

Comparative use of cancer therapies in Australian farm, rural nonfarm and urban residents aged 45 years and older

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Key points

- Information on surgical and nonsurgical therapies for prostate, breast and colorectal cancer in farm residents, not previously separated as a group from other rural people, were compared with rural nonfarm and urban counterparts in a large cohort in New South Wales, Australia
- Results suggest that use of surgical therapies was comparable between the three groups
- Farm and rural nonfarm residents were similarly disadvantaged compared with their urban counterparts in the use of some nonsurgical cancer therapies

Abstract

Objectives and importance of the study: To determine whether use of selected therapies for prostate, breast and colorectal cancer in farm residents differs from that in rural nonfarm and urban counterparts. Little is known about cancer therapies used by farm residents.

Study type: Data linkage cohort study.

Methods: Baseline survey information from the Sax Institute's 45 and Up Study cohort was linked with data from the New South Wales Admitted Patient Data Collection for 2006–2012. Adjusted odds of receiving surgery, chemotherapy, radiotherapy and/or brachytherapy for each cancer were compared between groups, controlling for selected variables.

Results: Differences in the likelihood of surgery for breast and colorectal cancer between groups were not significant. However, for prostate cancer, farm men had 35% greater odds

of prostatectomy than rural nonfarm men (odds ratio [OR] 1.35; 95% CI 1.05, 1.72). Urban men were most likely to have had brachytherapy, with three times greater odds of treatment than farm men (OR 2.90; 95% CI 1.51, 5.56). Urban women were most likely to have had chemotherapy for breast cancer, having twice the odds of receiving this treatment as farm women (OR 2.24; 95% CI 1.25, 4.04). The odds of chemotherapy for colorectal cancer among rural nonfarm residents were two-thirds the odds among urban men (OR 0.62; 95% CI 0.44, 0.90) and urban women (OR 0.57; 95% CI 0.37, 0.88). Age, distance, income and health insurance factors contributed to differences in nonsurgical care between groups.

Conclusions: Cancer-related surgical services for breast and colorectal cancer were comparable between groups. Farm and rural nonfarm residents may have been disadvantaged in relation to nonsurgical therapies for prostate, breast and colorectal cancer compared with urban counterparts.

Introduction

Improved survival rates for prostate, breast and colorectal cancers in Australia during the past 30 years have been largely attributed to better diagnostic methods, earlier detection and improvements in cancer treatment.¹ However, cancer treatments vary in complexity and availability to the general population. Poorer cancer survival in rural areas has been partly attributed to geographic and socio-economic difficulties that rural people experience in accessing optimal cancer treatments.² National data generally show a correlation between decreased expenditure on specialist services and increased remoteness from urban centres.³

Cancer risk and treatment indicators are periodically reported by remoteness category, but standard reports do not differentiate between farm residents and other rural people.⁴ Farm residents share unique sociodemographic characteristics as a rural subgroup, described elsewhere.⁵ International reviews suggest that farmer populations have reduced risk of colorectal and perhaps breast cancer, plus possible elevations in prostate cancer.⁶ There is limited information on cancer mortality in Australian farm groups and no published information on how Australian farm residents use cancer treatment services.⁷⁻⁸

With a focus on farm residents as the primary group of interest, the study sought to determine whether use of therapies for prostate, breast and colorectal cancer differed between farm, rural nonfarm and urban residents in a large population-based cohort in New South Wales (NSW), Australia. Findings may provide insight into whether farm residents experience more difficulty, or less, in receiving cancer treatment than other rural or urban groups. This has implications for cancer treatment services and assessment of comparative mortality risk.

Methods

Datasets and linkage

The study was based on the NSW 45 and Up Study cohort, managed by the Sax Institute in collaboration with major health agency partners. Information from the 45 and Up Study baseline questionnaire was used to define risk factors of interest and categorise participants into farm, rural nonfarm and urban comparison groups. The cohort comprises 267 119 NSW residents aged 45 years or older who were enrolled on the database of the Australian Department of Human Services (formerly Medicare Australia) between January 2006 and December 2009. Eligible individuals were randomly sampled from the database, which provides near-complete coverage of the NSW population. Details about 45 and Up Study methods and variables are available elsewhere.⁹

The 45 and Up Study data were linked with corresponding data in the NSW Admitted Patient Data Collection (APDC) for January 2006 to December 2012. The APDC records all inpatient separations from NSW public and private hospitals, multipurpose services, private day procedure centres and public nursing homes.¹⁰ Linkage of records between datasets was conducted using probabilistic data linkage methods by the NSW Centre for Health Record Linkage (CHeReL).¹¹ CHeReL also provided geocode-derived distances between the nondisclosed residential address and treating hospital for each record.

Definition of variables

'Farm residents' were defined as those who indicated that they lived in a 'house on farm' in the 45 and Up Study baseline questionnaire. Rural nonfarm and urban residents were further defined using the Accessibility/Remoteness Index of Australia (ARIA+), from postcode of residence.⁴ Participants whose ARIA+ classification indicated that they did not live in a 'major city', excluding those who also specified that they lived in a 'house on farm', were defined as rural nonfarm residents. The remaining urban participants were those who lived in a 'major city'. Where ARIA+ was not recorded, allocation was made by cross-checking with postcode of residence and distance to treating hospitals.

Variables of interest considered for inclusion in logistic regression models were age, distance from treating hospital, 'private health insurance with extras' status, and annual household income of \$70 000 or more. The latter approximated levels above or below the NSW 2006 average annual household income of \$70 000.¹² Private health insurance with extras status referred to those with more than basic private hospital coverage, such as for complementary outpatient services used as part of a cancer treatment regime (e.g. ambulance, accommodation services). For distance, the average distance from home address to a treating hospital in all records for each person was used. Parameter estimates for distance to hospital are presented per 10 km to assist with interpretation. Cancer status was established where a prostate, breast or colorectal cancer diagnosis was recorded in any of the 55 diagnosis code fields of any APDC admission record during the period. Therapeutic procedures were identified within any one of 51 procedure code fields on the APDC record. Diagnosis and procedure codes are based on the International Statistical Classification of Diseases and Related Health Problems, tenth revision, Australian modification (ICD-10-AM) and Medicare Benefits Schedule classification systems.¹⁰

Therapeutic procedures for each selected cancer were categorised into surgical, chemotherapy, radiotherapy and brachytherapy groups. Surgical procedures for women with breast cancer were defined separately for mastectomies (procedure codes 31518-00–31524-00) and excision of breast lesions (31500-00–31515-00). Surgical procedures for men with prostate cancer were defined by radical or laparoscopic prostatectomy (37209-00–37211-09). Surgeries for colorectal cancer for both men and women were defined by procedures relating to colectomies, resections or excision of colorectal tumours (32000-00–32069-00, 32099-00–32108-00). Transurethral resections of prostate, colonoscopies and aspirational biopsies were excluded, to avoid confusion with diagnostic procedures.

Brachytherapy implantation procedures (15327-00–15338-00) were compared for prostate cancer cases; and radiotherapy procedures (15100-00–15269-09) were compared for those with a prostate, breast or colorectal cancer admission. Chemotherapy was limited to the administration of antineoplastic pharmacological agents only (96199-00, 96200-00, 96201-00, 96202-00, 96203-00, 96204-00, 96205-00, 96206-00, 96207-00, 96208-00, 96209-00). Sensitivity analyses used wider categories of chemotherapy, such as administration of steroids, anti-infective agents or nutritional pharmacological therapies (96199-00–96209-09).

Analysis

Analysis was conducted using SAS (Cary, NC: SAS Institute; Version 9.3). Frequencies and average distances from home to hospital were calculated for farm, rural nonfarm and urban residents for specified cancer treatments. Binary logistic regression was used to calculate adjusted odds ratios for selected treatments for each resident group. Variables with p values <0.25 on univariate analyses were included in the base model. Effect estimates and standard errors were compared between univariate and multivariable models, and variance inflation factors were calculated to ensure that collinearity did not exist between variables. Interactions between resident group and other factors were created and tested to assess effect modification. Models were progressively reduced using a backward elimination approach (0.05 level), removing nonsignificant variables and accounting for any nonsignificant confounders. Residual plots were examined to identify cases with undue influence in regression models.

Adjusted odds ratios were generated, focusing on farm residents as the referent group. However, differences between rural nonfarm and urban groups were also examined using an urban referent; these are presented where results were significantly different in final models. The difference between groups in the final adjusted odds ratio represents a difference not explained by factors left in the final model, but caused by the effect of group residence or unknown factors.

Results

Table 1 presents information on variables selected for inclusion in models for the three resident groups within the 45 and Up Study cohort. Tables 2 and 3 present the proportions of farm, rural nonfarm and urban residents who underwent particular cancer therapies for each cancer type, their distance from the treating centre, and the adjusted odds for undergoing therapy. Data for radiotherapy, where at least one cell had less than five cases, are not presented.

Cancer therapies in men

Farm men were significantly more likely to have a prostatectomy than rural nonfarm men, with 35% higher odds of the procedure. The average distance to a treating health service was not a significant factor in the likelihood of having a prostatectomy. Small case numbers in the referent group affected calculation of odds ratios for both radiotherapy and chemotherapy for prostate cancer, resulting in wide confidence intervals that included the null value. As such, there was no apparent difference in the adjusted odds of chemotherapy or radiotherapy for prostate cancer. In contrast, urban men were significantly more likely to have brachytherapy, with almost three times the odds of farm men and twice the odds of rural nonfarm men.

Surgical procedures for colorectal cancer did not differ between farm, rural nonfarm and urban men. Urban men had significantly higher odds of undergoing chemotherapy for colorectal cancer than rural nonfarm men. Results of sensitivity analyses for prostate and colorectal cancer chemotherapy supported the main findings.

Table 1. Selected characteristics of farm, rural nonfarm and urban residents in the 45 and Up Study cohort, considered for models

Characteristic	Men				Women			
	Total	Farm	Rural nonfarm	Urban	Total	Farm	Rural nonfarm	Urban
Average age (n, 95% CI)	123 882	61.2 (61.0, 61.4)	63.7 (63.6, 63.8)	64.3 (64.2, 64.4)	143 192	58.6 (58.5, 58.8)	61.8 (61.7, 61.8)	62.5 (62.4, 62.5)
Annual income more than \$70 000 (n)	103 830 ^a	7 813	48 331	47 686	105 384 ^b	7 722	51 790	45 872
<i>n (%)</i> ^c of those who responded 'Yes'	34 334 (33.1)	2 313 (29.6)	12 697 (26.3)	19 324 (40.5)	28 477 (27.0)	2 164 (28.0)	10 995 (21.2)	15 318 (33.4)
Private health insurance with extras (n)	123 907	9 281	57 341	57 285	143 206	10 551	69 467	63 188
<i>n (%)</i> ^c of those who responded 'Yes'	60 499 (48.8)	4 339 (46.8)	24 595 (42.9)	31 565 (55.1)	70 454 (49.2)	5 228 (49.6)	29 688 (42.7)	35 538 (56.2)

CI = confidence interval

^a 16% of data missing

^b 26% of data missing

^c Chi-square test of proportions between resident groups significant to 0.05 level

Table 2. Procedures performed on farm, rural nonfarm and urban men who had a prostate or colorectal cancer diagnosis on any APDC admission record, 2006–2012

Procedures	Total	Farm	Rural nonfarm	Urban	Factors remaining in adjusted model
Prostate cancer (<i>n</i>)	5 637	371	2 618	2 648	
Prostatectomy: radical or laparoscopic (procedure codes 37209-00–37211-09)					
<i>n</i> (%) ^a of men with a diagnosis who had a procedure	2 022 (35.9)	170 (45.8)	901 (34.4)	951 (35.9)	<ul style="list-style-type: none"> • Age: OR 0.88 (95% CI 0.87, 0.89) • Private health insurance with extras (yes vs no): OR 1.17 (95% CI 1.03, 1.33)
Average distance (km) (95% CI) from residence to health service for a first procedure	2 019	142.1 (122.4, 161.8)	93.1 (85.9, 100.4)	14.1 (12.8, 15.5)	
Adjusted OR (95% CI) for procedure	5 634	1.00	0.74 (0.58, 0.95)	0.83 (0.64, 1.06)	
Chemotherapy: antineoplastic agents only (procedure codes 96199-00, 96200-00, 96201-00, 96202-00, 96203-00, 96204-00, 96205-00, 96206-00, 96207-00, 96208-00, 96209-00)					
<i>n</i> (%) ^a of men with a diagnosis who had a procedure	205 (3.6)	8 (2.2)	78 (3.0)	119 (4.5)	<ul style="list-style-type: none"> • Age: OR 1.04 (95% CI 1.03, 1.06) • Private health insurance with extras (yes vs no): OR 1.56 (95% CI 1.15, 2.10) • [Average distance to health service (per 10 km) was a nonsignificant confounder; OR = 0.96 (95% CI 0.93, 1.00)]
Average distance (km) (95% CI) from residence to health service for a first procedure	164	56.1 (22.0, 90.1)	49.0 (30.0, 68.0)	11.0 (8.0, 14.1)	
Adjusted OR (95% CI) for procedure	5 600	1.00	1.14 (0.54, 2.42)	1.33 (0.62, 2.88)	

Procedures	Total	Farm	Rural nonfarm	Urban	Factors remaining in adjusted model
Radiotherapy (procedure codes 15100-00–15269-09)					
<i>n</i> (%) ^a of men with a diagnosis who had a procedure	137 (2.4%)	8 (2.2%)	48 (1.8%)	81 (3.1%)	<ul style="list-style-type: none"> • Age: OR 1.06 (95% CI 1.04, 1.08) • Private health insurance with extras (yes vs no): OR 0.61 (95% CI 0.40, 0.92) • [Annual household income more than \$70 000 (yes vs no) was a nonsignificant confounder; OR 0.90 (95% CI 0.51, 1.60)]
Average distance (km) (95% CI) from residence to health service for a first procedure	128	198.6 (82.3, 314.8)	128.8 (86.8, 170.8)	7.5 (6.2, 8.7)	
Adjusted OR (95% CI) for procedure	4 672	1.00	0.54 (0.24, 1.24)	1.01 (0.45, 2.25)	
Brachytherapy: implantations (procedure codes 15327-00–15338-00)					
<i>n</i> (%) ^a of men with a cancer diagnosis who had a procedure	311 (5.5%)	18 (4.9%)	108 (4.1%)	185 (7.0%)	<ul style="list-style-type: none"> • Annual household income more than \$70 000 (yes vs no): OR 1.38 (95% CI 1.01, 1.77) • Private health insurance with extras (yes vs no): OR 1.83 (95% CI 1.36, 2.45) • Average distance to health service (per 10 km): OR 1.06 (95% CI 1.04, 1.08) • Cohort (rural nonfarm vs urban): OR 0.46 (95% CI 0.34, 0.63)
Average distance (km) (95% CI) from residence to health service for a first procedure	311	270.6 (182.0, 359.2)	183.7 (160.4, 206.9)	20.4 (16.0, 24.9)	
Adjusted OR (95% CI) for procedure	4 641	1.00	1.34 (0.72, 2.25)	2.90 (1.51, 5.56)	
Colorectal cancer (<i>n</i>)	1 878	96	917	865	
Colorectal surgery colectomies, resections, excisions (procedure codes 32000-00–32069-00, 32099-00–32108-00)					

Procedures	Total	Farm	Rural nonfarm	Urban	Factors remaining in adjusted model
<i>n</i> (%) ^a of men with diagnosis who had a procedure	1 382 (73.6)	76 (79.2)	664 (72.4)	642 (74.2)	<ul style="list-style-type: none"> • Age: OR 0.99 (95% CI 0.98, 1.00)
Average distance (km) (95% CI) from residence to health service for a first procedure	1 367	78.1 (59.0, 97.1)	54.0 (47.5, 60.4)	9.6 (8.2, 11.0)	
Adjusted OR (95% CI) for procedure	1 878	1.00	0.71 (0.42, 1.18)	0.79 (0.47, 1.32)	
Chemotherapy: antineoplastic agents only (procedure codes 96199-00, 96200-00, 96201-00, 96202-00, 96203-00, 96204-00, 96205-00, 96206-00, 96207-00, 96208-00, 96209-00)					
<i>n</i> (%) ^a of men with a cancer diagnosis who had a procedure	240 (12.8%)	9 (9.4%)	86 (9.4%)	145 (16.8%)	<ul style="list-style-type: none"> • Age: OR 0.98 (95% CI 0.96, 0.995) • Private health insurance with extras (yes vs no): OR 2.97 (95% CI 2.11, 4.17) • [Annual household income more than \$70 000 (yes vs no) was a nonsignificant confounder; OR 1.30 (95% CI 0.89, 1.90)] • [Average distance to health service (per 10 km) was a nonsignificant confounder; OR 0.97 (95% CI 0.93, 1.02)] • Cohort (rural nonfarm vs urban): OR 0.62 (95% CI 0.44, 0.90)
Average distance (km) (95% CI) from residence to health service for a first procedure	221	64.2 (0, 156.5)	48.4 (30.4, 66.5)	9.6 (7.8, 11.4)	
Adjusted OR (95% CI) for procedure	1 510	1.00	0.78 (0.37, 1.67)	1.25 (0.58, 2.72)	

APDC = Admitted Patient Data Collection; CI = confidence interval; OR = odds ratio; Bold text = odds ratio significant compared with referent resident group to 0.05 level

^a Chi-square test of proportions between resident groups significant to 0.05 level

Table 3. Procedures performed on farm, rural nonfarm and urban women who had a breast or colorectal cancer diagnosis on any APDC admission record, 2006–2012

Procedures	Total	Farm	Rural nonfarm	Urban	Factors remaining in adjusted model
Breast cancer	3 188	180	1 514	1 494	
Mastectomy (procedure codes 31518-00–31524-00)					
<i>n</i> (%) ^a of women with diagnosis who had procedure	1 135 (35.6)	63 (35.0)	542 (35.8)	530 (35.5)	• Age: OR 1.01 (95% CI 1.00, 1.01)
Average distance (km) (95% CI) from residence to health service for first procedure	1 117	98.4 (67.8, 128.9)	53.3 (46.2, 60.3)	11.4 (9.6, 13.2)	
Adjusted OR (95% CI) for procedure	3 188	1.00	1.01 (0.73, 1.39)	0.99 (0.72, 1.37)	
Excision, re-excision or open biopsy of lesion (procedure codes 31500-00–31515-00)					
<i>n</i> (%) ^a of women with diagnosis who had procedure	1 915 (60.1)	112 (62.2)	910 (60.1)	893 (59.8)	• Age: OR 0.98 (95% CI 0.97, 0.99) • Annual household income more than \$70 000 (yes vs no): OR 1.29 (95% CI 1.04, 1.60)
Average distance (km) (95% CI) from residence to health service for first procedure	1 842	96.7 (76.9, 116.4)	51.0 (46.0, 56.1)	11.2 (9.6, 12.9)	

Adjusted OR (95% CI) for procedure	2 343	1.00	1.06 (0.73, 1.55)	1.03 (0.70, 1.50)	
Chemotherapy: antineoplastic agents only (procedure codes 96199-00, 96200-00, 96201-00, 96202-00, 96203-00, 96204-00, 96205-00, 96206-00, 96207-00, 96208-00, 96209-00)					
<i>n</i> (%) ^a of women with diagnosis who had procedure	638 (20.0%)	22 (12.2%)	234 (15.5%)	382 (25.6%)	<ul style="list-style-type: none"> • Age: OR 0.97 (95% CI 0.96, 0.98) • Annual household income more than \$70 000 (yes vs no): OR 1.37 (95% CI 1.07, 1.75) • Private health insurance with extras (yes vs no): OR 2.42 (95% CI 1.91, 3.05) • Average distance to health service (per 10 km): OR 0.97 (95% CI 0.94, 0.995) • Cohort (rural nonfarm vs urban): OR 0.70 (95% CI 0.55, 0.88)
Average distance (km) (95% CI) from residence to health service for first procedure	624	57.4 (29.4, 85.5)	49.9 (38.0, 61.7)	9.5 (8.5, 10.5)	
Adjusted OR (95% CI) for procedure	2 330	1.00	1.56 (0.88, 2.77)	2.24 (1.25, 4.04)	
Colorectal cancer	1 401	80	711	610	
Colorectal surgery: colectomies, resections and excisions (procedure codes 32000-00–32069-00, 32099-00–32108-00)					
<i>n</i> (%) ^a of women with diagnosis who had procedure	1 099 (78.4%)	61 (76.3%)	549 (77.2%)	489 (80.2%)	<ul style="list-style-type: none"> • Nil
Average distance (km) (95% CI) from residence to health service for first procedure	1 089	92.9 (63.4, 122.4)	55.9 (48.4, 63.4)	10.7 (7.0, 14.5)	

Adjusted OR (95% CI) for procedure	1 401	1.00	1.06 (0.61, 1.82)	1.26 (0.73, 2.19)	
Chemotherapy: antineoplastic agents only (procedure codes 96199-00, 96200-00, 96201-00, 96202-00, 96203-00, 96204-00, 96205-00, 96206-00, 96207-00, 96208-00, 96209-00)					
<i>n</i> (%) ^a of women with diagnosis who had procedure	167 (11.9%)	9 (11.3%)	63 (8.9%)	95 (15.6%)	<ul style="list-style-type: none"> • Age: OR 0.95 (95% CI 0.94, 0.97) • Private health insurance with extras (yes vs no): OR 2.07 (95% CI 1.35, 3.16) • [Annual household income more than \$70 000 (yes vs no) was a nonsignificant confounder; OR 1.16 (95% CI 0.68, 2.00)] • Cohort (rural nonfarm vs urban): OR 0.57 (95% CI 0.37, 0.88)
Average distance (km) (95% CI) from residence to health service for first procedure	159	71.1 (20.3, 122.0)	82.5 (49.5, 115.5)	15.8 (2.9, 28.6)	
Adjusted OR (95% CI) for procedure	951	1.00	0.84 (0.35, 2.01)	1.47 (0.62, 3.49)	

APDC = Admitted Patient Data Collection; CI = confidence interval; OR = odds ratio

Bold text = odds ratio significant compared with referent resident group to 0.05 level

^a Chi-square test of proportions between resident groups significant to 0.05 level

Cancer therapies in women

There was little difference between residence groups for surgical procedures of the breast. Distance to a treating health service was not associated with having surgery in final models. Urban women were significantly more likely to undergo chemotherapy for breast cancer than either of the other groups, having 2.2 times the odds of this therapy as farm women. There was little difference between farm, rural nonfarm and urban women in the odds of colorectal surgery. Again, the average distance to a treating hospital was not a significant factor in the likelihood of surgery. As for men, urban women were significantly more likely to undergo chemotherapy for colorectal cancer than rural nonfarm women. Sensitivity analyses for breast and colorectal cancer chemotherapy in women supported the main findings.

Discussion

Although farm-specific data about provision of prostate, breast and colorectal cancer therapies are unavailable in the Australian literature, results for the general rural population that includes farm residents are mixed. Some studies have reported comparable levels of cancer-related surgery and chemotherapy in urban and rural cancer patients.¹³⁻¹⁶ Others have reported lower rates of prostatectomy, breast-conserving surgery, radiotherapy and chemotherapy in rural areas.^{2,14-18}

Apart from socio-economic difficulties related to travel, the availability of specialist services can be an issue in rural areas.² Limited access to specialist urologists was one reason suggested for lower rates of radical prostatectomy in rural areas in the 1990s¹⁹, but farm and rural nonfarm men were not disadvantaged compared with urban men in our study. It is not known why farm men underwent more prostatectomies than rural nonfarm men, despite longer distances to treatment and similar prostate cancer risk in the two groups (reported elsewhere⁸). Urban men were more likely than either rural group to have chemotherapy and brachytherapy – a viable alternative to radical prostatectomy for early prostate cancer. However, these treatments are available in less than half of all Australian radiation oncology facilities.²⁰

Rates of surgery for colorectal cancer were reportedly lower among rural residents than among urban residents in Queensland, but comparable in South Australia.¹³⁻¹⁶ In contrast, the proportion of surgical procedures for breast cancer was lower in rural women in Queensland and Western Australia than in urban counterparts.^{14,16,21} In the current study, the rate of chemotherapy administration was higher among urban people than rural nonfarm residents for colorectal cancer, plus higher than both rural groups for breast cancer. This is consistent with delayed or lower odds of chemotherapy for breast and colorectal cancer patients in rural NSW, reported previously.¹⁷⁻¹⁸ In contrast, studies from South Australia and Western Australia have reported similar levels of chemotherapy for breast and colorectal cancers in urban and rural patients.¹³⁻¹⁴ More centralised treatment models have developed in these states to service sparse rural populations, which contrasts with NSW and its sizeable regional populations.¹³

Findings for chemotherapy and radiotherapy in our study should be considered with some caution because of low case numbers, which affect confidence intervals and the potential significance of results. Validation studies have also found these procedures to be underreported in the APDC, with prostate cancer therapies less accurately recorded for nonurban cases. Potentially, the latter could lead to a positive bias towards higher odds of prostate cancer therapies among urban men. In contrast, surgical treatments and brachytherapies are usually well captured.²²⁻²³

Other limitations include the 45 and Up Study cohort not being completely representative of the NSW population, although linkage with population datasets has shown that such biases are limited. Also, the definition of 'farm resident' in this study was open to respondents' interpretation of 'farm'; therefore, characteristic exposures, practices and lifestyles of farm residents may be more varied. This could affect the representativeness of subgroups. However, misclassification errors are likely to

be nondifferential and independent of other risk factors, leading to a null bias and underestimation of relationships between farm residence and cancer therapy.

Conclusion

Acknowledging limitations, this study found that cancer-related surgical services were generally comparable between farm, rural nonfarm and urban residents for breast and colorectal cancers. Farm men were more likely to have a prostatectomy than rural nonfarm men, and urban men had greater use of brachytherapy than either rural group. Generally higher use of nonsurgical therapies by urban residents in this study (up to 2012), supports earlier reports of disadvantage in specialist cancer services in rural areas.² In addition, the study suggests that this disadvantage is similar across farm and rural nonfarm resident groups.

Challenges for providing oncology services in rural areas include rural demographics; limitations in communications technology; difficulty in recruiting and retaining technically qualified personnel; and challenges in planning and coordinating surgical, pathology and oncology services.^{13,17,19} Ongoing development of the Rural Cancer Centres initiative, telemedicine and CanNET cancer networking services are likely to address rural–urban imbalances, and improve the accessibility, quality and coordination of rural cancer services.²⁵

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Competing interests

None declared.

Author contributions

JD conceived and designed the analysis, reviewed the literature, analysed and interpreted the data and drafted and revised the manuscript. TL interpreted and critically reviewed the data and revised the manuscript. BA interpreted and critically reviewed the data and provided feedback on the manuscript. TD critically reviewed the methods and provided feedback on the manuscript. All authors read and approved the final manuscript.

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