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Bariatric surgery in breast and endometrial cancer patients in California: Population-based prevalence and survival

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Abstract

Background: The number of bariatric surgeries performed in the United States has increased substantially since the 1990’s. However, the prevalence and prognostic impact of bariatric surgery, or weight-loss surgery (WLS), among cancer patients are not known.

Objectives: We investigated the population-based prevalence of WLS in women with breast or endometrial cancer and conducted exploratory analysis to examine whether post-diagnosis WLS is associated with survival.

Setting: Administrative statewide database.

Methods: WLS records for women with non-metastasized breast (n=395,146) or endometrial (n=69,859) cancer were identified from the 1991–2014 California Cancer Registry data linked with the California Office of Statewide Health Planning and Development database.

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Characteristics of the patients were examined according to history of WLS. Using body mass index data available since 2011, a retrospective cohort of breast and endometrial cancer patients with obesity (n=12,540) was established and followed until 2017 (5% loss-to-follow-up). Multivariable cause-specific Cox proportional hazards models were used to examine the associations between post-diagnostic WLS and time to death.

Results: WLS records were identified for 2,844 (0.7%) breast and 1,140 (1.6%) endometrial cancer patients; about half of the surgeries were performed after cancer diagnosis. Post-diagnosis WLS was performed in ~1% of patients with obesity and was associated with a decreased hazard for death (cause-specific hazard ratio=0.37; 95% confidence interval=0.014–0.99; P=0.049), adjusting for age, stage, comorbidity, race/ethnicity, and socioeconomic status.

Conclusions: About 2,000 breast or endometrial cancer patients in California underwent post-diagnosis WLS between 1991 and 2014. Our data support survival benefits of WLS after breast and endometrial cancer diagnosis.

Keywords

bariatric surgery; obesity; breast cancer; endometrial cancer; survival

Introduction

The prevalence of obesity, defined as a body mass index (BMI) of ≥30kg/m^2, steadily increased in recent decades in the United States (US), affecting nearly 40% of adults in 2015–2016[1]. Obesity is associated with numerous health conditions including diabetes, coronary heart disease, and many types of cancer including cancers in the esophagus, colon, rectum, endometrium, breast (among postmenopausal women) and others[2–4]. Endometrial cancer has been the cancer type most strongly associated with obesity[3,4]; risk decreased significantly in association with weight loss[5]. Data from >36,000 postmenopausal women in the Women's Health Initiative (WHI) observational study have shown that women who intentionally lost ≥5% of their baseline weight were at a significantly lower risk of endometrial cancer compared to women with stable weight (hazard ratio (HR)=0.60; 95% confidence interval (CI)=0.42–0.86)[5]. The WHI observational study also reported reduced risk of postmenopausal breast cancer in association with ≥5% weight loss (HR=0.88; 95% CI=0.79–0.98)[6,7].

Obesity has been also associated with all-cause mortality[8] and mortality from breast and endometrial cancer[9]. Obesity has been consistently associated with poorer overall-and breast cancer-specific survival as well as progression-free survival among women with breast cancer[10–13], independent of stage and treatment[14–17]. In a meta-analysis of 82 studies, relative risk (RR) of death comparing women with obesity vs. normal weight was 1.41, and RR of death per 5 kg/m^2 increase in BMI was 1.17[10]. Although data for endometrial cancer have been less consistent[18–22], a significant association between obesity and poorer survival has been reported in a 2016 meta-analysis[23] and in all five larger studies (n>500 patients) conducted in the US[19–21,24,25], independent of stage and treatment in studies that adjusted for these factors [19,20,25].

Bariatric surgery, or weight-loss surgery (WLS), is now considered as the most effective treatment in maintaining significant long-term weight loss in patients with obesity[26–30]. The number of WLS performed in the US increased exponentially in the 1990's and early 2000's[31–35]. The estimated WLS procedures performed in 2019 was about 256,000 [32,34]. Inverse associations between WLS and endometrial cancer risk were reported in a 2018 meta-analysis (RR=0.32)[36] and four additional studies (RR ranging from 0.21 to 0.56)[37–40]. For breast cancer, inverse associations (RR ranging from 0.17 to 0.75) were reported from all[37–43] but one[44] of the published studies.

Given the reported strong inverse associations between WLS and risk of breast[38,39,41,43] and endometrial cancer[37–39] and the well-established association between obesity and all-cause and cancer-specific mortality[8,9], it is possible that an increasing number of breast and endometrial cancer patients may opt to undergo WLS. However, the population-based prevalence of WLS among breast and endometrial cancer patients is not known. Furthermore, the association between post-diagnostic WLS and survival in breast cancer and endometrial cancer patients has not been investigated to our knowledge. Using data from the California Cancer Registry (CCR) and the California Office of Statewide Health Planning and Development (OSHPD) that includes inpatient, emergency department, and ambulatory surgery data, we examined the prevalence of WLS in women with breast cancer and endometrial cancer and evaluated whether post-diagnosis WLS is associated with survival outcome.

Materials and Methods

Database:

The CCR is the statewide population-based cancer registry in California and provides demographic, tumor characteristic, and survival data on all incident cancer patients diagnosed among residents in California since 1988. The CCR regularly conducts data linkage with the OSHPD database[45–47]. Since 1991, OSHPD provides inpatient discharge data (Patient Discharge Data (PDD)) from California-licensed hospitals. Additionally, since 2005, Emergency Department Data (EDD) from hospitals licensed to provide emergency medical services in California and Ambulatory Surgery Data (ASD) from licensed surgical clinics and hospitals licensed for outpatient surgery in California[48] are available. Licensed hospitals include general acute care, acute psychiatric, chemical dependency recovery, and psychiatric health facilities[48]. The CCR database includes the Charlson Comorbidity Index, a weighted score of 16 co-morbid medical conditions including diabetes identified using the OSHPD records between 1 year prior to cancer diagnosis and 6 months after cancer diagnosis[47].

Identification of non-metastasized (localized/regional stage) breast and endometrial cancer:

We identified from the CCR non-metastasized first primary invasive breast (n=405,517) and endometrial (n=72,121) cancer between 1991 and 2014 in California among women aged 20 or older at diagnosis (see Supplementary Methods for details). Patients diagnosed with distant (metastasized) or unknown stage were excluded because these patients may not consider WLS for their obesity.

Identification of WLS:

WLS procedures in OSHPD data were identified using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) procedure codes (for PDD) and Current Procedural Terminology (CPT) codes (for EDD and ASD) for records noted with diagnosis of obesity or morbid obesity (Supplementary Methods), using similar approaches as previous studies[31,40,49–52]. We applied the same list of procedure codes used in the report published by the OSHPD[49] with minor modifications to exclude non-specific procedures in the stomach (Table 1 and Supplementary Table 1).

Construction of a retrospective cohort of breast and endometrial cancer patients with obesity for exploratory survival analysis:

We retrospectively constructed a cohort of breast and endometrial cancer patients with obesity diagnosed at localized or regional stage to conduct exploratory analysis to evaluate the association between WLS and time to death (see Statistical Analysis for methods to minimize potential biases). Patients who underwent WLS prior to cancer diagnosis were not included in this cohort. Information on BMI/obesity is typically not available in the OSHPD database except for WLS patients whose obesity condition was indicated by the diagnosis codes at the time of WLS. To identify cancer patients with obesity but without WLS diagnosis codes, we used height and weight information that became available in the CCR database starting around 2011. For cancer patients diagnosed in 2011–2012 and 2013–2014, height and weight information was available for ~20% and ~30%, respectively, allowing us to identify a large number of patients with obesity (BMI≥30 kg/m^2). Specifically, among 97,071 women diagnosed with a first primary localized or regional stage breast cancer (n=76,261) or endometrial cancer (n=15,810) between 2011–2014, 13,617 patients (9,941 breast cancer; 3,676 endometrial cancer) had obesity. Of these, we excluded 959 patients who underwent WLS prior to cancer diagnosis (723 breast cancer; 236 endometrial cancer), and 79 patients whose survival time information was missing, and 39 patients with unknown dates of second primary cancer diagnosis. The final retrospective cohort for survival analysis consisted of 12,540 patients with obesity diagnosed with breast (n=9,151) or endometrial (n=3,389) cancer between 2011–2014.

Statistical analysis:

We conducted descriptive analysis to evaluate the frequency of WLS in 395,146 breast cancer patients and 69,859 endometrial cancer patients after excluding patients diagnosed with cancers of digestive tract (Supplementary Methods).

The CCR routinely ascertains vital status of cancer patients by following up with hospitals and conducting linkages to state and national large administrative databases[53]. A patient whose vital status has not been updated for more than 15 months after the last contact is considered lost to follow-up[54]; 5% of our survival analysis cohort were lost to follow-up at the end date of follow-up (December 31, 2017). We calculated the survival time from date of first cancer diagnosis (breast or endometrial) to date of death, date of diagnosis of second primary cancer, date of last known follow-up, or the end date of follow-up, whichever came first. For patients who were still alive at time of last follow-up, time to death was censored at the date of last known follow-up or the end date of follow-up. Because diagnosis of second primary cancer may influence the decision to 20 undergo WLS and prognosis of these patients would be primarily determined by the type of cancer rather than WLS, we treated patients who developed a second primary cancer during the follow up period as a competing risk and removed them from the risk set by censoring them at the time of second cancer diagnosis (n=732 and n=237 among breast and endometrial cancer patients, respectively). Patients with an incomplete date (unknown month/day) of second cancer diagnosis (n=30) had dates assigned at the middle of the year/month (e.g., June/15). A cause-specific Cox proportional hazards model, where "cause-specific" refers to deaths of all causes as the outcome of interest and considers diagnosis of another cancer as censoring, was used to evaluate the association between WLS and time to death. The association is quantified through the cause-specific HR and corresponding 95% CI. We treated WLS as a time-varying covariate to account for the length of time between WLS and first cancer diagnosis for each subject[55].

We conducted multivariable analyses separately for breast cancer and endometrial cancer patients as well as combining the two sets of patients (stratified by cancer site). As WLS is an elective procedure and healthier cancer-free patients might be more likely to opt for WLS, we statistically adjusted for prognostic factors, including stage, Charlson Comorbidity Index[47], age at cancer diagnosis, race/ethnicity, and neighborhood socioeconomic status (SES)[56,57] (Supplementary Methods). Given the limited number of deaths relative to the number of covariates in the model, we additionally constructed a multivariable model adjusting for quintiles of a propensity score calculated based on the covariates listed above[58,59]. In addition, we conducted a series of sensitivity analyses to evaluate whether the observed associations are robust (Supplementary Methods), such as increasing BMI cut point to ≥35 kg/m^2 (instead of ≥30 kg/m^2) for inclusion as non-WLS group and additionally adjusting for BMI by restricting the participants to those with BMI information (about 30% of the survival analysis cohort). All p-values reported are two-sided.

Results

Descriptive analysis

Among the 395,146 breast cancer patients and 69,859 endometrial cancer patients diagnosed in California between 1991–2014, we identified WLS records for 2,844 breast cancer patients (0.7%) and 1,140 endometrial cancer patients (1.6%) (Table 2). Because of the cross-sectional nature of the CCR-OSHPD linkage, follow up time to ascertain post-diagnosis WLS varied depending on the year of cancer diagnosis. For example, cancer patients diagnosed in 2011–2014 have been followed for post-diagnostic WLS only for a maximum of 4 years (i.e. up to December 31, 2014; the most recent OHSPD data available for this analysis). Despite this limitation, a significant proportion of WLS we identified was performed after cancer diagnosis (49% for breast cancer patients (n=1,407) and 59% for endometrial cancer patients (n=677)). Consistent with the differences in follow-up time after cancer diagnosis, patients who underwent WLS *after* cancer diagnosis were diagnosed in earlier years than patients who underwent WLS *prior to* cancer diagnosis. Compared to the no-WLS group, the two WLS groups were younger at cancer diagnosis and more likely to have a comorbid condition(s), particularly for the group with a WLS record prior to cancer. The proportion of Asian/Pacific Islanders was much lower in both WLS groups compared to the no-WLS group. Although the no-WLS group had a higher SES than the two WLS groups, this difference was not observed when limiting the comparisons to patients with obesity. In the breast cancer cohort, patients who underwent WLS after cancer diagnosis were more likely to have an ER-negative tumor, but this difference disappeared when examining women of ages 50 or older. Stage at diagnosis was similar across the three groups for breast cancer patients. For endometrial cancer patients, patients who underwent WLS after cancer diagnosis had a much higher proportion of localized stage cancer.

The majority (97%) of the WLS group had only one record of WLS; 4–5% had a record of revision/removal of a previous bariatric procedure or device(s) (Table 2). Among patients who underwent WLS after cancer diagnosis, average time interval between cancer diagnosis and WLS was 6.4 years and 5.5 years for breast and endometrial cancer patients, respectively.

Almost all the bariatric surgeries were inpatient procedures: 94% from the PDD, 6% from the ASD, and no records from the EDD (Supplementary Table 1). The most common WLS procedures codes were 44.38 (laparoscopic gastroenterostomy) and 44.31 (high gastric bypass). Other codes observed for ~200 to ~400 records include 44.39 (other gastroenterostomy without gastrectomy), 43.82 (laparoscopic vertical (sleeve) gastrectomy), 44.95 (Laparoscopic gastric restrictive procedure), and 43.89 (open and other partial gastrectomy).

Survival analysis among patients with obesity diagnosed with breast or endometrial cancer between 2011 and 2014

Compared to patients who did not undergo WLS, those who underwent WLS after cancer diagnosis were younger, of higher SES, more likely to have been diagnosed at localized stage. Average time interval between cancer diagnosis and WLS was 1.74 and 1.52 years for breast and endometrial cancer patients, respectively (Supplementary Table 2). Patients who underwent WLS after their cancer diagnosis had a statistically significantly decreased hazard for death of any cause (cause-specific HR=0.37, 95% CI=0.14–0.99, P=0.049) compared to patients with breast cancer or endometrial cancer and obesity who had not yet undergone WLS when adjusting for stage, age at cancer diagnosis, SES, race/ethnicity, and comorbidity (Table 3). The statistical significance of this association weakened slightly in the alternative multivariable model adjusting for propensity score, but the HR estimate was essentially identical (HR=0.38; 95% CI=0.14–1.04; P=0.059).

As 75% of patients were enrolled (i.e., diagnosed with cancer) in 2013–2014 and could be followed up for a maximum of 3–4 years (Supplementary Table 3), there is a large decrease in the number at risk between years 3–5 (Supplementary Table 4). Multivariable HRs for covariates are presented in Supplementary Table 5. The association between WLS and death remained in the same direction for all of the sensitivity analyses and, in general, the magnitudes of the HRs were similar to the primary analysis including when the no-

WLS group included patients with BMI 35-<80 kg/m^2 only (Figure 1). When limiting the analyses to women with a Charlson Comorbidity Index of 0, the association was attenuated (cause-specific HR=0.76, 95% CI=0.242.40) but remained in the same direction. When we restricted the analyses to women with BMI information (kg/m^2) at the time of cancer diagnosis (i.e., ~30% of the survival analysis cohort), an inverse association (HR=0.61; 95% CI=0.15–2.43) was still observed.

Discussion

Using the population-based cancer incidence data from the CCR linked with the population-based hospital discharge database in California, our analysis is among the first to describe the population-based prevalence of WLS in women with breast cancer and endometrial cancer, showing that more than half of WLS among these cancer patients were performed after their cancer diagnosis. Our analysis provides the first evidence that WLS after breast cancer or endometrial cancer diagnosis is associated with better survival.

In California, about 14,000 bariatric surgeries were performed each year between 2005–2014[49]. Our cross-sectional analysis of the CCR-OSHPD data found that 2,844 breast cancer patients and 1,140 endometrial cancer patients diagnosed between 1991 and 2014 underwent WLS either before or after their cancer diagnosis. Demographic characteristics of the WLS group are in line with the previously reported characteristics of WLS patients in the general population. For example, the race/ethnicity distribution of the WLS group in our study was similar to the distribution reported among WLS patients in the general population in California in 2005–2009 (~68% NHW; ~9% non-NHB, ~ 18% Hispanic; 3% Asian/Pacific Islander)[49]. In our study, the mean age at breast cancer diagnosis was younger in the WLS group than in the no-WLS group, especially for the group who underwent WLS after cancer diagnosis (Table 2), consistent with the report that the majority (97%) of bariatric surgeries are conducted for women younger than age 65[49]. The difference in age at cancer diagnosis likely explains the apparent difference in ER-positivity across WLS and no-WLS groups because ER-positivity is more common in older patients[60] and the difference in ER positivity was not observed among women of ages 50 or older. The higher proportion of patients with comorbidity in the two WLS groups is likely to reflect the common indications for WLS: morbid obesity or obesity with a comorbid condition[61].

Consistent with the established association of obesity with increased risk of endometrial cancer[3,4] and postmenopausal breast cancer[62,63], as well as poorer survival in breast cancer patients[10,11] and possibly in endometrial cancer patients[19,20], our data demonstrate a decreased risk of death (cause-specific hazard) in at-risk breast cancer and endometrial cancer patients who subsequently underwent WLS. Weight loss following WLS in cancer survivors was shown to be similar to that in the general population[64]. The survival benefits following WLS are likely, at least partially, to be due to reduction in excess weight and improvement in metabolic disorders including diabetes or insulin resistance and dyslipidemia[26,30,65,66]. WLS has been also shown to lower levels of systemic inflammation markers such as C-reactive protein (CRP)[65–69]. Markers of systemic inflammation such as CRP, neutrophil-lymphocyte ratio, or platelet-lymphocyte ratio, and dyslipidemia were shown to be correlated with crown-like structures in the breast tissue, a marker of breast adipose tissue inflammation[70,71], and associated with poor survival among breast[72–75] and endometrial cancer patients[76,77].

In a 2014 survey of gynecologic oncology providers, only 51% consistently provided counseling about weight loss to patients with overweight/obesity, but the majority of respondents were open to offering WLS as a treatment if WLS is "proven to reduce the risk of cancer, recurrence, or improve mortality"[78]. Despite the paucity of data on the role of WLS on survival in cancer patients, sufficient evidence on reduced risk of endometrial cancer has led WLS to gain attention as a means to lower mortality in endometrial cancer patients[79,80]. Our findings provide additional information for healthcare providers to consider when consulting non-metastasized breast and endometrial cancer patients with obesity or morbid obesity and referring their patients to medical or surgical weight loss.

The strength of our study is that it is the first investigation using population-based databases to examine the prevalence of WLS and its potential impact on survival among cancer patients. One of the limitations of our study is that BMI information was available for only a subset of patients thus limiting the sample size for survival analysis and adjustment for BMI. In addition, we cannot exclude the possibility that healthier cancer-free patients were more likely to choose to undergo post-diagnosis WLS, an elective procedure, whereas patients with recurrent cancer or other serious health conditions would opt out of WLS. We minimized this potential bias by adjusting for cancer stage and Charlson Comorbidity Index in the analysis. The results did not change when we limited the analysis to patients diagnosed with localized cancer and the direction of the association was unchanged when the analysis was limited to women without comorbidity. Survival rates are high for localized breast and endometrial cancer: for localized breast cancer, 5-year and 7-year relative survival rates are 99% and 98%, respectively; for localized endometrial cancer, 95% and 94%, respectively[81]. Thus, we believe that selective uptake of WLS based on their cancer/prognostic status cannot completely explain the ~3-fold difference in survival between the two groups.

Conclusions

About 2,800 patients with breast cancer and ~1,100 patients with endometrial cancer diagnosed between 1991 and 2014 in California underwent WLS for obesity. More than half of these WLS were performed after their cancer diagnosis. Our data support survival benefits of WLS after breast or endometrial cancer diagnosis but confirmation of results in a prospective study is needed. If medically indicated and benefits outweigh risks, WLS might be an option to manage morbid obesity uncontrolled by lifestyle intervention in breast cancer and endometrial cancer patients.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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- Prevalence of bariatric surgery studied in breast/endometrial cancer survivors.
- ~2000 survivors in California diagnosed between 1988–2014 underwent bariatric surgery.
- Survival benefits of post-diagnosis bariatric surgery observed.

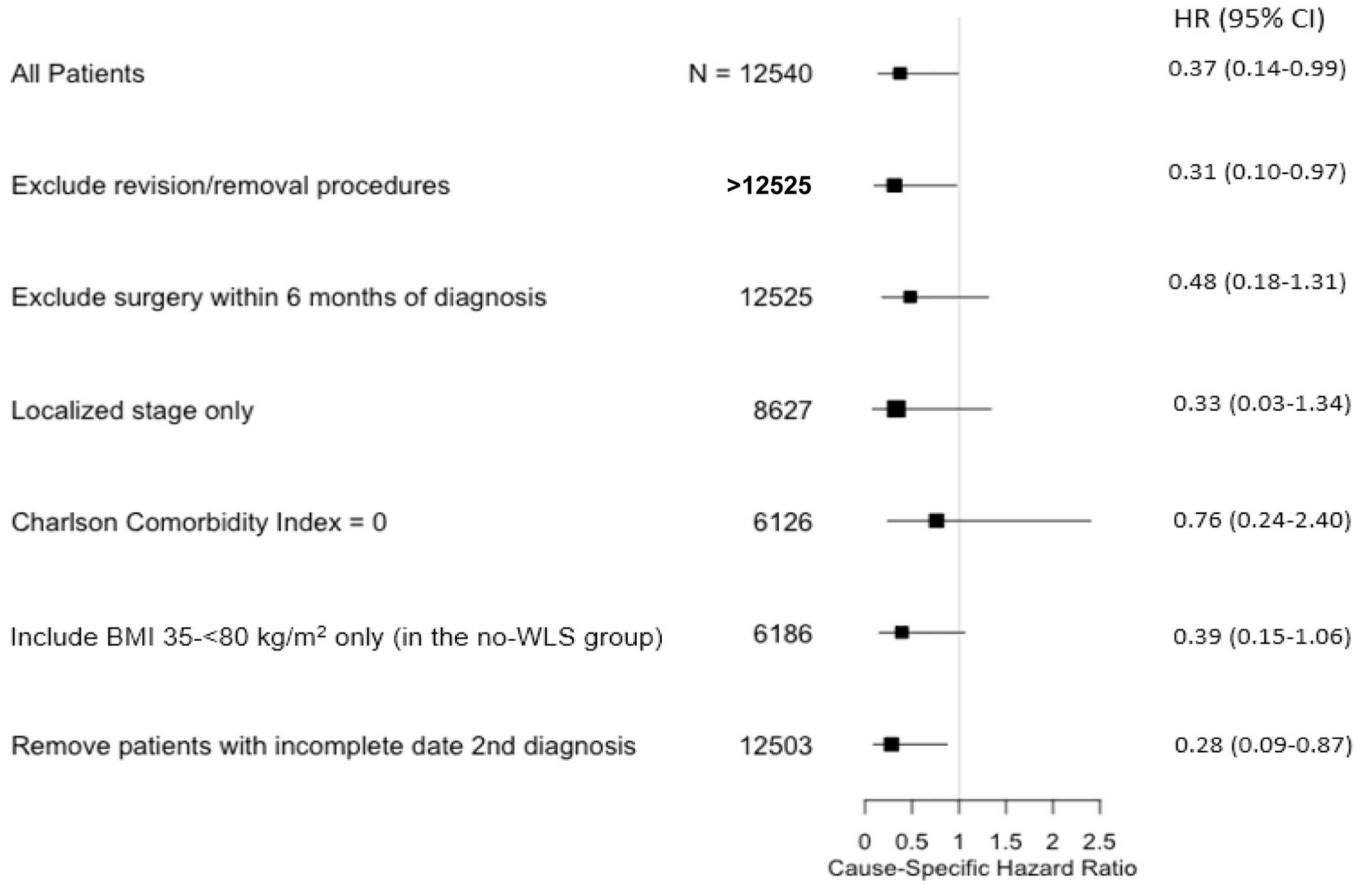

Figure 1.

Forest plot for the association between bariatric surgery and time to death among subgroups of patients with obesity diagnosed with breast cancer and endometrial cancer between 2011 and 2014*

Abbreviations: BMI, body mass index; NHW, non-Hispanic white; NHB, non-Hispanic black; SES, socio-economic status

* Stratified by cancer site and adjusted for stage (localized, regional), age at cancer diagnosis (<40, 40–49, 50–59, 60–69, 70–79, ≥80), Charlson Comorbidity Index (0, ≥1, unknown), race/ethnicity (NHW, NHB, Hispanic, Asian/Pacific Islanders/Other), SES (quintiles)

Table 1.

Diagnostic and procedure codes used to define WLS

	Data source	
	PDD (inpatient, 1991–2014)	**ASD/EDD (2005–2014)**
Procedure code format	ICD-9-CM	CPT code
Procedure codes for WLS	8 codes (43.7, 43.82, 43.89, 44.31, 44.38, 44.39, 44.68, 44.95)	9 codes (43644, 43645, 43770, 43775, 43842, 43843, 43845, 43846, 43847)
Procedure codes for revision or removal of bariatric surgery component	3 codes (44.5, 44.96, 44.97)	13 codes (43771, 43772, 43773, 43774, 43848, 43850, 43855, 43860, 43865, 43886, 43887, 43888, s2083)

Abbreviation: WLS, weight loss surgery; PDD, Patient Discharge Data; EDD, Emergency Department Data; ASD, Ambulatory Surgery Data; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification, CPT, Current Procedural Terminology

Table 2.

Demographic, tumor, and WLS characteristics for women with breast cancer or endometrial cancer diagnosed in California during 1991–2014*

	Breast cancer			Endometrial cancer		
	Did not have a WLS record (Total n=392,302)	**Had a WLS record *prior to* cancer diagnosis (Total n=1,437)**	**Had a WLS record *after* cancer diagnosis (Total n=1,407)**	**Did not have a WLS record (Total n=68,719)**	**Had a WLS record *prior to* cancer diagnosis (Total n=463)**	**Had a WLS record *after* cancer diagnosis (Total n=677)**
Characteristics	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Age at cancer diagnosis						
Mean ± SD	60 ± 14	55 ± 9	49 ± 8	62 ± 12	55 ± 9	47 ± 10
<40	23964 (6%)	53 (4%)	186 (13%)	2613 (4%)	31 (7%)	156 (23%)
40–49	74521 (19%)	331 (23%)	535 (38%)	7385 (11%)	86 (19%)	203 (30%)
50–59	94245 (24%)	553 (38%)	532 (38%)	18611 (27%)	203 (44%)	258 (38%)
60–69	91007 (23%)	432 (30%)	154 (11%)	20356 (30%)	143 (31%)	60 (8%)
70+	108565 (28%)	68 (5%)		19754 (29%)		
Race/ethnicity						
Non-Hispanic white	264029 (67%)	1037 (72%)	1016 (72%)	46291 (67%)	325 (70%)	466 (69%)
Non-Hispanic black	23225 (6%)	136 (9%)	155 (11%)	3295 (5%)	29 (6%)	35 (5%)
Hispanic	59917 (15%)	224 (16%)	196 (14%)	11337 (17%)	94 (20%)	135 (20%)
Asian/Pacific Islander	41404 (11%)	40 (3%)	21 (1%)	7068 (10%)	15 (4%)	41 (6%)
Other/U nknown	3727 (1%)		19 (1%)	728 (1%)		
Socio-economic status						
1 (lowest)	46272 (12%)	216 (15%)	156 (11%)	9237 (13%)	82 (18%)	111 (16%)
2 (lower middle)	67063 (17%)	299 (21%)	306 (22%)	12536 (18%)	98 (21%)	155 (23%)
3 (middle)	80592 (21%)	354 (25%)	331 (24%)	14500 (21%)	104 (22%)	174 (26%)
4 (upper middle)	92372 (24%)	340 (24%)	320 (23%)	15789 (23%)	103 (22%)	143 (21%)
5 (highest)	106003 (27%)	228 (16%)	294 (21%)	16657 (24%)	76 (16%)	94 (14%)
[Among patients with obesity diagnosed with cancer in 2011 or later]						
1 (lowest)	1553 (17%)	100 (15%)	18 (30%)	651 (19%)	43 (19%)	22 (46%)

	Breast cancer			Endometrial cancer		
	Did not have a WLS record (Total n=392,302)	Had a WLS record *prior to* cancer diagnosis (Total n=1,437)	Had a WLS record *after* cancer diagnosis (Total n=1,407)	Did not have a WLS record (Total n=68,719)	Had a WLS record *prior to* cancer diagnosis (Total n=463)	Had a WLS record *after* cancer diagnosis (Total n=677)
Characteristics	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
2 (lower middle)	1919 (21%)	154 (22%)		695 (21%)	51 (22%)	
3 (middle)	2014 (22%)	159 (23%)	16 (27%)	755 (22%)	51 (22%)	
4 (upper middle)	2013 (22%)	161 (23%)	26 (43%)	721 (21%)	50 (22%)	25 (54%)
5 (highest)	1580 (17%)	112 (16%)		558 (17%)	34 (15%)	
Year of cancer diagnosis (and maximum follow up time to ascertain post-diagnosis WLS)						
1991–1998 (max: 24 years)	114537 (29%)	22 (1%)	407 (29%)	19287 (28%)	19 (4%)	179 (26%)
1999–2002 (max: 16 years)	67417 (17%)	77 (5%)	306 (22%)	10247 (15%)		144 (21%)
2003–2006 (max: 12 years)	65458 (17%)	214 (15%)	364 (26%)	10794 (16%)	72 (16%)	178 (26%)
2007–2010 (max: 8 years)	70127 (18%)	438 (30%)	270 (19%)	13045 (19%)	143 (31%)	129 (19%)
2011–2014 (max: 4 years)	74763 (19%)	686 (48%)	60 (4%)	15346 (22%)	229 (49%)	47 (7%)
Stage at diagnosis						
Localized	258209 (66%)	1009 (70%)	957 (68%)	53964 (79%)	352 (76%)	608 (90%)
Regional	134093 (34%)	428 (30%)	450 (32%)	14755 (21%)	111 (24%)	69 (10%)
Charlson Comorbid Index at cancer diagnosis						
Mean ± SD	0.34± 0.81	0.52 ± 0.94	0.37 ± 0.76	0.45 ± 0.91	0.63 ± 0.91	0.50 ± 0.84
0	217413 (78%)	878 (66%)	753 (74%)	44515 (71%)	(~60%)[¶]	419 (64%)
1+	62664 (22%)	460 (34%)	270 (26%)	18103 (29%)	(~40%)[¶]	235 (36%)
Not determined	112225 (−)	99 (−)	384 (−)	6101 (−)	<15	23 (−)
Estrogen receptor (ER)						
Negative	68649 (20%)	263 (19%)	323 (26%)	-	-	-
Positive	270131 (80%)	1106 (81%)	904 (74%)	-	-	-

	Breast cancer			Endometrial cancer		
	Did not have a WLS record (Total n=392,302)	Had a WLS record *prior to* cancer diagnosis (Total n=1,437)	Had a WLS record *after* cancer diagnosis (Total n=1,407)	Did not have a WLS record (Total n=68,719)	Had a WLS record *prior to* cancer diagnosis (Total n=463)	Had a WLS record *after* cancer diagnosis (Total n=677)
Characteristics	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Unknown/borderline[¶]	53522 (−)	68 (−)	180 (−)	-	-	-
[Among age≥50]						
Negative	45050 (18%)	176 (17%)	118 (19%)			
Positive	208026 (82%)	831 (82%)	499 (81%)			
Unknown/borderline	40741 (−)	46 (−)	69 (−)			
Total number of OSHPD records of WLS (per patient)						
Only 1 record	-	1393 (97%)	1356 (96%)		446 (96%)	662 (98%)
>2 records	-	44 (3%)	51 (3%)	-	17 (4%)	15 (2%)
Revision/removal procedure						
No (New WLS procedures)	-	1385 (96%)	1343 (95%)	-	442 (95%)	652 (96%)
Yes (Had a record of a revision/removal procedure)		52 (4%)	64 (5%)		21 (5%)	25 (4%)
Age at WLS, first record						
Mean ± SD	-	50 ± 9	55 ± 8		50 ± 9	53 ± 10
<40	-	65 (5%)	15 (1%)	-	29 (6%)	29 (4%)
40–49	-	318 (22%)	133 (9%)	-	92 (20%)	118 (17%)
50–59	-	603 (42%)	480 (34%)	-	196 (42%)	192 (28%)
60–69	-	384 (27%)	568 (40%)	-	130 (28%)	268 (40%)
70+	-	67 (5%)	211 (15%)	-	16 (3%)	70 (10%)
Time interval between WLS and cancer diagnosis						
[WLS *prior to* cancer diagnosis]	-	(n=1,437)		-	(n=463)	-
Mean ± SD (years)	-	5.4 ± 4.0		-	5.3 ± 3.7	-
>5 years	-	667 (46%)		-	205 (44%)	-
2 – <5 years	-	421 (29%)		-	163 (35%)	-

	Breast cancer			Endometrial cancer		
	Did not have a WLS record (Total n=392,302)	**Had a WLS record *prior to* cancer diagnosis (Total n=1,437)**	**Had a WLS record *after* cancer diagnosis (Total n=1,407)**	**Did not have a WLS record (Total n=68,719)**	**Had a WLS record *prior to* cancer diagnosis (Total n=463)**	**Had a WLS record *after* cancer diagnosis (Total n=677)**
Characteristics	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
0 – <2 years	-	349 (24%)		-	95 (21%)	-
[WLS *after* cancer diagnosis]	-		(n=1,407)	-		(n=677)
Mean ± SD (years)	-		6.4 ± 4.5			5.5 ± 4.2
>0 – 2 years	-		207 (15%)	-		137 (20%)
>2 – 5 years	-		474 (34%)	-		253 (37%)
>5 – 10 years	-		425 (30%)	-		185 (27%)
>10 years	-		301 (21%)	-		102 (15%)

Abbreviation: WLS, weight loss surgery.

[*] Included 395,146 female breast cancer patients and 69,859 endometrial cancer patients. Cells with small numbers were combined due to the OSHPD small cell suppression policy.

[¶] Suppressed due to the OSHPD small cell suppression policy.

Table 3.

Association between WLS and time to death among patients with obesity diagnosed with breast cancer and endometrial cancer between 2011 and 2014[*]

Cancer site	WLS (after cancer diagnosis)	Total N	Death N	HR (95% CI)[¶]	P-value	HR (95% CI)[**]	P-value
Breast cancer							
	No	9091	967	1 (ref)		1 (ref)	
	Yes	60	<15[§]	0.52 (0.17–1.61)	0.25	0.48 (0.15–1.53)	0.22
Endometrial cancer							
	No	3343	451	1 (ref)		1 (ref)	
	Yes	46	<15[§]	0.21 (0.030–1.50)	0.12	0.23 (0.033–1.70)	0.15
Combined[†]							
	No	12434	1417	1 (ref)		1 (ref)	
	Yes	106	<15[§]	0.37 (0.14–0.99)	0.049	0.38 (0.14–1.04)	0.059

Abbreviation: HR, hazard ratio; CI, confidence interval; NHW, non-Hispanic white; NHB, non-Hispanic black; API, Asian/Pacific Islander; SES, socioeconomic status

[*] WLS group had a diagnosis code for obesity or morbid obesity. Excluding those who had undergone WLS prior to cancer diagnosis.

[§] Suppressed due to the OSHPD small cell suppression policy.

[¶] Adjusted for stage (localized, regional), age at cancer diagnosis (<40, 40–49, 50–59, 60–69, 70–79, ≥80), Charlson Comorbid Index (0, ≥1, unknown), race/ethnicity (NHW, NHB, Hispanic, Asian/Pacific Islanders/Other), SES (quintiles).

[**] Adjusted for quintiles of propensity score.

[†] Combined analysis of breast cancer and endometrial cancer patients was stratified by cancer site.