The European Journal of Public Health Advance Access published September 5, 2012
European Journal of Public Health, 1–6
© The Author 2012. Published by Oxford University Press on behalf of the European Public Health Association. All rights reserved.
doi:10.1093/eurpub/cks107

Reproductive history patterns and long-term mortality rates: a Danish, population-based record linkage study

Priscilla K. Coleman[1], David C. Reardon[2], Byron C. Calhoun[3]

1 Human Development and Family Studies, Bowling Green State University, Bowling Green, OH, USA
2 Director of the Elliot Institute, Springfield, IL, USA
3 Department of Obstetrics and Gynecology, West Virginia University, Charleston, WV, USA

Correspondence: Pricilla K. Coleman, 16D FCS Building, Bowling Green State University, Bowling Green, OH 43403, USA, Tel: +419 372 6492, Fax: 419 372 7854, e-mail: pcolema@bgnet.bgsu.edu

Background: Inconsistent definitions and incomplete data have left society largely in the dark regarding mortality risks generally associated with pregnancy and with particular outcomes, immediately after resolution and over the long-term. Population-based record-linkage studies provide an accurate means for deriving maternal mortality rate data. **Method:** In this Danish population-based study, records of women born between 1962 and 1993 ($n = 1\,001\,266$) were examined to identify associations between patterns of pregnancy resolution and mortality rates across 25 years. **Results:** With statistical controls for number of pregnancies, birth year and age at last pregnancy, the combination of induced abortion(s) and natural loss(es) was associated with more than three times higher mortality rate than only birth(s). Moderate risks were identified with only induced abortion, only natural loss and having experienced all outcomes compared with only birth(s). Risk of death was more than six times greater among women who had never been pregnant compared with those who only had birth(s). Increased risks of death were 45%, 114% and 191% for 1, 2 and 3 abortions, respectively, compared with no abortions after controlling for other reproductive outcomes and last pregnancy age. Increased risks of death were equal to 44%, 86% and 150% for 1, 2 and 3 natural losses, respectively, compared with none after including statistical controls. Finally, decreased mortality risks were observed for women who had experienced two and three or more births compared with no births. **Conclusion:** This study offers a broad perspective on reproductive history and mortality rates, with the results indicating a need for further research on possible underlying mechanisms.

Introduction

Challenges to acquiring and disseminating accurate data pertaining to maternal mortality rates are longstanding global concerns. In a description of the difficulties inherent in measures of maternal mortality rates and the resultant unreliability of all existing estimates, the World Health Organization[1] reported '*Maternal deaths are hard to identify precisely because this requires information about deaths among women of reproductive age, pregnancy status at or near the time of death and the medical cause of death. All three components can be difficult to measure accurately*' (p. 4). Even under ideal conditions wherein countries have routine registration of deaths in place, maternal deaths are significantly underreported.[2] Horon[3] noted that US physicians fail to report recent or current pregnancies on a minimum of 50% of death certificates.

The World Health Organization defines a 'maternal death' as one that occurs during pregnancy or within 42 days of termination (through delivery or abortion, spontaneous or induced) from any cause related to or exacerbated by the pregnancy or its management, not including accidental or incidental causes.[4] By contrast, 'pregnancy-associated death' is defined by the American College of Obstetricians and Gynecologists and the Centers for Disease Control in the USA as any death during pregnancy or within 1 year of the pregnancy outcome irrespective of cause.[5] A subset of pregnancy-associated deaths recognized by these agencies is termed 'pregnancy-related deaths' and is reserved for complications of the pregnancy itself, events initiated by the pregnancy or the aggravation of an unrelated condition by the physiologic or pharmacologic effects of the pregnancy.[6] The Centers for Disease Control defines 'abortion-related deaths' based on direct and indirect causes, including 'aggravation of a pre-existing condition by the physiologic or psychologic effects of the abortion irrespective of the time elapsed between the abortion and the death'.[7]

Given the variability inherent in the aforementioned definitions and reporting issues, death certificates alone are inadequate for tabulating deaths of women related to or associated with pregnancy outcomes. Indeed, a study of pregnancy-associated deaths (as defined by the Centers for Disease Control) in Finland revealed that without data linkage to complete pregnancy and abortion records, 73% of all pregnancy-associated deaths could not have been identified from death certificates alone.[8] Inconsistent definitions and incomplete data confined to a brief window of time have left society largely in the dark regarding true mortality risks generally associated with pregnancy and with particular outcomes, immediately after pregnancy resolution and across the years that follow.

Large population-based record-linkage studies, containing complete reproductive history data in conjunction with data related to deaths, provide a unique opportunity to bypass many of the limitations of the currently available maternal mortality rate data in most countries. In a record-based study by Reardon *et al.*,[9] US women who aborted, when compared with women who delivered, were 62% more likely to die during an 8-year period from any cause after adjustments were made for age. Further, in a large Finnish population-based study led by Gissler *et al.*,[10] post-pregnancy death rates within 1 year were reported to be nearly four times greater among women who had an induced abortion (100.5 per 100 000) compared with women who carried to term (26.7 per 100 000). Spontaneous abortion had a pregnancy associated mortality rate of 47.8 per 100 000. In a later study, Gissler *et al.*[11] again found that mortality rate was significantly lower after a birth (28.2 per 100 000) than after a spontaneous abortion (51.9 per 100 000) and after an induced abortion (83.1 per 100 000).

Using Danish population-based data collected for 25 years, two objectives were pursued in the current study. The first objective was 2-fold: (i) to determine if reproductive histories consisting exclusively of no pregnancies, only miscarriage(s) or only induced

Downloaded from http://eurpub.oxfordjournals.org/ by guest on September 12, 2014

abortion(s) were associated with increases or decreases in mortality risk, when compared with a reproductive history consisting of only birth(s), and (ii) to examine the extent to which mortality risks associated with particular outcomes are modified when experienced in conjunction with other types of outcomes (e.g. is an increased risk of death associated with natural loss moderated by a full-term pregnancy?). The second objective was to determine if a dose response is evidenced wherein repeated births, miscarriages and induced abortions are associated with heighted protection against death or increased risk of death, when the effects of other outcomes are statistically controlled.

Method

Database

A Danish register-based study was conducted using merged data from the following databases: (i) Statistic Denmark, (ii) the National Hospital Register (1977–2004), which provided data on miscarriages, ectopic pregnancies and other losses, (iii) the Fertility Database, which supplied data on births and stillbirths, (iv) the National Board of Health Abortion Registry (1973–2004), (v) the Cause of Death Register and (vi) the Centralized Civil Register (1980–2004), which provided death dates. Data from all registries were linked using the personalized identification numbers assigned to all residents of Denmark. Importing data from the various databases enabled the researchers to construct reproductive histories for the population. The study was approved by the National Board of Health and the Data Protection Agency.

Study population

The study population ($n = 1\,001\,266$) included all women in Denmark born between the years 1962 and 1993, who did not die before the age of 16 years or before January 1980, which was the start date for recording of deaths. Women born between 1962 and 1969, 1970 and 1979, 1980 and 1989 and after 1990 comprised 30.4% ($n = 302\,911$), 32.6% ($n = 326\,460$), 26.3% ($n = 263\,820$) and 10.8% ($n = 108\,075$) of the population, respectively. The average age of women at the end of their first pregnancy was 24.69 years (SD = 4.63), with a range from 12.19 to 43.39 years, whereas the average age of women at the end of their last recorded pregnancy was 29.4 years (SD = 4.93), with a range from 12.19 to 43.39 years. For the full population, the average number of pregnancies per woman was 1.23 (SD = 1.61). The 5137 recorded deaths occurred between 11 January 1980 and 31 December 2004, and the mean age at death was 27.4 (SD = 7.30).

In addition to being included in the analyses involving the full data set, data from the oldest women in the population were analysed separately. These women likely had the most complete reproductive histories because at the close of the study (December 2004), they were nearing the end of their reproductive years, whereas the younger women were in the beginning or middle of their reproductive years. For the oldest women, those born between 1962 and 1966, the average age at the end of their first pregnancy was 25.19 years (SD = 4.96), with a range from 12.32 to 43.37 years. The average age at the last pregnancy for the oldest group was 31.83 years (SD = 4.75), with a range from 12.32 to 43.39 years. In the oldest segment, the average number of pregnancies during the study period was 2.56 (SD = 1.71), and among women in the oldest group who died, the average age of death was 30.74 years (SD = 7.30).

Procedure

Pregnancy outcomes were segregated by live birth, induced abortion and natural losses, which included stillbirth and miscarriage (if treated at a hospital) involving one or more fetuses, ectopic pregnancy and other products of conception.

Two sets of logistic regression analyses were conducted. In the first set of analyses, death rates for women who experienced various reproductive histories (no pregnancies, only induced abortions, only natural losses, a combination of induced abortion and natural losses, a combination of induced abortion and birth, a combination of birth and natural losses and having experienced all outcomes) were compared with death rates of women who only experienced live births (singletons and/or multiples). In these analyses, control variables included year of birth, number of pregnancies and age at last pregnancy. Year of birth was used as a control variable because as women get older, they are more likely to die from various causes, and our focus was exclusively on reproductive events as predictors of mortality rates. The number of pregnancies and age at last pregnancy were controlled because of the increased physical demands on women's bodies associated with numerous pregnancies and with those occurring toward the end of a woman's reproductive years.

In the second set of logistic regression analyses, mortality rates associated with the number of induced abortions (zero, one, two and three or more), number of natural losses (zero, one, two and three or more) and number of births (zero, one, two and three or more) were examined. The comparison group within each type of reproductive event included women who had not experienced the particular outcome. Similar to the first set of analyses, the dependent variable in these analyses was deaths. Control variables for the second set of analyses included age at last pregnancy and year of birth.

The two above sets of analyses were performed using the data of the full population ($n = 1\,001\,266$). In addition, both sets of analyses were repeated with a sample of women who were born between 1962 and 1966 ($n = 192\,604$). Focusing exclusively on the oldest women in the population enabled exploration of the study objectives, using data on women for whom nearly complete reproductive histories were available. In the tests conducted using the oldest women, year of birth was dropped as a statistical control variable, as only five birth years were covered.

Results

Reproductive history pattern results for the full population

As indicated in table 1, when women's year of birth was statistically controlled, compared with women who had only given birth, increased risks were observed among several groups: never pregnant 644%, only induced abortion 470%, only natural loss 234%, all potential outcomes (induced abortion, natural loss and birth) 20.9%, combined outcomes of induced abortion and natural loss 340% and combined outcomes of induced abortion and birth 30%. No significant differences were observed in mortality rates among women who had a combination of births and natural loss and women who had only experienced births after controlling for birth year.

In the results of the fully controlled model examining different types of reproductive histories, also presented in table 1, with age at last pregnancy and the number of pregnancies controlled along with year of birth, the general pattern of significant effects observed remained with changes in the magnitude of specific effects. Compared with the only birth group, the induced abortion group, only natural loss group, induced abortion and natural loss group, induced abortion and birth group, natural loss and birth group and the all outcomes group were associated with a 66%, 181%, 327%, 56%, 29% and a 94% increased risk of death, respectively.

Reproductive history pattern results for women born between 1962 and 1966

As indicated in table 2, among the oldest women studied, significantly increased risks of death were observed relative to the no

Downloaded from http://eurpub.oxfordjournals.org/ by guest on September 12, 2014

Table 1 Logistic regression analysis results for deaths associated with reproductive history, using birth only as the reference group

Reproductive history	*N* total	*N* deaths (per 100 000)	Significance	OR	CI (95%)
Experienced all outcomes	33 670	185	0.000	1.563	1.333–1.832
Experienced all outcomes[a]			0.000	1.209	1.031–1.148
Experienced all outcomes[b]			0.000	2.233	1.898–2.627
Experienced all outcomes[c]			0.000	1.945	1.571–2.409
No pregnancies	509 087	2794	0.000	1.561	1.446–1.685
No pregnancies[a]			0.020	7.444	6.898–8.057
No pregnancies[b]			–	–	–
No pregnancies[c]			–	–	–
Induced abortion(s) only	41 135	427	0.000	2.967	2.641–3.333
Induced abortion(s) only[a]			0.000	5.704	5.072–6.414
Induced abortion(s) only[b]			0.000	1.657	1.440–1.883
Induced abortion(s) only[c]			0.000	1.662	1.453–1.902
Natural loss(es) only	9320	75	0.000	2.294	1.811–2.908
Natural loss(es) only[a]			0.000	3.341	2.634–4.238
Natural loss(es) only[b]			0.000	2.758	2.164–3.515
Natural loss(es) only[c]			0.000	2.815	2.207–3.592
Induced abortion(s) and natural loss(es)	3590	46	0.000	3.671	2.724–4.947
Induced abortion(s) and natural loss(es)[a]			0.000	4.407	3.265–5.950
Induced abortion(s) and natural loss(es)[b]			0.000	4.456	3.282–6.049
Induced abortion(s) and natural loss(es)[c]			0.000	4.278	3.142–5.823
Induced abortion(s) and birth(s)	93 187	505	0.000	1.541	1.381–1.720
Induced abortion(s) and birth(s)[a]			0.000	1.306	1.170–1.450
Induced abortion(s) and birth(s)[b]			0.000	1.668	1.493–1.864
Induced abortion(s) and birth(s)[c]			0.000	1.562	1.373–1.777
Birth(s) and natural loss(es)	64 625	236	0.625	1.037	0.898–1.197
Birth(s) and natural loss(es)[a]			0.164	0.903	0.781–1.043
Birth(s) and natural loss(es)[b]			0.000	1.374	1.187–1.591
Birth(s) and natural loss(es)[c]			0.002	1.293	1.103–1.514
Birth(s) only	246 652	869			

OR, odds ratio; CI, confidence interval.
a: Controlled for year of woman's birth.
b: Controlled for age at last pregnancy and year of woman's birth.
c: Controlled for age at last pregnancy, year of birth and number of pregnancies.

pregnancies group (583%), only induced abortion group (466%), only natural loss group (213%), induced abortion and natural loss group (307%) and the induced abortion and birth group (20%), when compared with the birth only group, without control variables entered into the analyses. No significant differences were detected between the only birth group and the birth and natural loss or between the only birth group and the all outcomes group. With age at last pregnancy and number of pregnancies controlled, the increased risks of dying when compared with the only birth group were 98% for the only induced abortion group, 206% for the only natural loss group, 351% for the induced abortion and natural loss group, 47% for the induced abortion and birth group, 32% for the birth and natural loss group and 95% for the all outcomes group.

Repeated outcome results for the full population

The data presented in table 3 illustrate associations between variations in the number of distinct forms of reproductive outcomes (induced abortion, natural loss and birth) and death rates for the full population of women examined. The table includes uncontrolled logistic regression analysis effects and effects that have been controlled for the woman's age at last pregnancy, year of birth and the types of reproductive outcomes that are not the primary focus. For example, in the analysis conducted to examine mortality rates associated with zero, one, two and three or more abortions, the number of natural losses and births are controlled. The uncontrolled results of these analyses should be viewed cautiously, as the women who comprised the various groups had multiple types of reproductive outcomes and only in the controlled results is an understanding of the unique impact of particular outcomes (single and multiple) possible.

Examination of the statistically controlled effects reveals that for induced abortion and natural loss, a 'dose effect' was evidenced wherein experiencing one of these outcomes was associated with a small increased risk of death (45% increased risk for induced abortion and 44% increased risk for natural loss), two experiences resulted is moderately increased risk estimates (114% for induced abortion and 86% for natural loss) and for women who had experienced three or more induced abortions and three or more natural losses, the increased risks of death observed were 191% and 150%, respectively. Finally, also in the controlled analyses, significantly decreased mortality risks were evidenced with multiple births: three or more births corresponded to a 44% decreased risk and two births with an 83% lower risk of death.

Repeated outcome results for the women born between 1962 and 1966

The data presented in table 4 illustrate associations between variations in the number of distinct forms of reproductive outcomes (induced abortion, natural loss and birth) and death rates for the oldest segment of the population. The table includes uncontrolled logistic regression analysis effects and effects that have been statistically controlled for the woman's age at last pregnancy and the types of reproductive outcomes that are not the primary focus of a given analysis. Remarkably similar results to those obtained for the full sample were derived for the sample of the oldest women. Specifically, in the controlled analyses, the increased risks associated with one, two and three or more induced abortions were 49%, 96% and 152%, respectively. Likewise, for natural loss the increased risks were 43%, 70% and 164% for one, two and three or more natural losses, respectively. For the oldest segment, the greatest protective effect of birth was for two births (108% reduced risk) with the risk of death decreased by 63% among women who had three or more births.

Downloaded from http://eurpub.oxfordjournals.org/ by guest on September 12, 2014

Table 2 Logistic regression analysis results for deaths associated with reproductive history, using birth only as the reference group for women born between 1962 and 1966

Reproductive history	*N* total	*N* deaths (per 100 000)	Significance	OR	CI (95%)
Experienced all outcomes	15 991	128	0.071	1.195	0.985–1.450
Experienced all outcomes[a]			0.000	2.188	1.794–2.608
Experienced all outcomes[b]			0.000	1.948	1.500–2.529
No pregnancies	23 375	1031	0.000	6.834	6.149–7.594
No pregnancies[a]			–	–	–
No pregnancies[b]			–	–	–
Induced abortion(s) only	5922	218	0.000	5.660	4.824–6.641
Induced abortion(s) only[a]			0.000	1.960	1.640–2.343
Induced abortion(s) only[b]			0.000	1.981	1.656–2.369
Natural loss(es) only	1883	39	0.000	3.132	2.256–4.350
Natural loss(es) only[a]			0.000	3.000	2.148–4.180
Natural loss(es) only[b]			0.000	3.062	2.190–4.282
Induced abortion(s) and natural loss(es)	972	26	0.000	4.070	2.732–6.065
Induced abortion(s) and natural loss(es)[a]			0.000	4.655	3.100–6.991
Induced abortion(s) and natural loss(es)[b]			0.000	4.518	3.001–6.802
Induced abortion(s) and birth(s)	39 177	316	0.000	1.204	1.047–1.385
Induced abortion(s) and birth(s)[a]			0.000	1.557	1.352–1.792
Induced abortion(s) and birth(s)[b]			0.000	1.473	1.253–1.733
Birth(s) and natural loss(es)	25 516	159	0.414	0.920	0.778–1.109
Birth(s) and natural loss(es)[a]			0.000	1.395	1.164–1.670
Birth(s) and natural loss(es)[b]			0.000	1.324	1.090–1.610
Birth(s) only	79 768	535			

a: Controlled for age at last pregnancy.
b: Controlled for age at last pregnancy and number of pregnancies.

Table 3 Logistic regression analysis results for full population associated with number of reproductive outcomes of various forms

Reproductive history	*N* total	*N* deaths (per 100 000)	Significance	OR	CI (95%)
Induced abortion group					
Three or more abortions	16 856	140 (831)	0.000	1.740	1.469–2.061
Three or more abortions[a]			0.000	2.917	2.441–3.487
Two abortions	32 732	242 (739)	0.000	1.548	1.359–1.763
Two abortions[a]			0.000	2.140	1.859–2.463
One abortion	121 994	781 (640)	0.000	1.339	1.240–1.446
One abortion			0.000	1.450	1.316–1.596
No abortions[b]	829 684	3974 (479)			
Natural loss group					
Three or more natural losses	5816	38 (653)	ns		
Three or more natural losses[c]			0.000	2.506	1.807–3.476
Two natural losses	18 138	95 (524)	ns		
Two natural losses[c]			0.000	1.869	1.505–2.296
One natural loss	87 251	409 (469)	ns		
One natural loss[c]			0.000	1.441	1.289–1.610
No natural losses[b]	890 061	4595 (516)			
Birth group					
Three or more births	85 170	301 (353)	0.000	0.594	0.528–0.669
Three or more births[d]			0.000	0.693	0.582–0.825
Two births	215 390	715 (332)	0.000	0.558	0.515–0.605
Two births[d]			0.000	0.544	0.472–0.627
One birth	137 574	779 (566)	ns		
One birth[d]			ns		
No births[b]	593 132	3342 (592)			

a: Controlled for age at last pregnancy, year of woman's birth, number of natural losses and number of births.
b: Reference group.
c: Controlled for age at last pregnancy, year of woman's birth, number of induced abortions and number of births.
d: Controlled for age at last pregnancy, year of woman's birth, number of induced abortions and number of natural losses.

Discussion

The purpose of this study was to examine associations between reproductive outcomes (induced abortion, natural loss and birth) and mortality rates during a 25-year period, using population-based data. When the data analysed included the full population of women born after 1962, with control subjects for the number of pregnancies, year of birth and age at last pregnancy, the results revealed the greatest increased risk of death for a reproductive history comprised exclusively of induced abortion and natural loss. Specifically, those who had experienced induced abortion(s) and natural loss(es) had more than three times the risk of death compared with women who had only experienced birth(s). Moderate risks were also identified with only one form of loss (induced abortion or natural loss) and with having experienced all reproductive outcomes compared with birth(s). Less pronounced, yet statistically significant, risks were identified for the induced abortion and birth group and for the natural loss and birth group

Downloaded from http://eurpub.oxfordjournals.org/ by guest on September 12, 2014

Table 4 Logistic regression analysis results associated with number of reproductive outcomes of various forms for women born between 1962 and 1966

Reproductive outcomes	*N* total	*N* deaths (per 100 000)	Significance	OR	CI (95%)
Induced abortion group					
Three or more abortions	7441	82 (1102)	ns		
Three or more abortions[a]			0.000	2.522	1.999–3.181
Two abortions	13 334	143 (1072)	0.000	0.791	0.667–0.939
Two abortions[a]			0.000	1.960	1.634–2.351
One abortion	41 287	463 (1121)	0.000	0.828	0.747–0.918
One abortion[a]			0.000	1.499	1.328–1.693
No abortions[b]	130 542	1764 (1351)			
Natural loss group					
Three or more natural losses	2956	9 (304)	0.048	0.689	0.477–0.976
Three or more natural losses[c]			0.000	2.641	1.813–3.849
Two natural losses	8115	35(431)	0.000	0.518	0.401–0.671
Two natural losses[c]			0.000	1.701	1.309–2.228
One natural loss	33 261	146 (439)	0.000	0.544	0.487–0.630
One natural loss[c]			0.000	1.438	1.251–1.653
No natural losses[b]	148 242	2495(1683)			
Birth group					
Three or more births	43 478	227 (522)	0.000	0.123	0.107–0.142
Three or more births[d]			0.000	0.610	0.493–0.756
Two births	85 677	486 (567)	0.000	0.134	0.121–0.149
Two births[d]			0.000	0.480	0.401–0.575
One birth	31 297	425 (1357)	0.000	0.323	0.289–0.361
One birth[d]			ns		
No births	32 152	1314 (4087)			

a: Controlled for age at last pregnancy, number of natural losses and number of births.
b: Reference group.
c: Controlled for age at last pregnancy, number of induced abortions and number of births.
d: Controlled for age at last pregnancy, number of induced abortions, and number of natural losses.

compared with only birth(s) in the fully controlled models. This suggests adverse effects of pregnancy loss may be attenuated by protective effects of birth. Finally, rather alarmingly high rates of death were evidenced among women who had not experienced any pregnancies compared with birth(s). Specifically, when age was controlled, risk of death was more than six times greater among women who had never been pregnant compared with those in the birth(s) only group. However, this finding could be somewhat of an artifact, as some of the women in the never pregnant category were women who died early in their reproductive years and obviously never had an opportunity to experience pregnancy.

In a second set of analyses, the focus was on examining the impact of repeated experiences of the same reproductive outcomes after controlling for other forms of loss, age at last pregnancy and year of birth with the reference group being women who had not experienced a given outcome. The results relative to induced abortion and natural loss revealed a 'dose effect' with one of these outcomes associated with modest increased risks of death, whereas two outcomes resulted is moderately high increased risk. Further, with three or more induced abortions and three or more natural losses, the increased risks of death compared with no induced abortions or no natural losses were nearly two times and one and a half times greater, respectively. Finally, in the controlled analyses, significantly decreased mortality risks associated with birth were observed for women who had experienced two and three or more births compared with no births.

All the aforementioned analyses were repeated using only women at the end of their reproductive years (born between 1962 and 1966), for whom the most complete histories were available. Similar patterns to those described previously using the full population were obtained when the oldest women were exclusively examined.

This study offers a broad perspective on reproductive history and mortality rates for an extended time frame, and the results suggest clear avenues for further study. Specifically, future research should be devoted to replicating this study using other population-based data sources from diverse cultures. To more fully understand the mechanisms underlying the trends evidenced in this study, additional work should explore the timing and cause of deaths in association with reproductive outcomes. Identification of mental or physical conditions and illnesses that precipitate untimely deaths among women with particular reproductive histories will be critically relevant information in efforts to identify physiological and psychological explanations for the effects observed.

Because of the exploratory nature of the current study, only the most obvious control variables were used. However, more focused follow-up studies should be devoted to identifying a wide range of demographic, personal and situational factors that may be vital to control in subsequent analyses of associations between reproductive history patterns and death rates.

Finally, future research should explore possible increased and decreased mortality risks revealed by distinct sequences of reproductive outcomes. For example, the results of this study revealed that a combination of birth and natural loss resulted in a slightly increased risk of death over experiencing only birth. If women undergo one or more losses before a successful birth, does this sequence incur more risk than if one or more successful births occur before a loss? Should distinct sequences involving more heightened risks be identified, this information may prove beneficial to efforts to explain associations between reproductive outcomes and mortality risks.

A few limitations of the data should be noted. First, reproductive history data pertaining to the oldest women sampled may have been missing a few outcomes, because these women were 15 years old in 1977 when miscarriage data first became available, and 11 years old when induced abortion data were initially recorded. Although miscarriages before age 15 years and induced abortions before age 11 years are decidedly rare events, if they did occur they are not reflected in the database. Second, only miscarriages that were treated in hospitals are captured in the registry,

Downloaded from http://eurpub.oxfordjournals.org/ by guest on September 12, 2014

rendering the category of natural losses not complete for all women sampled. Moreover, miscarriages that require treatment in hospitals would be inclined to occur at later periods of gestation and involve more serious complications. Third, because of data limitations, control subjects for mental and physical health history were not incorporated. Finally, because of the correlational nature of the analyses conducted, causal conclusions are precluded relative to reproductive history patterns and death rates.

The primary strengths of the study are the use of large scale population level data that includes reliable records on all possible reproductive outcomes and prospectively gathered data from different birth cohorts of women. The results of comprehensive studies of this nature offer more accurate information regarding mortality risks associated with reproductive outcomes than the data acquired by governmental agencies relying on information primarily garnered from death certificates.

Funding

Funding was provided by the World Expert Consortium for Abortion Research and Education.

Key points

- This study offers more accurate information regarding mortality risks associated with reproductive outcomes than the data acquired by death certificates.
- Distinct patterns of reproductive outcomes involving induced abortion, spontaneous abortion and birth across a 25 year window are associated with different levels of risk of dying.
- Mortality risks associated with induced abortion and spontaneous abortion are more pronounced when more than one is experienced.

References

1 World Health Organization. *Maternal Mortality in 2000-Estimates by UNICEF, WHO, & UNFPA*. Geneva, Switzerland: Department of Reproductive Health and Research, 2004.

2 World Health Organization. *Maternal Mortality in 2005—Estimates Developed by WHO, UNICEF, UNFPA, and the World Bank*. Geneva: World Health Organization, 2007.

3 Horon I. Under-reporting of maternal deaths on death certificates and the magnitude of the problem of maternal mortality. *Am J Public Health* 2005;95:478–82.

4 Deneux-Tharaux C, Berg C, Bouvier-Colle MH, et al. Underreporting of pregnancy-related mortality in the U.S. and Europe. *Obstet Gynecol* 2005;106:684–92.

5 CDC. *Strategies to Reduce Pregnancy-Related Deaths: From Identification and Review to Action*. Atlanta: Centers for Disease Control and Prevention, 2001. Available at: www.cdc.gov/reproductivehealth/ProductsPubs/PDFs/Strategies_taged.pdf (15 September 2011, date last accessed).

6 Atrash HK, Lawson HW, Ellerbrock TV, Rowley DL, Koonin LM. Pregnancy-Related Mortality. In: *From data to Action: CDC's Public Surveillance for Women, Infants, and Children*. Atlanta Georgia: Centers for Disease Control and Prevention, 1995: 141–54.

7 Bartlett LA, Berg CJ, Shulman HB, et al. Risk factors for legal induced abortion related mortality in the United States. *Obstet Gynecol* 2004;103:729–37.

8 Gissler M, Berg C, Bouvier-Colle MH, Buekens P. Methods for identifying pregnancy-associated deaths: population-based data from Finland 1987-2000. *Paediatr Perinat Epidemiol* 2004;18:448–55.

9 Reardon DC, Ney PG, Scheuren FJ, et al. Deaths associated with pregnancy outcome: a record linkage study of low income women. *South Med J* 2002;95:834–41.

10 Gissler M, Kauppila R, Merilainen J, et al. Pregnancy associated deaths in Finland 1987-1994: definition problems and benefits of record linkage. *Acta Obstet Gynecol Scand* 1997;76:651–7.

11 Gissler M, Berg C, Bouvier-Colle M, Buekins P. Pregnancy-associated mortality after birth, spontaneous abortion, or induced abortion in Finland, 1987-2000. *Am J Obstet Gynecol* 2004;190:422–7.

Downloaded from http://eurpub.oxfordjournals.org/ by guest on September 12, 2014