**Appendices**

**Supplementary Table S1. Cohort inclusion and exclusion criteria**

|  |  |  |  |
| --- | --- | --- | --- |
| **Criteria** | **Total Cohort** | **Number Lost** | **Percent Lost** |
| Total breast cancer cases in SEER-Medicare diagnosed between 2010-2015 | 225428 |  |  |
| Restrict to breast cancer is the only cancer or first of many | 204861 | 20567 | 9.12 |
| Restrict to female | 203205 | 1656 | 0.81 |
| Restrict to not diagnosed by autopsy or death certificate | 202017 | 1188 | 0.58 |
| Restrict to known month of diagnosis | 201267 | 750 | 0.37 |
| Restrict to triple negative breast cancer (TNBC) | 16010 | 185257 | 92.05 |
| Restrict to age 66 years and older at diagnosis | 9205 | 6805 | 42.50 |
| Restrict to Medicare fee for service (Parts A and B) and no HMO enrollment 12 months prior and post diagnosis or until death | 5194 | 4011 | 43.57 |
| Restrict to stage I-III | 4598 | 596 | 11.47 |
| Received surgery (breast conserving surgery or mastectomy) | 4333 | 265 | 6.12 |

**Supplementary Table S2. Codes used to identity radiation, mastectomy, breast conserving surgery**

|  |  |  |
| --- | --- | --- |
| **Treatment** | **Code type** | **Specific codes** |
| Radiation | ICD 9 diagnosis codes | V58.0, v66.1, v67.1 |
| ICD 9 procedure codes | 92.2, 92.20, 92.21, 92.22, 92.23, 92.24, 92.25, 92.26, 92.27, 92.28, 92.29,  92.3, 92.30, 92.31, 92.32, 92.33, 92.39  92.4, 92.41 |
| ICD 10 procedure codes | 3E0F304, 3E0F704, 3E0F804, 3E0G304, 3E0G704, 3E0G804, 3E0H304, 3E0H704, 3E0H804, 3E0J304, 3E0J704, 3E0J804, 3E0L304, 3E0L704, 3E0M304, 3E0M704, 3E0Y304, 3E0Y704, DBY07ZZ, DBY17ZZ, DBY27ZZ, DBY57ZZ,  DBY67ZZ, DBY77ZZ, DDY57ZZ, DDY77ZZ, DMY07ZZ, DMY17ZZ, DWY27ZZ, DWY37ZZ, D7040ZZ, D7050ZZ, D7060ZZ, DB000ZZ, DB010ZZ, DB020ZZ, DB050ZZ, DB060ZZ, DB070ZZ, DD050ZZ, DD070ZZ, DH060ZZ, DH080ZZ, DM000ZZ, DM010ZZ, DW020ZZ, DW030ZZ, D71497Z, D71498Z, D71499Z,  D7149BZ, D7149CZ, D7149YZ, D714B7Z, D714B8Z, D714B9Z, D714BBZ, D714BCZ, D714BYZ, D71597Z, D71598Z, D71599Z, D7159BZ, D7159CZ, D7159YZ, D715B7Z, D715B8Z, D715B9Z, D715BBZ, D715BCZ, D715BYZ, D71697Z, D71698Z, D71699Z, D7169BZ, D7169CZ, D7169YZ, D716B7Z, D716B8Z, D716B9Z, D716BBZ, D716BCZ, D716BYZ, DB1097Z, DB1098Z, DB1099Z, DB109BZ, DB109CZ, DB109YZ, DB10B7Z, DB10B8Z, DB10B9Z, DB10BBZ, DB10BCZ, DB10BYZ, DB1197Z, DB1198Z, DB1199Z, DB119BZ, DB119CZ, DB119YZ, DB11B7Z, DB11B8Z, DB11B9Z, DB11BBZ, DB11BCZ, DB11BYZ, DB1297Z, DB1298Z, DB1299Z, DB129BZ, DB129CZ, DB129YZ, DB12B7Z, DB12B8Z, DB12B9Z, DB12BBZ, DB12BCZ, DB12BYZ, DB1597Z, DB1598Z, DB1599Z, DB159BZ, DB159CZ, DB159YZ, DB15B7Z, DB15B8Z, DB15B9Z, DB15BBZ, DB15BCZ, DB15BYZ, DB1797Z, DB1798Z, DB1799Z, DB179BZ, DB179CZ, DB179YZ, DB17B7Z, DB17B8Z, DB17B9Z, DB17BBZ, DB17BCZ, DB17BYZ, DD1597Z, DD1598Z, DD1599Z, DD159BZ, DD159CZ,  DD159YZ, DD15B7Z, DD15B8Z, DD15B9Z, DD15BBZ, DD15BCZ, DD15BYZ, DD1797Z, DD1798Z, DD1799Z, DD179BZ, DD179CZ, DD179YZ, DD17B7Z, DD17B8Z, DD17B9Z, DD17BBZ, DD17BCZ, DD17BYZ, DM1097Z, DM1098Z, DM1099Z, DM109BZ, DM109CZ, DM109YZ, DM10B7Z, DM10B8Z, DM10B9Z, DM10BBZ, DM10BCZ, DM10BYZ, DM1197Z, DM1198Z, DM1199Z, DM119BZ, DM119CZ, DM119YZ, DM11B7Z, DM11B8Z, DM11B9Z, DM11BBZ, DM11BCZ, DM11BYZ, DW1297Z, DW1298Z, DW1299Z, DW129BZ, DW129CZ, DW129YZ, DW12B7Z, DW12B8Z, DW12B9Z, DW12BBZ, DW12BCZ, DW12BYZ, DW1397Z, DW1398Z, DW1399Z, DW139BZ, DW139CZ, DW139YZ, DW13B7Z, DW13B8Z, DW13B9Z, DW13BBZ, DW13BCZ, DW13BYZ, D7041ZZ, D7042ZZ, D7051ZZ, D7052ZZ, DB001ZZ, DB002ZZ, DB011ZZ, DB012ZZ, DB021ZZ, DB022ZZ, DB051ZZ, DB052ZZ, DB071ZZ, DB072ZZ, DD051ZZ, DD052ZZ, DD071ZZ, DD072ZZ, DM001ZZ, DM002ZZ, DM011ZZ, DM012ZZ, DW021ZZ, DW022ZZ, D7043ZZ, D7053ZZ, D7063ZZ,  DB003ZZ, DB013ZZ, DB023ZZ, DB053ZZ, DB073ZZ, DD053ZZ, DD073ZZ, DM003ZZ, DM013ZZ, DW023ZZ, D7044ZZ, D7045ZZ, D7054ZZ, D7055ZZ, DB004ZZ, DB005ZZ,  DB014ZZ, DB015ZZ, DB024ZZ, DB025ZZ, DB054ZZ, DB055ZZ, DB074ZZ, DB075ZZ, DD054ZZ, DD055ZZ, DD074ZZ, DD075ZZ, DM004ZZ, DM005ZZ, DM014ZZ, DM015ZZ, DW024ZZ, DW025ZZ, 0BH001Z, 0BH031Z, 0BH041Z, 0BH071Z, 0BH081Z, 0BHK01Z, 0BHK31Z, 0BHK41Z, 0BHK71Z, 0BHK81Z, 0BHL01Z, 0BHL31Z, 0BHL41Z, 0BHL71Z, 0BHL81Z, 0DHP01Z, 0DHP31Z, 0DHP41Z, 0DHP71Z, 0DHP81Z, 0HHT01Z, 0HHT31Z, 0HHT71Z, 0HHT81Z,  0HHU01Z, 0HHU31Z,  0HHU71Z, 0HHU81Z, 0HHV01Z, 0HHV31Z, 0HHV71Z, 0HHV81Z, 0HHW01Z, 0HHW31Z,  0HHW71Z, 0HHW81Z, 0HHWX1Z, 0HHX01Z, 0HHX31Z, 0HHX71Z, 0HHX81Z, 0HHXX1Z, 0WH801Z, 0WH831Z, 0WH841Z, 0WH901Z, 0WH931Z, 0WH941Z, 0WHB01Z, 0WHB31Z, 0WHB41Z, 0WHQ01Z 0WHQ31Z, 0WHQ41Z, 0WHQ71Z, 0WHQ81Z, 0XH401Z, 0XH431Z, 0XH441Z, 0XH501Z, 0XH531Z, 0XH541Z, CW73NZZ, CW73YZZ, D7Y4FZZ, D7Y5FZZ, DBY0FZZ, DBY1FZZ, DBY2FZZ, DBY5FZZ, DBY7FZZ, DDY5FZZ, DDY7CZZ, DDY7FZZ, DMY0FZZ, DMY1FZZ, DWY2FZZ  D7043Z0, D7053Z0, D7063Z0, DB003Z0, DB013Z0, DB023Z0, DB053Z0, DD053Z0, DD073Z0, DW023Z0 |
|  | CPT/HCPCs codes | 19296, 19297, 32701, 61793, 61796, 61797, 61798, 61799, 61800, 63620, 63621, 32701, 61793, 77373, G0173, G0251, G0339, G0340, 0082T, 77371-77399 , 77401-77427, 77427-77499, 77520-77525, 77750-77799  G0173, G0174, G0242, G0243, G0251, G0338-G0340, G6002-G6017, 0073T, 0082T |
|  | Revenue center codes | 0330,0333 |
| Mastectomy | ICD 9 procedure codes | 85.33, 85.34, 85.4, 85.41, 85.43, 85.45, 85.47, 85.35, 85.36, 85.42, 85.44, 85.46, 85.48 |
| ICD 10 procedure codes | 0H0T0JZ, 0H0U0JZ, 0HTT0ZZ, 0HTU0ZZ, [0KTH0ZZ](https://www.icd10data.com/ICD10PCS/Codes/0/K/T/H/0KTH0ZZ), [0KTJ0ZZ](https://www.icd10data.com/ICD10PCS/Codes/0/K/T/J/0KTJ0ZZ), 0H0V0JZ, 0HTV0ZZ, 0KTH0ZZ, 0KTJ0ZZ, 0H5T0ZZ, 0H5U0ZZ, 0H5V0ZZ |
|  | CPT/HCPC codes | 19140, 19180, 19182, 19200, 19220, 19240, 19260, 19271, 19272, 19300, 19303-19307 |
| Breast conserving surgery | ICD 9 procedure codes | 85.2, 85.20, 85.21, 85.22, 85.23, 85.24, 85.25 |
| ICD 10 procedure codes | 0H5T3ZZ, 0H5T8ZZ, 0H5U3ZZ, 0H5U8ZZ, 0H5V3ZZ, 0H5V8ZZ, 0HBT0ZZ, 0HBT3ZZ, 0HBT7ZZ, 0HBT8ZZ, 0HBU0ZZ, 0HBU3ZZ, 0HBU7ZZ, 0HBU8ZZ, 0HBV0ZZ, 0HBV3ZZ, 0HBV7ZZ, 0HBV8ZZ, 0HBY0ZZ, 0HBY3ZZ, 0HBY7ZZ, 0HBY8ZZ, 0HTY0ZZ, 0H5W0ZZ, 0H5W3ZZ, 0H5W7ZZ, 0H5W8ZZ, 0H5WXZZ, 0H5X0ZZ, 0H5X3ZZ, 0H5X7ZZ, 0H5X8ZZ, 0H5XXZZ, 0HBW0ZZ, 0HBW3ZZ, 0HBW7ZZ, 0HBW8ZZ, 0HBWXZZ, 0HBX0ZZ, 0HBX3ZZ, 0HBX7ZZ, 0HBX8ZZ, 0HBXXZZ, 0HTWXZZ, 0HTXXZZ |
| CPT/HCPCs codes | 38790, 38792, 38900, 78800, 78801 |

**Supplementary Table S3. IPTW cox proportional hazards model predicting all-cause mortality**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **HR** | **95% CI** | **P value** |
| Treatment |  |  |  |
| BCS + RT | 1.00 (Reference) | | |
| BCS | 3.44 | 2.56 - 4.62 | <0.0001 |
| Mastectomy | 1.91 | 1.57 - 2.32 | <0.0001 |
| Mastectomy + RT | 2.21 | 1.65 - 2.97 | <0.0001 |

Abbreviations: BCS – breast conserving surgery; RT – radiotherapy; HR hazard ratio

**Supplementary Table S4. IPTW Fine-Gray Subdistribution hazard model for breast cancer death**

|  |  |  |  |
| --- | --- | --- | --- |
|  | | | |
|  | **sHR** | **95% CI** | **P value** |
| Treatment |  |  |  |
| BCS + RT | 1.00 (Reference) | | |
| BCS | 3.25 | 2.45 - 4.32 | <0.001 |
| Mastectomy | 1.65 | 1.31 - 2.08 | <0.001 |
| Mastectomy + RT | 2.59 | 2.02 - 3.32 | <0.001 |

Abbreviations: BCS – breast conserving surgery; RT – radiotherapy; sHR Subdistribution hazard ratio

**Supplementary Table S5a. Multivariate Cox proportional hazards model predicting all-cause mortality after excluding those who survived for only one month**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **HR** | **95%CI** | **P value** |
| Treatment |  |  |  |
| BCS + RT | 1.00 (Reference) | | |
| BCS | 2.99 | 2.37 - 3.76 | <0.0001 |
| Mastectomy | 2.00 | 1.67 - 2.40 | <0.0001 |
| Mastectomy + RT | 1.76 | 1.41 - 2.20 | <0.0001 |
| Tumor size |  |  |  |
| ≤2 cm | 1.00 (Reference) | | |
| > 2 and ≤ 5 cm | 1.09 | 0.85 - 1.41 | 0.49 |
| > 5 cm | 1.58 | 1.20 - 2.06 | 0.0009 |
| Stage |  |  |  |
| I | 1.00 (Reference) | | |
| II | 2.06 | 1.55 - 2.72 | <0.0001 |
| III | 4.10 | 3.05 - 5.51 | <0.0001 |
| Age at diagnosis (years) | |  |  |
| 66-74 | 1.00 (Reference) | | |
| 75-84 | 1.52 | 1.30 - 1.77 | <0.0001 |
| 85+ | 2.49 | 2.08 - 2.98 | <0.0001 |
| Race |  |  |  |
| White | 1.00 (Reference) | | |
| Black | 0.89 | 0.73 - 1.09 | 0.26 |
| Other | 0.94 | 0.67 - 1.30 | 0.70 |
| Charlson Comorbidity Score | |  |  |
| 0 | 1.00 (Reference) | | |
| 1 | 1.25 | 1.05 - 1.50 | 0.01 |
| 2 | 1.49 | 1.18 - 1.89 | 0.001 |
| 3+ | 2.30 | 1.84 - 2.87 | <0.0001 |
| Census tract median household income |  |  |  |
| <$40,000 | 1.00 (Reference) | | |
| $40,001 - $50,000 | 1.07 | 0.86 - 1.33 | 0.54 |
| $50,001 - $60,000 | 0.98 | 0.79 - 1.23 | 0.88 |
| >$60,000 | 0.91 | 0.75 - 1.10 | 0.33 |
| Missing | 1.03 | 0.78 - 1.37 | 0.83 |
| Region |  |  |  |
| Midwest | 1.24 | 1.016-1.516 | 0.03 |
| Northeast | 0.96 | 0.785-1.165 | 0.66 |
| South | 1.20 | 1.006-1.426 | 0.04 |
| West | 1.00 (Reference) | | |

BCS - breast conserving surgery; RT – radiotherapy; HR – hazard ratio

**Supplementary Table S5b. Pairwise comparison - Multivariate Cox proportional hazards model predicting all-cause mortality after excluding those who survived for a month or less**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatment** | **HR** | **95% CI** | **P valuea** |
| BCS vs BCS + RT | 2.99 | 2.37 - 3.76 | <0.0001 |
| BCS vs Mastectomy + RT | 1.70 | 1.31 - 2.20 | 0.0004 |
| BCS vs Mastectomy | 1.49 | 1.21 - 1.84 | 0.0011 |
| Mastectomy + RT vs BCS + RT | 1.76 | 1.41 - 2.20 | <0.0001 |
| Mastectomy vs BCS + RT | 2.00 | 1.67 - 2.40 | <0.0001 |
| Mastectomy vs Mastectomy + RT | 1.14 | 0.94 - 1.38 | 0.57 |

a The Tukey multiple comparison test was used to compare each pair and adjust for multiple comparisons Abbreviations: BCS – breast conserving surgery; RT – radiotherapy; HR – hazard ratio. Covariates adjusted for include: tumor size, tumor stage, age at diagnosis, race, census tract median household income, US census region and Charlson comorbidity score.

**Supplementary Table S6a. Fine-Gray Subdistribution hazard model for breast cancer death after excluding those who survived for a month or less**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **sHR** | **95% CI** | **P value** |
| Treatment |  |  |  |
| BCS + RT | 1.00 (Reference) | | |
| BCS | 2.65 | 1.86 - 3.77 | <0.0001 |
| Mastectomy | 1.63 | 1.25 - 2.11 | 0.0002 |
| Mastectomy + RT | 1.96 | 1.46 - 2.64 | <0.0001 |
| Tumor size |  |  |  |
| ≤2 cm | 1.00 (Reference) | | |
| > 2 and ≤ 5 cm | 1.15 | 0.82 - 1.60 | 0.43 |
| > 5 cm | 1.69 | 1.20 - 2.40 | 0.003 |
| Stage |  |  |  |
| I | 1.00 (Reference) | | |
| II | 3.10 | 2.07 - 4.65 | <0.0001 |
| III | 6.69 | 4.38 - 10.20 | <0.0001 |
| Age at diagnosis (years) |  |  |  |
| 66-74 | 1.00 (Reference) | | |
| 75-84 | 1.11 | 0.90 - 1.38 | 0.33 |
| 85+ | 1.51 | 1.16 - 1.97 | 0.002 |
| Race |  |  |  |
| White | 1.00 (Reference) | | |
| Black | 0.73 | 0.53 - 1.00 | 0.05 |
| Other | 0.60 | 0.35 - 1.03 | 0.07 |
| Charlson Comorbidity Score |  |  |  |
| 0 | 1.00 (Reference) | | |
| 1 | 0.95 | 0.73 - 1.24 | 0.71 |
| 2 | 1.27 | 0.92 - 1.77 | 0.15 |
| 3+ | 1.21 | 0.82 - 1.79 | 0.33 |
| Census tract median household income |  |  |  |
| <40,000 | 1.00 (Reference) | | |
| 40,001 - 50,000 | 1.02 | 0.75 - 1.38 | 0.92 |
| 50,001 - 60,000 | 1.04 | 0.77 - 1.40 | 0.81 |
| >60,000 | 0.83 | 0.64 - 1.09 | 0.19 |
| Missing | 1.01 | 0.67 - 1.52 | 0.97 |
| Region |  |  |  |
| Midwest | 1.32 | 1.01 - 1.74 | 0.05 |
| Northeast | 0.89 | 0.67 - 1.18 | 0.4 |
| South | 1.25 | 0.98 - 1.58 | 0.07 |
| West | 1.00 (Reference) | | |

Abbreviations: BCS – breast conserving surgery; RT – radiotherapy; sHR Subdistribution hazard ratio

**Supplementary Table S6b. Pairwise comparison - Fine-Gray Subdistribution hazard model for breast cancer death after excluding those who survived for a month or less**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **sHR** | **95% CI** | **P valuea** |
| BCS vs BCS + RT | 2.65 | 1.86 - 3.77 | <0.0001 |
| BCS vs Mastectomy + RT | 1.35 | 0.91 - 2.00 | 0.44 |
| BCS vs Mastectomy | 1.63 | 1.17 - 2.26 | 0.02 |
| Mastectomy + RT vs BCS + RT | 1.96 | 1.46 - 2.64 | <0.0001 |
| Mastectomy vs BCS + RT | 1.63 | 1.25 - 2.11 | 0.001 |
| Mastectomy vs Mastectomy + RT | 0.83 | 0.63 - 1.08 | 0.52 |

a The Tukey multiple comparison test was used to compare each pair and adjust for multiple comparisons Abbreviations: BCS – breast conserving surgery; RT – radiotherapy; sHR Subdistribution hazard ratio. Covariates adjusted for include: tumor size, tumor stage, age at diagnosis, race, census tract median household income, US census region and Charlson comorbidity score.

**Supplementary Table S7a. Continuous age and tumor size broke further - Multivariate Cox proportional hazards model predicting all-cause mortality**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | | |
|  | **HR** | **95%CI** | **P value** |
| Treatment |  |  |  |
| BCS + RT | 1.00 (Reference) | | |
| BCS | 2.93 | 2.33 - 3.68 | <0.0001 |
| Mastectomy | 1.98 | 1.65 - 2.37 | <0.0001 |
| Mastectomy + RT | 1.73 | 1.38 - 2.16 | <0.0001 |
| Tumor size |  |  |  |
| ≤1 cm | 1.00 (Reference) | | |
| > 1 and ≤ 2 cm | 1.64 | 1.21 - 2.22 | 0.002 |
| > 2 and ≤ 5 cm | 1.62 | 1.13 - 2.33 | 0.009 |
| > 5 and ≤ 10 cm | 2.47 | 1.68 - 3.64 | <0.0001 |
| > 10 cm | 2.16 | 1.39 - 3.36 | 0.0007 |
| Stage |  |  |  |
| I | 1.00 (Reference) | | |
| II | 1.94 | 1.47 - 2.58 | <0.0001 |
| III | 3.86 | 2.87 - 5.18 | <0.0001 |
| Age at diagnosis (years) |  |  |  |
| 1 year | 1.05 | 1.04 - 1.06 | <0.0001 |
| Race |  |  |  |
| White | 1.00 (Reference) | | |
| Black | 0.91 | 0.74 - 1.11 | 0.36 |
| Other | 0.97 | 0.70 - 1.34 | 0.85 |
| Charlson Comorbidity Score |  |  |  |
| 0 | 1.00 (Reference) | | |
| 1 | 1.25 | 1.05 - 1.50 | 0.01 |
| 2 | 1.47 | 1.16 - 1.86 | 0.002 |
| 3+ | 2.27 | 1.82 - 2.83 | <0.0001 |
| Census tract median household income |  |  |  |
| <40,000 | 1.00 (Reference) | | |
| 40,001 - 50,000 | 1.07 | 0.87 - 1.33 | 0.52 |
| 50,001 - 60,000 | 0.99 | 0.80 - 1.24 | 0.96 |
| >60,000 | 0.90 | 0.75 - 1.09 | 0.28 |
| Missing | 0.98 | 0.74 - 1.30 | 0.89 |
| Region |  |  |  |
| Midwest | 1.24 | 1.01 - 1.51 | 0.04 |
| Northeast | 0.97 | 0.80 - 1.18 | 0.79 |
| South | 1.22 | 1.03 - 1.45 | 0.02 |
| West | 1.00 (Reference) | | |

Abbreviations: BCS – breast conserving surgery; RT – radiotherapy; HR – hazard ratio

**Supplementary Table S7b. Pairwise comparison - Continuous age and tumor size broke further - Multivariate Cox proportional hazards model predicting all-cause mortality**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatment** | **HR** | **95% CI** | **P valuea** |
| BCS vs BCS + RT | 2.93 | 2.33 - 3.68 | <0.0001 |
| BCS vs Mastectomy + RT | 1.70 | 1.31 - 2.20 | 0.0004 |
| BCS vs Mastectomy | 1.48 | 1.21 - 1.8 | 0.001 |
| Mastectomy + RT vs BCS + RT | 1.73 | 1.38 - 2.16 | <0.0001 |
| Mastectomy vs BCS + RT | 1.98 | 1.65 - 2.37 | <0.0001 |
| Mastectomy vs Mastectomy + RT | 1.14 | 0.94 - 1.39 | 0.53 |

a The Tukey multiple comparison test was used to compare each pair and adjust for multiple comparisons Abbreviations: BCS – breast conserving surgery; RT – radiotherapy; HR- hazard ratio. Covariates adjusted for include: tumor size, tumor stage, age at diagnosis, race, census tract median household income, US census region and Charlson comorbidity score.

**Supplementary Table S8a: Continuous age and tumor size broke further - Fine-Gray Subdistribution hazard model for breast cancer death**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **sHR** | **95% CI** | **P value** |
| Treatment |  |  |  |
| BCS + RT | 1.00 (Reference) | | |
| BCS | 2.67 | 1.89 - 3.78 | <0.0001 |
| Mastectomy | 1.63 | 1.26 - 2.11 | 0.0002 |
| Mastectomy + RT | 1.94 | 1.44 - 2.61 | <0.0001 |
| Tumor size |  |  |  |
| ≤1 cm | 1.00 (Reference) | | |
| > 1 and ≤ 2 cm | 2.04 | 1.19 - 3.50 | 0.01 |
| > 2 and ≤ 5 cm | 2.06 | 1.17 - 3.62 | 0.01 |
| > 5 and ≤ 10 cm | 2.96 | 1.64 - 5.36 | 0.0003 |
| > 10 cm | 3.27 | 1.75 - 6.12 | 0.0002 |
| Stage |  |  |  |
| I | 1.00 (Reference) | | |
| II | 2.92 | 1.96 - 4.35 | <0.0001 |
| III | 6.38 | 4.21 - 9.66 | <0.0001 |
| Age at diagnosis (years) |  |  |  |
| 1 year | 1.02 | 1.01 - 1.03 | 0.006 |
| Race |  |  |  |
| White | 1.00 (Reference) | | |
| Black | 0.75 | 0.55 - 1.03 | 0.07 |
| Other | 0.65 | 0.38 - 1.09 | 0.1 |
| Charlson Comorbidity Score |  |  |  |
| 0 | 1.00 (Reference) | | |
| 1 | 0.95 | 0.73 - 1.23 | 0.69 |
| 2 | 1.30 | 0.93 - 1.80 | 0.12 |
| 3+ | 1.23 | 0.84 - 1.81 | 0.29 |
| Census tract median household income |  |  |  |
| <40,000 | 1.00 (Reference) | | |
| 40,001 - 50,000 | 1.03 | 0.76 - 1.39 | 0.87 |
| 50,001 - 60,000 | 1.04 | 0.77 - 1.40 | 0.81 |
| >60,000 | 0.85 | 0.65 - 1.11 | 0.22 |
| Missing | 1.01 | 0.67 - 1.52 | 0.98 |
| Region |  |  |  |
| Midwest | 1.31 | 1.00 - 1.73 | 0.05 |
| Northeast | 0.89 | 0.67 - 1.18 | 0.42 |
| South | 1.27 | 1.01 - 1.61 | 0.04 |
| West | 1.00 (Reference) | | |

Abbreviations: BCS – breast conserving surgery; RT – radiotherapy; sHR Subdistribution hazard ratio

**Supplementary Table S8b. Pairwise comparison - Continuous age and tumor size broke further - Fine-Gray Subdistribution hazard model for breast cancer death**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **sHR** | **95% CI** | **P valuea** |
| BCS vs BCS + RT | 2.67 | 1.89 - 3.78 | <0.0001 |
| BCS vs Mastectomy + RT | 1.38 | 0.93 - 2.04 | 0.37 |
| BCS vs Mastectomy | 1.64 | 1.19 - 2.27 | 0.01 |
| Mastectomy + RT vs BCS + RT | 1.94 | 1.44 - 2.61 | <0.0001 |
| Mastectomy vs BCS + RT | 1.63 | 1.26 - 2.11 | 0.001 |
| Mastectomy vs Mastectomy + RT | 0.83 | 0.64 - 1.10 | 0.57 |

a The Tukey multiple comparison test was used to compare each pair and adjust for multiple comparisons Abbreviations: BCS – breast conserving surgery; RT – radiotherapy; sHR Subdistribution hazard ratio. Covariates adjusted for include: tumor size, tumor stage, age at diagnosis, race, census tract median household income, US census region and Charlson comorbidity score.

**Supplementary Table S9: Chemotherapy receipt by treatment**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | BCS (N= 402) | | BCS + RT (N= 2110) | | Mastectomy (N= 1219) | | Mastectomy + RT (N= 602) | | P valuea |
| Characteristic | N | % | N | % | N | % | N | % |  |
| Chemotherapy |  |  |  |  |  |  |  |  | <0.0001 |
| Yes | 118 | 29.35 | 1280 | 60.66 | 549 | 45.04 | 478 | 79.40 |  |
| No | 284 | 70.65 | 830 | 39.34 | 670 | 54.96 | 124 | 20.60 |  |

a P values based on Pearson χ2 . Abbreviations: BCS – breast conserving surgery; RT - Radiotherapy

**Supplementary Table S10a. Multivariate Cox proportional hazards model predicting all-cause mortality including chemotherapy adjustment**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **HR** | **95% CI** | **P value** |
| Treatment |  |  |  |
| BCS + RT | 1.00 (Reference) | | |
| BCS | 2.80 | 2.22 - 3.51 | <0.0001 |
| Mastectomy | 1.92 | 1.60 - 2.30 | <0.0001 |
| Mastectomy + RT | 1.84 | 1.47 - 2.31 | <0.0001 |
|  |  |  |  |
| Tumor size |  |  |  |
| ≤2 cm | 1.00 (Reference) | | |
| > 2 and ≤ 5 cm | 1.08 | 0.84 -1.39 | 0.54 |
| > 5 cm | 1.52 | 1.17 – 1.99 | 0.002 |
| Stage |  |  |  |
| I | 1.00 (Reference) | | |
| II | 2.29 | 1.73 – 3.04 | <0.0001 |
| III | 4.92 | 3.65 – 6.62 | <0.0001 |
| Age at diagnosis (years) |  |  |  |
| 66-74 | 1.00 (Reference) | | |
| 75-84 | 1.28 | 1.09 - 1.51 | 0.003 |
| 85+ | 1.81 | 1.48 - 2.22 | <0.0001 |
| Race |  |  |  |
| White | 1.00 (Reference) | | |
| Black | 0.88 | 0.72 - 1.07 | 0.21 |
| Other | 0.96 | 0.70 - 1.33 | 0.82 |
| Charlson Comorbidity Score |  |  |  |
| 0 | 1.00 (Reference) | | |
| 1 | 1.24 | 1.04 -1.49 | 0.02 |
| 2 | 1.43 | 1.13 - 1.81 | 0.003 |
| 3+ | 2.17 | 1.74 - 2.71 | <0.0001 |
| Census tract median household income |  |  |  |
| <40,000 | 1.00 (Reference) | | |
| 40,001 - 50,000 | 1.03 | 0.83 - 1.28 | 0.78 |
| 50,001 - 60,000 | 0.96 | 0.77 - 1.20 | 0.72 |
| >60,000 | 0.89 | 0.74 - 1.08 | 0.22 |
| Missing | 0.98 | 0.73 - 1.30 | 0.87 |
| Region |  |  |  |
| Midwest | 1.19 | 0.97 - 1.45 | 0.09 |
| Northeast | 0.96 | 0.79 - 1.17 | 0.69 |
| South | 1.17 | 0.98 - 1.39 | 0.08 |
| West | 1.00 (Reference) | | |
| Chemotherapy |  | | |
| Yes | 1.00 (Reference) | | |
| No | 1.71 | 1.45 – 2.02 | <0.0001 |

Abbreviations: BCS – breast conserving surgery; RT – radiotherapy; HR – hazard ratio

**Supplementary Table S10b. Pairwise Comparison - multivariate Cox proportional hazards model predicting all-cause mortality including chemotherapy adjustment**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatment** | **HR** | **95% CI** | **P valuea** |
| BCS vs BCS + RT | 2.80 | 2.22 - 3.51 | <0.0001 |
| BCS vs Mastectomy + RT | 1.52 | 1.17 – 1.97 | 0.009 |
| BCS vs Mastectomy | 1.46 | 1.19 - 1.80 | 0.002 |
| Mastectomy + RT vs BCS + RT | 1.84 | 1.47 - 2.31 | <0.0001 |
| Mastectomy vs BCS + RT | 1.92 | 1.60 - 2.30 | <0.0001 |
| Mastectomy vs Mastectomy + RT | 1.05 | 0.85 - 1.27 | 0.98 |

a The Tukey multiple comparison test was used to compare each pair and adjust for multiple comparisons Abbreviations: BCS – breast conserving surgery; RT – radiotherapy; HR – hazard ratio. Covariates adjusted for include: tumor size, tumor stage, age at diagnosis, race, census tract median household income, US census region, Charlson comorbidity score and chemotherapy.

**Supplementary Table S11a: Fine-Gray Subdistribution hazard model for breast cancer death including chemotherapy adjustment**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **sHR** | **95% CI** | **P value** |
| Treatment |  |  |  |
| BCS + RT | 1.00 (Reference) | | |
| BCS | 2.61 | 1.83 - 3.73 | <0.0001 |
| Mastectomy | 1.61 | 1.24 - 2.09 | 0.0004 |
| Mastectomy + RT | 1.97 | 1.47 - 2.66 | <0.0001 |
| Tumor size |  |  |  |
| ≤2 cm | 1.00 (Reference) | | |
| > 2 and ≤ 5 cm | 1.15 | 0.82 - 1.60 | 0.42 |
| > 5 cm | 1.67 | 1.18 - 2.36 | 0.004 |
| Stage |  |  |  |
| I | 1.00 (Reference) | | |
| II | 3.11 | 2.07 - 4.68 | <0.0001 |
| III | 6.91 | 4.50 - 10.61 | <0.0001 |
| Age at diagnosis (years) |  |  |  |
| 66-74 | 1.00 (Reference) | | |
| 75-84 | 1.10 | 0.88 - 1.36 | 0.41 |
| 85+ | 1.41 | 1.05 - 1.90 | 0.02 |
| Race |  |  |  |
| White | 1.00 (Reference) | | |
| Black | 0.74 | 0.54 - 1.01 | 0.06 |
| Other | 0.64 | 0.38 - 1.07 | 0.09 |
| Charlson Comorbidity Score |  |  |  |
| 0 | 1.00 (Reference) | | |
| 1 | 0.96 | 0.74 - 1.24 | 0.74 |
| 2 | 1.29 | 0.93 - 1.78 | 0.13 |
| 3+ | 1.21 | 0.82 - 1.78 | 0.34 |
| Census tract median household income |  |  |  |
| <40,000 | 1.00 (Reference) | | |
| 40,001 - 50,000 | 1.02 | 0.75 - 1.40 | 0.88 |
| 50,001 - 60,000 | 1.02 | 0.76 - 1.38 | 0.89 |
| >60,000 | 0.84 | 0.64 - 1.10 | 0.21 |
| Missing | 1.00 | 0.66 - 1.51 | 0.99 |
| Region |  |  |  |
| Midwest | 1.31 | 0.99 - 1.72 | 0.05 |
| Northeast | 0.89 | 0.67 - 1.18 | 0.41 |
| South | 1.26 | 0.99 - 1.59 | 0.05 |
| West | 1.00 (Reference) | | |
| Chemotherapy |  | | |
| Yes | 1.00 (Reference) | | |
| No | 1.12 | 0.88 – 1.43 | 0.36 |

Abbreviations: BCS – breast conserving surgery; RT – radiotherapy; sHR Subdistribution hazard ratio

**Supplementary Table S11b. Pairwise comparison - Fine-Gray Subdistribution hazard model for breast cancer death including chemotherapy adjustment**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **sHR** | **95% CI** | **P valuea** |
| BCS vs BCS + RT | 2.61 | 1.83 - 3.73 | <0.0001 |
| BCS vs Mastectomy + RT | 1.33 | 0.89 – 1.98 | 0.51 |
| BCS vs Mastectomy | 1.62 | 1.17 - 2.27 | 0.02 |
| Mastectomy + RT vs BCS + RT | 1.97 | 1.47 - 2.66 | <0.0001 |
| Mastectomy vs BCS + RT | 1.61 | 1.24 - 2.09 | 0.002 |
| Mastectomy vs Mastectomy + RT | 0.82 | 0.62 - 1.07 | 0.46 |

a The Tukey multiple comparison test was used to compare each pair and adjust for multiple comparisons Abbreviations: BCS – breast conserving surgery; RT – radiotherapy; sHR Subdistribution hazard ratio. Covariates adjusted for include: tumor size, tumor stage, age at diagnosis, race, census tract median household income, US census region, Charlson comorbidity score and chemotherapy.

**Supplementary Table S12. Factors associated with receiving radiotherapy after breast conserving surgery**

|  |  |  |  |
| --- | --- | --- | --- |
| Characteristics | OR | 95% CI | P Value |
| Age at diagnosis (years) |  |  |  |
| 66-74 | Reference | | |
| 75-84 | 0.57 | 0.44-0.73 | <0.0001 |
| 85+ | 0.11 | 0.08-0.16 | <0.0001 |
| Race |  |  |  |
| White | Reference | | |
| Black | 1.2 | 0.83-1.73 | 0.33 |
| Other | 0.61 | 0.36-1.05 | 0.08 |
| Region |  |  |  |
| Midwest | 0.99 | 0.69-1.43 | 0.96 |
| Northeast | 1.25 | 0.90-1.74 | 0.19 |
| South | 0.83 | 0.61-1.13 | 0.23 |
| West | Reference | | |
| Stage |  |  |  |
| I | Reference | | |
| II | 1.35 | 0.80-2.30 | 0.27 |
| III | 1.01 | 0.55-1.88 | 0.97 |
| Charlson Comorbidity Score |  |  |  |
| 0 | Reference | | |
| 1 | 0.62 | 0.46-0.83 | 0.002 |
| 2 | 0.6 | 0.38-0.95 | 0.03 |
| 3+ | 0.41 | 0.27-0.62 | <0.0001 |
| Census tract median household income |  |  |  |
| <$40,000 |  |  |  |
| $40,001 - $50,000 | 0.92 | 0.62-1.35 | 0.66 |
| $50,001 - $60,000 | 1.43 | 0.96-2.14 | 0.08 |
| >$60,000 | 1.65 | 1.18-2.32 | 0.004 |
| Missing | 1.02 | 0.61-1.72 | 0.94 |