trimester terminations (includes induced and spontaneous abortions and ectopic pregnancy).
2d trimester	Maternal deaths ÷ total known conceptions — first trimester fetal losses	Maternal deaths ÷ 2d trimester terminations (includes induced and spontaneous abortions and ectopic pregnancy).
3d trimester	Maternal deaths ÷ deliveries (live and stillbirths)	Maternal deaths ÷ deliveries (live and stillbirths).

[1] Life tables usually measure the probability of survival over time with respect to a single cause of nonsurvival. In applying life tables to maternal mortality, there are two causes of nonsurvival, that is, termination of pregnancy because of fetal death due to the abortion, or circumstances leading to maternal death.

Consideration should be given to development of an expanded reporting mechanism designed to include all types of fetal loss, including the month of gestation at which the pregnancy is terminated. Such reporting should be legally mandated to insure compliance.

Both proposed methods have certain limitations. The major difficulties are first, that the ascertainment or quality of reporting of early spontaneous abortions, many of which are unsuspected, may vary in different localities and, second, that denominators consisting of total conceptions or trimester terminations include variable proportions of different pregnancy outcomes for different cohorts. Because rates derived from both methods would be dependent upon the relative and variable proportions of pregnancy events, particularly induced abortion and delivery, comparisons between different cohorts may require the additional procedure of rate adjustment.

The termination mortality rate would provide a somewhat better measurement than the life table method because it relates risk more directly with the duration of pregnancy at termination and is more easily calculated. However, because it does not resolve the problem of the variable proportions of pregnancy events, its usefulness as a comparative measure or as an index of the quality of medical care is somewhat limited.

As the limitations of the TMMR become generally recognized, it is expected that the method of assessment of maternal risk will change. For the present, the most sensitive and useful comparisons should be made by comparing mortality rates from similar pregnancy events, the most important of which are induced abortion and delivery.

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The maternal mortality rate has traditionally been measured by the ratio of deaths from all maternal causes to live births in a defined population per unit of time. Maternal deaths from abortions and stillbirths affect the numerator, but not the denominator, of the rate.

This paper addresses the issue of whether or not the maternal mortality rate as currently defined is an adequate index of risk by examining several aspects of theoretical and practical importance. The complex relationship among legal abortions, illegal abortions, live births, and maternal deaths is discussed, and consideration is given to some hypothetical situations in which the traditional maternal death rate could increase despite declining maternal deaths.

The paper also seeks to stimulate discussion of ways in which the measurement of maternal risk might be improved. It is recommended that all recognized conceptions be made legally reportable, including an estimation of the gestational age at which pregnancy is concluded, and that maternal mortality rates which are event specific and specific by trimester of termination replace the traditional maternal mortality rate for comparisons of different cohorts of pregnant women.