

## ORIGINAL ARTICLE

# Lung, breast and bowel cancer treatment for Aboriginal people in New South Wales: a population-based cohort study

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cancer treatment for Aboriginal people, lung cancer, breast cancer, colorectal cancer, treatment, indigenous.

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**Abstract**

**Background:** Aboriginal Australians have higher cancer mortality than non-Aboriginal Australians. Lower rates of cancer treatment among Aboriginal people can contribute to this.

**Aims:** To investigate demographic, clinical and access factors associated with lung, breast and bowel cancer treatment for Aboriginal people compared with non-Aboriginal people in New South Wales, Australia.

**Methods:** Population-based cohort study using linked routinely collected datasets, including all diagnoses of primary lung, breast or bowel cancer from January 2009 to June 2012. Treatment (surgery, radiotherapy or chemotherapy) within 6 months from diagnosis was measured. Access was measured using minimum distance to radiotherapy or hospital with a cancer-specific multidisciplinary team, visit to a specialist and possession of private health insurance. Logistic regression modelling was employed.

**Results:** There were 587 Aboriginal and 34 015 non-Aboriginal people diagnosed with cancer. For lung cancer, significantly fewer Aboriginal than non-Aboriginal people received surgery (odds ratio 0.46, 95% confidence interval 0.29–0.73,  $P < 0.001$ ) or any treatment (surgery, chemotherapy or radiotherapy; odds ratio 0.64, 95% confidence interval 0.47–0.88,  $P = 0.006$ ) after adjusting for sex, age, disease extent and comorbidities. They were less likely to have an attendance with a surgeon (27.0%, 62/230 vs 33.3%, 2865/8597,  $P = 0.04$ ) compared with non-Aboriginal people. There were no significant differences in cancer treatment for Aboriginal people compared with non-Aboriginal people for breast or bowel cancers after adjusting for patient sex, age, disease extent and comorbidities.

**Conclusion:** Aboriginal people were significantly less likely to receive surgery for lung cancer than non-Aboriginal people and had fewer attendances with a surgeon, suggesting a need to strengthen referral pathways.

**Introduction**

Aboriginal Australians have shorter life expectancy than non-Aboriginal Australians.<sup>1</sup> This is driven by higher mortality rates from diseases including circulatory disease<sup>1</sup> (1.6 times the non-indigenous rate), diabetes<sup>1</sup> (six times the

non-indigenous rate), kidney disease<sup>1</sup> (2.6 times the non-indigenous rate) and cancer<sup>2</sup> (1.4 times the non-indigenous rate). Cancer mortality rates decreased by 13% for non-Aboriginal people over 1998 to 2015, but worryingly increased by 21% for Aboriginal people.<sup>1</sup>

The reasons for this disparity in cancer mortality rates are complex and include patient factors and healthcare factors.<sup>3</sup> The disparity is partly explained by Aboriginal people having a higher prevalence of risk factors<sup>1</sup> (e.g. smoking, alcohol use, obesity) that increase cancer incidence, including cancers with poorer prognosis,<sup>4</sup> and increase the prevalence of comorbid conditions that can negatively impact on cancer survival.<sup>5</sup> More advanced disease at diagnosis<sup>5,6</sup> contributes to higher mortality.

Abbreviations: AIHW, Australian Institute of Health and Welfare; APDC, Admitted Patient Data Collection; CI, confidence interval; ICD-10-AM, International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification; MBS, Medicare Benefits Schedule; NSW, New South Wales; NSWCR, New South Wales Cancer Registry; OR, odds ratio; PBS, Pharmaceutical Benefits Scheme; RD, NSW Outpatient Radiation Oncology Dataset.

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Variations in treatment also contribute to the differences in mortality. Aboriginal people reportedly have lower use of cancer treatments,<sup>5–11</sup> and higher likelihood of sub-optimal treatment compared with guidelines than non-Aboriginal people.<sup>12</sup> In New South Wales (NSW), Aboriginal people were less likely to receive surgery than non-Aboriginal people for non-metastatic non-small cell lung cancer,<sup>13</sup> breast cancer<sup>8</sup> and localised or regional prostate cancer.<sup>9</sup> Similar surgery rates were observed between Aboriginal and non-Aboriginal people for colorectal cancer.<sup>14</sup> Cancer treatment can be complex, requiring consultation with specialists and treatment in specialist centres. It can require travel and time away from home, and can incur substantial out-of-pocket costs. Providing person-centred care that is integrated across health sectors and provides optimal and culturally appropriate care is a priority in improving outcomes for Aboriginal and Torres Strait Islander people.<sup>15</sup>

To date, no NSW population-level studies have compared chemotherapy or radiotherapy cancer treatment for Aboriginal people and non-Aboriginal people. This study brings together population-level surgery, radiotherapy and chemotherapy data for the first time in NSW. Three of the most frequently diagnosed cancers among Aboriginal people are analysed: breast, lung and bowel cancers. We aim to confirm the surgical treatment patterns identified in other NSW studies, and to explore any differences in radiotherapy and chemotherapy treatment patterns. A further goal is to explore whether travel distance, use of specialists or private health insurance status impact on people receiving treatment.

## Methods

### Study design

The study was designed in consultation with the Cancer Institute NSW's Aboriginal Advisory Group which provides Aboriginal community representation by Aboriginal people.

A population-based, retrospective cohort study was conducted using linked routinely collected data from the NSW Cancer Registry<sup>16</sup> (NSWCR), NSW Admitted Patient Data Collection (APDC), Medicare Benefits Schedule (MBS), Pharmaceutical Benefits Scheme (PBS) and NSW Outpatient Radiation Oncology Dataset (RD).

The NSWCR is a statutory population-based register of all invasive cancer cases (excluding non-melanoma skin cancer) diagnosed in NSW residents since 1972. The NSW APDC, maintained by the NSW Ministry of Health with mandatory reporting, contains all admissions to NSW public and private hospitals. The RD contains demographic and clinical details for outpatient radiation oncology treatments at public and private facilities in NSW. Probabilistic

data linkage was performed by the Centre for Health Record Linkage with an estimated false-positive linkage rate of five per 1000.<sup>17</sup>

The MBS contains information on Medicare services including outpatient and some in-hospital procedures, the PBS includes information about Commonwealth government-subsidised dispensed prescription medicines.<sup>18</sup> These were linked to the NSWCR cancer cohort by the Australian Institute of Health and Welfare (AIHW).

Approval for this study was from the NSW Population and Health Services Research Ethics Committee (HREC/15/CIPHS/15), AIHW Ethics Committee (EO2016/1/224) and Aboriginal Health and Medical Research Council Ethics Committee (1201/16).

### Study population

Adults aged over 17 diagnosed with a first primary lung, bowel or breast (women only) cancer between January 2009 and June 2012 were identified from the NSWCR. The International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification (ICD-10-AM) identified cancer type using codes C34 (lung), C50 (breast), C18-C20 (bowel). Residents of local health districts next to the NSW border were excluded (Northern NSW, Southern NSW, Murrumbidgee, Far West and Albury) because these residents often visit interstate hospitals and therefore treatment capture is incomplete in the study datasets. Aboriginal and Torres Strait Islander status was assigned using Aboriginality information in the NSWCR, APDC, NSW Emergency Department Data Collection and the Cause of Death Unit Record File (held by the NSW Ministry of Health Secure Analytics for Population Health Research and Intelligence) using a 'weight of evidence' method.<sup>19</sup>

### Outcome variables

Treatments within 6 months from diagnosis were identified from the linked data. Procedure codes, diagnosis codes, MBS item numbers and PBS Anatomical Therapeutic Chemical codes used in defining treatment are listed in Supporting Information Table S1. Surgical procedure codes were defined by a Clinical Advisory Group. Public and private inpatient and outpatient radiotherapy were identified from the APDC, RD and MBS data. Public and private inpatient and outpatient chemotherapy were identified from the APDC, MBS and PBS data.<sup>20</sup>

### Adjustment variables

Several factors may influence treatment decisions. Demographic factors were age at diagnosis, sex (except

breast cancer), remoteness of residence (using the Accessibility/Remoteness Index of Australia<sup>21</sup>), and socioeconomic position (using the Index of Relative Socio-Economic Disadvantage<sup>22</sup>) from the NSWCR. Clinical factors were patient comorbidity (using the Charlson comorbidity index<sup>23</sup> and diagnoses recorded in the APDC in the month of diagnosis and the 5 years prior) and extent of disease at diagnosis from the NSWCR.

Potential barriers to treatment were identified through consultation with the Cancer Institute NSW's Aboriginal Advisory Group: attendance by a surgeon, medical oncologist or radiation oncologist (defined using MBS and provider speciality codes; Table S1), minimum distance required to travel to treatment, and possession of private health insurance. Distance was measured from postcode of residence to the nearest hospital with a relevant cancer-specific multidisciplinary team (MDT) listed in CanRefer<sup>24</sup> and active in 2012, and to the nearest radiotherapy facility that was in operation at the time of diagnosis. Treatment location for chemotherapy is harder to identify because of the diverse mechanisms for chemotherapy delivery and was not measured. Geodetic distance was calculated using the geocode algorithm in SAS.<sup>25</sup>

## Statistical analyses

Pearson Chi-squared tests with significance at  $\alpha = 0.05$  were used in unadjusted comparisons. Association between treatment and Aboriginality was adjusted for three risk adjustment sets using logistic regression models for each cancer and treatment type. Adjustment 1 comprised age at diagnosis, sex, comorbidity and disease extent. Adjustment 2 additionally included remoteness and socioeconomic position. Adjustment 3 additionally included the potential treatment barriers. Adjusted odds ratios (OR) are reported with 95% confidence intervals (CI) and *P*-values. Statistical analyses were performed using SAS version 9.4.

## Results

There were 587 Aboriginal and 34 015 non-Aboriginal people diagnosed with a first primary lung, breast or bowel cancer included in the study (Fig. 1). The proportions of colon, rectosigmoid and rectal cancers were similar for Aboriginal and non-Aboriginal people ( $P = 0.76$ , not shown) so any differences in radiotherapy use due to different treatment protocols for these cancers are not expected. For each cancer type, Aboriginal people tended to be diagnosed younger ( $P < 0.001$ ), live more remotely ( $P < 0.001$ ) and have greater socioeconomic disadvantage than non-Aboriginal people ( $P < 0.001$ ; Table 1). At presentation, Aboriginal people had greater disease spread

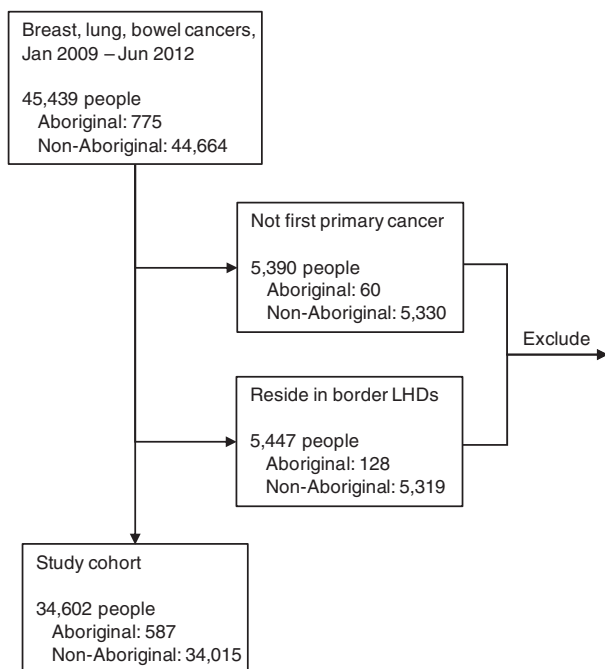


Figure 1 Study cohort.

for breast and bowel cancers ( $P = 0.05$  and  $P = 0.003$  respectively) and more comorbidities for lung cancer ( $P = 0.003$ ) compared with non-Aboriginal people.

The unadjusted results showed lower rates of lung surgery (11.7% vs 15.9%,  $P = 0.09$ ), and higher rates of breast chemotherapy (59.2% vs 46.9%,  $P < 0.001$ ), bowel radiotherapy (20.5% vs 11.7%,  $P < 0.001$ ) and bowel chemotherapy (50.0% vs 38.7%,  $P = 0.003$ ) for Aboriginal people compared with non-Aboriginal people (Table 3). Other treatment modalities showed no significant differences.

Ideally a health system would provide similar treatment to patients regardless of remoteness or wealth. This was measured by adjusting for available patient and cancer characteristics that would clinically affect treatment use: age, sex (except for breast cancer), comorbidity and disease spread (Table 3, adjustment 1). Adjusted results showed Aboriginal people received less surgery (OR 0.46, 95% CI 0.29–0.73,  $P < 0.001$ ) or any treatment for lung cancer (OR 0.64, 95% CI 0.47–0.88,  $P = 0.006$ ) than non-Aboriginal people. After further adjusting for remoteness and socioeconomic disadvantage, the reduced odds of receiving lung cancer surgery persisted (Table 3, adjustment 2). For breast and bowel cancers, the significantly higher chemotherapy rates for Aboriginal people compared with non-Aboriginal people did not persist after adjusting for age, disease extent, sex and comorbidity. Radiotherapy use for bowel cancer tended to be higher for Aboriginal people (OR 1.48, 95% CI 1.00–2.19,  $P = 0.05$ ; Table 3, adjustment 1).

**Table 1** Patient demographic and clinical characteristics by cancer diagnosis

	Lung		Breast		Bowel	
	Aboriginal	Non-Aboriginal	Aboriginal	Non-Aboriginal	Aboriginal	Non-Aboriginal
Number of people	230	8597	191	13 255	166	12 163
Age at diagnosis (years)	$P < 0.001$		$P < 0.001$		$P < 0.001$	
<60	78 (33.9%)	1492 (17.4%)	121 (63.4%)	6428 (48.5%)	71 (42.8%)	2870 (23.6%)
60–69	71 (30.9%)	2511 (29.2%)	47 (24.6%)	3531 (26.6%)	47 (28.3%)	3152 (25.9%)
70–79	63 (27.4%)	2622 (30.5%)	14 (7.3%)	1876 (14.2%)	37 (22.3%)	3379 (27.8%)
80+	18 (7.8%)	1972 (22.9%)	9 (4.7%)	1420 (10.7%)	11 (6.6%)	2762 (22.7%)
Median (interquartile range)	66 (56–72)	71 (63–79)	54 (47–63)	60 (50–69)	62 (53–71)	70 (60–79)
Sex	$P = 0.38$				$P = 0.54$	
Male	128 (55.7%)	5034 (58.6%)			85 (51.2%)	6517 (53.6%)
Female	102 (44.3%)	3563 (41.4%)	191 (100%)	13 255 (100%)	81 (48.8%)	5646 (46.4%)
Remoteness of residence	$P < 0.001$		$P < 0.001$		$P < 0.001$	
Major cities	111 (48.3%)	6496 (75.6%)	100 (52.4%)	10 526 (79.4%)	89 (53.6%)	9152 (75.2%)
Inner regional	63 (27.4%)	1608 (18.7%)	47 (24.6%)	2168 (16.4%)	45 (27.1%)	2289 (18.8%)
Outer regional and remote	56 (24.3%)	493 (5.7%)	44 (23.0%)	561 (4.2%)	32 (19.3%)	722 (5.9%)
Area-based socioeconomic position	$P < 0.001$		$P < 0.001$		$P < 0.001$	
Least disadvantaged	6 (2.6%)	1120 (13%)	16 (8.4%)	3206 (24.2%)	5 (3.0%)	2179 (17.9%)
2nd quintile	20 (8.7%)	1355 (15.8%)	25 (13.1%)	2801 (21.1%)	21 (12.7%)	2287 (18.8%)
3rd quintile	28 (12.2%)	1618 (18.8%)	26 (13.6%)	2493 (18.8%)	33 (19.9%)	2318 (19.1%)
4th quintile	54 (23.5%)	1998 (23.2%)	52 (27.2%)	2481 (18.7%)	36 (21.7%)	2715 (22.3%)
Most disadvantaged	122 (53.0%)	2506 (29.1%)	72 (37.7%)	2274 (17.2%)	71 (42.8%)	2664 (21.9%)
Charlson comorbidity score	$P = 0.003$		$P = 0.28$		$P = 0.39$	
0	130 (56.5%)	5750 (66.9%)	171 (89.5%)	12 271 (92.6%)	129 (77.7%)	9904 (81.4%)
1	45 (19.6%)	1392 (16.2%)	9 (4.7%)	459 (3.5%)	15 (9.0%)	814 (6.7%)
2+	55 (23.9%)	1455 (16.9%)	11 (5.8%)	525 (4.0%)	22 (13.3%)	1445 (11.9%)
Extent of disease at diagnosis	$P = 0.23$		$P = 0.05$		$P = 0.003$	
Localised	46 (20.0%)	1328 (15.4%)	80 (41.9%)	6555 (49.5%)	32 (19.3%)	3505 (28.8%)
Regional	51 (22.2%)	1852 (21.5%)	79 (41.4%)	5106 (38.5%)	90 (54.2%)	5209 (42.8%)
Distant	106 (46.1%)	4207 (48.9%)	23 (12.0%)	986 (7.4%)	38 (22.9%)	2535 (20.8%)
Unknown	27 (11.7%)	1210 (14.1%)	9 (4.7%)	608 (4.6%)	6 (3.6%)	914 (7.5%)

**Table 2** Potential barriers to treatment by cancer diagnosis

	Lung			Breast			Bowel		
	Aboriginal	Non-Aboriginal	<i>P</i> -value	Aboriginal	Non-Aboriginal	<i>P</i> -value	Aboriginal	Non-Aboriginal	<i>P</i> -value
Number of people	230	8597		191	13 255		166	12 163	
Visit to specialist									
Oncologist <sup>†</sup>	144 (62.6%)	4754 (55.3%)	0.03	159 (83.2%)	10 777 (81.3%)	0.49	96 (57.8%)	5416 (44.5%)	<0.001
Medical	107 (46.5%)	3747 (43.6%)	0.38	134 (70.2%)	8482 (64%)	0.08	89 (53.6%)	5121 (42.1%)	0.003
Radiation	95 (41.3%)	2941 (34.2%)	0.03	110 (57.6%)	8015 (60.5%)	0.42	28 (16.9%)	1407 (11.6%)	0.03
Surgeon	62 (27.0%)	2865 (33.3%)	0.04	156 (81.7%)	11 189 (84.4%)	0.30	126 (75.9%)	9649 (79.3%)	0.28
Minimum travel distance (km)									
To surgery, mean (SD)	104 (140)	31 (63)		73 (108)	20 (44)		85 (130)	31 (63)	
To radiotherapy, mean (SD)	99 (135)	29 (59)		88 (126)	24 (51)		81 (126)	30 (59)	
Private health insurance	21 (9.1%)	2513 (29.2%)	<0.001	40 (20.9%)	7388 (55.7%)	<0.001	37 (22.3%)	5427 (44.6%)	<0.001

<sup>†</sup>Oncologist includes 14 people with oncologist visits that could not be classified as medical or radiation oncologists.

SD, standard deviation.

**Table 3** Fact of treatment (unadjusted and adjusted odds ratios (OR)) by cancer diagnosis

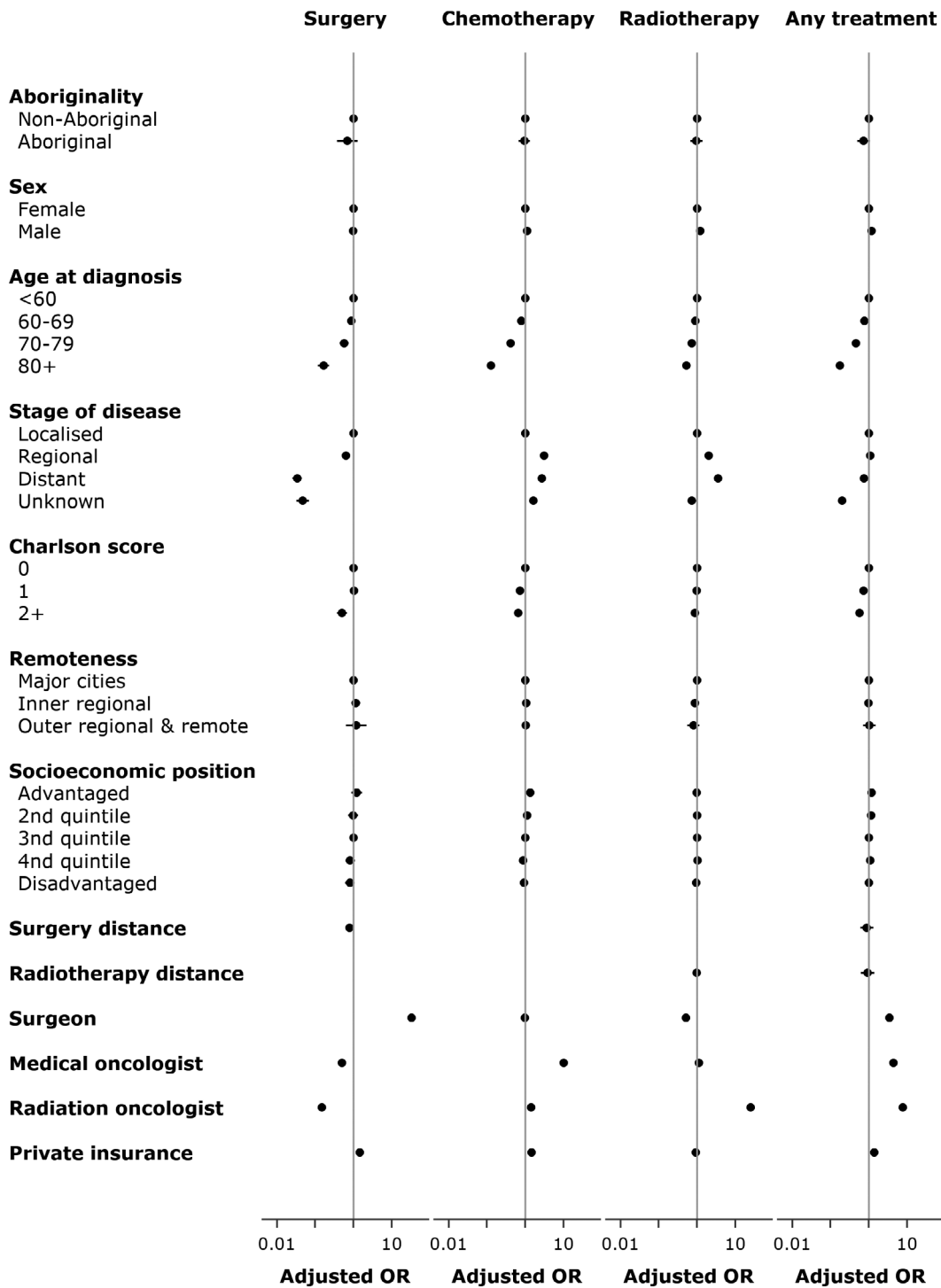
	Aboriginal (%)		Non-Aboriginal (%)		Unadjusted		Adjustment 1		Adjustment 2		Adjustment 3	
					OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value
<b>Lung cancer</b>												
Surgery	27 (11.7%)	1363 (15.9%)	0.71 (0.47–1.06)	0.09	0.46 (0.29–0.73)	<0.001	0.55 (0.34–0.87)	0.01	0.75 (0.40–1.40)	0.37		
Radiotherapy	102 (44.3%)	3423 (39.8%)	1.20 (0.93–1.57)	0.17	1.15 (0.87–1.53)	0.32	1.23 (0.93–1.63)	0.15	0.96 (0.67–1.36)	0.80		
Chemotherapy	93 (40.4%)	3320 (38.6%)	1.08 (0.83–1.41)	0.57	0.83 (0.62–1.11)	0.21	0.98 (0.72–1.32)	0.87	0.94 (0.66–1.32)	0.70		
Any above treatment	156 (67.8%)	5896 (68.6%)	0.97 (0.73–1.28)	0.81	0.64 (0.47–0.88)	0.006	0.78 (0.57–1.08)	0.13	0.74 (0.51–1.07)	0.11		
<b>Breast cancer</b>												
Surgery	168 (88.0%)	11 742 (88.6%)	0.94 (0.61–1.46)	0.78	1.11 (0.64–1.93)	0.71	1.31 (0.76–2.27)	0.34	1.72 (0.96–3.08)	0.07		
Breast-conserving	97 (50.8%)	6757 (51.0%)	0.99 (0.75–1.32)	0.96	1.10 (0.81–1.50)	0.55	1.23 (0.90–1.69)	0.19	1.33 (0.93–1.89)	0.12		
Mastectomy	71 (37.2%)	4985 (37.6%)	0.98 (0.73–1.32)	0.90	0.96 (0.71–1.31)	0.80	0.91 (0.67–1.24)	0.55	0.91 (0.65–1.28)	0.60		
Radiotherapy	87 (45.5%)	6526 (49.2%)	0.86 (0.65–1.15)	0.31	0.89 (0.66–1.20)	0.46	1.00 (0.74–1.35)	0.98	1.09 (0.75–1.58)	0.66		
Chemotherapy	113 (59.2%)	6214 (46.9%)	1.64 (1.23–2.19)	<0.001	1.23 (0.89–1.72)	0.22	1.27 (0.91–1.77)	0.16	1.38 (0.96–1.98)	0.08		
Any above treatment	181 (94.8%)	12 460 (94.0%)	1.15 (0.61–2.19)	0.66	0.92 (0.43–1.99)	0.84	0.98 (0.45–2.12)	0.96	1.29 (0.56–2.95)	0.55		
<b>Bowel cancer</b>												
Surgery	139 (83.7%)	9994 (82.2%)	1.12 (0.74–1.69)	0.60	0.88 (0.53–1.44)	0.60	0.93 (0.56–1.52)	0.77	1.14 (0.67–1.95)	0.63		
Radiotherapy	34 (20.5%)	1417 (11.7%)	1.95 (1.33–2.86)	<0.001	1.48 (1.00–2.19)	0.05	1.49 (1.00–2.21)	0.05	2.07 (1.06–4.04)	0.03		
Chemotherapy	83 (50.0%)	4712 (38.7%)	1.58 (1.16–2.15)	0.003	0.89 (0.62–1.28)	0.53	0.96 (0.67–1.38)	0.84	0.99 (0.63–1.54)	0.95		
Any above treatment	155 (93.4%)	10 845 (89.2%)	1.71 (0.93–3.17)	0.09	1.13 (0.56–2.29)	0.73	1.22 (0.60–2.46)	0.58	1.42 (0.66–3.09)	0.37		

Adjustment 1: age, sex (except breast cancer), Charlson comorbidity score, extent of disease.

Adjustment 2: factors in adjustment 1 and area-based socioeconomic disadvantage and geographic remoteness of residence.

Adjustment 3: factors in adjustment 2 and having seen a surgeon, having seen a radiation oncologist, having seen a medical oncologist and private health insurance status. Receipt of surgery additionally adjusted for distance to nearest hospital with a cancer-specific multidisciplinary team and receipt of radiotherapy additionally adjusted for distance to nearest radiotherapy facility. Any treatment additionally adjusted for the two distance variables.

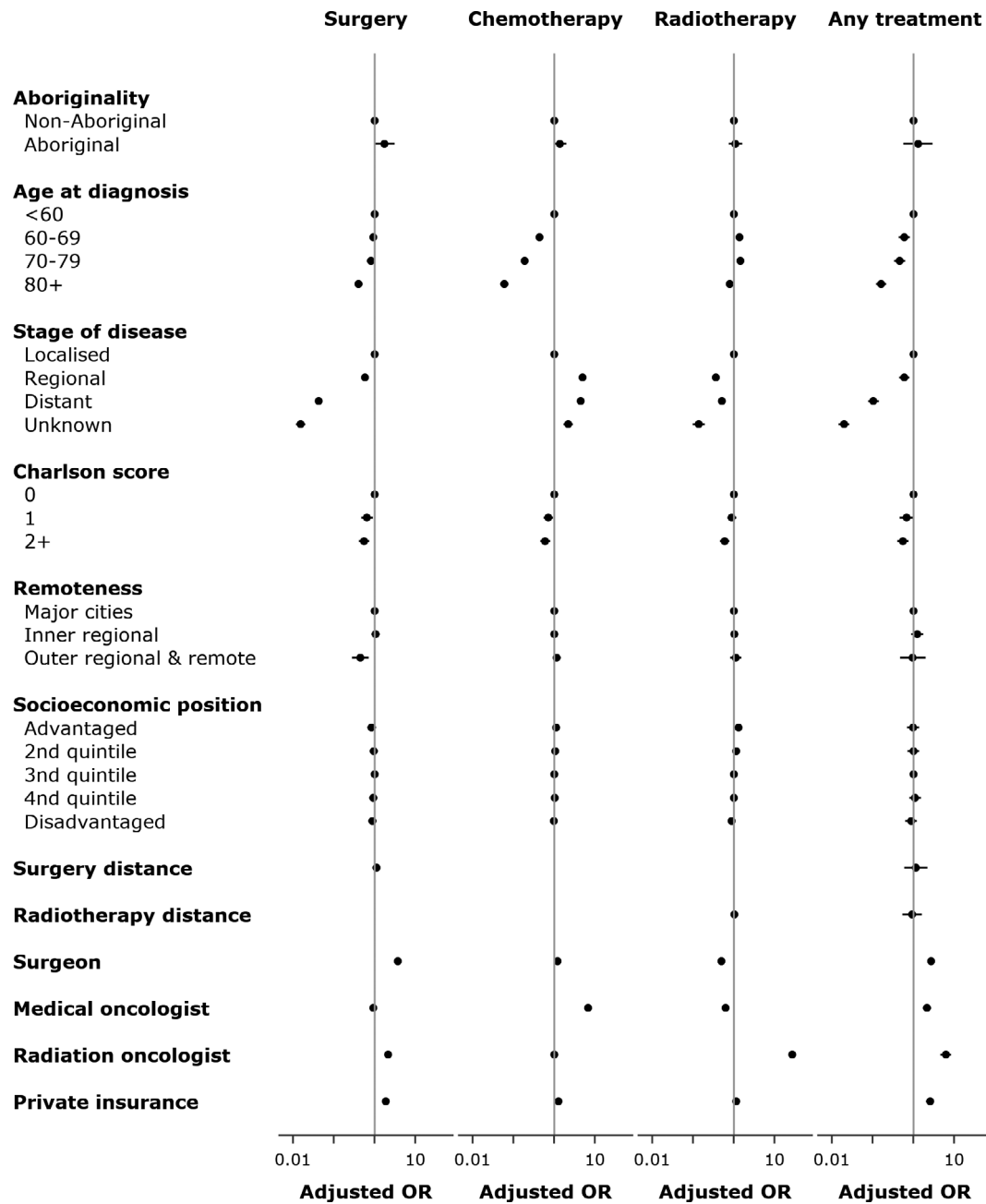
CI, confidence interval.



**Figure 2** Forest plots of multivariable adjusted odds ratios (OR) (with 95% confidence intervals) of receiving surgery, radiotherapy, chemotherapy or any treatment for lung cancer. All variables are categorical except distance variables which shows odds change per 100 km.

Analysis of potential treatment barriers showed higher rates of radiation oncologist visits among Aboriginal people (41.3% vs 34.2%,  $P = 0.03$ ; Table 2) diagnosed with lung cancer, although radiotherapy use was similar (OR 1.20,

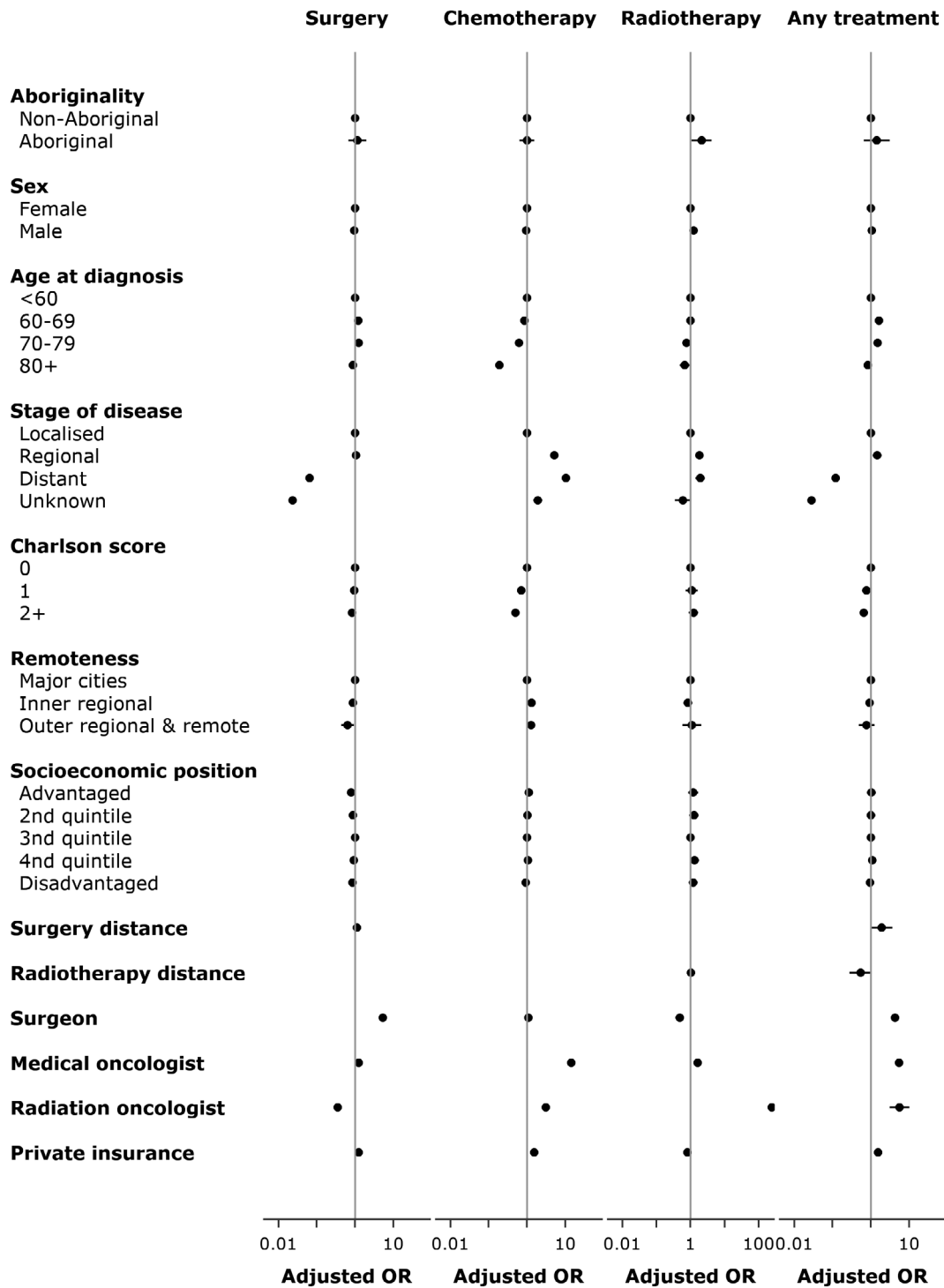
95% CI 0.93–1.57, unadjusted; Table 3). Aboriginal people with lung cancer visited a surgeon less than non-Aboriginal people (27.0% vs 33.3%,  $P = 0.04$ ), consistent with less surgery on an unadjusted basis (Table 3). There were no



**Figure 3** Forest plots of multivariable adjusted odds ratios (OR) (with 95% confidence intervals) of receiving surgery, radiotherapy, chemotherapy or any treatment for breast cancer. All variables are categorical except distance variables which shows odds change per 100 km.

differences in the rates of seeing an oncologist or surgeon between Aboriginal and non-Aboriginal women diagnosed with breast cancer (Table 2). For bowel cancer, Aboriginal people were more likely to have visited a medical or radiation oncologist than non-Aboriginal people ( $P = 0.003$  and  $P = 0.03$ , respectively; Table 2), consistent with the higher radiotherapy and chemotherapy rates in the unadjusted results (Table 3). After adjusting for sex, age, disease extent

and comorbidities, a difference in oncologist visits was not apparent for bowel cancer, although Aboriginal people were less likely to attend a surgeon (OR 0.56, 95% CI 0.38–0.82,  $P = 0.003$ ). For lung cancer, after these adjustments surgeon visits remained lower (OR 0.59, 95% CI 0.43–0.81,  $P = 0.001$ ) and radiation oncologist visits higher for Aboriginal people (OR 1.33, 95% CI 1.01–1.76,  $P = 0.04$ ).



**Figure 4** Forest plots of multivariable adjusted odds ratios (OR) (with 95% confidence intervals) of receiving surgery, radiotherapy, chemotherapy or any treatment for bowel cancer. All variables are categorical except distance variables which shows odds change per 100 km.

For all three cancers, distance to nearest radiotherapy centre or hospital with a specialist MDT was on average around three times further for Aboriginal people compared

with non-Aboriginal people, and Aboriginal people had significantly lower rates of private health insurance ( $P < 0.0001$ ).



The final model adjusted for distance to surgery, distance to radiotherapy, visit to a surgeon, medical oncologist or radiation oncologist and possession of private health insurance, as well as sex, age, disease extent, comorbidities, socioeconomic position and remoteness of residence. Forest plots of the full model (adjustment 3; Table 3) are shown in Figures 2 (lung), 3 (breast) and 4 (bowel). After this adjustment, odds of lung cancer surgery were 0.75 for Aboriginal compared to non-Aboriginal people, although the CI were wide (95% CI 0.04–1.40,  $P = 0.37$ , adjustment 3; Table 3). Consultation with oncologists or surgeon was strongly associated with receiving treatment across all three cancers. In general, distance to treatment was not a significant indicator of receiving treatment when specialist visits were included in the model. When specialist visits were removed from the models, more distant travel to treatment significantly reduced the odds of receiving lung surgery, lung radiotherapy and breast radiotherapy.

Patients with private health cover had significantly higher odds of receiving surgery, chemotherapy or any treatment across all three cancer types (Figs 2–4).

## Discussion

We found differences in lung cancer treatment between Aboriginal and non-Aboriginal people in NSW. Despite the relative youth of Aboriginal people diagnosed with lung cancer, significantly fewer patients underwent surgery compared with non-Aboriginal people. Thus treatment differences found in earlier Australian studies persist.<sup>11,13</sup> In our study, after adjusting for sex, age, disease extent and comorbidities, we found Aboriginal people with lung cancer were around 50% less likely to have lung surgery compared with non-Aboriginal people. Surgery is the recommended treatment for localised non-small cell lung cancers, the tumour type that comprises the majority of lung cancer cases. Radiotherapy is recommended for inoperable non-small cell lung cancers or people unfit for surgery.<sup>26</sup> However, radiotherapy use was similar and overall treatment use across the three modalities was 40% lower among Aboriginal people. This is consistent with a case-control study in Queensland that identified lower odds of active treatment with radiotherapy, chemotherapy or surgery among Aboriginal people (46%, 72/158) compared with non-Aboriginal people (72%, 109/152) after accounting for tumour type, stage at diagnosis and comorbidities ascertained from a medical record review.<sup>11</sup>

An important factor in receiving lung surgery was consultation with a surgeon and Aboriginal people were less likely to have a surgeon attendance. When surgeon attendance was accounted for, distance to a hospital with

a lung MDT was not associated with receipt of surgery. A NSW study reported that Aboriginal people with non-metastatic non-small cell lung cancer who did not receive surgery were more likely to be younger, from major cities and without comorbidities.<sup>13</sup> This highlights the importance of referral pathways. Since 2015, the Australian Optimal Care Pathway for lung cancer has outlined the expected pathways of initial investigations, referral, diagnosis and treatment for people presenting with suspected lung cancer.<sup>27</sup> Referral to a specialist who is an MDT member is recommended for people with a non-emergency presentation. To facilitate this referral, localised optimal care pathways have been implemented in areas in NSW using general practitioner decision aid software that provide referral details for lung specialists and for rapid access clinics.

One quarter of lung cancer diagnoses in NSW are via an emergency hospital admission.<sup>28</sup> Specialist consultations in an inpatient setting would not be captured in our study. Emergency presentation has been linked to lower use of potentially curative surgery.<sup>29</sup> It is not known if Aboriginal people are more likely to have an emergency lung cancer diagnosis. People in the general community delay seeking medical attention due to a perceived lack of urgency about symptoms and stigma around smoking.<sup>30</sup> To help raise symptom awareness and counteract fatalism a handbook on lung cancer for Aboriginal and Torres Strait health workers has been published.<sup>31</sup> The handbook also provides information for workers to support patients through treatment and reiterate their role in guiding other health professionals about the cultural needs of Aboriginal people. Increasing access to treatment, and importantly care that meets the needs of Aboriginal people,<sup>32</sup> is essential given that the reported difference in lung cancer survival between Aboriginal and non-Aboriginal people was mostly due to lower rates of curative intent treatment.<sup>11</sup>

We found that treatment use in the NSW health system was similar for Aboriginal and non-Aboriginal people for breast and bowel cancers. There were no differences found in treatment use for these cancers after adjusting for sex, age, disease extent and comorbidities. Our results provide evidence of progress in breast cancer treatment for Aboriginal women in NSW, with an earlier population-based study on women diagnosed 2001–2007 finding more Aboriginal women did not receive breast cancer surgery (15%, 43/288) compared with non-Aboriginal women (11%, 3061/27 562) even after adjustment for age, year of diagnosis, extent of disease, comorbidity, rurality and socioeconomic position (OR 0.60, 95% CI 0.39–0.95,  $P = 0.03$ ).<sup>8</sup> We found similar rates of breast-conserving surgery and mastectomy among Aboriginal and non-Aboriginal women, as did

studies in other Australian states<sup>33,34</sup> although the previous NSW study reported higher mastectomy use among Aboriginal women.<sup>8</sup>

There have been changes to breast cancer treatment over recent decades with breast-conserving surgery with adjuvant radiotherapy established as having equivalent recurrence and survival outcomes to mastectomy for early-stage breast cancer.<sup>35</sup> Increased availability of radiotherapy centres in regional NSW, with four centres opening between 2007 and 2012 and a further two after our study period, facilitates the uptake of breast-conserving surgery and radiotherapy. Additionally, hypofractionated radiotherapy regimens for early-stage breast cancer, which reduce the standard course length from 5 to 3 weeks, have become recommended treatment.<sup>36</sup> Reduced travel time and time away from home can make the choice of breast-conserving surgery with radiotherapy compared to mastectomy more acceptable.

For bowel cancer, our results strengthen findings from an earlier population-based study in NSW that found similar surgery rates between Aboriginal and non-Aboriginal bowel cancer patients during 2001–2007.<sup>14</sup> That study reported that adjuvant chemotherapy and radiotherapy use for Aboriginal people, based on a medical record review of a sample of Aboriginal people diagnosed 2001–2010 ( $n = 145$ ), was the same as that reported in NSW population-based treatment pattern surveys. Our study found no evidence of lower use of chemotherapy and radiotherapy on a population basis.

The focus for breast and bowel cancers should be on prevention, screening and earlier diagnosis for Aboriginal people, who were diagnosed with more advanced disease than their non-Aboriginal counterparts, similar to findings from other studies.<sup>8,11,13,34</sup> Participation by Aboriginal people in the national bowel screening programme is estimated to be half that of non-Aboriginal people (21% vs 43%).<sup>37</sup> Participation by Aboriginal women in mammographic screening through BreastScreen NSW, although it has increased, remains lower than non-Aboriginal women (42% vs 53%).<sup>38</sup> Screening programmes need to continue to engage Aboriginal people in the planning and delivery of services to improve participation.<sup>15</sup>

The primary strength of this study is its population basis and the linked hospital, MBS and PBS data which provided comprehensive capture of outpatient radiotherapy and chemotherapy treatments that may be poorly captured in studies relying on hospital record abstraction. Our study also investigated potential barriers to treatment. Private health insurance requires further exploration as health insurance status may be functioning as a proxy for health literacy or health-seeking behaviours which may influence treatment choice. Our study used a robust method of identifying Aboriginality.<sup>19</sup> However, comparison

of our findings to earlier studies should be made with caution since apparent changes in outcomes for Aboriginal people over time can be due to changes in people choosing to self-identify as Aboriginal.<sup>39</sup>

The main limitation of our study is we could not measure if the treatment received was optimal guideline-based therapy. We did not have qualitative factors such as stigma, fatalism, individual choice and cultural safety of care at hospitals that may act as barriers to treatment. Another limitation is the study's relatively old time period due to unavoidable delays in linking the datasets. We did not adjust for tumour histology or location, which are known to affect receipt of lung resection,<sup>26</sup> although there is no expectation these would vary by Aboriginality and is unlikely to affect our findings.

## Conclusion

We presented a comprehensive population-based study of surgery, radiotherapy and chemotherapy treatments for lung, breast and bowel cancers among Aboriginal and non-Aboriginal people for the first time in NSW. Our results provide evidence that overall treatment use for breast and bowel cancer treatment for Aboriginal people is equivalent to the rest of the community. However, Aboriginal people were 40% less likely than non-Aboriginal people to have any treatment for lung cancer. Underlying this, was fewer attendances with a surgeon and lower use of surgery. There is a need to strengthen referral pathways to lung cancer surgeons and specialist MDT care for Aboriginal people.

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## Data accessibility

Restrictions by the data custodians mean that the datasets are not publicly available or able to be provided by the authors. Researchers wanting to access the datasets used in this study should refer to the Centre for Health Record Linkage application process ([www.cherel.org.au/apply-for-linked-data](http://www.cherel.org.au/apply-for-linked-data)).

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## Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's web-site:

**Table S1.** Codes for the study definitions.

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