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## Pregnancy-associated mortality after birth, spontaneous abortion, or induced abortion in Finland, 1987-2000

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### KEY WORDS

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**Objective:** To test the hypothesis that pregnant and recently pregnant women enjoy a “healthy pregnant women effect,” we compared the all natural cause mortality rates for women who were pregnant or within 1 year of pregnancy termination with all other women of reproductive age.

**Study design:** This is a population-based, retrospective cohort study from Finland for a 14-year period, 1987 to 2000. Information on all deaths of women aged 15 to 49 years in Finland (n = 15,823) was received from the Cause-of-Death Register and linked to the Medical Birth Register (n = 865,988 live births and stillbirths), the Register on Induced Abortions (n = 156,789 induced abortions), and the Hospital Discharge Register (n = 118,490 spontaneous abortions) to identify pregnancy-associated deaths (n = 419).

**Results:** The age-adjusted mortality rate for women during pregnancy and within 1 year of pregnancy termination was 36.7 deaths per 100,000 pregnancies, which was significantly lower than the mortality rate among nonpregnant women, 57.0 per 100,000 person-years (relative risk [RR] 0.64, 95% CI 0.58-0.71). The mortality was lower after a birth (28.2/100,000) than after a spontaneous (51.9/100,000) or induced abortion (83.1/100,000). We observed a significant increase in the risk of death from cerebrovascular diseases after delivery among women aged 15 to 24 years (RR 4.08, 95% CI 1.58-10.55).

**Conclusion:** Our study supports the healthy pregnant woman effect for all pregnancies, including those not ending in births.

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The number of maternal (obstetric) deaths has decreased below 10 cases per 100,000 live births in most

developed countries.<sup>1</sup> However, the number of all deaths during pregnancy or within the first year after pregnancy termination is considerable higher.<sup>2,3</sup> The Centers of Disease Control and Prevention (CDC) and the American College of Obstetricians and Gynecologists (ACOG) have defined “pregnancy-associated death” as a death of a woman while pregnant or within 1 year of termination

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of pregnancy, irrespective of the cause of death or the site of pregnancy. A pregnancy-related death has been defined as the death of a woman while pregnant or within 1 year of termination of the pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes.<sup>4</sup> From a public health point of view, it is important to focus not only on maternal deaths caused by direct obstetric causes, but also on other pregnancy-associated deaths, which are considerably more common. Methodologically this task is more challenging because of the difficulty in ascertaining all pregnancy-associated deaths.<sup>5</sup>

Several methods have been used to gather information on pregnancy-associated deaths, including the following: inclusion of a check box on death certificates to indicate recent pregnancy; creation of a confidential inquiry system comprised of anonymous case reports on all maternal or pregnancy-associated deaths; reviews of medical examiner records, coroner records, and autopsy reports; reviews of newspaper-published obituaries and death reports; and collection of ad hoc research data, as conducted in the Reproductive Age Mortality Studies (RAMOS).<sup>3</sup> One particularly effective method is the linking of birth and death certificate data.<sup>3,6</sup> The pitfall of this approach, however, is that pregnancies not ending in either a live birth or stillbirth usually are not captured.

Previous studies on maternal deaths after births have shown “the healthy pregnant woman effect,” according to which the risk of a medical-condition-related death within 1 year after a birth is lower than the risk among nonpregnant women in the same age group.<sup>7,8</sup> Women with serious medical conditions may be more likely to have a spontaneous or therapeutic abortion and are also at greater risk of dying. Therefore, all natural cause mortality among women having an abortion may be greater than that of nonpregnant women in the same age group, but this has not been examined with empiric data.

The aim of this study was to link information on all deaths among women of reproductive age (from 15 to 49 years) in Finland to population-based register data on reproductive events to obtain a reliable estimate of pregnancy-associated mortality. We then compared this age-adjusted mortality rate during pregnancy and the year after pregnancy with the mortality rate among nonpregnant women in an effort to investigate the risk of death by its cause. Deaths from external causes (unintentional accidental and intentional injuries) were excluded from this study.

## Material and methods

All deaths among women of reproductive age, from 15 to 49 years old ( $n = 15,823$ ), during 1987 to 2000 were

identified from the Finnish Cause-of-Death Register. The register contains data from the death certificates written either by the physician who took care of the patient or who performed the autopsy. The register is believed to include comprehensive information on all deaths of Finnish citizens and permanent residents who died in Finland. At least basic information on deaths of Finnish citizens that occurred abroad is collected, but there is no information on deaths of visitors to Finland and other nonpermanent residents.

The information on deaths was linked to the following three registers maintained by the National Research and Development Centre for Welfare and Health (STAKES).

1. Medical Birth Register (MBR) collects information on all live births and stillbirths with a gestational age of at least 22 weeks or with a birth weight of at least 500 g. The MBR is collected from all delivery hospitals and, in the case of home births, by the assisting health care personnel, and sent to STAKES. Fewer than 1% of all deliveries are missing from the MBR, but information on those deliveries is obtained from the Central Population Register and the Cause-of-Death Register. The majority of register content corresponds well or satisfactorily with the hospital record data.<sup>9</sup>
2. Register on Induced Abortions collects data on all induced abortions performed in Finland. According to the national legislation, a permit is needed for terminating a pregnancy, and notification that a termination has been performed must be sent to STAKES within 1 month of the procedure. More than 99% of induced abortions listed in hospital records were reported to the register, and there was a good agreement between the register data and the hospital record for most variables in 1993.<sup>10</sup>
3. Hospital Discharge Register (HDR) collects information on all inpatient episodes in health care facilities and is the major source of information on pregnancies ending in spontaneous abortion and ectopic pregnancies. The pregnancies were identified using information on patients' main or secondary diagnosis in International Classification of Diseases (ICD) codes (ICD 9: 630-676 in 1987-1995 and ICD 10: O00-99 in 1996-2000). In late 1980s, in total 95% of hospitalizations were registered, and 97% of main diagnoses concerning pregnancy, birth, and puerperium were correctly reported at the three-digit ICD code level, when register information and hospital records were compared.<sup>11</sup> A death that occurred during pregnancy or after a spontaneous abortion or an ectopic pregnancy is included in the register only if the woman was hospitalized. Approximately 75% of spontaneous abortions and ectopic pregnancies are treated in hospitals.<sup>12</sup>

**Table I** All deaths and pregnancy-associated mortality by age groups, Finland, 1987-2000

	Age group (y)							Total
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	
All deaths	669	847	990	1489	2447	3870	5511	15,823
Pregnancy associated	33	73	95	90	84	32	12	419
Per 100 deaths	5.0	8.5	9.8	6.0	3.5	0.8	0.2	2.6
Per 100,000 pregnancies	57.0	35.2	25.6	29.1	56.3	74.2	308.2	36.7

Different registers were combined by using women's unique personal identification numbers as keys. The Ethical Committee at STAKES approved the study protocol. Separate permits to use administrative register data were received from STAKES, Statistics Finland, and the Data Protection Authority.

During the study period the data sources included information on 865,988 live births or stillbirths (later: births), 156,789 induced abortions, and 118,490 spontaneous abortions or ectopic pregnancies. In total, 419 deaths were identified in which the woman was pregnant or had been pregnant within 1 year before her death.

The underlying cause of death for natural causes (due to a disease or a medical condition involving ICD 9/ICD 10 codes 001-799/A01-R99) was categorized into the following subgroups: deaths from diseases of the circulatory system (390-459/I00-I99), deaths from malignant neoplasms (140-239/C00-D48), and other natural deaths (001-799/A01-R99 excluding diseases of the circulatory system and malignant neoplasms).

Mortality from melanoma (172/C43), breast cancer (174/C50), cancer of the female genital tract (179-184/C51-C58), cancer of the central nervous system (191-192/C70-C72), ischemic and cardiovascular diseases (410-429/I20-I52), and cerebrovascular diseases (430-438/I60-I69) were analyzed separately because previous literature suggests them to be pregnancy related.

All natural deaths were also classified as direct pregnancy-related deaths (deaths caused by a disease or its management unique to the pregnancy), indirect pregnancy-related deaths (a previously existing disease or disease that developed during pregnancy and was aggravated by the pregnancy), or not-pregnancy-related deaths (deaths not related to pregnancy or its management), also referred as coincidental or fortuitous deaths.<sup>13,14</sup> This classification was based on the review of death certificates, which included all causes of death and a narrative story on the events that led up to the death, including information on deceased's previous medical condition and comorbidity.

Pregnancy-associated mortality was calculated per 100,000 pregnancies. Separate calculations were made for deaths occurring after births (including deaths during pregnancy and deaths after a live or stillbirth), after spontaneous abortions (including also ectopic pregnancies), and after induced abortions. These mortality rates

were then compared with the mortality rate per 100,000 person-years among the nonpregnant population. The mortality rates and risk ratios were age adjusted by using age distribution for all pregnant women.

Differences between groups were tested with use of the  $\chi^2$  test, the *t* test, the test for relative proportions, and the Fisher exact test. Standardized mortality ratios or risk ratios with 95% CI were calculated by dividing the mortality rate among women who were or had been pregnant within the preceding year by the mortality rate among women who had not been pregnant within the preceding year.

## Results

We found 419 pregnancy-associated deaths equaling 2.6% of all deaths among women of reproductive age (Table I). The proportion of all deaths that were pregnancy-associated was the highest for women ages 25 to 29 years (9.8%) and the lowest among women aged 40 to 49 years (less than 1%). The pregnancy-associated mortality rate was at its lowest for women aged 25 to 29 years but increased for both women aged 20 years or younger and women aged 35 to 49 years.

The total pregnancy-associated mortality rate was 36.7 per 100,000 pregnancies, which was significantly lower than the mortality among nonpregnant women, 93.5 per 100,000 person-years (relative risk [RR] 0.39, 0.36-0.43) (Table II). The adjustment for age decreased the differences in mortality between pregnant and nonpregnant women (RR 0.64, 0.58-0.71). After age adjustment, mortality after a birth remained significantly lower than among nonpregnant women. No statistically significant difference was observed for spontaneous abortions, but the mortality rate after an induced abortion remained higher than that among nonpregnant women (RR 1.45, 1.22-1.73).

The age-adjusted pregnancy-associated mortality rate from natural causes was lower than the mortality rate among nonpregnant women for all pregnancies ( $P < .001$ ), as well as after a birth ( $P < .001$ ), after a spontaneous abortion ( $P = .003$ ), and after an induced abortion ( $P = .047$ ) (Table III). The majority of pregnancy-associated deaths from natural causes were not pregnancy related.

**Table II** Mortality per 100,000 population and risk ratio by the type of pregnancy compared with mortality among nonpregnant women, Finland, 1987-2000

	Pregnancy-associated mortality			Total	Mortality among nonpregnant women
	Pregnancy or birth	Spontaneous abortion or ectopic pregnancy	Induced abortion		
Deaths	224	66	129	419	15,404
Per 100,000 population					
Crude rate	25.9	55.7	82.3	36.7	93.5
Age-adjusted rate*	28.2	51.9	83.1	36.7	57.0
Risk ratios					
Crude 95% CI	0.28 (0.24-0.32)	0.59 (0.47-0.76)	0.88 (0.74-1.04)	0.39 (0.36-0.43)	1.00
Age-adjusted* 95% CI	0.49 (0.43-0.56)	0.91 (0.71-1.17)	1.45 (1.22-1.73)	0.64 (0.58-0.71)	1.00

\* By the age distribution of all pregnant women.

**Table III** Pregnancy-associated mortality, maternal deaths, and mortality among nonpregnant women\*

	Pregnancy-associated mortality			Total	Mortality among nonpregnant women, age-adjusted (crude)
	Pregnancy or birth	Spontaneous abortion or ectopic pregnancy	Induced abortion		
No.	224	66	129	419	15,404
All causes	25.9 <sup>†</sup>	55.7	82.3 <sup>†</sup>	36.7 <sup>†</sup>	57.0 (93.5)
Natural causes	16.3 <sup>†</sup>	21.1 <sup>‡</sup>	22.3 <sup>‡</sup>	17.6 <sup>†</sup>	32.0 (62.9)
Direct pregnancy related	3.9	3.4	1.3	3.5	NA
Indirect pregnancy related	0.3	0.4	0.6	0.4	NA
Not pregnancy related	12.0	17.3	20.4	13.7	NA
Violent causes	9.6 <sup>†</sup>	34.6 <sup>‡</sup>	60.0 <sup>†</sup>	19.1 <sup>†</sup>	24.2 (29.9)

Test of relative proportions compared to the age-adjusted mortality among nonpregnant women. NA, not applicable.

\* Mortality rates calculated per 100,000 pregnancies or person-years.

<sup>†</sup>  $P < .001$ ,

<sup>‡</sup>  $P = .05$ .

The age-adjusted cancer mortality varied between 5.5 and 6.4 per 100,000 pregnancies by the type of pregnancy, which is less than one half the mortality rate among nonpregnant women (Table IV). The pregnancy-associated mortality for breast cancer (RR 0.25, 0.13-0.49) was lower than the corresponding rates among nonpregnant women. Neither did we observe an increased mortality risk for cancers of the female genital tract (RR 0.52, 0.26-1.05), for cancer of the central nervous system (RR 0.53, 0.28-1.00), or for melanoma (RR 1.15, 0.46-2.86).

The age-adjusted pregnancy-associated mortality from diseases of circulatory system varied between 3.6 and 7.4 per 100,000 pregnancies, whereas the mortality rate among nonpregnant women was within the same range (6.1 per 100,000). Among women aged 15 to 24 years, the pregnancy-associated mortality rate from diseases of circulatory system was double that of nonpregnant women (RR 2.02, 1.08-3.89), primarily because of the increased mortality from cerebrovascular diseases after giving birth (RR 4.08, 1.58-10.55). The majority

of these deaths were from intracerebral hemorrhages. The mortality from diseases of the circulatory system among recently pregnant women was 30% lower among women aged 25 to 34 years ( $P = .096$ ), and 69% lower among women aged 35 to 49 years ( $P < .001$ ) than among nonpregnant women. The differences for other causes of death were statistically insignificant.

## Comment

In previous studies, the effect of pregnancy on mortality has been estimated by comparing the life expectancy and mortality rates among married and single women.<sup>15-18</sup> The usefulness of this approach, however, has decreased because of the increase in common-law marriages and childbearing outside of marriage. For example, the percentage of children born to unmarried women ranges between 33% and 40% in Finland, France, the United Kingdom, and the United States and between 45% and 64% in the Scandinavian countries.<sup>19,20</sup>

**Table IV** Pregnancy-associated mortality and mortality among nonpregnant women for cancers, diseases of the natural causes by age group and type of pregnancy, Finland, 1987-2000\*

	Mortality rate per 100,000 pregnancies				Nonpregnant women	Mortality risk ratio
	Pregnancy or birth	Spontaneous abortion or ectopic pregnancy	Induced abortion	Total		
Cancers	39	8	10	57	5004	
Age-adjusted	5.5 <sup>†</sup>	6.1 <sup>‡</sup>	6.4 <sup>‡</sup>	5.2 <sup>†</sup>	13.0	0.40 (0.31-0.52)
15-24 y	2.8	—NS	1.5	2.3	3.9	0.54 (0.24-1.22)
25-34 y	3.2 <sup>†</sup>	4.6	5.2	3.5 <sup>†</sup>	9.6	0.32 (0.21-0.48)
35-49 y	12.3 <sup>†</sup>	20.3 <sup>§</sup>	18.9 <sup>§</sup>	14.0 <sup>†</sup>	53.9	0.27 (0.19-0.39)
Diseases of the circulatory system	33	6	10	49	2124	
Age-adjusted	3.9 <sup>‡</sup>	3.6	7.4	4.3 <sup>‡</sup>	6.1	0.72 (0.54-0.96)
15-24 y	4.0	4.9	4.4	4.1 <sup>‡</sup>	1.9	2.02 (1.08-3.89)
25-34 y	3.3 <sup>‡</sup>	1.5 <sup>†</sup>	8.7 <sup>‡</sup>	3.5	4.4	0.69 (0.45-1.05)
35-49 y	6.1 <sup>†</sup>	11.6 <sup>†</sup>	6.3 <sup>†</sup>	7.1 <sup>†</sup>	22.8	0.31 (0.18-0.52)
All natural causes	141	25	35	201	10,323	
Age-adjusted	17.9 <sup>†</sup>	16.6 <sup>§</sup>	22.9 <sup>‡</sup>	17.6 <sup>†</sup>	32.0	0.55 (0.48-0.64)
15-24 y	15.2	14.6	13.3	14.7	13.1	1.05 (0.76-1.46)
25-34 y	12.0 <sup>†</sup>	9.3 <sup>§</sup>	22.6	12.6 <sup>†</sup>	24.4	0.45 (0.36-0.56)
35-49 y	36.2 <sup>†</sup>	46.6 <sup>†</sup>	40.9 <sup>†</sup>	38.7 <sup>†</sup>	105.3	0.36 (0.29-0.45)

\* Age-adjustment performed by using the age distribution of all pregnant women during the whole study period.

<sup>†</sup>  $P < .001$ .

<sup>‡</sup>  $P = .05$ .

<sup>§</sup>  $P = .01$ .

Our population-based data taken from several administrative registers were unique. It included all deaths occurring within 1 year after a birth or an induced abortion and the majority of deaths after a spontaneous abortion. Because the information was collected independently, there were no recall or reporting bias. In addition, the coverage and the data quality of these registers have been shown to be high,<sup>9-11</sup> which further strengthens the credibility of our findings.

Although our data are reliable, the number of pregnancy-associated deaths after a spontaneous abortion or an ectopic pregnancy as well as during pregnancy may be underestimated. Women who were not hospitalized and whose pregnancy was not mentioned on the death certificates were not identified with our method. Deaths that occurred during early pregnancy or after an early spontaneous abortion were probably missed more often than deaths that occurred later in pregnancy. Because gestational age is not recorded in the HDR and is seldom mentioned on death certificates, we were unable to compare the distribution of gestational age among pregnancy-associated deaths and among all pregnant women. We considered this as the only source of selection bias in our study.

Previous studies have shown that parturients are healthy and that their mortality rate is lower than expected on the basis of the general age-specific mortality rate.<sup>7-8</sup> Fox et al<sup>21</sup> pointed out that a woman's health

status influenced her characteristics and the observed mortality model reflects the net effect of the selection process. Vallin and Nizard<sup>22</sup> have presented another explanation for the healthy parturient effect. Healthy women have a better chance of giving birth referred to as the selection effect and, thereafter, have a lower risk of death because their behavior is generally self-conservative for the babies and themselves, known as the protection effect. Our data showed that the healthy parturient effect is true for pregnant women in general.

Women who underwent an induced abortion had a pregnancy-associated mortality rate from natural causes that was one third higher than that of women who had given birth. These deaths included both terminations in early pregnancy (indicating most often an unwanted pregnancy) and in late pregnancy (included practically all cases for medical reasons). After excluding all terminations for medical reasons, the pregnancy-associated mortality rate from all natural causes declined from 22.3 to 15.9 per 100,000 induced abortions, a rate lower than the mortality rate after a birth. The same finding was true for cancer mortality (decline from 6.5 to 2.7 per 100,000 induced abortions) and deaths from diseases of the circulatory system (decline from 7.4 to 5.7 per 100,000 induced abortions). This calculation, however, does not take account the fact that some early terminations for other reasons, may be performed because of women's preexisting medical

reason(s). Their number and effect on our analysis remained unknown.

Mortality from diseases of the circulatory system was lower among recently pregnant women than among women who had not been pregnant 1 year before their death. Recently delivered women younger than 25 years, however, had a 4-fold risk of death from cerebrovascular diseases, the majority of which were intracerebral hemorrhages. The mortality rate did not differ by the type of pregnancy, a finding that suggests that the hematologic effects of pregnancy increase the risk for cerebrovascular deaths among some women. These women smoked more often than did other women, but our data did not include information on other risk factors, such as overweight and obesity or the use of oral contraceptives or other medication. Although it may prove difficult to target any health promotion directly at this group, because the number of such deaths is low (2 per 100,000 pregnancies), these cases and their background factors should be investigated in more detail.

Deaths from natural causes can be prevented by improving care and surveillance during pregnancy, during childbirth, and afterward pregnancy, because as much as 30% to 40% of all pregnancy-related deaths and 40% to 60% of obstetric deaths have been considered preventable.<sup>23-25</sup> Because the majority of pregnancy-associated deaths were not related to pregnancy, it is important to focus also on other than obstetric deaths. We did not include injury deaths in this study, but neither should their prevention be neglected, because their proportion of all deaths among women in reproductive age is considerable.

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