

## ONLINE RESOURCES

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**Online Resource 1 Australian Classification of Health Interventions (ACHI) procedure codes**

| <b>Type of surgery</b>    | <b>ACHI Block</b> | <b>ACHI Codes</b>   | <b>Description</b>   |
|---------------------------|-------------------|---|--|
| Breast conserving surgery | 1744              | 30347-00, 31500-00  | Excision of lesion of breast                                       |
|                           |                   | 30342-00  | Local excision of lesion of breast                                 |
|                           |                   | 30346-00  | Local excision of lesion of breast with frozen section biopsy      |
|                           | 1745              | 30342-01  | Segmental resection of breast                                      |
|                           |                   | 30346-01  | Segmental resection of breast with frozen section biopsy           |
|                           | 1746              | 30350-00  | Partial mastectomy   |
|                           |                   | 30350-01  | Partial mastectomy with frozen section biopsy                      |
| Re-excision               | 1744              | 30348-00, 31515-00  | Re-excision of lesion of breast                                    |
| Mastectomy                | 1747              | 30356-03  | Subcutaneous mastectomy with frozen section biopsy, bilateral      |
|                           |                   | 30356-01  | Subcutaneous mastectomy with frozen section biopsy, unilateral     |
|                           |                   | 30356-02, 30354-01, 31524-01                              | Subcutaneous mastectomy, bilateral                                 |
|                           |                   | 30356-00, 30354-00, 31524-00                              | Subcutaneous mastectomy, unilateral                                |
|                           | 1748              | 30338-03  | Simple mastectomy with frozen section biopsy, bilateral            |
|                           |                   | 30338-01  | Simple mastectomy with frozen section biopsy, unilateral           |
|                           |                   | 30338-02, 30351-01, 31518-01                              | Simple mastectomy, bilateral                                       |
|                           |                   | 30338-00, 30351-00, 31518-00                              | Simple mastectomy, unilateral                                      |
|                           | 1749              | 30353-03  | Extended simple mastectomy with frozen section biopsy, bilateral   |
|                           |                   | 30353-01  | Extended simple mastectomy with frozen section biopsy, unilateral  |
|                           |                   | 30353-02  | Extended simple mastectomy, bilateral                              |
|                           |                   | 30353-00  | Extended simple mastectomy, unilateral                             |
|                           | 1750              | 30359-03  | Modified radical mastectomy with frozen section biopsy, bilateral  |
|                           |                   | 30359-01  | Modified radical mastectomy with frozen section biopsy, unilateral |
|                           |                   | 30359-02  | Modified radical mastectomy, bilateral                             |
|                           |                   | 30359-00  | Modified radical mastectomy, unilateral                            |
|                           | 1751              | 30359-07  | Radical mastectomy with frozen section biopsy, bilateral           |
| 30359-05                  |                   | Radical mastectomy with frozen section biopsy, unilateral |  |
| 30359-06                  |                   | Radical mastectomy, bilateral                             |  |
| 30359-04                  |                   | Radical mastectomy, unilateral                            |  |

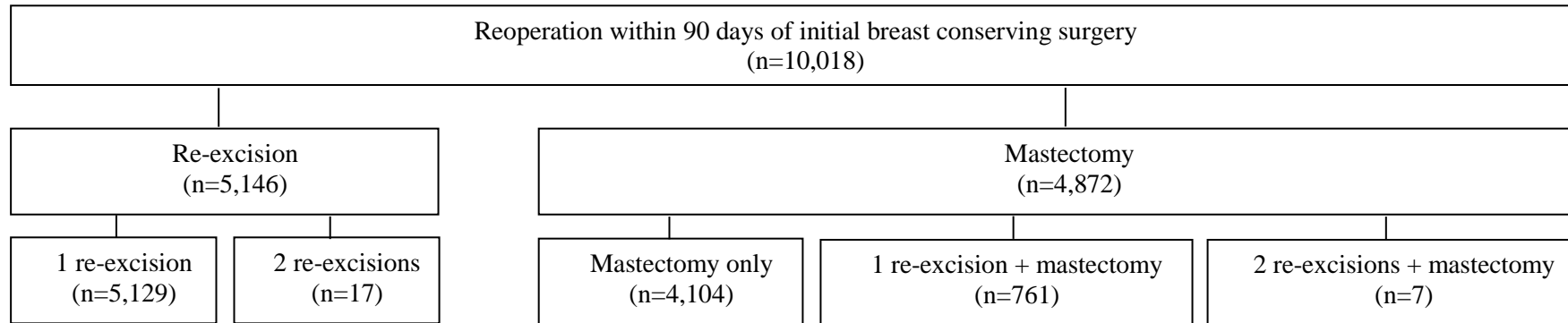
## Online Resource 2 Distribution of hospitals and patients by hospital type, surgical volume and hospital location

| Variable                               | Distribution of hospitals |                           | Distribution of patients |                           |
|--|---------------------------|---------------------------|--------------------------|---------------------------|
|  | Metropolitan<br>N (%)     | Non-metropolitan<br>N (%) | Metropolitan<br>N (%)    | Non-metropolitan<br>N (%) |
| <b>Hospital type</b>                   | p=0.003 <sup>a</sup>      |                           | p<0.001 <sup>a</sup>     |                           |
| Public                                 | 35 (42.2)                 | 51 (65.4)                 | 11,402 (42.9)            | 4,114 (52.1)              |
| Private                                | 48 (57.8)                 | 27 (34.6)                 | 15,157 (57.1)            | 3,785 (47.9)              |
| <b>BCS surgical volume<sup>b</sup></b> | p<0.001 <sup>a</sup>      |                           | p<0.001 <sup>a</sup>     |                           |
| <1                                     | 20 (24.1)                 | 33 (42.3)                 | 58 (0.2)                 | 98 (1.2)                  |
| 1-4                                    | 6 (7.2)                   | 15 (19.2)                 | 128 (0.5)                | 397 (5.0)                 |
| 5-14                                   | 15 (18.1)                 | 12 (15.4)                 | 1,232 (4.6)              | 1,365 (17.3)              |
| 15-49                                  | 24 (28.9)                 | 17 (21.8)                 | 6,844 (25.8)             | 5,380 (68.1)              |
| 50-99                                  | 10 (12.1)                 | 1 (1.3)                   | 6,782 (25.5)             | 659 (8.3)                 |
| 100+                                   | 8 (9.6)                   | 0 (0.0)                   | 11,515 (43.4)            | 0 (0.0)                   |
| <b>Total</b>                           | 83 (100.0)                | 78 (100.0)                | 26,559 (100.0)           | 7,899 (100.0)             |

Abbreviations: BCS, breast conserving surgery.

<sup>a</sup>p-values from Pearson's  $\chi^2$  test.

<sup>b</sup>Average annual BCS cases per hospital, 2002-2013.



**Online Resource 3**

**Flow diagram showing the number of women undergoing re-excision and mastectomy within 90 days of initial breast conserving surgery, NSW, Australia, 2002-2013**

**Online Resource 4 Area- and hospital-level variance ( $\sigma^2$ ) and the proportional change in variance (%) between baseline and subsequent models, for any reoperation versus no reoperation, and separately, for re-excision or mastectomy versus no reoperation<sup>a</sup>**

| Model                                | Variables   | Any reoperation |                |         |       | Reoperation (re-excision) |                |         |      | Reoperation (mastectomy) |                |         |       |
|--------------------------------------|---|-----------------|----------------|---------|-------|---------------------------|----------------|---------|------|--------------------------|----------------|---------|-------|
|                                      |   | $\sigma$        | SE of $\sigma$ | p-value | PCV   | $\sigma$                  | SE of $\sigma$ | p-value | PCV  | $\sigma$                 | SE of $\sigma$ | p-value | PCV   |
| <i>Random intercept for hospital</i> |   |                 |                |         |       |                           |                |         |      |                          |                |         |       |
| Baseline                             | Age-group   | 0.174           | 0.033          | 0.000   |       | 0.194                     | 0.037          | 0.000   |      | 0.208                    | 0.041          | 0.000   |       |
| Model 2                              | + Aboriginal status, country of birth                             | 0.176           | 0.033          | 0.000   | -1.1  | 0.195                     | 0.038          | 0.000   | -0.5 | 0.215                    | 0.044          | 0.000   | -3.4  |
| Model 3                              | + tumour type, previous cancer, comorbidities                     | 0.179           | 0.034          | 0.000   | -2.9  | 0.197                     | 0.039          | 0.000   | -1.5 | 0.214                    | 0.043          | 0.000   | -2.9  |
| Model 4                              | + calendar year   | 0.177           | 0.033          | 0.000   | -1.7  | 0.204                     | 0.040          | 0.000   | -5.2 | 0.200                    | 0.040          | 0.000   | 3.8   |
| Model 5                              | + area-level socioeconomic status                                 | 0.178           | 0.033          | 0.000   | -2.3  | 0.203                     | 0.039          | 0.000   | -4.6 | 0.196                    | 0.039          | 0.000   | 5.8   |
| Model 6                              | + hospital type, BCS surgical volume                              | 0.156           | 0.031          | 0.000   | 10.3  | 0.201                     | 0.040          | 0.000   | -3.6 | 0.156                    | 0.033          | 0.000   | 25.0  |
| Model 7                              | + combined residential and hospital location                      | 0.148           | 0.030          | 0.000   | 14.9  | 0.201                     | 0.041          | 0.000   | -3.6 | 0.125                    | 0.028          | 0.000   | 39.9  |
| Model 7a                             | Model 7 + interaction calendar year, location <sup>b</sup>        | 0.143           | 0.029          | 0.000   | 17.8  | 0.196                     | 0.042          | 0.000   | -1.0 | 0.122                    | 0.028          | 0.000   | 41.3  |
| Model 7b                             | Model 7 + interaction calendar year, surgical volume <sup>b</sup> | 0.144           | 0.028          | 0.000   | 17.2  | 0.197                     | 0.041          | 0.000   | -1.5 | 0.124                    | 0.029          | 0.000   | 40.4  |
| <i>Random intercept for SLA</i>      |   |                 |                |         |       |                           |                |         |      |                          |                |         |       |
| Baseline                             | Age-group   | 0.002           | 0.002          | 0.179   |       | 0.010                     | 0.004          | 0.008   |      | 0.007                    | 0.003          | 0.017   |       |
| Model 2                              | + Aboriginal status, country of birth                             | 0.002           | 0.001          | 0.115   | 0.0   | 0.010                     | 0.004          | 0.007   | 0.0  | 0.007                    | 0.003          | 0.014   | 0.0   |
| Model 3                              | + tumour type, previous cancer, comorbidities                     | 0.002           | 0.001          | 0.222   | 0.0   | 0.010                     | 0.003          | 0.005   | 0.0  | 0.008                    | 0.003          | 0.011   | -14.3 |
| Model 4                              | + calendar year   | 0.002           | 0.002          | 0.210   | 0.0   | 0.010                     | 0.004          | 0.007   | 0.0  | 0.007                    | 0.003          | 0.010   | 0.00  |
| Model 5                              | + area-level socioeconomic status                                 | 0.002           | 0.002          | 0.198   | 0.0   | 0.010                     | 0.004          | 0.013   | 0.0  | 0.007                    | 0.003          | 0.012   | 0.00  |
| Model 6                              | + hospital type, BCS surgical volume                              | 0.003           | 0.002          | 0.160   | -50.0 | 0.009                     | 0.004          | 0.017   | 10.0 | 0.004                    | 0.002          | 0.035   | 42.9  |
| Model 7                              | + combined residential and hospital location                      | 0.003           | 0.002          | 0.148   | -50.0 | 0.009                     | 0.004          | 0.011   | 10.0 | 0.002                    | 0.002          | 0.191   | 71.4  |
| Model 7a                             | Model 7 + interaction calendar year, location <sup>b</sup>        | 0.002           | 0.002          | 0.214   | 0.0   | 0.009                     | 0.004          | 0.012   | 10.0 | 0.001                    | 0.001          | 0.199   | 85.7  |
| Model 7b                             | Model 7 + interaction calendar year, surgical volume <sup>b</sup> | 0.002           | 0.002          | 0.156   | 0.0   | 0.010                     | 0.004          | 0.021   | 0.0  | 0.001                    | 0.001          | 0.115   | 85.7  |

Abbreviations: SE, standard error; PCV, proportional change in variance; SLA, statistical local area; BCS, breast conserving surgery.

<sup>a</sup> Multilevel, cross-classified binomial (any reoperation) and multinomial (re-excision, mastectomy) logistic regression models.

<sup>b</sup> Calendar year modelled as a continuous variable in interaction model.

**Online Resource 5 Adjusted odds ratios for any reoperation versus no reoperation, and separately, for re-excision or mastectomy versus no reoperation within 90 days of initial breast conserving surgery, NSW, Australia 2002-2013<sup>a</sup>**

| Characteristic                             | Any reoperation  | Reoperation (re-excision) | Reoperation (mastectomy) |
|--|------------------|---------------------------|--------------------------|
|  | OR (95% CI)      | OR (95% CI)               | OR (95% CI)              |
| <b>Age (years)</b>                         |                  |                           |                          |
| <35  | 1.22 (1.02-1.47) | 0.91 (0.71-1.17)          | 1.60 (1.28-2.01)         |
| 35-49                                      | 1.41 (1.33-1.49) | 1.24 (1.15-1.34)          | 1.61 (1.48-1.74)         |
| 50-64                                      | 1.00             | 1.00                      | 1.00                     |
| 65-79                                      | 0.89 (0.83-0.94) | 0.82 (0.76-0.89)          | 0.96 (0.89-1.04)         |
| 80+  | 0.51 (0.45-0.58) | 0.37 (0.30-0.44)          | 0.69 (0.59-0.80)         |
| <b>Aboriginal status</b>                   |                  |                           |                          |
| Non-Aboriginal                             | 1.00             | 1.00                      | 1.00                     |
| Aboriginal                                 | 1.13 (0.88-1.47) | 0.87 (0.60-1.25)          | 1.40 (1.03-1.89)         |
| <b>Country of birth</b>                    |                  |                           |                          |
| Australia/New Zealand                      | 1.00             | 1.00                      | 1.00                     |
| Europe                                     | 1.02 (0.95-1.09) | 0.99 (0.90-1.09)          | 1.04 (0.94-1.14)         |
| East Asia                                  | 1.22 (1.10-1.35) | 1.15 (1.02-1.31)          | 1.29 (1.13-1.47)         |
| Other                                      | 1.01 (0.92-1.10) | 1.02 (0.91-1.14)          | 0.99 (0.88-1.13)         |
| Unknown                                    | 0.94 (0.80-1.11) | 0.94 (0.76-1.16)          | 0.95 (0.76-1.18)         |
| <b>Tumour type</b>                         |                  |                           |                          |
| Invasive                                   | 1.00             | 1.00                      | 1.00                     |
| Insitu/mixed                               | 1.81 (1.72-1.91) | 1.76 (1.64-1.89)          | 1.86 (1.74-1.99)         |
| <b>Previous breast cancer<sup>b</sup></b>  |                  |                           |                          |
| No   | 1.00             | 1.00                      | 1.00                     |
| Yes  | 0.55 (0.40-0.78) | 0.52 (0.33-0.83)          | 0.58 (0.38-0.90)         |
| <b>Other previous cancer<sup>b</sup></b>   |                  |                           |                          |
| No   | 1.00             | 1.00                      | 1.00                     |
| Yes  | 0.85 (0.64-1.13) | 0.74 (0.50-1.10)          | 0.95 (0.67-1.35)         |
| <b>Number of comorbidities<sup>b</sup></b> |                  |                           |                          |
| No comorbidities                           | 1.00             | 1.00                      | 1.00                     |

| Characteristic  | Any reoperation  | Reoperation (re-excision) | Reoperation (mastectomy) |
|---|------------------|---------------------------|--------------------------|
|   | OR (95% CI)      | OR (95% CI)               | OR (95% CI)              |
| 1 comorbidity   | 0.91 (0.82-1.01) | 0.89 (0.77-1.02)          | 0.93 (0.82-1.07)         |
| 2 comorbidities   | 1.01 (0.78-1.31) | 0.82 (0.57-1.18)          | 1.17 (0.86-1.60)         |
| 3+ comorbidities  | 0.68 (0.42-1.12) | 0.64 (0.31-1.31)          | 0.69 (0.36-1.33)         |
| <b>Year of BCS</b>  |                  |                           |                          |
| 2002-2005   | 1.00             | 1.00                      | 1.00                     |
| 2006-2009   | 1.00 (0.94-1.06) | 1.22 (1.12-1.32)          | 0.84 (0.77-0.91)         |
| 2010-2013   | 0.92 (0.86-0.97) | 1.21 (1.12-1.31)          | 0.69 (0.64-0.75)         |
| <b>Index of relative socioeconomic disadvantage<sup>c</sup></b> |                  |                           |                          |
| Quintile 5 (Least disadvantaged)                                | 1.00             | 1.00                      | 1.00                     |
| Quintile 4  | 1.03 (0.94-1.11) | 1.03 (0.92-1.15)          | 1.01 (0.91-1.12)         |
| Quintile 3  | 0.97 (0.89-1.07) | 0.94 (0.83-1.07)          | 0.99 (0.89-1.11)         |
| Quintile 2  | 1.02 (0.91-1.14) | 1.02 (0.87-1.19)          | 1.02 (0.89-1.16)         |
| Quintile 1 (Most disadvantaged)                                 | 1.03 (0.93-1.15) | 1.07 (0.93-1.23)          | 0.99 (0.87-1.12)         |
| <b>Hospital type</b>  |                  |                           |                          |
| Public  | 1.00             | 1.00                      | 1.00                     |
| Private   | 1.12 (0.95-1.31) | 1.20 (0.99-1.46)          | 1.09 (0.92-1.28)         |
| <b>BCS surgical volume<sup>d</sup></b>                          |                  |                           |                          |
| <15   | 1.00             | 1.00                      | 1.00                     |
| 15-49   | 0.78 (0.64-0.96) | 0.88 (0.69-1.12)          | 0.71 (0.59-0.85)         |
| 50+   | 0.85 (0.66-1.09) | 0.93 (0.69-1.24)          | 0.73 (0.57-0.93)         |
| <b>Residential and hospital location</b>                        |                  |                           |                          |
| Metropolitan x metropolitan                                     | 1.00             | 1.00                      | 1.00                     |
| Metropolitan x non-metropolitan                                 | 1.21 (0.85-1.73) | 1.25 (0.79-1.99)          | 1.14 (0.79-1.66)         |
| Non-metropolitan x metropolitan                                 | 0.98 (0.88-1.09) | 0.93 (0.81-1.06)          | 1.04 (0.91-1.20)         |
| Non-metropolitan x non-metropolitan                             | 1.24 (1.02-1.52) | 0.96 (0.75-1.22)          | 1.45 (1.20-1.76)         |

Abbreviations: OR, odds ratio; CI, confidence interval; BCS, breast conserving surgery.

<sup>a</sup> ORs obtained from multilevel, cross-classified binomial (any reoperation) and multinomial (re-excision, mastectomy) logistic regression models, adjusted for patient-level factors, calendar year, area-level contextual factors, and health system-level factors.

<sup>b</sup> Recorded on or within 12 months prior to initial BCS.

<sup>c</sup> Index of relative socioeconomic disadvantage for statistical local area of residence.

<sup>d</sup> Average annual number of BCS cases per hospital, 2002-2013.

**Online Resource 6 Adjusted odds ratios for mastectomy versus re-excision in women undergoing re-operation within 90 days of initial breast conserving surgery, NSW, Australia 2002-2013<sup>a</sup>**

| <b>Characteristic</b>                      | <b><u>Mastectomy (versus re-excision)</u></b><br><b>OR (95% CI)</b> |
|--|---|
| <b>Age (years)</b>                         |   |
| <35  | 1.78 (1.31-2.42)  |
| 35-49                                      | 1.29 (1.17-1.43)  |
| 50-64                                      | 1.00  |
| 65-79                                      | 1.17 (1.05-1.29)  |
| 80+  | 1.87 (1.47-2.37)  |
| <b>Aboriginal status</b>                   |   |
| Non-Aboriginal                             | 1.00  |
| Aboriginal                                 | 1.60 (1.03-2.49)  |
| <b>Country of birth</b>                    |   |
| Australia/New Zealand                      | 1.00  |
| Europe                                     | 1.03 (0.91-1.17)  |
| East Asia                                  | 1.10 (0.94-1.28)  |
| Other                                      | 0.99 (0.84-1.16)  |
| Unknown                                    | 1.02 (0.77-1.33)  |
| <b>Tumour type</b>                         |   |
| Invasive                                   | 1.00  |
| Insitu/mixed                               | 1.06 (0.98-1.16)  |
| <b>Previous breast cancer<sup>b</sup></b>  |   |
| No   | 1.00  |
| Yes  | 1.12 (0.61-2.08)  |
| <b>Other previous cancer<sup>b</sup></b>   |   |
| No   | 1.00  |
| Yes  | 1.38 (0.84-2.26)  |
| <b>Number of comorbidities<sup>b</sup></b> |   |
| No comorbidities                           | 1.00  |



| <b>Characteristic</b>   | <b><u>Mastectomy (versus re-excision)</u></b> |
|---|---|
|   | <b>OR (95% CI)</b>                            |
| 1 comorbidity   | 1.06 (0.88-1.27)                              |
| 2 comorbidities   | 1.52 (0.96-2.40)                              |
| 3+ comorbidities  | 1.19 (0.47-3.02)                              |
| <b>Year of BCS</b>  |   |
| 2002-2005   | 1.00  |
| 2006-2009   | 0.69 (0.63-0.77)                              |
| 2010-2013   | 0.57 (0.51-0.63)                              |
| <b>Index of relative socioeconomic disadvantage<sup>c</sup></b> |   |
| Quintile 5 (Least disadvantaged)                                | 1.00  |
| Quintile 4  | 1.00 (0.88-1.14)                              |
| Quintile 3  | 1.06 (0.92-1.23)                              |
| Quintile 2  | 1.01 (0.85-1.20)                              |
| Quintile 1 (Most disadvantaged)                                 | 0.94 (0.80-1.10)                              |
| <b>Hospital type</b>  |   |
| Public  | 1.00  |
| Private   | 0.90 (0.77-1.07)                              |
| <b>BCS surgical volume<sup>d</sup></b>                          |   |
| <15   | 1.00  |
| 15-49   | 0.81 (0.67-0.98)                              |
| 50+   | 0.79 (0.63-0.99)                              |
| <b>Residential and hospital location</b>                        |   |
| Metropolitan x metropolitan                                     | 1.00  |
| Metropolitan x non-metropolitan                                 | 0.88 (0.60-1.29)                              |
| Non-metropolitan x metropolitan                                 | 1.15 (0.97-1.36)                              |
| Non-metropolitan x non-metropolitan                             | 1.49 (1.23-1.80)                              |

Abbreviations: OR, odds ratio; CI, confidence interval; BCS, breast conserving surgery.

<sup>a</sup> ORs obtained from multilevel, cross-classified binomial (mastectomy versus re-excision) logistic regression models in women undergoing reoperation (n=10,018), adjusted for patient-level factors, calendar year, area-level contextual factors, and health system-level factors.

<sup>b</sup> Recorded on or within 12 months prior to initial BCS.

<sup>c</sup> Index of relative socioeconomic disadvantage for statistical local area of residence.

<sup>d</sup> Average annual number of BCS cases per hospital, 2002-2013.