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Research Article

Trends in Endometrial Cancer Incidence by Race and Histology with a Correction for the Prevalence of Hysterectomy, SEER 1992 to 2008

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Abstract

Background: Incidence rates of endometrial cancer are routinely calculated without removing women who have had a hysterectomy from the denominator, which leads to an underestimate. Furthermore, as the number of women who have had a hysterectomy (hysterectomy prevalence) varies by race, the estimate of racial difference in endometrial cancer incidence is incorrect.

Methods: Data from 1992 to 2008 from the SEER Program were used to calculate incidence rates of endometrial cancer (corpus uterus and uterus, NOS) for 67,588 women 50 years and older. Data from the Behavioral Risk Factor Surveillance System were used to estimate hysterectomy prevalence. SEER area populations were reduced by hysterectomy prevalence, and corrected incidence rates were calculated.

Results: For women 50 years and older, the corrected incidence rate of endometrial cancer was 136.0 per 100,000 among whites and 115.5 among blacks, a 73% and 90% increase respectively compared with the uncorrected rate. The increase was greater for black women because hysterectomy prevalence was higher among black women (47%) than white women (41%). The corrected incidence among black women significantly increased 3.1% per year compared with a 0.8% significant decrease among white women resulting in higher rates among black women toward the end of the study period.

Conclusion: Correcting the incidence rate for hysterectomy prevalence provides more accurate estimates of endometrial cancer risk over time.

Impact: Comparisons of rates of endometrial cancer among racial groups may be misleading in the absence of denominator correction for hysterectomy prevalence. *Cancer Epidemiol Biomarkers Prev; 22(2); 233–41. ©2012 AACR.*

Introduction

Endometrial cancer is the most common cancer of the female genital tract and the fourth most commonly diagnosed cancer among women in the United States with 47,130 new cases and 8,010 deaths estimated in 2012 (1). The incidence rate for white women has been stable since 1992 but has been increasing among black women (2). Risk factors such as hormone replacement therapy use and obesity (3–7) and tumor characteristics including histologic subtype (8–12) vary by race.

Hysterectomy, the surgical removal of the uterus, is the second most frequently conducted major surgical procedure for women of reproductive age in the United States, and more than one third of all women have had a hysterectomy by age 60 (13, 14). From 2000 to 2004, the rate of hysterectomy in the United States was highest among women age 40 to 49 and varied by region with the highest rates found in the South and the lowest in the Northeast. Moreover, the proportion of women who have had a hysterectomy (referred to as "hysterectomy prevalence" in this article), varies by race and is highest among black women (14–18). Women who have had a hysterectomy are no longer at risk of endometrial cancer and failure to remove these women from the population at-risk leads to an underestimate of endometrial cancer incidence rates (15, 19–24) and an incorrect estimate of the difference in incidence among various population groups. Previous studies in the United States have reported endometrial cancer incidence rates corrected for hysterectomy prevalence for a fixed time interval (17, 23, 25); however, corrected trends of endometrial cancer have not been examined recently (26, 27).

This analysis examines trends in endometrial cancer incidence from 1992 to 2008 by histology among white and black women 50 years and older, both with and without correction for hysterectomy prevalence. In

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Note: Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (http://cebp.aacrjournals.org/).

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addition, corrected and uncorrected incidence rates are presented for white, black, Asian/Pacific Islander (API), and Hispanic women 50 years and older by endometrial cancer subtype.

Materials and Methods

Data sources

This analysis included white, black, and API women 50 years and older diagnosed from 1992 to 2008 with microscopically confirmed invasive cancer occurring in the corpus uterus (C54) and uterus NOS (C55) as defined by or converted to the International Classification of Diseases for Oncology, third edition (ICD-O-3; ref. 28). As approximately 90% of these cancers arise from the endometrium, we used the term endometrial cancer for all cancers of the corpus uterus and uterus NOS. Data were obtained from 12 population-based cancer registries in the Surveillance, Epidemiology, and End Results (SEER) Program (CT, HI, IA, NM, UT, metropolitan Detroit, metropolitan Atlanta, rural GA, Seattle-Puget Sound, San Francisco-Oakland, San Jose-Monterey, and Los Angeles; refs. 2, 29). These data cover 14% of the overall population of the United States (12% of whites, 12% of blacks, and 35% of APIs). Results are also presented for Hispanic women (22% population coverage), but these results are not mutually exclusive from the results by race. Women of American Indian/Alaska Native, other, and unknown race were excluded because there were not enough cases to analyze by histologic subtype.

Hysterectomy prevalence was estimated using data from the Centers for Disease Control and Prevention's (CDC's) Behavioral Risk Factor Surveillance System (BRFSS), the only national dataset available to estimate hysterectomy prevalence at the state level (30). The BRFSS is a cross-sectional state-specific telephone survey administered to adults 18 years and older living in households. While BRFSS results are based on self-reports, self-reports of hysterectomy have been found to be reliable (31, 32). BRFSS data were available for SEER states (CT, HI, IA, NM, and UT), but as BRFSS data are not routinely available at the county level, the entire state was used to represent SEER metropolitan areas (MI for Detroit, GA for Atlanta and rural GA, WA for Seattle Puget-Sound, and CA for San Francisco-Oakland, San Jose-Monterey, and Los Angeles). The hysterectomy question was asked each year from 1992 to 1999 and every other year thereafter (2000, 2002, 2004, 2006, 2008). This information along with race and current age was used to estimate annual race- and age-specific hysterectomy prevalence from 1992 to 2008.

Histology

The classification of endometrial cancer subtypes in this analysis was defined by Curtis and colleagues (33). Specifically, rates and trends are presented for 4 subtypes of endometrial cancer: type I which represents more than 80% of all endometrial cancer and is primarily endometrioid adenocarcinoma and adenocarcinoma, NOS (histology codes 8380 and 8140); type II which is primarily papillary serous cystadenocarcinoma and clear cell adenocarcinoma (codes 8460 and 8310); malignant mixed Mullerian tumors (codes 8950 and 8980); and all other invasive endometrial cancers combined including leiomyosarcomas, endometrial stromal, and adenosarcomas (33).

Within type I endometrial cancer, the proportion of cases belonging to the 2 most common histology codes changed over the study period; coding of adenocarcinoma, NOS (8140) decreased from a majority of the type I cases in 1992 to less than 10% in 2008, whereas the more specific endometrioid adenocarcinoma, NOS (8380) increased from less than 15% of the cases to a majority of the cases by 2008. As these codes both belong to type I endometrial cancer, the results over time were not impacted.

Statistical analysis

Age-adjusted incidence rates uncorrected for prevalence of hysterectomy among women 50 years and older by race were calculated using SEER*Stat software Version 7.07 (34). Rates were age-adjusted by the direct method using a truncated 2000 U.S. standard population with age groups 70 years and older combined (50–54, 55–59, . . ., 65–69, 70+) to align with estimates from the BRFSS. Rates were shown per 100,000 women and plotted on a log-linear scale (35). Rate ratios were calculated to quantify the changes in the risk of endometrial cancer among black, API, and Hispanic women relative to white women. In addition, incidence trends of endometrial cancer were estimated from 1992 to 2008 for 3-year time intervals (1992–1994, 1995–1997, . . ., 2007–2008) using Joinpoint Regression Program version 3.5.2 (36, 37). Joinpoint regression is a weighted least-squares regression technique that fits linear segments to log-transformed incidence rates and identifies time points at which statistically significant changes occur. Because of the 3-year time intervals, joinpoint models were fit allowing a maximum of one joinpoint. Trends were summarized by the annual percent change (APC) of the last segment. P values less than 0.05 were considered statistically significant.

The proportion of women who reported having a hysterectomy was estimated for women 50 years and older by race, 5-year age group and 3-year time interval using the BRFSS data from the states with SEER registries used in this analysis. Estimates for API and Hispanic women were imprecise and highly variable over time due to small unweighted sample sizes of women with hysterectomy. Therefore, only hysterectomy prevalence and corrected endometrial cancer incidence over the entire time period were calculated for these women. Finally, as there was some variation over time in hysterectomy prevalence estimates among white and black women, a linear regression was fit to the log of the prevalence rates over time for each race group. The smoothed estimated hysterectomy prevalence from the linear regression was back-transformed to the original scale and used for correction of the incidence rates.

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To estimate age-adjusted incidence rates and trends for women at risk of endometrial cancer, the SEER populations were reduced by the corresponding hysterectomy prevalence for each race, 5-year age group, and 3-year time interval (19, 20, 38). The corrected age-adjusted incidence rates for each race and year group were calculated as follows:

$$\sum_{i=50-54}^{70+}\left[\left(\frac{C_i}{L_i}\cdot\frac{1}{1-P_i}\right)\times 100,000\times\left(\frac{stdpop_i}{\sum_{j=50-54}^{70+} stdpop_j}\right)\right]$$

where C is the number of cases for a given race and year group, L is the population for a given race and year group, P is the estimated hysterectomy prevalence for a given race and year group, and *stdpop* is the 2000 U.S. standard population for a given age group. The standard error (SE) of the corrected incidence rate was calculated from the above equation considering the estimated hysterectomy prevalence as a constant. The populations used to calculate the incidence rates by age and year for white and black women combined were reduced by the race-, age-, and year-specific hysterectomy prevalence and then summed over race to provide the total population by age and year.

Because the SEs of the estimated hysterectomy prevalence rates from the BRFSS were large for some age and year groups among white and black women, we conducted a sensitivity analysis of the trend estimates by race for all histology types combined. To approximate the 95% confidence interval (CI) for the prevalence, the smoothed hysterectomy prevalence estimates were increased and then decreased by 10% for whites and 25% for blacks and the APC of incidence was estimated again. Because hysterectomy prevalence estimates over the entire time period were stable, a sensitivity analysis was not conducted for these estimates.

Results

Hysterectomy prevalence

Among women 50 years and older, the prevalence of hysterectomy from 1992 to 2008 was highest among black women (47%), lowest among API women (29%), and intermediate among white and Hispanic women (41% and 36%, respectively). Black women had higher hysterectomy prevalence than whites in all age groups. API women had lower hysterectomy prevalence than whites in younger age groups, but similar prevalence among women age 70+. All estimates of hysterectomy prevalence from the BRFSS and the smoothed estimates used for correction are presented in Supplementary Appendix A by age, race, and year.

Hysterectomy prevalence decreased over time among white women and remained fairly stable among black women (Fig. 1). Specifically, the prevalence among white women decreased from 42% in 1992 to 1994 to 36% in 2007 to 2008 but remained at 46% to 47% among black women. Although hysterectomy prevalence for all black women 50 years and older combined was stable, prevalence increased over time among women 60 years and older but decreased among women 50 to 59 years (Supplementary Appendix A).

Corrected and uncorrected endometrial cancer incidence rates and trends

The corrected age-adjusted incidence rates of endometrial cancer from 1992 to 2008 were highest among white

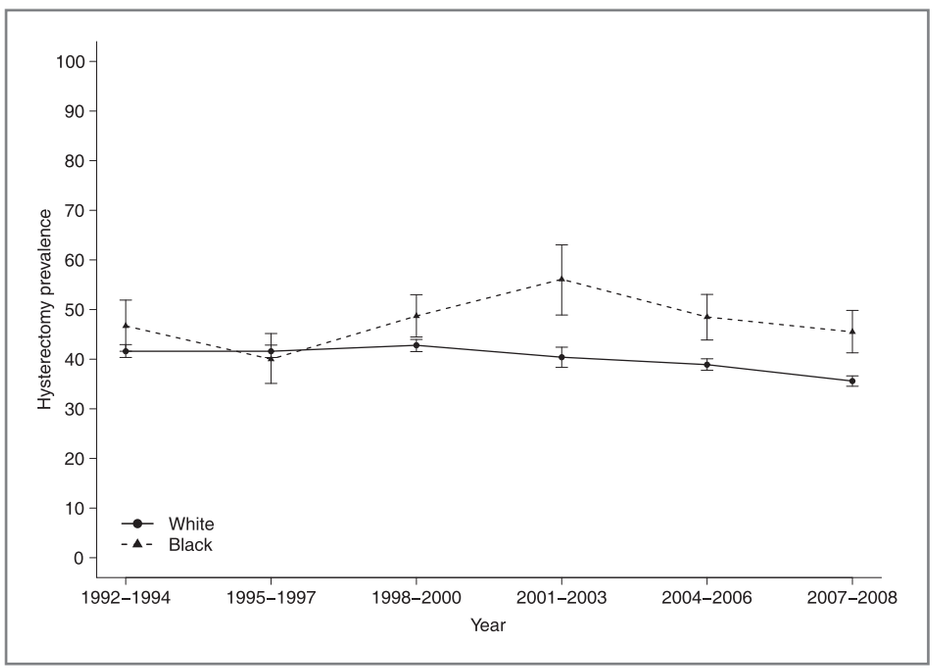

Figure 1. Estimated hysterectomy prevalence over time among white and black women age 50+. Error bars represent the 95% CI. Source: BRFSS public use file.

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Table 1. Age-adjusted endometrial cancer incidence rates by race and subtype, corrected and uncorrected for hysterectomy prevalence among women 50+, SEER 1992 to 2008

Type	Race	No. of cases	Uncorrected rate	Rate ratio	Corrected rate	Rate ratio
All						
	White	57,966	78.8	1.00	136.0	1.00
	Black	4,980	60.9	0.77	115.5	0.85
	API	4,642	47.5	0.60	67.4	0.50
	Hispanic[a]	4,802	51.0	0.65	82.3	0.61
Type I						
	White	48,702	66.3	1.00	114.2	1.00
	Black	2,993	36.4	0.55	69.0	0.60
	API	3,757	38.3	0.58	54.1	0.47
	Hispanic[a]	3,779	39.6	0.60	63.8	0.56
Type II						
	White	3,760	5.0	1.00	8.9	1.00
	Black	820	10.2	2.04	19.4	2.18
	API	348	3.6	0.72	5.3	0.60
	Hispanic[a]	414	4.6	0.92	7.7	0.87
Malignant mixed Mullerian tumors						
	White	2511	3.3	1.00	5.9	1.00
	Black	627	7.8	2.36	14.8	2.51
	API	220	2.3	0.70	3.4	0.58
	Hispanic[a]	261	2.9	0.88	4.9	0.83
Other						
	White	2993	4.1	1.00	7.0	1.00
	Black	540	6.5	1.59	12.3	1.76
	API	317	3.3	0.80	4.6	0.66
	Hispanic[a]	348	3.6	0.88	5.8	0.83

NOTE: ICD-O-3 histology codes for type I: 8050, 8140–8141, 8143, 8210–8211, 8260–8263, 8323, 8340, 8380–8381, 8440, 8470–8471, 8480–8481, 8490, 8550, 8560, 8570, 8571–8573.

Type II: 8310, 8441, 8460–8462.

Malignant mixed Mullerian: 8950–8951, 8980–8981.

Other: All other invasive endometrial cancers.

Source: incidence data from Surveillance, Epidemiology, and End Results (SEER) 13 areas covering about 14% of the U.S. population (CT, HI, IA, NM, UT, metropolitan Detroit, metropolitan Atlanta, rural GA, Seattle-Puget Sound, San Francisco-Oakland, San Jose-Monterey, and Los Angeles).

Hysterectomy prevalence data from BRFSS public use file.

[a]Hispanic is not mutually exclusive from white, black, and Asian Pacific Islander (API).

women (136.0 per 100,000), followed by black (115.5), Hispanic (82.3), and were lowest among API women (67.4; Table 1). As expected, the corrected rates were higher than the uncorrected for each race group (73%, 90%, 61%, and 42% increases, respectively). Compared with white women, the rate ratio for black women increased from 0.77 (23% lower risk) before correction to 0.85 (15% lower risk) after correction. In contrast, the rate ratio for API women compared with white women decreased from 0.60 (40% lower risk) before correction to 0.50 (50% lower risk) after correction. As hysterectomy prevalence was not constant over time, the corrected trends were not parallel to the uncorrected trends among blacks and whites (Fig. 2). Specifically, from 1992 to 2008 among white women, the corrected incidence significantly decreased 0.8% per year compared with a 0.5% annual decrease using uncorrected incidence. The corrected incidence among black women significantly increased 3.1% per year, which was almost twice the 1.8% increase based on uncorrected incidence rates. From 1992 to 2008, the uncorrected incidence rates among white women were higher than among black women. After correction, however, the incidence rates for black women surpassed those among white women from 2004 to 2008. After collapsing to 3-year groups, no changes were identified in the corrected or uncorrected incidence trends. Joinpoint may have been able to detect more complex underlying trends if it had been feasible to use single year data.

As expected, the incidence rate was highest for type I endometrial cancer (Table 1). Specifically, the corrected

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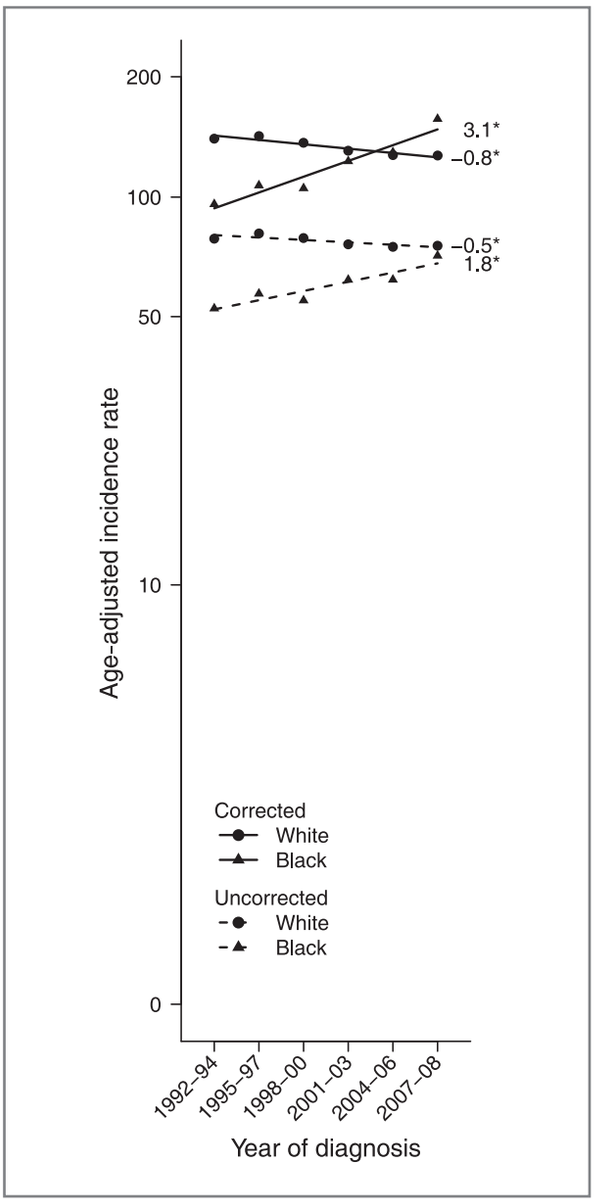

Figure 2. Age-adjusted endometrial cancer incidence rates by race, corrected and uncorrected for hysterectomy prevalence among women age 50+, SEER from 1992–2008. The APC is shown next to the regression line and the asterisk indicates APC is statistically significant, $P < 0.05$. Source: incidence data from SEER 13 areas covering about 14% of the U.S. population (CT, HI, IA, NM, UT, metropolitan Detroit, metropolitan Atlanta, rural GA, Seattle-Puget Sound, San Francisco-Oakland, San Jose-Monterey, and Los Angeles). Hysterectomy prevalence data from BRFSS public use file.

incidence of type I endometrial cancer was highest among white women, similar among black and Hispanic women, and lowest among API women (114.2, 69.0, 63.8, and 54.1, respectively). The corrected incidence trend from 1992 to 2008 showed a significant decline among white women (1.2% per year) but a significant increase among black women (2.3% per year; Fig. 3). In contrast, the corrected incidence rates for the other 3 subtypes of endometrial cancer (type II, malignant mixed Mullerian tumors, and all others combined) were higher among black women than white women. In addition, the trend for corrected rates of type II endometrial cancer was nonsignificantly increasing among white women (1.5% per year) and significantly increasing among black women (5.1% per year). Both corrected and uncorrected incidence rates for malignant mixed Mullerian tumors were increasing among white and black women. Specifically, among black women, the corrected incidence rate of malignant mixed Mullerian tumors significantly increased 3.8% a year compared with a nonsignificant 2.4% annual increase based on uncorrected rates. The corrected incidence trend among white women for malignant mixed Mullerian tumors (1.6%) changed minimally compared with the uncorrected (1.5%).

A sensitivity analysis showed that for all endometrial cancer types combined a 10% change in hysterectomy prevalence among white women resulted in an APC ranging from an annual decrease of 0.8 to 0.9% (95% CIs, −1.2 to −0.4 and −1.3 to −0.5, respectively). Among black women, a 25% change in hysterectomy prevalence resulted in an increase in APC ranging from 2.5 to 4.3% (95% CIs, 1.4–3.6 and 2.4–6.1, respectively). The APCs were fairly robust to these changes in hysterectomy prevalence; statistical significance was retained and 95% CIs of the APCs overlapped the original APC estimates.

Discussion

A primary goal of this analysis was to assess the effect of using a more accurate population-at-risk, that is, women with an intact uterus, on the relative magnitude of race-specific incidence rates of endometrial cancer. When using a denominator that included all women (the uncorrected rates), the incidence trend of endometrial cancer was higher among white women than black women during the entire study period, 1992 to 2008. After correction, incidence for black women surpassed that for white women from 2004 to 2008. The removal of individuals from a denominator without changing the numerator will always increase the resulting rate. However, in the case of endometrial cancer, the correction had the largest impact on black women because of their higher hysterectomy prevalence. During the entire study period, the overall uncorrected rate of endometrial cancer was highest among white women followed by black, Hispanic, and API women. Correction did not change the rank order of the overall rates but reduced the relative difference between black and white women especially toward the end of the study period. Furthermore, because the baseline hysterectomy prevalence was higher among black women and changed over time, trends in endometrial cancer among black women were especially affected. The difference in hysterectomy prevalence between black and white women has been previously observed but is not yet fully understood (39, 40).

The differences in hysterectomy prevalence also impacted the results by histologic subtype. Both with

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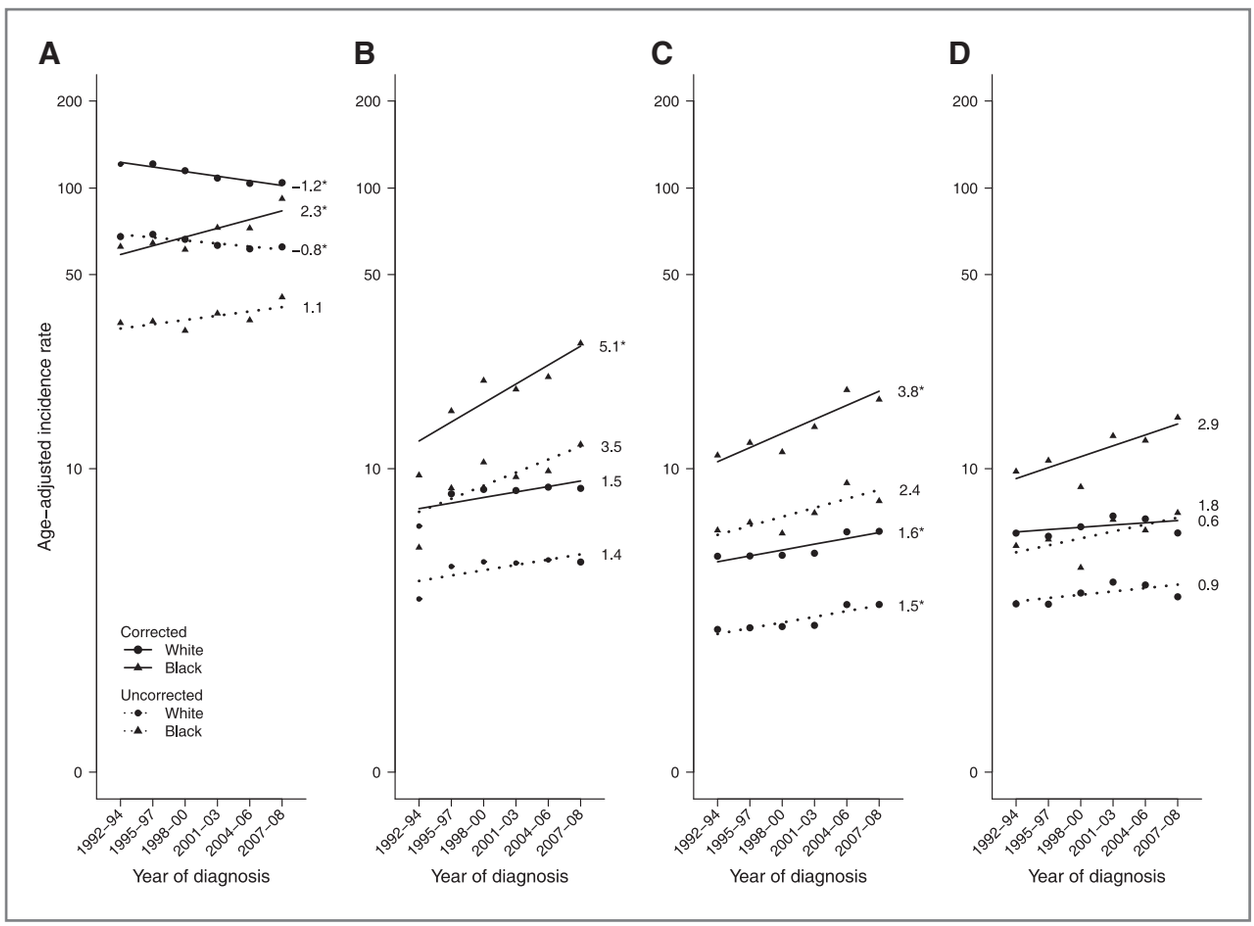

Figure 3. Age-adjusted endometrial cancer incidence rates among black and white women by subtype, corrected and uncorrected for hysterectomy prevalence among women age 50+, SEER from 1992 to 2008. The APC is shown next to the regression line and the asterisk indicates APC is statistically significant, $P < 0.05$. A, type I endometrial cancer; B, type II endometrial cancer; C, malignant mixed Mullerian tumors; D, other histologic types. Source: incidence data from SEER 13 areas covering about 14% of the U.S. population (CT, HI, IA, NM, UT, metropolitan Detroit, metropolitan Atlanta, rural GA, Seattle-Puget Sound, San Francisco-Oakland, San Jose-Monterey, and Los Angeles).

and without a correction for hysterectomy prevalence, the incidence rate of type I endometrial cancer was highest among white women. Consistent with previous studies, the rates of type II, malignant mixed Mullerian tumors, and other types of endometrial cancer were highest among black women (41, 42). Specifically, compared with white women, the rate ratios for black women were about 2 times higher for these subtypes. Trends for types I and II endometrial cancer based on corrected rates increased sharply among black women but declined or showed nonstatistically significant increases among white women. Malignant mixed Mullerian tumors based on corrected rates increased among both black and white women. Estimates of hysterectomy prevalence were too unstable to present corrected trends by histologic subtype for API and Hispanic women; however, recent population-based analyses report an increase in incidence among these women (2, 43) and variation by subtypes (41) without correction for hysterectomy prevalence.

Several limitations for interpreting the findings of this study should be considered. First, the BRFSS is limited to those with working telephones and the median response rate for the nine states in our study has been declining from 67.0% in 1992 (range, 57.4%–80.7%) to 54.6% in 2008 (range, 38.3%–64.9%; ref. 44). Lower response rates to the BRFSS have been associated with the underrepresentation of racial and ethnic minorities (45). Second, the BRFSS data were only available for the entire state and so hysterectomy prevalence could not be estimated for specific metropolitan areas. This may lead to a misrepresentation of the hysterectomy prevalence in the metropolitan SEER areas if the hysterectomy prevalence in the SEER catchment area is different from the entire state. Third, as some race, age, and year strata had small sample sizes, the standard errors for estimating the prevalence of hysterectomy from the BRFSS were large, but the sensitivity analysis showed the results to be fairly invariable to changes in hysterectomy prevalence. Finally, as the estimates of hysterectomy prevalence were considered fixed when computing the

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variance of the corrected incidence rates, the variance used to fit the joinpoint models was underestimated.

To validate our findings, we compared the BRFSS hysterectomy prevalence estimates with other published reports. Surveillance reports for the United States provide estimates of rates of hysterectomy based on the National Hospital Discharge Survey (NHDS; refs. 13, 14, 18, 46). The hysterectomy surveillance report from 1994 to 1999, the most recent report to publish results by race, found incidence rates of hysterectomy to be higher among black women than among white women 35 to 39 and 40 to 44 years. The report also found uterine leiomyoma (fibroids) to be the most frequent diagnosis associated with hysterectomy and that the rate of leiomyoma was highest among black women (4.2 per 1,000) compared to white women (1.8 per 1,000) and women of other races (2.6 per 1,000; ref. 14). Results based on 90,000 women from the Women's Health Initiative Observational Study from 1994 to 1998 found that the proportion of women 50 to 79 years who had a hysterectomy was about 40% among whites, 45% among Hispanics, 53% among blacks, and 34% among APIs (16). In addition, our estimates were similar to those in previous studies that estimated hysterectomy prevalence among SEER states by race using data from the BRFSS (20, 23).

We also compared the BRFSS hysterectomy prevalence estimates with those from 2 other population-based surveys from the CDC's National Center for Health Statistics: the National Health and Nutrition Examination Survey (NHANES) and the National Health Interview Survey (NHIS; refs. 47, 48). Of these surveys, the NHIS is the most directly comparable with the current study, although state-level estimates are not available as they are in BRFSS. National hysterectomy prevalence estimates were obtained for white, black, API, and Hispanic women 50 years and older from NHIS for the survey years 1993, 1994, 1999, 2000, 2005, and 2008 (Supplementary Appendix B). The NHIS is administered via personal household interviews to a nationally representative random probability sample of noninstitutionalized, civilian U.S. adults (48). The annual response rate of NHIS is close to 90% of the eligible households in the sample. The hysterectomy prevalence estimates for the whole study period, 1992 to 2008 for the BRFSS and 1993 to 2008 for the NHIS are very similar for white women (40.8% and 39.5%, respectively). The same estimate for black women is 12% higher in the BRFSS data than in the national NHIS data (46.8% and 41.8%, respectively). The hysterectomy prevalence estimates are higher among black women than white women in both surveys. The results over time show a similar pattern even though the absolute levels of hysterectomy prevalence are higher in the BRFSS. Hysterectomy prevalence peaks in the middle of the study period and is followed by a decline in the most recent period. After reviewing other sources of information on hysterectomy prevalence, the available evidence indicates that hysterectomy prevalence is higher among black women than white women. The magnitude of the difference is unclear.

Finally, the decision on which measure of endometrial cancer to present, uncorrected or corrected, depends on the question of interest. If the measure is risk of developing endometrial cancer among women with a uterus, it would be important to use the corrected denominator. It would also be important to use the corrected denominator when assessing health disparities as hysterectomy prevalence varies by race. As indicated by previous research, the issue is complex for measurements such as lifetime risk of developing endometrial cancer (49).

While there are limitations to the estimation of hysterectomy prevalence, especially for smaller populations of women, the results of this study show the utility of the method for producing more accurate incidence rates of endometrial cancer by race over time. Without a correction for the population-at-risk (i.e., women with an intact uterus), incidence rates are underestimated. More importantly, when hysterectomy prevalence changes over time and differentially among population subgroups, comparisons of trends can be misleading without correction.

Disclosure of Potential Conflicts of Interest

N.C. Lee is a Consultant/Advisory Board member of Cancer Prevention and Research Institute of Texas. No potential conflicts of interest were disclosed by the other authors.

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Conception and design: P.M. Jamison, A.-M. Noone, L.A.G. Ries, B.K. Edwards
Development of methodology: P.M. Jamison, A.-M. Noone, L.A.G. Ries, B.K. Edwards
Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): P.M. Jamison, A.-M. Noone, B.K. Edwards
Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): P.M. Jamison, A.-M. Noone, L.A.G. Ries, N.C. Lee, B.K. Edwards
Writing, review, and/or revision of the manuscript: P.M. Jamison, A.-M. Noone, L.A.G. Ries, N.C. Lee, B.K. Edwards
Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): P.M. Jamison, A.-M. Noone
Study supervision: P.M. Jamison

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References

1. American Cancer Society. Cancer facts & figures 2012. Atlanta, GA: American Cancer Society; 2012.
2. SEER Cancer Statistics Review, 1975–2008. In: Howlader N, Noone AM, Krapcho M, et al., editors. Available from: http://seer.cancer.gov/csr/

Published OnlineFirst December 12, 2012; DOI: 10.1158/1055-9965.EPI-12-0996

1975_2008/, based on November 2010 SEER data submission, posted to the SEER web site, 2011. Bethesda, MD: National Cancer Institute; 2011.
3. Cook LS, Weiss NS, Doherty JA, Chen C. Endometrial cancer. In: Schottenfeld D, Fraumeni JF Jr, editors. Cancer epidemiology and prevention. 3rd ed. New York City: Oxford University Press; 2006. p. 1027–43.
4. Crosbie EJ, Zwahlen M, Kitchener HC, Egger M, Renehan AG. Body mass index, hormone replacement therapy, and endometrial cancer risk: a meta-analysis. Cancer Epidemiol Biomarkers Prev 2010;19: 3119–30.
5. Richardson LC, Thomas C, Bowman BA. Obesity and endometrial cancer: challenges for public health action. Womens Health 2009;5:595–7.
6. Sonoda Y, Barakat RR. Screening and the prevention of gynecologic cancer: endometrial cancer. Best Pract Res Clin Obstet Gynaecol 2006;20:363–77.
7. Weiss JM, Saltzman BS, Doherty JA, Voigt LF, Chen C, Beresford SA, et al. Risk factors for the incidence of endometrial cancer according to the aggressiveness of disease. Am J Epidemiol 2006;164:56–62.
8. Hill HA, Eley JW, Harlan LC, Greenberg RS, Barrett RJ, Chen VW. Racial differences in endometrial cancer survival: the black/white cancer survival study. Obstet Gynecol 1996;88:919–26.
9. Madison T, Schottenfeld D, James SA, Schwartz AG, Gruber SB. Endometrial cancer: socioeconomic status and racial/ethnic differences in stage at diagnosis, treatment, and survival. Am J Public Health 2004;94:2104–11.
10. Duong LM, Wilson RJ, Ajani UA, Singh SD, Eheman CR. Trends in endometrial cancer incidence rates in the United States, 1999–2006. J Womens Health (Larchmt) 2011;20:1157–63.
11. Evans T, Sany O, Pearmain P, Ganesan R, Blann A, Sundar S. Differential trends in the rising incidence of endometrial cancer by type: data from a UK population-based registry from 1994 to 2006. Br J Cancer 2011;104:1505–10.
12. Felix AS, Weissfeld JL, Stone RA, Bowser R, Chivukula M, Edwards RP, et al. Factors associated with Type I and Type II endometrial cancer. Cancer Causes Control 2010;21:1851–6.
13. Whiteman MK, Hillis SD, Jamieson DJ, Morrow B, Podgornik MN, Brett KM, et al. Inpatient hysterectomy surveillance in the United States, 2000–2004. Am J Obstet Gynecol 2008;198:34–7.
14. Keshavarz H, Hillis SD, Kieke BA, Marchbanks PA. Hysterectomy Surveillance — United States, 1994–1999. MMWR CDC Surveill Summ 2002;SS05:1–8.
15. Merrill RM, Layman AB, Oderda G, Asche C. Risk estimates of hysterectomy and selected conditions commonly treated with hysterectomy. Ann Epidemiol 2008;18:253–60.
16. Howard BV, Kuller L, Langer R, Manson JE, Allen C, Assaf A, et al. Risk of cardiovascular disease by hysterectomy status, with and without oophorectomy: the Women's Health Initiative Observational Study. Circulation 2005;111:1462–70.
17. Kjerulff KH, Guzinski GM, Langenberg PW, Stolley PD, Moye NE, Kazandjian VA. Hysterectomy and race. Obstet Gynecol 1993;82:757–64.
18. Lepine LA, Hillis SD, Marchbanks PA, Koonin LM, Morrow B, Kieke BA, et al. Hysterectomy surveillance–United States, 1980–1993. MMWR CDC Surveill Summ 1997;46:1–15.
19. Merrill RM, Feuer EJ. Risk-adjusted cancer-incidence rates (United States). Cancer Causes Control 1996;7:544–52.
20. Sherman ME, Carreon JD, Lacey JV Jr, Devesa SS. Impact of hysterectomy on endometrial carcinoma rates in the United States. J Natl Cancer Inst 2005;97:1700–2.
21. Wong CA, Jim MA, King J, Tom-Orme L, Henderson JA, Saraiya M, et al. Impact of hysterectomy and bilateral oophorectomy prevalence on rates of cervical, uterine, and ovarian cancer among American Indian and Alaska Native women, 1999–2004. Cancer Causes Control 2011;22:1681–9.
22. Lyon JL, Gardner JW. The rising frequency of hysterectomy: its effect on uterine cancer rates. Am J Epidemiol 1977;105:439–43.
23. Merrill RM. Impact of hysterectomy and bilateral oophorectomy on race-specific rates of corpus, cervical, and ovarian cancers in the United States. Ann Epidemiol 2006;16:880–7.
24. Lacey JV Jr, Chia VM, Rush BB, Carreon DJ, Richesson DA, Ioffe OB, et al. Incidence rates of endometrial hyperplasia, endometrial cancer and hysterectomy from 1980 to 2003 within a large prepaid health plan. Int J Cancer 2012;131:1921–9.
25. Saraiya M, Lee NC, Blackman D, Smith M, Morrow B, McKenna MA. Self-reported Papanicolaou smears and hysterectomies among women in the United States. Obstet Gynecol 2001;98:269–78.
26. Gwinn ML, Lee NC, Rubin GL. Trends in the incidence of endometrial and ovarian cancers. MMWR CDC Surveill Summ 1986;35:23SS–7SS.
27. Merrill RM. Stat bite: trends in corpus uteri cancer incidence. J Natl Cancer Inst 1996;88:1019.
28. World Health Organization. International classification of diseases for oncology. 3rd ed. Geneva, Switzerland: World Health Organization; 2000.
29. Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov) SEER*Stat Database: Incidence – SEER 13 Regs Research Data, Nov 2010 Sub (1992–2008), National Cancer Institute, DCCPS, Surveillance Research Program, Cancer Statistics Branch, based on the November 2010 submission. [Accessed 2011 July 26].
30. Centers for Disease Control and Prevention (CDC). Behavioral risk factor surveillance system survey data. Atlanta, GA: U.S. Department of Health and Human Services, CDC. [Accessed 2011 Sept 9]. Available from: http://www.cdc.gov/brfss/technical_infodata/surveydata.htm; 2011.
31. Brett KM, Madans JH. Hysterectomy use: the correspondence between self-reports and hospital records. Am J Public Health 1994; 84:1653–5.
32. Phipps AI, Buist DS. Validation of self-reported history of hysterectomy and oophorectomy among women in an integrated group practice setting. Menopause 2009;16:576–81.
33. Curtis RE, Freedman DM, Sherman ME, Fraumeni JF Jr. Risk of malignant mixed Mullerian tumors after tamoxifen therapy for breast cancer. J Natl Cancer Inst 2004;96:70–4.
34. Surveillance Research Program, National Cancer Institute SEER*Stat software. [Accessed 2011 Sept 1]. Available from: www.seer.cancer.gov/seerstat) version 7.0.7. 2012.
35. Devesa SS, Donaldson J, Fears T. Graphical presentation of trends in rates. Am J Epidemiol 1995;141:300–4.
36. Joinpoint Regression Program. Statistical Research and Applications Branch, National Cancer Institute. [Accessed 2012 Apr 26]. Available from: http://surveillance.cancer.gov/joinpoint/. 2011.
37. Kim HJ, Fay MP, Feuer EJ, Midthune DN. Permutation tests for joinpoint regression with applications to cancer rates. Stat Med 2000;19: 335–51.
38. Merrill RM, Lyon JL, Wiggins C. Comparison of two methods based on cross-sectional data for correcting corpus uterine cancer incidence and probabilities. BMC Cancer 2001;1:13.
39. Bower JK, Schreiner PJ, Sternfeld B, Lewis CE. Black-White differences in hysterectomy prevalence: the CARDIA study. Am J Public Health 2009;99:300–7.
40. Powell LH, Meyer P, Weiss G, Matthews KA, Santoro N, Randolph JF Jr, et al. Ethnic differences in past hysterectomy for benign conditions. Womens Health Issues 2005;15:179–86.
41. Sabatino SA, Stewart SL, Wilson RJ. Racial and ethnic variations in the incidence of cancers of the uterine corpus, United States, 2001–2003. J Womens Health (Larchmt) 2009;18:285–94.
42. Sherman ME, Devesa SS. Analysis of racial differences in incidence, survival, and mortality for malignant tumors of the uterine corpus. Cancer 2003;98:176–86.
43. Eheman C, Henley SJ, Ballard-Barbash R, Jacobs EJ, Schymura MJ, Noone AM, et al. Annual Report to the Nation on the status of cancer, 1975–2008, featuring cancers associated with excess weight and lack of sufficient physical activity. Cancer 2012;118: 2338–66.
44. Centers for Disease Control and Prevention (CDC). Behavorial Risk Factor Surveillance System Summary Data Quality Reports. Atlanta, GA: U.S. Department of Health and Human Services, CDC. [Accessed 2012 May 9]. Available from: http://www.cdc.gov/brfss/technical_infodata/quality.htm; 2012.
45. Schneider KL, Clark MA, Rakowski W, Lapane KL. Evaluating the impact of non-response bias in the Behavioral Risk Factor Surveillance System (BRFSS). J Epidemiol Community Health 2012;66:290–5.

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46. Centers for Disease Control and Prevention (CDC) NCHS. National hospital discharge survey. Hyattsville, MD: U.S. Department of Health and Human Services, CDC: 2012.
47. Centers for Disease Control and Prevention (CDC) NCHS. National Health and Nutrition Examination Survey. Hyattsville, MD: U.S. Department of Health and Human Services, CDC: 2012.
48. Centers for Disease Control and Prevention (CDC) NCHS. National health interview survey. Hyattsville, MD: U.S. Department of Health and Human Services, CDC: 2012.
49. Wun LM, Merrill RM, Feuer EJ. Estimating lifetime and age-conditional probabilities of developing cancer. Lifetime Data Anal 1998; 4:169–86.

Published OnlineFirst December 12, 2012; DOI: 10.1158/1055-9965.EPI-12-0996

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