Declining Hysterectomy Prevalence and the Estimated Impact on Uterine Cancer Incidence in Scotland

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Highlights

- Hysterectomy prevalence in Scotland has decreased by 23% between 1996 to 2015.
- Uterine cancer incidence increased by 20% after adjusting for hysterectomies.
- Annual percentage change in uterine cancer incidence in Scotland remained stable.

Abstract

Aim: Hysterectomy prevalence is decreasing worldwide. It is not clear if changes in the population at risk (women with intact uteruses) have contributed to an increased uterine cancer incidence. This study aims to assess the effect of changing trends in hysterectomy prevalence on uterine cancer incidence in Scotland.

Methods: The population of women aged 25 years or older with intact uteri was estimated using estimated hysterectomy prevalence in 1995 and the number of procedures performed in Scotland (1996 – 2015). Age-standardised uterine cancer incidence was estimated using uncorrected (total) or corrected (adjusted for hysterectomy prevalence) populations as denominators and the number of incident cancers as numerators. Annual percentage change in uterine cancer was estimated.

Results: Hysterectomy prevalence fell from 13% to 10% between 1996-2000 and 2011-2015, with the most marked decline, from 20% to 6%, in the 50-54 year age group. Age-standardised incidence of uterine cancer increased after correction for hysterectomy prevalence by 20-22%. Annual percentage change in incidence of uterine cancer remained stable through the study period and was 2.2 (95% CI 1.8 -2.7) % and 2.1 (95% CI1.7- 2.6) %, for uncorrected and corrected estimates, respectively.

Conclusion: Uterine cancer incidence in Scotland corrected for hysterectomy prevalence is higher than estimates using a total female population denominator. The annual percentage increase in uterine cancer incidence was stable in both uncorrected and corrected populations despite declining hysterectomy prevalence. The rise in uterine cancer incidence, thus, may be driven by other factors including an ageing population, changing reproductive choices and obesity.

Introduction

Uterine cancer or more specifically, corpus uteri cancer is the most common gynaecological cancer and the fourth most common cancer affecting women in the United Kingdom [1]. In the past ten years, the incidence of uterine cancer in Scotland has increased by 32%, representing the greatest relative increase among all cancer types [2]. Similar trends have been reported in other developed countries. In the United States of America, uterine cancer is set to become the third most common female malignancy, surpassing lung and colorectal cancer [3, 4]. This increase in incidence is attributed to low grade endometrioid or type 1 cancers, thought to be driven by excess oestrogen and insulin associated with obesity [5]. Several authors, however, have highlighted that the changing patterns in hysterectomy could play an important part in influencing time trends in uterine cancer [6, 7]. In Scotland, the numbers of hysterectomies performed for benign conditions have more than halved since the mid-1990s [7], leaving a larger population of women at risk of developing uterine cancer. Similar patterns are seen in England and Wales [8].

Inclusion of women who have had a hysterectomy in the population denominator leads to under-estimation of incidence and risk of uterine cancer [9-11]. A lack of information regarding hysterectomy prevalence means that the total population of women is commonly used as the denominator in estimates of uterine cancer incidence. Thus, the true incidence of uterine cancer and accurate data on time trends are not known. We have tested the hypothesis that correcting for changing trends in hysterectomy prevalence will influence recent time trends in uterine cancer incidence.

Materials and Methods

Data source

Mid-year population data in five year age groups for 1996-2015 were provided by the National Records of Scotland [12]. As a consequence of imprecise coding, epidemiological studies tend to use uterine cancer [i.e. malignant neoplasm of corpus uteri (C54) and malignant neoplasm of uterus, part unspecified (C55), a majority of which arise from the endometrium] as the outcome of interest. Uterine cancer cases were identified by ICD-10 (tenth revision of International Classification of Diseases and Related Health Problems) codes of C54-55 and were obtained by year of diagnosis (1996-2015) and five-year age groups from Information Services Division (ISD) Scotland [2]. The study period was chosen to reflect the recent reduction in numbers of hysterectomies and to include the most recent data on cancer incidence.

As in many countries, data on the prevalence of hysterectomy in Scotland are not available. Estimates of hysterectomy prevalence were generated using the assumption that the prevalence in 1995 was similar to that estimated in England and Wales [6]. The number of hysterectomies carried out in Scotland between 1996 and 2015 by age group and calendar year was obtained from ISD [corresponding to the Office of Population Censuses and Surveys (OPCS-4) codes for hysterectomy Q07.2, Q07.4, Q07.5, Q08.2 and R25.1]. These data were derived from information regarding inpatient and day cases from publically funded hospitals in the Scottish Morbidity Records database, which corresponds to the Hospital Episode Statistics databases in England and Wales. A national linked database of general hospital discharge records, cancer registrations and mortality records has been established in Scotland by probability matching since 1981, while cancer registration data are recorded and available from 1958 onwards[13, 14]. More recently, widespread use of the Community Health Index (CHI), a unique national identifying number has strengthened the reliability of this data, with false positive and false negative linkages maintained below 1%[15].

Statistical Methods

Estimation of hysterectomy prevalence and population at-risk

The estimation of hysterectomy prevalence for each of the five year periods and the subsequent estimation of the female population at-risk of uterine cancer were performed using the method described by Lyon and Gardner [9]. The number of Scottish women who had a hysterectomy prior to 1996 by five year age groups between 25 and 85+ years was estimated by multiplying the number of women in Scotland derived from mid-year population estimates by the hysterectomy prevalence estimated for England and Wales in the same age group. The lower age limit of 24 years was chosen to match estimates for England and Wales [6]. The number of women who subsequently had a hysterectomy by calendar year and age group was:

1. divided by the total female population to provide estimates of hysterectomy prevalence
2. subtracted from the number of women in the original cohort to provide estimates of the population with an intact uterus and are therefore at risk of uterine cancer.

The proportions of women who had an intact uterus was estimated by dividing the number of women estimated to have an intact uterus by the whole population of women in the cohort in each five year strata of age and calendar period. These proportions were used as correction factors and were multiplied by the mid-year population estimates for each age group and calendar year for women aged 25 years or olderin Scotland between 1997 and 2015 to obtain estimates of the female population at risk of uterine cancer. The latter step enabled changes in population size and distribution from the original 1996 cohort to be taken into account.

Estimation of uncorrected and corrected incidences of uterine cancer and analysis of trends

The incidence of uterine cancer was estimated for each age group and five year period. The number of cases of uterine cancer (Supplementary Table 2) formed the numerator for estimates of incidence and the total female population was the denominator for uncorrected estimates while the female

population at risk was the denominator for corrected estimates of uterine cancer incidence. Direct-standardisation using the European Standard Population 2013 [16] was used to generate age-standardised estimates.

The annual percentage change (APC) was estimated using JoinPoint software using the Akaike Information Criterion model. A minimum of zero joinpoints and a maximum of three joinpoints were allowed in the regression to identify linearity of time trends [17]. Mid-year age-standardised incidence of uterine cancer was used as the dependent variable, and calendar year as the independent variable in the regression models. The analysis was carried out using Rx64 3.3.3 and JoinPoint regression software (Desktop version 4.5.0.1). Methodological detail are included in Supplementary Material.

Results

Hysterectomy prevalence among all women aged 25 years or older in Scotland was estimated to be 13% in 1996-2000 and 10% in 2011-2015 (Table 1). The proportions of women who had a hysterectomy decreased over time in younger women (for example from 20% to 6% for women of 50-54 years of age, but increased in the women over 64 years of age; for example from 18% to 20% in women of 70-74 years of age between 1996-2000 and 2011-2015. The numbers of incident uterine cancers increased by 40%, from 2,432 cases in 1996-2000 to 3,973 cases in 2011-2015.

Corrected and uncorrected incidence of uterine cancer

Before correction, uterine cancer incidence (95% confidence intervals) per 100,000 women increased from 20.5 (19.7 to 21.3) in 1996-2000 to 28.4 (27.5 to 29.3) in 2011-2015. Following correction for hysterectomy prevalence, the age-standardised incidence of uterine cancer was 20-22% higher over all time periods (Table 1 & Figure 1).

The uncorrected increase in incidence between the first and last five year calendar period was 39%. After correction, the incidence of uterine cancer increased by 36%; from 25/100,000 (95%CI 24-26) women in 1996-2000 to 34/100,000 (95%CI 33-35) in 2011-2015 (Table 1). This discrepancy between uncorrected and corrected time trends reflects the decrease in prevalence of hysterectomy over time and a smaller difference between the whole female population and the female population at risk in the latter time periods. The peak age of uterine cancer incidence increased; from 60-64 years in 1996-2001 to 70-74 years in 2011-2015 (Figure 1).

The joinpoint regression analysis did not identify any joinpoints, demonstrating that the annual rate of increase in uterine cancer incidence was linear throughout the study period. Figure 2 shows time trends in uterine cancer incidence from 1996 to 2015 before and after correction for hysterectomy prevalence. The annual percentage changes were 2.2% (95% CI 1.8 to 2.7) in uncorrected incidence and were slightly lower at 2.1% (95% CI 1.7 to 2.6) in corrected incidences.

Discussion

Hysterectomy prevalence decreased between 1996 and 2015 in Scotland, resulting in a higher proportion of women at risk of uterine cancer. Correcting female population estimates for hysterectomy prevalence revealed an increase in estimated uterine cancer incidence by 22% between 1996 -2010 and by 20% between 2011-2015. However, correcting for changing hysterectomy prevalence had little effect on time trends of uterine cancer estimates.

Patterns of changing prevalence of hysterectomy varied with age. Estimated hysterectomy prevalence between 1996 and 2015 decreased among women < 65 years, while increasing in older women, as a consequence of the age-period-cohort effect [18, 19]. Hysterectomy prevalence was particularly high in the cohort born in 1942-1950 and likely to have undergone a hysterectomy between 1982-2000; hysterectomies were commonly performed among women aged 40 to 50 years [6].

Approximately 60% of British women with heavy menstrual bleeding referred to a gynaecologist underwent a hysterectomy prior to 1991 [20]. Subsequent introduction of effective non-surgical therapies including endometrial ablation and the levonorgestrel-releasing intrauterine coil resulted in a reduction in hysterectomies. The annual number of hysterectomies performed in England fell by two-thirds between 1995 and 2005 [8].

The hysterectomy prevalence estimates obtained in Scotland were lower than those reported by previous UK studies in earlier time periods [6] and half the prevalence reported by a recent German study [21]. These differences could be due to time trends described above and one or both of lower starting hysterectomy prevalence or a sharper decrease in hysterectomy incidence over time in Scotland.

The estimates of uncorrected and corrected uterine cancer incidence obtained were higher than those estimated for England and Wales for 1971-1992. Redburn and Murphy report a corrected

uterine cancer incidence of 16/100,000 women in England and Wales in 1992 [6], compared with 21/100,000 women in our study in 1996-2000. This increase is in keeping with reported trends in UK uterine cancer incidence. The effects of correcting for hysterectomy on uterine cancer incidence appear to have remained constant at 17-22% over the time period covered by the two studies. This finding suggests that factors other than changing hysterectomy prevalence (e.g rising trends in obesity and diabetes, global changes in reproductive choices i.e. nulliparity [22]) are contributing to the increasing incidence and risk of uterine cancer over time. In Finnish populations, correcting for hysterectomy resulted in a 29% increase in the incidence of uterine cancer. In Finland, uncorrected uterine cancer rates showed a plateau in the 1980s, not seen in corrected rates, which was explained by the increasing prevalence of hysterectomy [23]. These are converse to our findings in Scotland where time trends in uncorrected and corrected incidence were similar, thus re-iterating the possible causative role of obesity in increasing uterine cancer incidence.

Our findings differ from American studies reporting corrected incidence rates of uterine cancer of 57-66/100,000 women, almost double the reported rate in Scotland [24]. The increase following correction for hysterectomy prevalence ranged from 65-73% in white, non-Hispanic women, and up to 93% in black non-Hispanic women [25, 26]. This difference emphasises the potential significant underestimation of uterine cancer in a population where hysterectomies are commonly performed.

This study is the first to estimate uterine cancer incidence corrected for hysterectomy prevalence in Scotland, where the rates of hysterectomy have more than halved in the last 15 years[7]. A strength of this study is the robust national population-based data capture, coding and linkage of uterine cancer cases and hysterectomy procedures. Hospital admissions and surgical procedures, including hysterectomy are recorded for all patients admitted to Scottish National Health Service (NHS) hospitals. The quality of cancer registration data in Scotland is believed to be comparatively high[27]. This is based on routinely available indicators and studies of completeness of case ascertainment[28] and data reliability[29]. Recent quality assurance data suggests that in hospital

discharge records coding of clinical conditions and procedures is maintained at an accuracy of 89-94%[30]. Uterine cancer was used as the main outcome, which incorporates both malignant neoplasm of the corpus uteri (C54) and malignant neoplasm of uterus part unspecified (C55), as a large proportion of cancers of the uterus are described as "not specified". Neoplasm of the corpus uteri is a more precise code for uterine or endometrial cancer, because the malignant neoplasm of the uterus, part unspecified code may incorporate cancer of the cervix. However, in a sensitivity analysis limited to cases coded as corpus uteri (C54), the percentage increase from uncorrected to corrected incidence was identical at 20-22%.

A limitation of this study in the estimation of hysterectomy prevalence is the use of the Lyon and Gardner approach [9] which assumes a static population and that hysterectomy prevalence at the start of 1996 would be similar in Scotland to that in England and Wales. The correction factors derived were obtained using an index population originating from the population in the first year of interest from which women who have had hysterectomies in subsequent years are cumulatively excluded. Unfortunately we were unable to find a source of data that would have allowed us to validate our estimates of hysterectomy prevalence. This approach does not permit a completely accurate estimate of time at risk because all estimates were based on calendar years rather than using exact dates. Women who have a hysterectomy for uterine cancer are included in the numerator in the year in which the cancer was recorded and are excluded from the denominator (and numerator) for the subsequent year. Joinpoint regression aims to identify time points where trends change. Although this analysis only applies to annual percentage change and prevalence change was not carried out from one period to the next, prevalence change had been accounted for during the estimation of incidence. Finally, ISD data are collected from publically funded NHS hospitals and information on the anecdotally small number of hysterectomies carried out privately were not available.

This study has shown that the incidence of uterine cancer is significantly underestimated when hysterectomy prevalence is not taken into account. However, even after adjusting for hysterectomy prevalence, the incidence of uterine cancer has increased by 36% between 1996 and 2015. Thus, the increase in uterine cancer incidence must have other causative factors. Ageing of the population contributes to increasing numbers of incident cases over time but does not influence age-standardised rates. As hysterectomy prevalence decreased over time the relative difference between uncorrected and corrected estimates of incidence declined slightly but still remained around 20%. While we anticipated that correcting for declining hysterectomy prevalence would result in a larger female population at risk and thus a greater annual percentage increase in incidence, the annual percentage change remained stable over the study period. Consequently, while uterine-sparing therapies and a decrease in hysterectomy prevalence have contributed to the recent increase in uterine cancer incidence in Finland, this is not the case in Scotland. It is instead likely that the obesity epidemic is a key driver in the upsurge of uterine cancer cases.

Another factor to consider is that the recent decline in hysterectomies has not yet affected the age group where uterine cancers occur. Women born after 1955, who have undergone the lowest number of hysterectomies are approaching the peak age (60-69) for first diagnosis of uterine cancer. Thus the impact of declining hysterectomy prevalence may be impending. A further explanation for our findings is that morbidly obese women who are at the highest risk of uterine cancer, are the least likely to be offered a hysterectomy for benign causes, because of increased surgical morbidity.

We have demonstrated the importance of using a corrected female population denominator, by excluding women who have had a hysterectomy, in providing more accurate estimates of uterine cancer incidence in Scotland. Ongoing research is required to establish the longer-term consequences of the reducing prevalence of hysterectomy, particularly as the cohort of women among whom it will have the most impact reaches the age at which uterine cancer incidence is

highest. Identifying effective approaches to the prevention and management of obesity remains an important challenge to thwart further increases in uterine cancer incidence.

Additional Information

Ethical approval and consent to participate

The study was assessed by the University of Edinburgh Self-Audit for Ethical Review and confirmed to have no foreseeable ethical risks and did not require formal ethical approval and consent.

Conflict of interest statement

None declared

Keywords

Endometrial; Womb ; Uterine; Cancer; Hysterectomy

Authors' contributions

This article presents independent research performed by GR for her MPH dissertation at the University of Edinburgh. The data were provided by the Information Services Division, of National Health Service National Services Scotland (ISD). DB and SW provided the concept and designed the study. SW acquired the data. GR performed the data analysis and wrote the first draft of the manuscript. VS and SW contributed to data interpretation and the paper's critical revisions. VS prepared the final manuscript version which was reviewed and approved by all authors.

The views expressed are those of the authors and not necessarily those of the NHS, the NIHR or ISD.

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Figure Captions

Figure 1. Age-specific uterine cancer incidence in Scotland for 1996-2001 and 2011-2015, uncorrected and corrected for prevalence of hysterectomy.

Figure 2. Annual age-standardized incidence of uterine cancer before and after correcting for hysterectomy prevalence for the study period (1996-2015.)

Tables

Table 1: Estimated proportions (of women aged 25 years or older in Scotland who had a hysterectomy by five-year age-group from 25-29 to 85+and five year periods between 1996 and 2015.

Age Group	Percentage prevalence of hysterectomies in females in Scotland			
	1996-2000	2001-2005	2006-2010	2011-2015
25-29	0.3	0.1	0	0
30-34	1.6	0.5	0.2	0.1
35-39	5	2	0.7	0.3
40-44	10.4	5.4	2.4	1
45-49	16.1	11	6	2.7
50-54	20.2	16.4	11.2	6.2
55-59	20.3	20.4	16.6	11.4
60-64	19.1	20.5	20.5	16.8
65-69	18.2	19.2	20.6	20.7
70-74	17.7	18.3	19.4	20.8
75-79	17	17.8	18.4	19.5
80-84	15.5	17.1	17.9	18.5
85+	13.2	15.5	17.1	17.9

Table 2: Age-standardised incidence of uterine cancer per 100,000 female population for each five-year period between 1996 and 2015 in Scotland before and after adjusting for hysterectomy prevalence and absolute and relative increases after correction.

Five Year Period	Uncorrected incidence/100,000 (95%CI)	Corrected incidence/100,000 (95%CI)	Absolute change (increase) after correction/ 100,000	Percentage increase after correction (%)
1996-2000	20.5 (19.7 – 21.3)	25.0 (24.0 – 26.0)	4.5	22
2001-2005	22.6 (21.8 – 23.5)	27.6 (26.6 – 28.6)	5.0	22
2006-2010	25.0 (24.2 – 25.9)	30.4 (29.4 – 31.5)	5.4	22
2011-2015	28.4 (27.5 – 29.3)	34.1 (33.0 – 35.2)	5.7	20

Figures

Figure 1

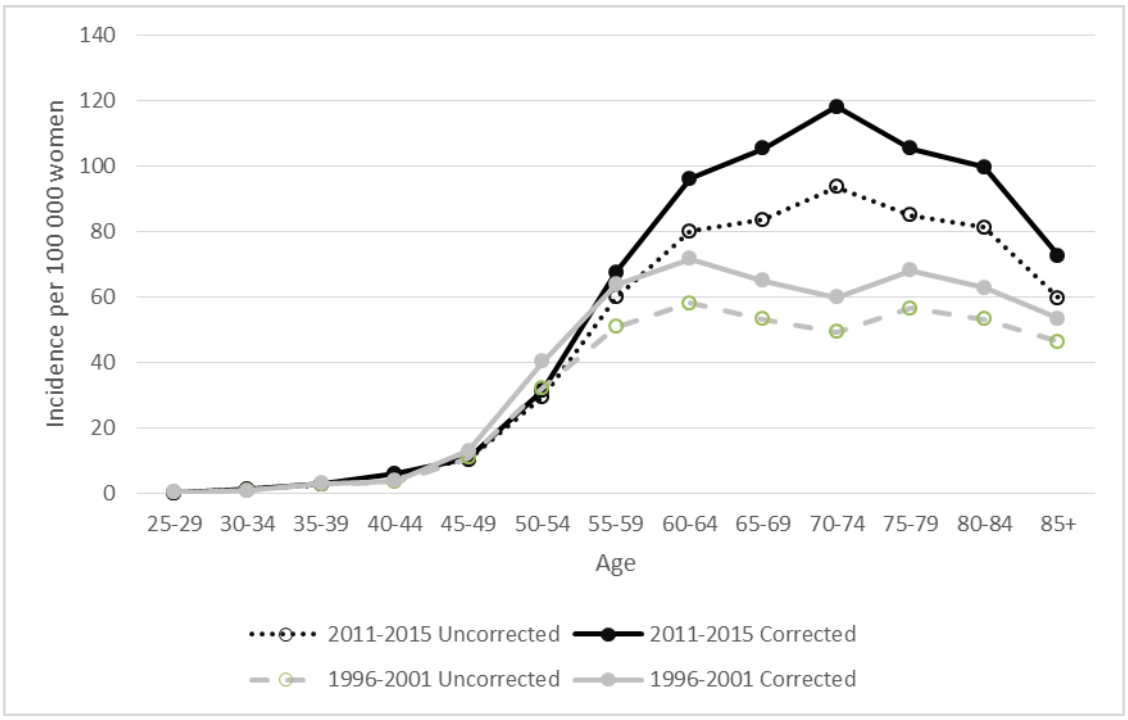
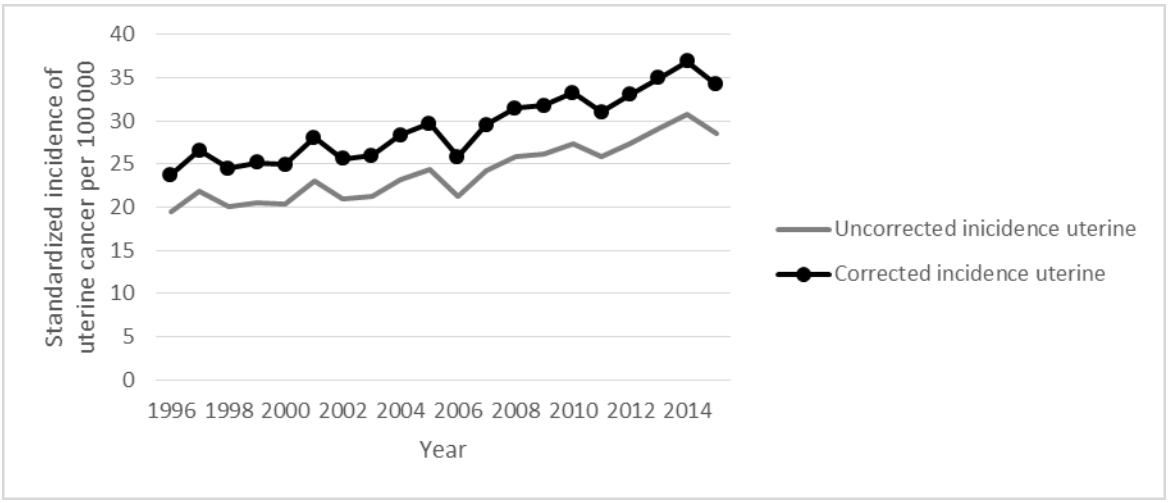


Figure 2



Supplementary Information : Estimating prevalence of hysterectomy in Scotland (1996-2015)

This file describes the method used to derive estimates of hysterectomy prevalence in Scotland during the study period 1996-2015. The approach adopted was essentially that used by Lyon & Gardner [9], and was based on the following principles:-

- The study period would be divided into periods of five calendar years (1996-2000; 2001-2005; 2006-2010; and 2011-2015).
- Within each time period, age-specific prevalence of hysterectomy would be estimated for five-year age intervals (0-4, 5-9, 10-14, 15-19... ...80-84, with a final open interval 85+); however, zero prevalence would be assumed for all ages below 25 years.
- The starting prevalence values required to 'initialise' the method of Lyon & Gardner would be the five-year age-specific averages for England and Wales during the period 1991-1995 as reported by Redburn & Murphy (Table 1 in[6]).

Reflecting these principles, estimation proceeded as now described.

First, all-Scotland female population totals for 1996 (the earliest year of the study period) were obtained from National Records of Scotland [12].Then, a cohort model population was created by 'aging' these values following the method of Lyon & Gardner. Adopting the notation of ref. 9, the period- and age-specific population is generated as follows:-

for $j = 1$: P_{i1} = 1996 female population of Scotland

for $j > 1$: $P_{ij} = P_{i-1, j-1}$,

where i represents the grouped age (0-4, 5-9, 10-14, 15-19... ...80-84, 85+) and j denotes the five-year time period (j = 1: 1996-2000; j = 2: 2001-2005; j = 3: 2006-2010; j = 4: 2011-2015). An illustration of the aging process is given in Supplementary Table 1. Note that age groups earlier than 25 years are necessarily involved in the process (to avoid age groups of interest being 'lost' as time advances) even though - as previously stated - an assumption of zero hysterectomy prevalence at

ages <25 was made. Under this scheme, the size of the population is assumed to remain static (i.e. births, deaths and migrations are deemed not to occur). This is clearly a highly artificial assumption, and merits highlighting as a limitation of the method.

Next, the model population was adjusted by removing the numbers of women deemed to have had a hysterectomy. Continuing with the notation of Lyon & Gardner, the population in each age group / time period stratum (the quantity P_{ij} introduced above) was modified as follows:-

for $j = 1$: $P'_{i1} = P_{i1}(1 - H_{i1})$

for $j > 1$: $P'_{ij} = P'_{i-1, j-1} - P_{ij}H_{ij}$,

where H_{i1} represents the prevalence of hysterectomy in the ith age group for the period 1991-1995 as reported by Redburn & Murphy (Table 1 in ref. 6) and the H_{ij} ($j > 1$) represent the observed hysterectomy incidence rate (in the actual - not model - population of interest) for the preceding five-year time period. Some illustration of the process may be helpful.

Supplementary Table 2 repeats the '1996-2000' column of Supplementary Table 1, but with additional elements in each cell as follows. The central element represents the prevalence of hysterectomy (from Redburn & Murphy, re-expressed as a proportion e.g. '1.6%' is presented as 0.016). This is the quantity H_{i1}, in the notation of Lyon & Gardner. The lowermost cell entry gives the adjusted population P'_{i1}. Thus, for the age group 25-29 the adjusted population P'_{i1} is given by

198 148 * (1 - 0.003) = 198 148 * 0.997 = 197 554 *(rounded to nearest integer)*.

Similarly, the adjusted population P'_{i1} for age group 30-34 is calculated as

208 113 * (1 - 0.016) = 208 113 * 0.984 = 204 783.

For the remaining time periods (2001-2005 and later), the calculation of P'_{ij} is more complex, because the quantity H_{ij} now represents the observed *incidence* of hysterectomy (described by Lyon & Gardner as 'the operative hysterectomy rate') in the preceding five-year time period j-1. A

detailed example calculation for P'_{ij} is now provided. For the age-group 30-34 in the time period 2001-2005, the model population total P_{ij} is 198,148; the adjusted model population total in the previous age group / time period $P'_{i-1,\ j-1}$ is 197 554 (see Table 2); and the operative hysterectomy rate H_{ij} is approximated by calculating the average of the observed hysterectomy incidence rates for ages 30-34 over the five individual years of the *preceding* time period (1996-2000). It merits highlighting that the notation of Lyon & Gardner is arguably slightly misleading here. The quantity H_{ij} for $j > 1$ is defined as 'the operative hysterectomy rate for the *preceding* five-year period' [ref. (9) p. 440; emphasis added], so it might be more correct to identify this quantity as H_{ij-1}. However, the original notation is retained in the interests of consistency.

The numbers of hysterectomies performed at ages 30-34 and the corresponding year-specific total Scottish female populations, together with the hysterectomy incidence rates during 1996-2000, are

1996: 461 / 208 113 (incidence rate = 0.00222)

1997: 405 / 208 070 (0.01946)

1998: 429 / 206 727 (0.00208)

1999: 369 / 203 848 (0.00181)

2000: 250 / 199 590 (0.00125).

The average of the five rates is 0.00186, and this is treated as the five-year operative hysterectomy rate at ages 30-34 for the period 1996-2000. After Lyon & Gardner, the adjusted population is calculated as $P'_{ij} = P'_{i-1,\ j-1} - P_{ij}\ H_{ij}$; substituting the values derived as just described yields

P'_{ij} = 197 554 - (198 148 * 0.001865) = 197,185 *(rounded to nearest integer)*. This is the adjusted (i.e. hysterectomy-free) model population aged 30-34 in the five-year time period 2001-2005.

The final stage in the process of Lyon & Gardner involves calculating the 'correction factor'

$$f_{ij} = P'_{ij} \,/\, P_{ij},$$

representing the adjustment which is applied to the *actual* (observed) population to arrive at the adjusted (hysterectomy-free) population, intended for use here as the denominator in calculating the incidence of endometrial cancer. Continuing with the example used above, the correction factor f_{ij} for the age group 30-34 during the period 2001-2005 is (197 185 / 198 148) = 0.995139. The actual Scottish female population aged 30-34 during 2001-2005 is approximated as the sum of the five year-specific population totals

2001: 197 055 women aged 30-34

2002: 192 648

2003: 185 991

2004: 178 776

2005: 172 849

TOTAL: 927 319

Applying the correction factor, the adjusted (hysterectomy-free) female population aged 30-34 during the time period is estimated as 0.995139 * 927 319 = 922 812 *(rounded to nearest integer)*. 3)

Supplementary Table 3 shows the correction factors f_{ij} for the age range of interest (25 upwards) for each of the four time periods. This may be directly compared with Table 2 in Lyon & Gardner. Note that the correction factors may also be interpreted as prevalence rates for hysterectomy via the simple relation

prevalence = 1 - f_{ij}.

Adjusted population totals (i.e. the observed population in each age group / time period multiplied by the correction factors of Table 3) were used as denominators in the calculation of endometrial cancer rates for this study; they represent the estimated numbers of women at risk i.e. those considered hysterectomy-free.

Supplementary Table Legends

Supplementary Table 1. Observed (column '1996') and aged (remaining columns) population totals (women in Scotland). Note that cell contents propagate diagonally from upper left to lower right as time progresses. Italicised cells in leftmost column mark age groups which are not of direct interest i.e. those for which prevalence estimates will not be derived (these rows are intentionally left blank).

Supplementary Table 2. Illustration of calculating adjusted population P'_{i1} for earliest time period (see text for details).

Supplementary Table 3: Correction factors (proportion of actual population assumed not to have undergone hysterectomy) in specified age group / time period. The quantity (1 - cell content) is interpreted as the prevalence of hysterectomy.

Supplementary Table 1

	Time Period			
Age group	1996-2000	2001-2005	2006-2010	2011-2015
10-14				
15-19				
20-24				
25-29	198 148	170 987	153 140	156 660
30-34	208 113	198 148	170 987	153 140
35-39	194 993	208 113	198 148	170 987
40-44	171 653	194 993	208 113	198 148
45-49	178 707	171 653	194 993	208 113
etc.	...	...	...	...

Supplementary Table 2

age group	1996-2000
10-14	
15-19	
20-24	
25-29	198 148 0.003 197 554
30-34	208 113 0.016 204 783
35-39	194 993 0.050 185 243
40-44	171 653 0.104 153 801
45-49	178 707 0.161 149 935
etc.	...

Supplementary Table 3

Age group	**1996-2000**	**2001-2005**	**2006-2010**	**2011-2015**
25-29	0.997	0.999	1.000	1.000
30-34	0.984	0.995	0.998	0.999
35-39	0.950	0.980	0.993	0.997
40-44	0.896	0.944	0.976	0.990
45-49	0.839	0.890	0.940	0.973
50-54	0.798	0.836	0.888	0.938
55-59	0.797	0.796	0.834	0.886
60-64	0.809	0.795	0.795	0.832
65-69	0.818	0.808	0.794	0.793
70-74	0.823	0.817	0.806	0.792
75-79	0.830	0.822	0.816	0.805
80-84	0.845	0.829	0.821	0.815
85+	0.868	0.845	0.829	0.821