Supplementary Table 1. Procedure codes used to define bariatric surgery and number of OSHPD records marked with each procedure code among female non-metastasized breast cancer patients and endometrial cancer patients diagnosed in California during 1991-2014 ¶

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Bariatric surgery procedure code | Code definition | All patients | Cancer site | | Time sequence between bariatric surgery and cancer diagnosis | |
| Breast cancer | Endo-metrial cancer | Bariatric surgery *prior to* cancer diagnosis | Bariatric surgery after cancer diagnosis |
| **PDD (ICD-9-CM procedure codes)** | | | | | | |
| 43.7 | Partial gastrectomy with anastomosis to jejunum | 46 (1%) | \* | <15 | 25 (1%) | 21 (1%) |
| 43.82 | Laparoscopic vertical (sleeve) gastrectomy | 352 (8%) | 247 (8%) | 105 (5%) | 52 (2%) | 300 (13%) |
| 43.89 | Open and other partial gastrectomy | 271 (6%) | 195 (6%) | 76 (4%) | 106 (5%) | 165 (7%) |
| 44.31 | High gastric bypass | 1086 (25%) | 774 (25%) | 312 (15%) | 780 (37%) | 306 (13%) |
| 44.38 | Laparoscopic gastroenterostomy | 1401 (32%) | 985 (32%) | 416 (20%) | 547 (26%) | 854 (38%) |
| 44.39 | Other gastroenterostomy without gastrectomy | 429 (10%) | 295 (9%) | 134 (7%) | 268 (13%) | 161 (7%) |
| 44.5 (revision) | Revision of gastric anastomosis | 64 (1%) | 43 (1%) | 21 (1%) | 41 (2%) | 23 (1%) |
| 44.68 | Laparoscopic gastroplasty | 50 (1%) | \* | <15 | 25 (1%) | 25 (1%) |
| 44.95 | Laparoscopic gastric restrictive procedure | 281 (6%) | 207 (7%) | 74 (4%) | 98 (5%) | 183 (8%) |
| 44.96 (revision) | Laparoscopic revision of gastric restrictive procedure | 29 (1%) | \* | <15 | <15 | \* |  |
| 44.97 (removal) | Laparoscopic removal of gastric restrictive device(s) | 81 (2%) | 62 (2%) | 19 (1%) | 27 (1%) | 54 (2%) |
| **ASD (CPT procedure codes)** | | | | | | |
| 43770 | Laparoscopy, surgical, gastric restrictive procedure; placement of adjustable gastric restrictive device (eg, gastric band and subcutaneous port components) | 187 (4%) | 144 (5%) | 43 (2%) | 76 (4%) | 111 (5%) |
| Other CPT procedure codes with ≥1 ASD records  43644: Laparoscopy, surgical, gastric restrictive procedure; with gastric bypass and Roux-en-Y gastroenterostomy (roux limb 150 cm or less)  43771: Laparoscopy, surgical, gastric restrictive procedure; revision of adjustable gastric restrictive device component only  43772: Laparoscopy, surgical, gastric restrictive procedure; removal of adjustable gastric restrictive device component only  43773: Laparoscopy, surgical, gastric restrictive procedure; removal and replacement of adjustable gastric restrictive device component only  43774: Laparoscopy, surgical, gastric restrictive procedure; removal of adjustable gastric restrictive device and subcutaneous port components  43775: Laparoscopy, surgical, gastric restrictive procedure; longitudinal gastrectomy (ie, sleeve gastrectomy)  43842: Gastric restrictive procedure, without gastric bypass, for morbid obesity; vertical-banded gastroplasty  43843: Gastric restrictive procedure, without gastric bypass, for morbid obesity; other than vertical-banded gastroplasty  43848: Revision, open, of gastric restrictive procedure for morbid obesity, other than adjustable gastric restrictive device (separate procedure)  43886: Gastric restrictive procedure, open; revision of subcutaneous port component only  43887: Gastric restrictive procedure, open; removal of subcutaneous port component only  43888: Gastric restrictive procedure, open; removal and replacement of subcutaneous port component only | | 75 (2%) | 58 (2%) | 17 (1%) | 23 (1%) | 52 (2%) |
| Other CPT procedure codes with no ASD records  43645: Laparoscopy, surgical, gastric restrictive procedure; with gastric bypass and small intestine reconstruction to limit absorption  43845: Gastric restrictive procedure with partial gastrectomy, pylorus-preserving duodenoileostomy and ileoileostomy (50 to 100 cm common channel) to limit absorption (biliopancreatic diversion with duodenal switch)  43846: Gastric restrictive procedure, with gastric bypass for morbid obesity; with short limb (150 cm or less) Roux- en-Y gastroenterostomy  43847: Gastric restrictive procedure, with gastric bypass for morbid obesity; with small intestine reconstruction to limit absorption  43850: Revision of gastroduodenal anastomosis (gastroduodenostomy) with reconstruction; without vagotomy  43855: Revision of gastroduodenal anastomosis (gastroduodenostomy) with reconstruction; with vagotomy  43860: Revision of gastrojejunal anastomosis (gastrojejunostomy) with reconstruction, with or without partial gastrectomy or intestine resection; without vagotomy  43865: Revision of gastrojejunal anastomosis (gastrojejunostomy) with reconstruction, with or without partial gastrectomy or intestine resection; with vagotomy  s2083: Adjustment of gastric band diameter via subcutaneous port by injection or aspiration of saline | | 0 | 0 | 0 | 0 | 0 |

¶ Numbers represent number of bariatric surgery records noted with each procedure code; thus numbers do not add up to the total number of subjects.

\*Numbers are not presented to suppress sample size counts in related cells with n <15.

Supplementary Table 2. Characteristics of women with obesity diagnosed with breast and endometrial cancer between 2011-2014 included in the survival analysis.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Breast Cancer | |  | Endometrial Cancer | | | |
|  | Did not have a WLS record  (Total n=9,091) | Had a WLS record after cancer diagnosis  (Total n=60) |  | Did not have a WLS record  (Total n=3,343) | | Had a WLS record after cancer diagnosis  (Total n=46) | |
| Characteristics | N (%) | N (%) |  | N (%) | | N (%) | |
| Age at cancer diagnosis |  |  |  |  | |  | |
| (Mean ± SD) | 60 ± 12 | 51 ± 10 |  | 59 ± 12 | | 52 ± 11 | |
| Race/ethnicity |  |  |  |  | |  | |
| Non-Hispanic white | 5161 (57%) | 33 (55%) |  | 1906 (57%) | | 27 (59%) | |
| Other | 3930 (43%) | 27 (45%) |  | 1437 (43%) | | 19 (41%) | |
| Socio-economic status |  |  |  |  | |  | |
| 1 (lowest) | 1559 (17%) | 17 (28%) |  | 641 (19%) | | 22 (48%) | |
| 2 (lower middle) | 1920 (21%) |  | 696 (21%) | |
| 3 (middle) | 2014 (22%) | 16 (27%) |  | 744 (22%) | | 24 (52%) | |
| 4 (upper middle) | 2015 (22%) | 27 (45%) |  | 709 (21%) | |
| 5 (highest) | 1583 (17%) |  | 553 (17%) | |
| Stage at diagnosis |  |  |  |  | |  | |
| Localized | 5946 (65%) | >67%¶ |  | 2592 (78%) | | >67%¶ | |
| Regional | 3145 (35%) | <33%¶ |  | 751 (22%) | | <33%¶ | |
| Charlson Comorbid Index at cancer diagnosis |  |  |  |  | |  | |
| Mean ± SD | 0.64 ± 1.10 | 0.46 ± 0.87 |  | 0.78 ± 1.20 | | 1.11 ± 1.34 | |
| Time interval between cancer diagnosis and WLS |  |  |  |  | |  | |
| Mean ± SD (years) | - | 1.74 ± 0.89 |  |  | | 1.52 ± 1.05 | |
|  |  |  |  | |  | |  | |

¶ Suppressed due to the OSHPD small cell suppression policy.

Supplementary Table 3. Number of breast or endometrial patients included in the survival analysis according to the year of their first cancer diagnosis.

|  |  |
| --- | --- |
| Year of first cancer diagnosis | Number of patients (%) |
| 2011 | 1,256 (10%) |
| 2012 | 1,861 (15%) |
| 2013 | 4,068 (32%) |
| 2014 | 5,355 (43%) |

\* Patients who were diagnosed with a second primary cancer were censored at the time of second cancer diagnosis and removed from the risk set.

Supplementary Table 4. Number of breast or endometrial patients included in the survival analysis who are at risk at each follow-up time\*

|  |  |
| --- | --- |
| Follow-up (year) | N at risk |
| 0 (at WLS) | 12,540 |
| 1 | 11,657 |
| 2 | 10,989 |
| 3 | 10,043 |
| 4 | 5,267 |
| 5 | 2,151 |
| 6 | 750 |

\* Patients who were diagnosed with a second primary cancer were censored at the time of second cancer diagnosis and removed from the risk set.

Supplementary Table 5. Cause-specific hazard ratios and 95% confidence intervals for the multivariable Cox model stratified by cancer site among patients with obesity diagnosed with breast cancer or endometrial cancer between 2011 and 2014§.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | HR | (95% CI) |
| Bariatric surgery |  |  |  |
| (after cancer diagnosis) | No | 1 (ref) |  |
|  | Yes | 0.37 | (0.14-0.99)\* |
| Stage | Localized | 1 (ref) |  |
|  | Regional | 3.29 | (2.93-3.63)\* |
| Age | <40 | 1 (ref) |  |
|  | 40-49 | 0.82 | (0.59-1.12) |
|  | 50-59 | 0.90 | (0.67-1.21) |
|  | 60-69 | 1.25 | (0.94-1.67) |
|  | 70-79 | 1.93 | (1.44-2.59)\* |
|  | ≥80 | 5.27 | (3.89-7.14)\* |
| Charlson Comorbidity Index§§ | 0 | 1 (ref) |  |
|  | ≥1 | 1.89 | (1.68-2.13)\* |
| Race/ethnicity§§ | Non-Hispanic white | 1 (ref) |  |
|  | Non-Hispanic black | 1.49 | (1.26-1.76)\* |
|  | Hispanic | 0.89 | (0.78-1.03) |
|  | Asian/Pacific Islander/other | 0.89 | (0.70 to 1.12) |
| Socioeconomic status | 1 (lowest) | 1 (ref) |  |
|  | 2 (lower middle) | 0.93 | (0.80-1.09) |
|  | 3 (middle) | 0.73 | (0.62-0.87)\* |
|  | 4 (upper middle) | 0.71 | (0.60-0.84)\* |
|  | 5 (highest) | 0.72 | (0.60-0.86)\* |

Abbreviation: HR, hazard ratio; CI, confidence interval

§ 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 Comorbid Index (0, ≥1, unknown), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, Asian/Pacific Islanders/other, unknown), socioeconomic status (quintiles).

§§ Individuals with unknown Charlson Comorbidity Index and unknown race/ethnicity were included in the model as separate categories (data not shown).

\*Denotes significance at the 5% level.

**Supplementary Methods**

**Identification of non-metastasized (localized/regional stage) breast and endometrial cancer**: We identified 438,458 females diagnosed with first primary invasive breast cancer (SEER recode 26000; International Classification of Diseases for Oncology, 3rd edition (ICD-O-3) site code C50.0-C50.9) and 80,818 females diagnosed with first primary invasive endometrial cancer (SEER recode 27020, ICD-O-3 site code C54.1 and C54.9) between 1991 and 2014 in California who were aged 20 or older at diagnosis and have not been diagnosed with other cancers before their breast or endometrial cancer diagnosis. Because patients diagnosed with distant (metastasized) stage may not consider bariatric surgery as a treatment option for their obesity as patient with an earlier stage cancer, we excluded patients diagnosed at distant stage or at an unknown stage (32,941 breast cancer and 8,697 endometrial cancer patients), leaving 405,517 breast cancer and 72,121 endometrial cancer patients.

**Identification of bariatric surgery records**: Each OSHPD data record contains up to 25 diagnostic codes (one principal diagnosis and up to 24 other diagnoses) and up to 21 procedural codes 1. Bariatric surgery 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 (ICD-9-CM diagnostic codes 278.0, 278.00, 278.01), similar to methods used previously 2-5. We applied the same list of procedure codes used in the report published by the OSHPD 2 with minor modifications to exclude non-specific procedures in the stomach (Table 1 and Supplementary Table 1).

**Methods for descriptive analysis:** We conducted descriptive analysis to evaluate the frequency of bariatric surgery in females with breast or endometrial cancer. For descriptive analyses, we excluded 2% (n=10,371) of the 405,517 breast cancer patients and 3% (n= 2,262) of the 72,121 endometrial cancer patients who subsequently developed cancers of digestive tract (ICD-O-3 site code C15.0-C18.9, C26.0, C19.9, C20.9, C21.0-C21.2, C21.8, C22.0, C22.1, C23.9-25.9, C48.0-C48.2, C26.8, C26.9, C48.8), leaving 395,146 breast cancer patients and 69,859 endometrial cancer patients. This exclusion was done for two reasons: (1) a few procedure codes for bariatric surgery could also be used for other procedures of the digestive system (e.g. 43.89, partial gastrectomy; 44.38 and 44.39, gastroenterostomy) and (2) bariatric procedures may not be recommended or contraindicated for patients with cancers of digestive system. Socioeconomic status (SES) was estimated by using neighborhood SES information available at the CCR data, which was created by principal component analysis of block group level variables from the 2000 Census (for cases diagnosed between 1988 and 2005) 6, 7 or American Community Survey (for cases diagnosed since 2006) 8.

**Statistical methods for survival analysis:** We conducted multivariable analyses separately for breast cancer and endometrial cancer patients as well as combining the two sets of patients adjusting for stage (localized, regional), age at cancer diagnosis (<40, 40-49, 50-59, 60-69, 70-79, ≥80), Charlson Comorbidity Index (0, ≥1, unknown) 9, race/ethnicity (non-Hispanic white (NHW), non-Hispanic Black (NHB), Hispanic, Asian/Pacific Islanders/Other), neighborhood socioeconomic status (SES, in quintiles) 6, 8. The combined analysis was performed using a Cox model stratified by cancer site. In addition, given the limited number of deaths relative to the number of covariates in the model, we constructed a multivariable model adjusting for quintiles of a propensity score calculated based on the covariates listed above 10, 11. We conducted sensitivity analyses to evaluate whether the observed associations are robust by excluding patients 1) who have had a record of revision or removal procedures of WLS, 2) who underwent WLS within 6 months of cancer diagnosis, 3) who were diagnosed at regional stage (i.e., limiting the analyses to patients with localized stage cancer), 4) who had a Charlson Comorbidity Index ≥1, 5) whose BMI at cancer diagnosis was either under 35 kg/m2 or over 80 kg/m2 from the no-WLS group (i.e., limiting the comparison group to women with BMI 35-80 kg/m2), or 6) who had an incomplete date (i.e., missing day/month) of second cancer diagnosis. The sensitivity analyses were performed using the stratified Cox proportional hazards model. All p-values reported are two-sided.

**References**

1. California Office of Statewide Health Planning and Development (OSHPD). Research Data Request Information. Accessed November 1, 2019, <https://oshpd.ca.gov/data-and-reports/research-data-request-information/>

2. Fong N, Shabbir S, Holliday-Hanson M, Parker J. Trends in Bariatric Surgery in California Hospitals, 2005 to 2009. Accessed November 1, 2019, <https://data.chhs.ca.gov/dataset/number-of-weight-loss-surgeries-performed-in-california-hospitals/resource/e650ed8b-1d73-437d-b949-f7166be9501f>

3. Livingston EH. The incidence of bariatric surgery has plateaued in the U.S. *Am J Surg*. Sep 2010;200(3):378-85. doi:10.1016/j.amjsurg.2009.11.007

4. Weiss AC, Parina R, Horgan S, Talamini M, Chang DC, Sandler B. Quality and safety in obesity surgery-15 years of Roux-en-Y gastric bypass outcomes from a longitudinal database. *Surg Obes Relat Dis*. Jan 2016;12(1):33-40. doi:10.1016/j.soard.2015.04.018

5. Jen HC, Rickard DG, Shew SB, et al. Trends and outcomes of adolescent bariatric surgery in California, 2005-2007. *Pediatrics*. Oct 2010;126(4):e746-53. doi:10.1542/peds.2010-0412

6. Yost K, Perkins C, Cohen R, Morris C, Wright W. Socioeconomic status and breast cancer incidence in California for different race/ethnic groups. *Cancer Causes Control*. Oct 2001;12(8):703-11. doi:10.1023/a:1011240019516

7. Shariff-Marco S, Yang J, John EM, et al. Impact of neighborhood and individual socioeconomic status on survival after breast cancer varies by race/ethnicity: the Neighborhood and Breast Cancer Study. *Cancer Epidemiol Biomarkers Prev*. May 2014;23(5):793-811. doi:10.1158/1055-9965.EPI-13-0924

8. Yang J, Schupp CW, Harrati A, Clarke C, Keegan TH, Gomez SL. Developing an area-based socioeconomic measure from American Community Survey data. Cancer Prevention Institute of California, Fremont, California. Accessed November 1, 2020, <https://cancerregistry.ucsf.edu/sites/g/files/tkssra1781/f/wysiwyg/Yang%20et%20al.%202014_CPIC_ACS_SES_Index_Documentation_3-10-2014.pdf>

9. Lichtensztajn DY, Giddings BM, Morris CR, Parikh-Patel A, Kizer KW. Comorbidity index in central cancer registries: the value of hospital discharge data. *Clin Epidemiol*. 2017;9:601-609. doi:10.2147/clep.S146395

10. Joffe MM, Rosenbaum PR. Invited commentary: propensity scores. *Am J Epidemiol*. Aug 15 1999;150(4):327-33.

11. Austin PC. An Introduction to Propensity Score Methods for Reducing the Effects of Confounding in Observational Studies. *Multivariate Behav Res*. May 2011;46(3):399-424. doi:10.1080/00273171.2011.568786