The Breast Cancer Epidemic: Modeling and Forecasts Based on Abortion and Other Risk Factors

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ABSTRACT

Using national cancer registration data for female breast cancer incidence in eight European countries—England & Wales, Scotland, Northern Ireland, the Irish Republic, Sweden, the Czech Republic, Finland, and Denmark—for which there is also comprehensive data on abortion incidence, trends are examined and future trends predicted. Seven reproductive risk factors are considered as possible explanatory variables. Induced abortion is found to be the best predictor, and fertility is also a useful predictor. Forecasts are made using a linear regression model with these explanatory variables. Previous forecasts using the same model and incidence data for years through 1997 for England & Wales are compared with numbers of cancers observed in years from 1998–2004 in an Appendix. The forecast predicted 100.5% of the cancers observed in 2003, and 97.5% of those observed in 2004.

The Challenge of Abortion for Epidemiologists in Female Breast Cancer Research

It is difficult for epidemiologists to discover women's abortion history. In any study the numbers of women who have had abortions may be underreported.[1]

National data on abortions in most countries tends to be deficient, with abortions underreported. Official abortion statistics in the United States[2] and France[3] are known to understate the numbers of legal induced abortions. The countries considered in this study are believed to have nearly complete official abortion counts.

The long lag time for the development of breast cancer magnifies the problem. The average age of diagnosis is over 60, while most abortions and live births occur at ages under 30. The modern increase in breast cancer incidence is obvious at ages over 45,[4] and Figure 1 for England & Wales shows the increase is small below age 45.

Abortion did not become legal in most Western countries until the 1970s, and earlier abortions among older women are not recorded. Consequently, the older women, whose breast cancer incidence is known, have abortions not detectable by a longitudinal study,[1,5,6] while the younger women, whose abortion history is known, tend to be too young to have experienced most of the modern increase in breast cancer.[1,5,7-11] Where the increased risk is apparent, even under age 40 in a study free of recall bias,[12] there is an acknowledged need to extend the study to women older than 40.

The long time lags, however, can be used to make long-term forecasts of cancer trends.

Trends

Since 1971 the overall increase has been 80%,[4] as shown for England & Wales in Figure 1.

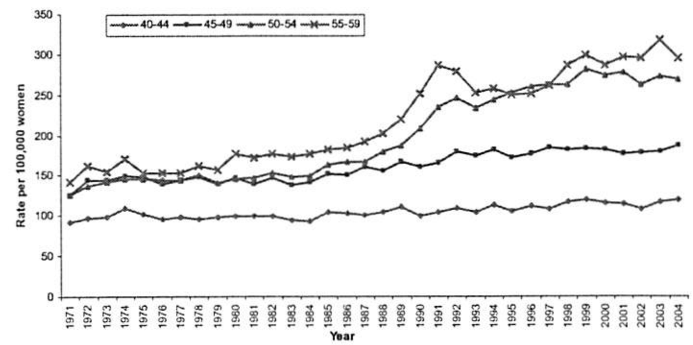

Figure 1. Average Yearly Rate of Incidence of Female Breast Cancer in England & Wales within Age Groups 40-44, 45-49, 50-54 and 55-59 from 1971-2004

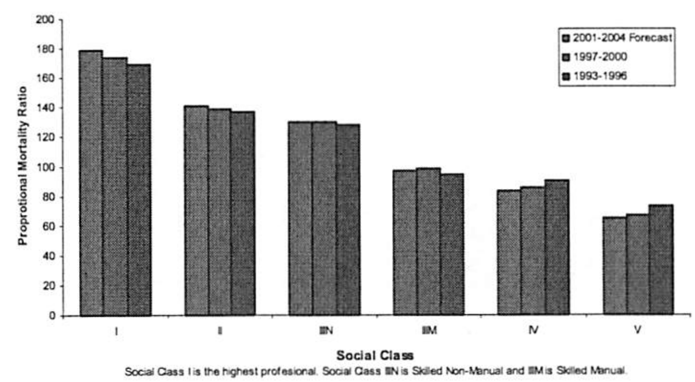

Figure 2. Female Breast Cancer Mortality by Social Class: Proportional mortality ratios show increased reverse gradient across social class of women in England & Wales.

In contrast to other cancers, breast cancer is more common in upper-class women. This reverse gradient[13] is becoming steeper: see Figure 2. The reported standardized mortality ratio (SMR) in England for the highest social class I increased to 174 for the years 1997–2000, compared to an SMR of 169 for the years 1993–1996. As upper-class women have higher survival rates, the incidence gradient is steeper than the mortality gradient. Fertility differences do little to explain this gradient. However, the age at first birth among women who have children does provide a two-fold partial explanation. The least deprived women studied in a British survey[14] were found to have a greater preference for abortion when pregnant. Higher-class women have a later age at first birth[15] and consequently higher-class women have nulliparous abortions, which are more carcinogenic.

Local variation within countries can be examined in addition to international comparisons. The South East of England has more breast cancer than other parts of the British Isles.[16] It also has the highest abortion rate.[17] Ireland has the lowest rate of breast cancer

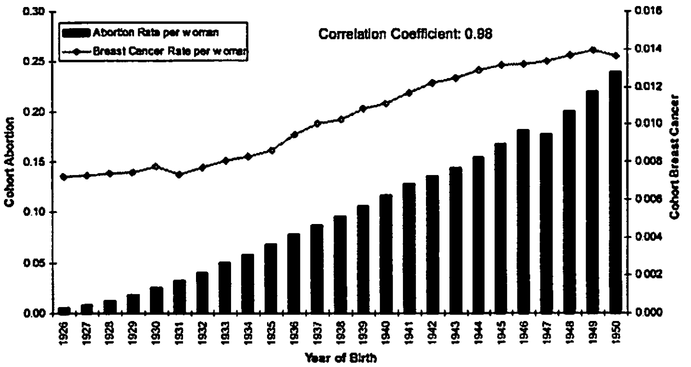

Figure 3. Cohort Breast Cancer Incidence within Ages 50-54 vs. Cumulated Cohort Abortion Rate for Women in England & Wales: Cohorts are defined by year of birth.

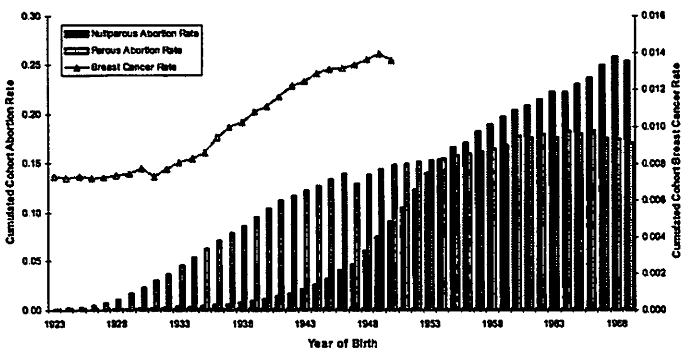

Figure 4. Cumulated Cohort Rates of Abortion (Parous and Nulliparous) and Cumulated Cohort Rate of Breast Cancer within Ages 50-54 for Women in England & Wales

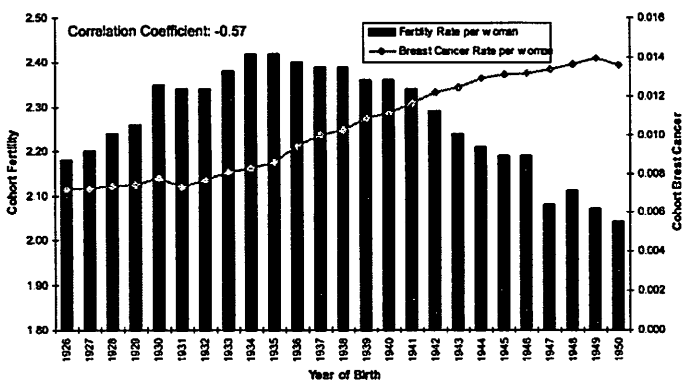

Figure 5. Cohort Breast Cancer Incidence within Ages 50-54 vs. Cumulated Cohort Fertility for Women in England & Wales: Cohorts are defined by year of birth.

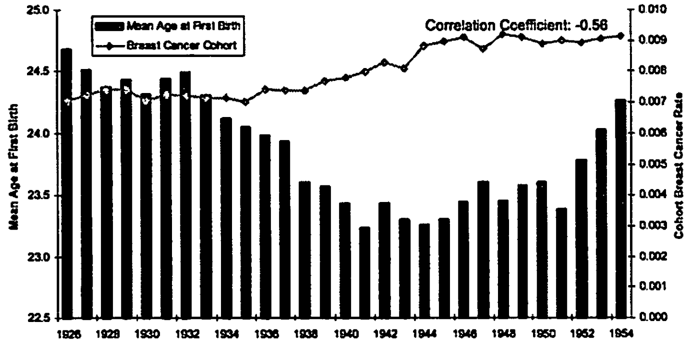

Figure 6. Cohort Mean Age at First Birth vs Cumulated Cohort Breast Cancer within Age Group 45-49 for Women in England & Wales

and the lowest abortion rate. Fertility, higher in Ireland than in England, is also a factor. But in the South East of England fertility is not lower than the English average and does not explain the above-average breast cancer rate.

Risk Factors

Seven known risk factors were examined as an explanation for these trends:

When a woman is nulliparous, an induced abortion has a greater carcinogenic effect[18] because it leaves breast cells in a state of interrupted hormonal development in which they are more susceptible.

A low age at first birth is protective.[19]

Childlessness increases the risk.[20]

A larger number of children (higher fertility) increases protection.

Breastfeeding gives additional protection.

Hormonal contraceptives are conducive to breast cancer.

Hormone replacement therapy (HRT) is also conducive to breast cancer.

Modeling for England & Wales

For four of these risk factors we are fortunate to have useful English national data. The total fertility rates (TFRs) and completed cohort fertility rates are as published by the Office for National Statistics (ONS),[15] and the total abortion rates (TARs) and cohort abortion rates are derived by the author from official data.[17]

Figure 3 shows cumulated cohort abortion rates for successive birth cohorts of women born since 1926 in England & Wales, together with cumulated cohort breast cancer rates for women aged 50–54. The correlation coefficient is high (>0.9), and it is useful to include this variable as an explanatory variable in modeling.

Figure 4 shows the rates decomposed into parous and nulliparous cohort rates. The increasing proportion of nulliparous abortions affecting the women now entering age groups where they are likely to have breast cancer is apparent. This trend is a driver of the further increases in breast cancer incidence now observed.

Figure 5 shows average number of children, representing the cumulated cohort fertility rate for successive birth cohorts of English women compared with their breast cancer rate for cancer in women aged 50–54. The correlation coefficient is -0.57, so this variable is also useful to include in modeling.

Figure 6 shows mean age at first birth in England & Wales for successive birth cohorts. If the correlation were positive it could help to explain the trend, but it is negative.

Figure 7 shows cohort childlessness. The correlation in the graph is negative, and this variable is not used in the model to explain the British trend.

Two explanatory variables are selected for modeling: x_1 (abortion) and x_2 (fertility). The trends for abortion and fertility are shown in Figures 8 and 9 for countries considered.

The Mathematical Model is then:

$$Y_i = a + b_1x_{1i} + b_2x_{2i} + e_i$$

where Y represents cumulated cohort incidence of breast cancer within a particular age group; a is intercept, b_1 and b_2 are coefficients, and e is random error.

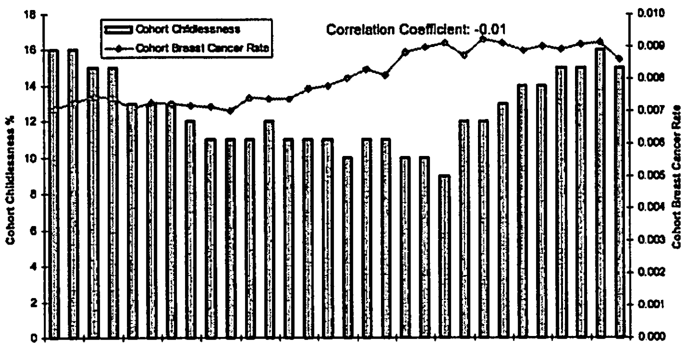

Figure 7. Cumulated Cohort Breast Cancer Rates within Ages 45-49 vs. Cohort Childlessness Percentage for England & Wales

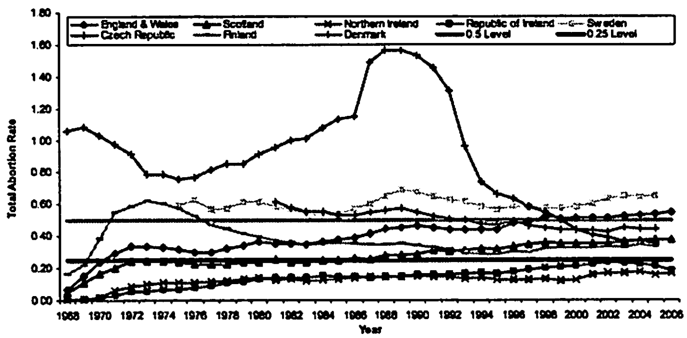

Figure 8. Total Abortion Rates: TARs in England & Wales, Scotland, Northern Ireland, Republic of Ireland, Sweden, Czech Republic, Finland, and Denmark; 1968-2006

Table 1. Model Fitting by Country: Regression Intercept and Coefficients, and Increase in Breast Cancer Incidence Forecast to Occur in 25 Years†

Country	No of Years Used	Goodness of Fit Multiple R	Intercept (a)	Coefficient of Abortion (b_1) (95% CI)	Coefficient of Fertility (b_2) (95% CI)	Increase Forecast
England & Wales	15	0.951	.0202	.0166 (.0065, .0396)	-.0047 (-.0135, .0041)	50.9%
Scotland *	28	0.603	.0093	.0040 (-.0047, .0127)	-.00053 (-.0029, .0018)	17.2%
Northern Ireland *	8	0.998	.0082	.0107 (.0074, .0140)	-.00020 (-.0006, .0002)	9.3%
Irish Republic *	8	0.997	.0083	.0099 (.0018, .0182)	-.00029 (-.0013, -0007)	8.3%
Sweden	6	0.998	.0097	.0128 (.0059, .0197)	-.00023 (-.0027, .0022)	31.3%
Czech Republic	9	0.859	.021	.0083 (.0014, .0151)	-.0094 (-.0423, .0236)	53%
Finland	16	0.630	.0058	.0298 (-.0092, .0687)	-.0014 (-.0101, .0072)	-6.8%
Denmark	8	0.991	.0065	.0155 (.00046, 0.0305)	-.00024 (-.003, 0.0026)	-4.1%

* 45-49 modeling used

† 25 years after latest year for which breast cancer incidence is available (2005 for Republic of Ireland; 2004 for England & Wales, Scotland, Northern Ireland, and Sweden; 2003 for Czech Republic and Finland; 2001 for Denmark).

Linear Regression. Response variable: cumulated cohort breast cancer incidence for women aged 50–54 or 45–49. Explanatory variables: cumulated cohort abortion rates and cumulated cohort fertility rates.

Table 2. Summary: Forecast Cases of Breast Cancer and DCIS

	Cancers						In Situ Cancers					
	Base Year	2005	2010	2015	2020	2025	Base Year	2005	2010	2015	2020	2025
England & Wales	39229	40018	45529	51849	58567	65252	3827	3848	4373	5074	5765	6319
Scotland	3917	3963	4482	5058	5639	6177	333	345	392	450	502	537
Northern Ireland	1117	1137	1256	1382	1508	1626	87	87	99	111	119	122
Republic of Ireland	2336	2336	2560	2883	3222	3601	163	163	178	200	223	248
Sweden	7293	7777	8519	9288	10096	10895	950	981	1077	1177	1281	1384
Czech Republic	5449	5596	6200	6804	7561	8412	248	258	278	300	334	372
Finland	3794	3824	3931	4005	4024	4045	.	.	.	.	.	.
Denmark	3952	4043	4175	4325	4452	4533	.	.	.	.	.	.

This model has desirable mathematical properties such as dimensional homogeneity, linearity, additivity, and parsimonious parameterization.

The model makes sense in terms of the factors not explicitly included. Higher fertility is associated with a lower age at first birth and less childlessness. Breastfeeding is strongly linked to fertility. Likewise lower fertility is associated with more use of hormonal contraceptives. Abortion can lead to prescription of hormonal contraceptives, and the mental health sequelae of abortion may lead to use of hormone replacement therapy.

The model was fitted to English female cohorts born in the years up to 1950 for cancer in women aged 50–54. The multiple R was 0.951. The estimated coefficient of abortion (b_1) is 0.0166 (95% CI, .0065-.0396), and the coefficient of fertility (b_2) is −0.0047 (95% CI, −.0135-.0041). The coefficient of fertility is rather small, with the 95% confidence interval straddling zero. Some improvement in breastfeeding may be offsetting fertility decline. These results are summarized in Table 1.

Forecasting for England & Wales

Forecasts are made using the model with the latest TFRs and TARs to estimate cumulated cohort rates of fertility and abortion for 25 years in the future. Here the recent rates for England & Wales in 2006 of TFR 1.86 and TAR 0.55 are used. Fitting this model gives an overall increase in the rate of cancer of 50.9%, which corresponds to a yearly compound increase of 1.7%. Assuming the breast cancer incidence rates for ages below 45 are constant, for ages 45–49 follow the trend as modeled for this age group, and for ages over 50 follow the trend as modeled for ages 50–54, we can estimate future breast cancer incidence rates for 25 future years with 2004 as base year for prediction. The numbers of new cancers to be expected in these years is then estimated using the Government Actuary's population projections by applying the forecast incidence rates to the expected numbers of women in the relevant age groups in each year.

The numbers of newly diagnosed cancers forecast by this model are expected to increase to 65,252 in 2025, compared to the reported number 39,229 in 2004 (a 66.3% increase). These are shown with forecasts for intermediate years in Table 2.

The 1997-based forecasts using this model published in 2002[21] have anticipated quite well the reported increases in female breast cancer in England & Wales in 1998 to 2004 [Appendix A].

Cases of ductal carcinoma in situ (DCIS), which also requires treatment, are registered separately and are also forecast. DCIS is shown on mammography, and the number of cases has increased in the age groups targeted by screening. In 2004 there were 39,229 breast cancers and 3,827 cases of DCIS registered in England & Wales.[4] The number of future cases is forecast by assuming that the ratio of cancers to DCIS stays constant in the main age groups affected. The increased numbers forecast are shown in Table 2.

These forecast numbers can be used to plan treatment facilities for women diagnosed with cancer.

Modeling Applied to the Social Gradient

In Scotland the incidence gradient (Figure 10) is less than the gradient in England (Figure 2), and the mortality gradient is almost

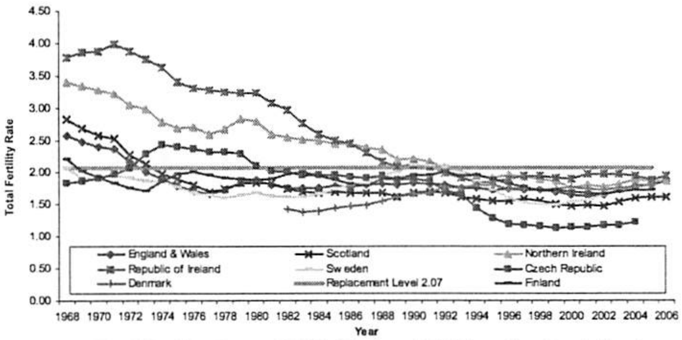

Figure 9. Total Fertility Rates: TFR in England & Wales, Scotland, Northern Ireland, Republic of Ireland, Sweden, Czech Republic, Finland, and Denmark; 1968-2006

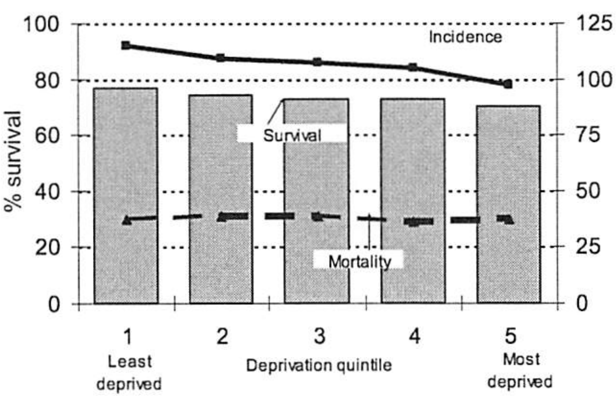

Figure 10. Cancer of the Female Breast, Scotland: Incidence, mortality and cause-specific survival at 5 years by deprivation quintile, for patients diagnosed 1991-95. **Source:** ISD publication *Trends in Cancer Survival in Scotland 1971-1995*

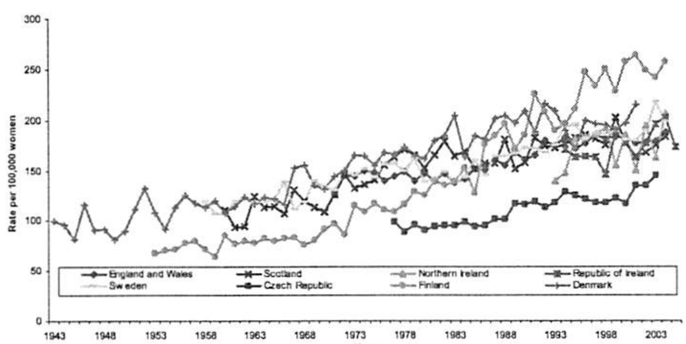

Figure 11. Breast Cancer in Women within Ages 45-49 in England & Wales, Scotland, Northern Ireland, Republic of Ireland, Sweden, Czech Republic, Finland, and Denmark; 1943-2005

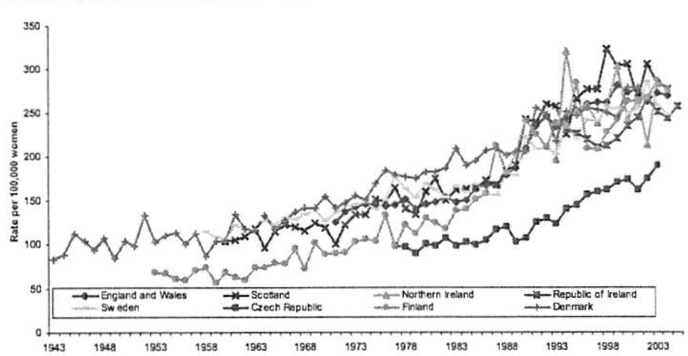

Figure 12. Breast Cancer in Women within Ages 50-54 in England & Wales, Scotland, Northern Ireland, Republic of Ireland, Sweden, Czech Republic, Finland, and Denmark; 1943-2005

flat.[22] These differences could result in part from the fact that the abortion rate has been lower in Scotland than in England since 1968 (Figure 8). Currently, the abortion rate is about 50% higher in England than in Scotland. However, over the same period, there has been a greater decline in fertility in Scotland (Figure 9).

Five social classes for Scotland are distinguished according to deprivation, whereas in England there are six social classes distinguished by occupation. The Scottish ratios of mortality to incidence for the social classes were used to derive an approximate gradient of incidence for England. The modeling for England for the age groups 45–49 and 50–54 described in the last section was used to estimate a further increase in incidence of breast cancer in England of 14.4% in the period 2001–2004, compared to 1997–2000. This was spread across the six social classes in England in proportion to the existing gradient, and an increased gradient of incidence across social class for England for the years 2001–2004 was determined. Using the Scottish ratios, this was then converted into the increased breast cancer mortality gradient for England & Wales shown in Figure 2.

Modeling and Forecasting for Scotland

Cancer registrations in Scotland started in 1960.[22] Rates have been higher than in England, but recently the increase over all ages in Scottish breast cancer rates has been less than in England (Figures 11 and 12). Figure 8 shows the lower Scottish abortion rates. Figure 9 shows the greater decline in Scottish birth rates. The trend in cohort breast cancer in ages 50–54 up to 2004 proved non-linear and difficult to fit the model. The model was fitted for Scotland for ages 45–49 with results shown in Table 1.

Forecasts were made using the latest 2006 TAR for Scotland, 0.376, and the latest TFR, 1.67, giving an overall increase in the rate of cancer of 17.2%, or a yearly increase of 0.64%. Numbers of new cancers expected in Scotland are 6,177 in 2025 compared to the 3,917 reported for 2004, which is a 57.7% increase, in line with the aging of the population.

The lower abortion rates in Scotland lead to a forecast of a lesser further increase in incidence of breast cancer in Scotland compared to England, partly offset by lower fertility now in Scotland. Breastfeeding rates have been very low in Scotland,[23] and this has reduced the protective effects of higher Scottish fertility in the past. With encouragement in recent years, the increase in breastfeeding has apparently offset the effects of the decline in the Scottish birth rate.

Northern Ireland

Data is limited, as cancer registration started in 1993. The incidence trends for the age groups 45–49 and 50–54 are shown in Figures 11 and 12. Abortions in England on women resident in Northern Ireland as reported in English abortion statistics are used to derive abortion rates for Northern Ireland. The trends in abortion and fertility in Northern Ireland are shown in Figures 8 and 9. Abortion rates in Ireland, where abortion is illegal, are much lower than in Great Britain. By smoothing the graph of cohort cancer incidence for Northern Ireland it was possible to fit the model and make estimates.

With this model fitted on the available years of data to 2004 for the age range 45–49, and the latest abortion and fertility rates entered, the 2006 TAR for Northern Ireland is 0.16, the latest TFR is 1.87, and the forecast increase in the rate of cancer is 9.3% (yearly increase 0.36%).

This forecasts an increase in new cancers in Northern Ireland to 1,626 in 2025 compared to the 1,117 reported for 2004, which is a 46% increase, largely due to aging of the population. This small increase follows from the very low abortion rate and comparatively high fertility in Northern Ireland.

Republic of Ireland

Data is limited, as cancer registration started in 1994. The incidence trends for the age groups 45–49 and 50–54 are shown in Figures 11 and 12. Data on women resident in the Republic in English abortion statistics are used to derive Irish abortion rates. The trends in abortion and fertility in the Republic of Ireland are shown in Figures 8 and 9. Abortion rates in the Republic are low, and Irish fertility rates are high compared with England.

Modeling used the latest available cancer data up to 2005 fitted for cohort incidence within ages 45–49. Forecasting used the TAR of 0.18 for 2006 and TFR of 1.86, giving a forecast increase in the rate of cancer of 8.3%, which corresponds to a yearly compound increase of 0.32%. This predicts an increase in numbers of new cancers in the Republic of Ireland to around 3,601 in 2025, compared to the 2,336 reported for 2005. The 54% increase is largely a consequence of the expected growth and aging of the Irish population.

Sweden

In Sweden cancer registration started in 1958. The incidence trends for the age groups 45–49 and 50–54 are shown in Figures 11and 12. The trends in abortion and fertility in Sweden are shown in Figures 8 and 9. The nonlinear trend in fertility makes modeling difficult. The abortion rates in Sweden are higher than in England at the adult ages, but in Sweden most abortions are parous. Breastfeeding is also successfully promoted in Sweden, offsetting the carcinogenic effect of a high abortion rate.[24]

Modeling is possible using recent years data. Forecasting with the latest TAR for Sweden of 0.65 and the latest TFR of 1.75 produces an overall increase in the rate of cancer of 31.3%, which corresponds to a yearly compound increase of 1.12%. From this model, new cancers in Sweden are expected to be 10,895 in 2025, compared to the 7,293 reported for 2005, a 49% increase.

Czech Republic

In the Czech Republic cancer registration started in 1977. The incidence trends are shown in Figures 11 and 12. Czech rates of breast cancer are low by comparison with other countries considered. Perhaps there is less genetic susceptibility. The trends in abortion and fertility in the Czech Republic are shown in Figures 8 and 9. Abortion rates in the Czech Republic were high, and most abortions are parous. Data for recent years was used to fit the model.

Forecasts using the latest TAR for the Czech Republic of 0.35 and the latest TFR of 1.23 gave an overall increase in the rate of cancer of 39.2%, or a yearly increase of 1.33%. The Czech abortion rate has declined markedly, but the Czech birth rate has declined even more remarkably in recent years. These are offsetting factors for breast cancer. The model predicts 8,412 new malignancies in the Czech Republic in 2025 compared to the 5,449 reported for 2003, a 54% increase.

Finland

In Finland cancer registration started in 1953 and data is available for years since 1977. The incidence trends are shown in Figures 11 and 12. The trends in abortion and fertility in Finland are shown in Figures 8 and 9. By using data for recent years it was possible to fit the model.

The latest available TAR for Finland is 0.34 and the latest TFR is 1.7. In the modeling these gave an expected decrease in the rate of cancer of 6.8%, i.e. a yearly compound decrease of 0.28%, reflecting the decline in the Finnish abortion rate and some recovery in the birth rate in Finland. The forecast increase to 4,045 breast cancers in 2025, compared to the 3,794 reported for 2003, results from the aging of the population.

A negative social gradient in Finland is reported in a large study. "Cancers of the breast were most common in high social classes throughout the whole observation period 1971–1995. The relative difference between the SIRs (Standardised Incidence Ratios) of social classes I and IV diminished from 2-fold in the period 1971–1975 to 1.5-fold in 1991–1995. SIRs were 1.67 in social class I and 0.81 in social class IV in 1971–1975 and 1.4 and 0.81 respectively in 1991–1995."[25]

The social gradient was not explicable in terms of fertility. "In Finland there is relatively little difference between social classes in the age at first birth and average number of children."[25] Abortion was not considered as an explanatory variable in this study. If it had been considered, the gradient might have been better understood. The lessening of the social gradient may be linked to a decline in the Finnish abortion rate.

Denmark

In Denmark cancer registration goes back to the 1940s but data after 2001 is not available. The trend is similar to other countries discussed above (Figures 11 and 12). Abortion rates declined after 1989 (Figure 8) and are less than in Sweden and England. Fertility shows a decline similar to that in Sweden (Figure 9).

Cohort fertility for years of birth before 1945 and abortion rates before 1973 were estimated. Age-specific fertility rates were not available for earlier years, and approximate estimates were made. Trend lines proved nonlinear, and model fitting was difficult. Modeling used a fixed intercept and recent data with results summarized in Table 1. The latest TAR (0.45) and TFR (1.8) gave an expected decrease in the rate of cancer of 4.1%, i.e. a yearly compound decrease of 0.16%. This decline reflects the decline in the Danish abortion rate.

A social gradient has also been found in Denmark.[26,27] A large Danish national study[27] found a higher incidence of breast cancer in the higher social classes. Academics (persons with higher education) had the highest risk of breast cancer, which was 74% above that of women in agriculture, who had the lowest risk. The records were adequate to control for various risk factors, and the study concluded that "the large social differences in fertility history among Danish women could not explain the social differences in breast cancer risk."[26] In particular, "[a]ge at first birth and parity could not explain the effect of socioeconomic group on breast cancer incidence and mortality."[27] Abortion was not considered as a relevant factor. If it had been considered the gradient might have been explained.

Summary

In most countries considered, women now over age 45 have had more abortions and fewer children than previous generations of women, and a further increase in breast cancer incidence is to be expected. Variations in breast cancer incidence across social class and across geographic regions can also be expected to increase.

In England, a high rate of abortion leads to the large forecast increase. In Scotland, the lower abortion rate, offset by lower fertility than in England, leads to a slightly lower rate of increase expected. In both Irish jurisdictions, a continuation of low abortion rates and comparatively high fertility rates lead to low forecast increases in incidence of breast cancer. In Sweden a high abortion rate is offset partly by fewer nulliparous abortions and a high level of fertility and breastfeeding.

In the Czech Republic, the forecast of an increase in breast cancer incidence is largely the result of the fallen birth rate. In Finland and Denmark, lower abortion rates imply less breast cancer in the future.

The negative or reverse social gradient whereby upper class women have more breast cancer is apparent in four countries where it is measured: England & Wales, Scotland, Finland, and Denmark. In all of these countries the known reproductive factors other than abortion fail to explain the gradient. But the known likelihood for upper class and upwardly mobile women to prefer abortions when pregnant could provide some explanation of this gradient. If abortions had been examined in the studies of this social gradient, the role of this factor could have been made clear.

Conclusion

The increase in breast cancer incidence appears to be best explained by an increase in abortion rates, especially nulliparous abortions, and lower fertility. And the social gradient, which is not explained by fertility, seems also attributable circumstantially to abortion. A linear regression model of successive birth cohorts of women with abortion and fertility as explanatory variables fitted to the cancer incidence up to 1977 has produced forecasts that have performed well in the years 1998–2004 in Great Britain (Appendix A). The new forecasts for eight countries can be tested in the coming years.

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Appendix A. Female Breast Cancers and Ductal Carcinoma in Situ (DCIS) in England & Wales: Comparison of Forecast Numbers Published in 2002[21] with Reported Incidence in the Years 1998–2004

Modelling based on breast cancer incidence data up to 1997 was used to forecast incidence over future years through 2027. Forecast rates were applied to the projected female population in the 1998-based forecast made by the UK Government Actuary to calculate forecast numbers of cancers.

In these 1997-based forecasts, the same rate of increase in incidence was assumed to apply to all age groups.

Two forecasts were made: (1) Using model fitting without weighting to allow for additionally carcinogenic effect of nulliparous abortions gave a lower increase in rates of 44.4% over 30 years, or 1.25% per annum. (2) With weighting to allow for the additionally carcinogenic effects of nulliparous abortions, the model gave a higher increase of 2.2% per annum or 92% over 30 years.

Tables 1A-3A show the observed cases from official counts of new cases and the expected numbers calculated with the unweighted model, for cancers, ductal carcinoma in situ (DCIS), and cancers combined with DCIS, respectively. The forecast tended to underestimate slightly the number of cancers; the ratio of observed to expected was 1.013 (101.3%) in 2004. For DCIS, the underestimate, O/E = 1.54 (154.3%) for 2004, was much more notable, probably owing to extension of screening programs. The combined rate of cancers and DCIS was somewhat underestimated, O/E = 1.04 (104.4%) in 2004.

Weighting for the increased carcinogenicity of nulliparous abortions gave the results shown in Tables 4A-6A for cancers, DCIS, and cancers combined with DCIS, respectively. Cancers were slightly overestimated, O/E = 0.946 (94.6%) for 2004. DCIS was underestimated, but less so than with the first model: O/E = 1.44 (144%) in 2004. The combined forecast proved quite good, with 100.5% of the total new malignancies anticipated in 2003, and 97.5% in 2004.

Table 1A. Number of Female Breast Cancers in England & Wales, Observed v. Predicted from Unweighted Model

		Age Groups						
Year		15-44	45-49	50-54	55-59	60+	All ages	% Observed/ Expected
1998	Expected	3842	3189	4678	3585	18856	34150	101.5
	Observed	4005	3099	4633	3880	19029	34646	
1999	Expected	3944	3177	4814	3731	19702	35368	102.5
	Observed	4153	3088	5031	4198	19791	36261	
2000	Expected	4062	3180	4904	3888	19294	35328	101.4
	Observed	4151	3042	4951	4138	19544	35826	
2001	Expected	4206	3236	4972	4119	19588	36121	100.7
	Observed	4161	2950	4957	4477	19846	36391	
2002	Expected	4310	3319	4797	4533	19836	36795	99.8
	Observed	4101	2993	4514	4819	20293	36720	
2003	Expected	4339	3412	4733	4788	20176	37448	103.6
	Observed	4214	3066	4554	5396	21575	38805	
2004	Expected	4482	3520	4743	4940	20543	38228	101.3
	Observed	4312	3268	4439	5136	21557	38712	

Forecast based on incidence of breast cancer up to 1997

Table 2A. Number of Cases of Female DCIS in England & Wales, Observed v. Predicted from Unweighted Model

		Age Groups						
Year		15-44	45-49	50-54	55-59	60+	All ages	% Observed/ Expected
1998	Expected	191	318	467	371	739	2086	115.6
	Observed	136	231	674	454	917	2412	
1999	Expected	196	317	480	386	751	2130	130.8
	Observed	255	272	765	488	1006	2786	
2000	Expected	202	317	489	402	761	2171	139.7
	Observed	279	243	804	544	1163	3033	
2001	Expected	209	323	496	426	769	2223	141.8
	Observed	264	272	832	622	1163	3153	
2002	Expected	214	331	478	469	780	2272	143.9
	Observed	290	261	813	675	1230	3269	
2003	Expected	219	340	472	496	799	2326	157.5
	Observed	278	249	817	789	1530	3663	
2004	Expected	223	351	473	511	822	2380	154.3
	Observed	315	275	827	612	1644	3673	

Table 3A. Combined Cases of Female Breast Cancer and DCIS in England & Wales, Observed v. Predicted from Unweighted Model

		Age Groups						
Year		15-44	45-49	50-54	55-59	60+	All ages	% Observed/ Expected
1998	Expected	4033	3507	5145	3956	19595	36236	102.3
	Observed	4141	3330	5307	4334	19946	37058	
1999	Expected	4140	3494	5294	4117	20453	37498	104.1
	Observed	4408	3360	5796	4686	20797	39047	
2000	Expected	4264	3497	5393	4290	20055	37499	103.6
	Observed	4430	3285	5755	4682	20707	38859	
2001	Expected	4415	3559	5468	4545	20357	38344	103.1
	Observed	4425	3222	5789	5099	21009	39544	
2002	Expected	4524	3650	5275	5002	20616	39067	102.4
	Observed	4391	3254	5327	5494	21523	39989	
2003	Expected	4558	3752	5205	5284	20975	39774	106.8
	Observed	4492	3315	5371	6185	23105	42468	
2004	Expected	4705	3871	5216	5451	21365	40608	104.4
	Observed	4627	3543	5266	5748	23201	42385	

Table 4A. Number of Female Breast Cancers in England & Wales, Observed v. Predicted from Model Weighted for Nulliparous Abortions

		Age Groups						
Year		15-44	45-49	50-54	55-59	60+	All ages	% Observed/ Expected
1998	Expected	3880	3220	4725	3621	19042	34488	100.5
	Observed	4005	3099	4633	3880	19029	34646	
1999	Expected	4022	3241	4909	3805	19450	35427	102.4
	Observed	4153	3088	5031	4198	19791	36261	
2000	Expected	4183	3275	5051	4005	19872	36386	98.5
	Observed	4151	3042	4951	4138	19544	35826	
2001	Expected	4375	3365	5172	4284	20374	37570	96.9
	Observed	4161	2950	4957	4477	19846	36391	
2002	Expected	4527	3487	5039	4761	20836	38650	95.0
	Observed	4101	2993	4514	4819	20293	36720	
2003	Expected	4666	3619	5021	5079	21402	39787	97.5
	Observed	4214	3066	4554	5396	21575	38805	
2004	Expected	4802	3771	5081	5292	21981	40927	94.6
	Observed	4312	3268	4439	5136	21557	38712	

Table 5A. Number of Cases of Female DCIS in England & Wales, Observed v. Predicted from Model Weighted for Nulliparous Abortion

		Age Groups						
Year		15-44	45-49	50-54	55-59	60+	All ages	% Observed/ Expected
1998	Expected	193	321	471	375	746	2106	114.5
	Observed	136	231	674	454	917	2412	
1999	Expected	200	323	490	394	765	2172	128.3
	Observed	255	272	765	488	1006	2786	
2000	Expected	208	327	504	414	784	2237	135.6
	Observed	279	243	804	544	1163	3033	
2001	Expected	218	336	516	443	800	2313	136.3
	Observed	264	272	832	622	1163	3153	
2002	Expected	225	348	503	493	819	2388	136.9
	Observed	290	261	813	675	1230	3269	
2003	Expected	232	361	501	526	847	2467	148.5
	Observed	278	249	817	789	1530	3663	
2004	Expected	239	376	507	547	881	2550	144.0
	Observed	315	275	827	612	1644	3673	

Table 6A. Combined Cases of Female Breast Cancer and DCIS in England & Wales, Observed v. Predicted from Model Weighted for Nulliparous Abortion

		Age Groups						
Year		15-44	45-49	50-54	55-59	60+	All ages	% Observed/ Expected
1998	Expected	4073	3541	5196	3996	19788	36594	101.3
	Observed	4141	3330	5307	4334	19946	37058	
1999	Expected	4222	3564	5399	4199	20215	37599	103.9
	Observed	4408	3360	5796	4686	20797	39047	
2000	Expected	4391	3602	5555	4419	20656	38623	100.6
	Observed	4430	3285	5755	4682	20707	38859	
2001	Expected	4593	3701	5688	4727	21174	39883	99.2
	Observed	4425	3222	5789	5099	21009	39544	
2002	Expected	4752	3835	5542	5254	21655	41038	97.4
	Observed	4391	3254	5327	5494	21523	39989	
2003	Expected	4898	3980	5522	5605	22249	42254	100.5
	Observed	4492	3315	5371	6185	23105	42468	
2004	Expected	5041	4147	5588	5839	22862	43477	97.5
	Observed	4627	3543	5266	5748	23201	42385	