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Timeliness of Primary Radiotherapy for Cervical Cancer in Queensland: A 10 Year Rural–Urban Retrospective Cohort Study

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ABSTRACT

Background: Timely delivery of primary radiotherapy for locally advanced cervical cancer is an important measure of quality cancer care. The impact of rural residence on timely access to radiotherapy for cervical cancer has not been examined in Australia.

Aim: To establish if there are differences in timely radiation therapy for Queensland people with cervical cancer in rural areas compared to urban areas.

Methods: This retrospective population-based cohort study included all Queensland patients diagnosed with cervical cancer 2015–2024 who received primary radiotherapy with curative intent. Primary outcomes were treatment commencement within 6 weeks of diagnosis and treatment duration of combined external beam radiotherapy and brachytherapy within 50 days. The secondary outcome was 5-year overall survival.

Results: Of 2115 patients diagnosed with cervical cancer, 794 received primary radiotherapy. 733 (92%) received brachytherapy. 30% commenced treatment within 6 weeks, and 39% completed treatment within 50 days. Compared with urban residence, rural residence was not associated with reduced likelihood of timely treatment commencement (OR = 0.85, 95% CI: 0.62–1.17, $p = 0.32$), or timely treatment duration (OR = 1.03, 95% CI: 0.76–1.41, $p = 0.84$). Rural patients were less likely to receive brachytherapy (89.4% vs. 93.9%; $p = 0.02$) and to complete prescribed fractions (84.8% vs. 90.4%; $p = 0.02$). Five-year survival was 70.3% (95% CI: 66.3%–73.9%), with no difference between urban (71.6%, 95% CI: 66.7%–76.0%) and rural patients (67.7%, 95% CI: 60.8%–73.7%; $p = 0.31$).

Conclusions: Rurality was not associated with inferior timeliness or survival outcomes for cervical cancer radiotherapy in Queensland. Adherence to recommended treatment timeframes was suboptimal across the health system.

1 | Introduction

Identifying and addressing inequities in cervical cancer is vital for achieving disease elimination. This strategy must include efforts to ensure high-quality treatment is accessible by all communities.

Standard treatment for locally advanced cervical cancer is external beam radiation therapy (EBRT) with sensitising chemotherapy when medically appropriate, followed by brachytherapy. The European Societies of Gynaecological Oncology (ESGO) and the European Society for Radiotherapy and Oncology

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(ESTRO) recently published updated quality indicators for radiation therapy of cervical cancer based on a systematic literature search, expert consensus and external review by a large international panel [1]. This statement includes two quality indicators pertaining to timely radiation treatment:

1. ≥90% of patients receiving primary radiation therapy should commence treatment within 6 weeks of referral, with a minimum target of 75%.
2. ≥90% of patients should complete their overall treatment course (from initiation of EBRT to completion of brachytherapy) within 50 days [1].

Other guidelines recommend that the duration of primary radiotherapy should not exceed 56 days [2, 3]. Timely radiotherapy is an important quality indicator because extended treatment time worsens locoregional control and overall survival in cervical cancer [1, 4] Published international literature examining the impact of rurality and distance from radiation treatment for cervical cancer is mostly from the United States and findings are varied [5]. Two studies found increased distance to treatment facility had negative impacts on all-cause mortality [6] or overall survival [7], while others found no difference in overall survival [8, 9].

The relationship between timely access to radiation for cervical cancer and rurality has not been studied in the Australian context. This is particularly relevant to Queensland, which has a large geographic area and a centralised model of gynaecological oncology care. The aim of this study was therefore to establish if there are any differences in timely radiation therapy for Queensland people with cervical cancer living in rural areas, compared to those living in urban areas.

2 | Methods

2.1 | Setting and Inclusion Criteria

This retrospective cohort study included all patients diagnosed with cervical cancer from 1st January 2015 to 31st December 2024 who received curative-intent primary radiation therapy in Queensland. Patients who had definitive surgical resection before radiation or received palliative radiation were excluded.

2.2 | Data Sources

Data were obtained from Cancer Alliance Queensland (CAQ) who maintain the Queensland Oncology Repository (QOR), a population-based databank supporting cancer control and quality assurance. Approximately 60 linked data sources contribute to the QOR, including the Queensland Cancer Register, private and public hospital admissions data, death data, treatment systems, public and private pathology and hospital clinical data systems. Cancer is a notifiable disease in Queensland, so all cases of cervical cancer are expected to be captured in the data set. Information is regularly updated, with follow-up on treatment and survival available for all patients until 31 December 2024.

2.3 | Variables

Patients were categorised as rural or urban based on residential address using the Remoteness Areas for Australia according to the Australian Statistical Geography Standard, Edition 3 [10]. Major cities were classified as "Urban" while inner regional, outer regional, remote, and very remote areas were grouped as "Rural".

Patient and clinical characteristics included age group at diagnosis (<40; 40–49; 50–59; 60–69; ≥70), self-reported Aboriginal and/or Torres Strait Islander status, area-based socioeconomic status defined by the Socio-Economic Indexes for Areas (SEIFA) developed by the Australian Bureau of Statistics [11] (advantaged = deciles 9 and 10; middle = deciles 3–8; disadvantaged = deciles 1 and 2), histological subtype according to ICD-10-AM 12th edition [12] (squamous cell carcinoma; adenocarcinoma; other), and comorbidity counts categorised by the number of pre-existing conditions according to the algorithm developed by Quan et al. [13] (none; one; two or more). Extent of disease at diagnosis was classified by FIGO stage (Stage I, II, III, IV, not stated). Stage was assigned contemporaneously and so spans FIGO 2009 and FIGO 2018 staging systems [14, 15].

Treatment characteristics included radiation facility type (public; private), receipt of brachytherapy (yes; no), receipt of intravenous chemotherapy (yes; no), receipt of prescribed fractions (yes; no), straight-line distance to EBRT facility from the person's residence (0–10, 11–50, 51–150, >150 km), days from diagnosis to treatment commencement, and duration of treatment (days from first EBRT fraction to last brachytherapy dose).

2.4 | Outcomes

The two primary outcomes of timely radiation therapy are based on the 2023 ESGO/ESTRO quality indicators [1]. These are:

1. Timely treatment commencement: Proportion of patients who commence primary radiotherapy treatment within 6 weeks (42 days). ESGO indicators suggest that this is measured from time of first referral to the centre. CAQ registry does not capture the referral date or tumour board meeting date, so date of diagnosis was used as a surrogate for date of referral. When available, the date of histological diagnosis is taken as the date of diagnosis; otherwise, the date of clinical diagnosis is used.
2. Timely treatment duration: Proportion of patients completing treatment within 50 days. This is calculated from the first EBRT fraction to the last brachytherapy fraction. Patients who do not receive brachytherapy are excluded from this endpoint.

The secondary outcome is 5-year overall survival.

Sensitivity analyses assessed treatment commencement within 8 weeks to account for the interval between diagnosis and referral, and treatment duration within 56 days, consistent with pre-existing standards [2, 3].

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2.5 | Statistical Methods

Descriptive statistics compared demographic, clinic and treatment characteristics among urban and rural cohorts. Univariable logistic regression models were used to identify differences in the primary outcomes between the urban and rural cohorts. Any differences were further interrogated using multivariable logistic regression to control for possible confounding variables (age, Aboriginal and/or Torres Strait Islander status, socioeconomic status, stage at diagnosis and comorbidity count). Results from logistic regressions are presented as odds ratios (ORs) with 95% confidence intervals (95% CIs). Statistical significance was defined as $p < 0.05$.

Five-year overall survival by rurality was calculated using the Kaplan–Meier method and compared using the log-rank test. The semi-complete method was used to account for the lack of full follow-up among patients diagnosed after 2019. Survival time was accrued from the date of diagnosis until the date of death, 5 years after diagnosis or the end of the study period, depending on which occurred first, with censoring of patients alive at the endpoint. Statistical analyses were performed using Stata v19.5 (StataCorp LLC, College Station, TX).

2.6 | Ethics

Exemption from Human Research Ethics Committee full review was approved by the Metro South Health Human Research Ethics Committee (EX/2025/QMS/121641).

3 | Results

There were 2115 patients diagnosed with cervical cancer in Queensland from 2015 to 2024. The study cohort treated with curative-intent primary radiation was 794 patients (Figure 1), of whom 733 (92%) had brachytherapy. Median follow-up was 3.2 years (interquartile range 1.4–5.6 years).

Around one-third (35.6%) lived in rural locations. 8.1% identified as Aboriginal and/or Torres Strait Islander peoples. Squamous cell carcinoma was the most common morphology (78.8%) and most patients had Stage II (32.6%) or Stage III (37.8%) disease (Table 1).

Compared to urban patients, rural patients were more likely to be Aboriginal and/or Torres Strait Islander peoples and to live in disadvantaged socioeconomic areas. There were no differences in stage, histology, or comorbidity burden between groups (Table 1).

Rural patients were less likely to receive all prescribed EBRT fractions (rural 84.8%, urban 90.4% $p = 0.02$). Although rates in both groups were high, rural patients were less likely than urban patients to receive brachytherapy (rural 89.4%, urban 93.9% $p = 0.02$). Rates of concurrent chemotherapy were high and similar (rural 94.7%, urban 95.1% $p = 0.80$). Rural patients were twice as likely to have EBRT in a private facility (54.4% rural, 28.6% urban; $p < 0.001$) and were more likely to live a long distance from the treatment facility (50.9% rural compared to 1.8% urban living more than 50 km from the radiotherapy facility, $p < 0.001$; Table 1).

Median time to commencement of radiation was 55.5 days (IQR 40–77 days), and was lengthier for rural (60 days, IQR 41–81 days) compared to urban patients (54 days, IQR 39–75 days) ($p = 0.004$). Less than one-third (29.7%) of the total cohort commenced radiation therapy within 6 weeks of diagnosis (Urban 30.9%, Rural 27.6%). Rurality was not associated with reduced likelihood of timely treatment commencement (OR 0.85, 95% CI: 0.62–1.17, $p = 0.32$; Table 2). In sensitivity analysis, 52.0% of the total cohort commenced radiation therapy within 8 weeks of diagnosis (Urban 55.0%, Rural 46.6%). Rural patients had lower unadjusted odds of commencement within 8 weeks compared to urban patients (OR 0.72, 95% CI: 0.53–0.96, $p = 0.02$). However, after multivariable adjustment the association was no longer significant (adjusted OR 0.81, 95% CI: 0.58–1.13, $p = 0.22$).

Among patients receiving EBRT and brachytherapy, median treatment duration was 51 days (IQR 47–57 days) and similar for rural (51 days, IQR 47–57 days) and urban cohorts (52 days, IQR 47.5–57 days) ($p = 0.55$). 39.0% (286/733) completed treatment within 50 days (Urban 38.7%, Rural 39.5%). Rurality was not associated with reduced likelihood of timely treatment duration (OR 1.03, 95% CI: 0.76–1.41, $p = 0.84$; Table 2). When extended to 56 days, 73.5% of patients completed treatment within this timeframe (Urban 72.9%, Rural 74.7%). Again, there was no evidence of an association with rurality (OR 1.10, 95% CI: 0.77–1.55, $p = 0.52$).

There was no linear association between distance to treatment and outcomes of interest (Table S1). Patients living 11–50 km from treatment were less likely to have timely commencement than those living within 10 km (0.62, 95% CI: 0.43–0.91). However, there was no statistical difference for patients living 51–150 km away, or those living > 150 km away. Patients living 51–150 km from treatment were less likely to have timely duration of treatment compared to those living within 10 km (OR = 0.51, 95% CI: 0.27–0.96). There was no statistically significant difference in likelihood of timely treatment duration for those living 11–50 km from treatment, or > 150 km from treatment.

A total of 203 deaths (26% of the study cohort) due to any cause occurred by 31 December 2024, evenly distributed by rurality ($p = 0.26$). Five-year overall survival was 70.3% (95% CI: 66.3%–73.9%), with no difference between urban (71.6%, 95% CI: 66.7%–76.0%) and rural patients (67.7%, 95% CI: 60.8%–73.7%; $p = 0.31$) (Figure 2).

4 | Discussion

In this population-based cohort study of Queensland patients with cervical cancer treated with primary radiotherapy over a 10-year period, we found no significant differences between rural and urban patients in meeting internationally recognised quality indicators for timely radiation treatment. Rates of timely treatment commencement and completion were similarly low in both cohorts and substantially below the

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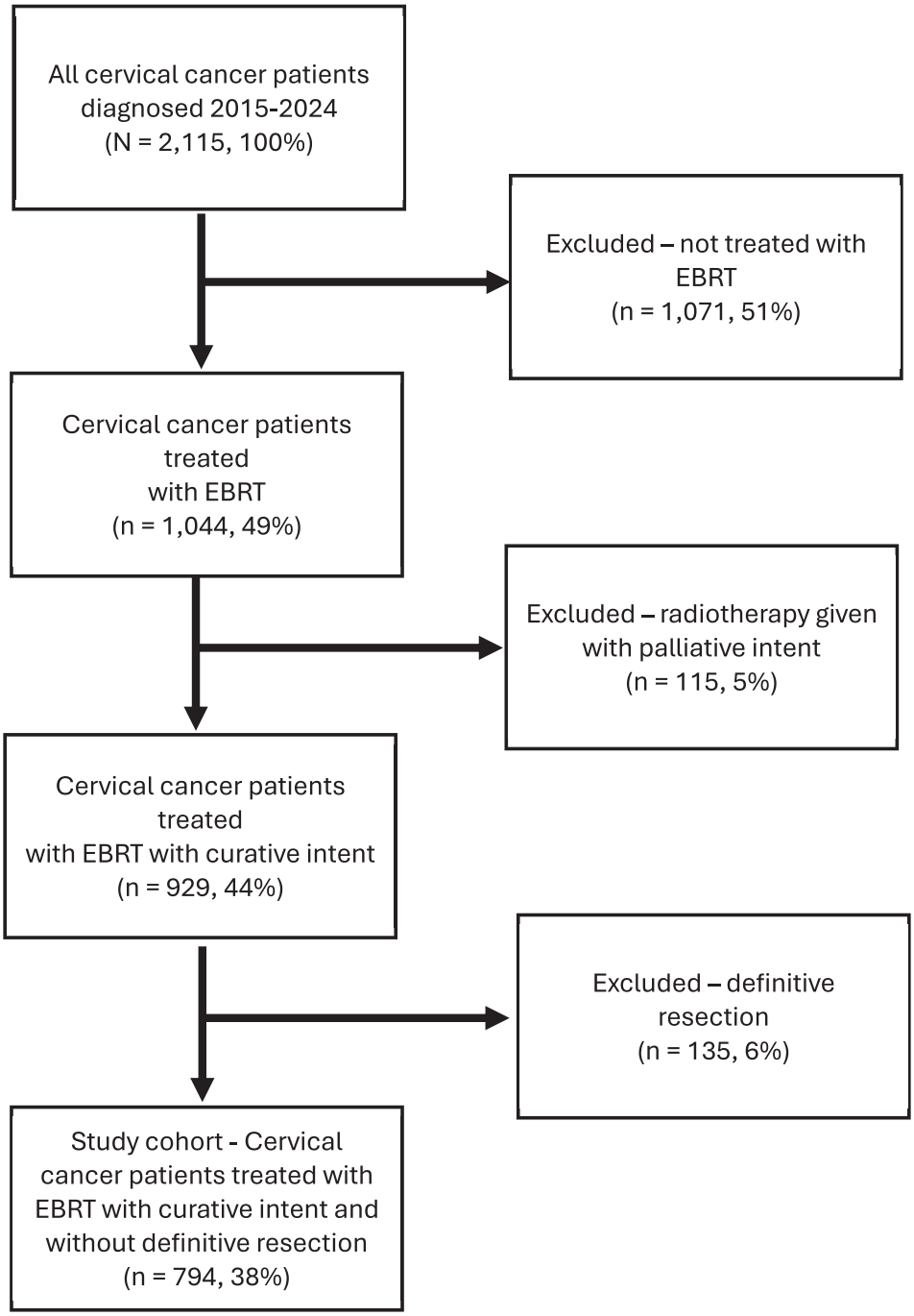


FIGURE 1 | Flow diagram for selection of the study cohort for cervical cancer patients treated with primary external beam radiotherapy (EBRT), Queensland, 2015–2024. Percentages shown are of all cervical cancer patients diagnosed between 2015 and 2024.

quality benchmarks suggested by ESGO/ESTRO. Five-year survival outcomes were comparable for urban and rural patients in our study.

The absence of a rural–urban disparity in timely radiotherapy contrasts with some studies from North America that reported inferior survival or increased mortality among patients living further from treatment facilities, potentially mediated through treatment delays or reduced access to specialist centres [7, 8]. Australian literature has reported relative excess risk of death from cervix cancer for women living in remote areas of NSW [16]. Similar to our findings, other studies have found no association between distance and survival [6, 9], or did not detect a disparity in timeliness of radiation based on rurality [17].

An important finding was the low proportion of patients meeting recommended quality indicators for timely radiotherapy. Less than one-third (29.7%) commenced treatment within 6 weeks of diagnosis and, even allowing an additional 2 weeks to account for the diagnosis-to-referral interval, only 52% commenced within 8 weeks. Although timely radiotherapy is widely recognised as a quality indicator, evidence supporting specific commencement thresholds remains limited [18–20], and comparisons between

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TABLE 1 | Demographic, clinical and treatment characteristics of cervical cancer patients who received primary external beam radiotherapy by place of residence, Queensland, 2015–2024.

	Urban ($N=511$)		Rural ($N=283$)		Total ($N=794$)	
Characteristic	***n***	**Col %**	***n***	**Col %**	***n***	**Col %**
Age group at diagnosis ($p=0.01$)						
<40 years	141	27.6	55	19.4	196	24.7
40–49 years	140	27.4	68	24.0	208	26.2
50–59 years	100	19.6	74	26.2	174	21.9
60–69 years	80	15.7	44	15.6	124	15.6
≥70 years	50	9.8	42	14.8	92	11.6
Aboriginal and/or Torres Strait Islander status ($p=0.006$)						
Aboriginal and/or Torres Strait Islander peoples	31	6.1	33	11.7	64	8.1
Other Queensland resident	480	93.9	250	88.3	730	91.9
Area-based socioeconomic status ($p<0.001$)						
Advantaged	106	20.7	0	0.0	106	13.3
Middle	320	62.6	153	54.1	473	59.6
Disadvantaged	85	16.6	130	45.9	215	27.1
Extent of disease at diagnosis ($p=0.30$)						
Stage I	91	17.8	63	22.3	154	19.4
Stage II	174	34.1	85	30.0	259	32.6
Stage III	199	38.9	101	35.7	300	37.8
Stage IV	37	7.2	28	9.9	65	8.2
Not stated	10	2.0	6	2.1	16	2.0
Histological subtype ($p=0.67$)						
Squamous cell carcinoma	403	78.9	223	78.8	626	78.8
Adenocarcinoma	89	17.4	46	16.3	135	17.0
Other	19	3.7	14	4.9	33	4.2
Comorbidity count ($p=0.16$)						
None	424	83.0	221	78.1	645	81.2
One	50	9.8	31	11.0	81	10.2
Two or more	37	7.2	31	11.0	68	8.6
Received prescribed fractions ($p=0.02$)						
Yes	462	90.4	240	84.8	702	88.4
No	49	9.6	43	15.2	92	11.6
EBRT facility type ($p<0.001$)						
Public	365	71.4	129	45.6	494	62.2
Private	146	28.6	154	54.4	300	37.8
Distance to EBRT facility ($p<0.001$)						
0–10 km	180	35.2	73	25.8	253	31.9
11–50 km	322	63.0	66	23.3	388	48.9

(Continues)

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TABLE 1 | (Continued)

Characteristic	Urban ($N=511$)		Rural ($N=283$)		Total ($N=794$)	
	n	Col %	*n*	Col %	*n*	Col %
51–150 km	9	1.8	66	23.3	74	9.3
>150 km	0	0.0	78	27.6	79	9.9
Had brachytherapy ($p=0.02$)						
Yes	480	93.9	253	89.4	733	92.3
No	31	6.1	30	10.6	61	7.7
Had concurrent chemotherapy ($p=0.80$)						
Yes	486	95.1	268	94.7	754	95.0
No	25	4.9	15	5.3	40	5.0

Note: p values are calculated using chi square test.
Abbreviation: EBRT, external beam radiotherapy.

TABLE 2 | Association between rural/urban status and timely radiotherapy commencement and treatment duration for patients with cervical cancer who received primary external beam radiotherapy, Queensland, 2015–2024.

			Univariate logistic regression	
	Yes	No	Unadjusted	Unadjusted
Place of residence	*n* (%)	*n* (%)	OR (95% CI)	*p*
Commencement of EBRT within 6 weeks of diagnosis				
Urban	158 (30.9%)	353 (69.1%)	Ref	
Rural	78 (27.6%)	205 (72.4%)	0.85 (0.62–1.17)	0.32
Duration of treatment ≤ 50 days[a]				
Urban	186 (38.7%)	294 (61.3%)	Ref	
Rural	100 (39.5%)	153 (60.5%)	1.03 (0.76–1.41)	0.84

Abbreviation: EBRT, external beam radiotherapy.
[a]Duration of treatment calculated from start of EBRT to end of last brachytherapy (excluding patients who did not receive brachytherapy).

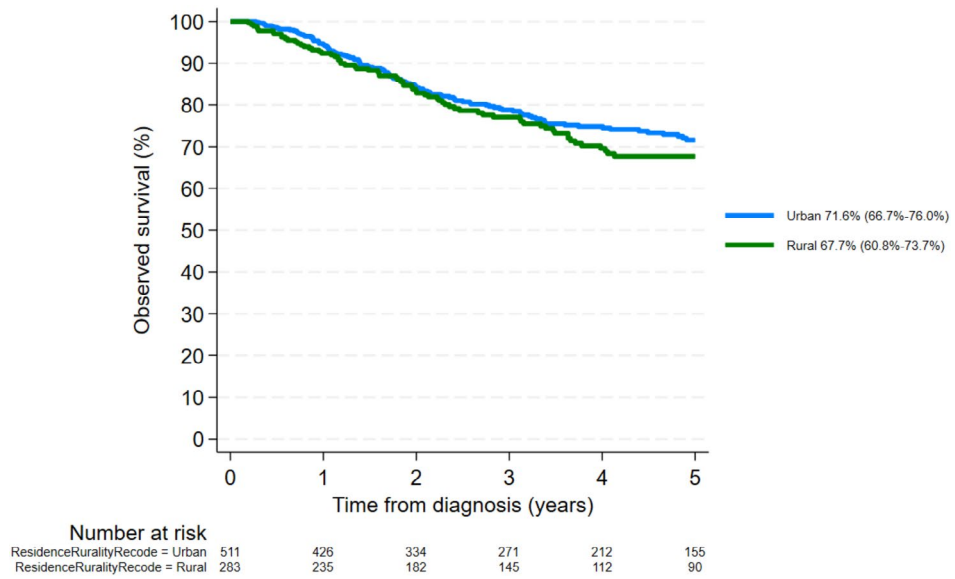


FIGURE 2 | Five-year observed survival for cervical cancer patients treated with primary external beam radiotherapy (EBRT) by place of residence, Queensland, 2015–2024.

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studies are complicated by inconsistent definitions. CAQ data from 2014 to 2018 using a 45-day benchmark found patients with cervical cancer had the lowest rate of timely radiotherapy commencement (40%) compared with other reported cancers in Queensland (69% for central nervous system/brain, 65% oesophagus, 61% lung, 56% rectal and 51% oropharynx) [21]. Examining referral and treatment pathways in cancer streams with higher rates of timely radiation may identify opportunities to improve timeliness for patients with cervical cancer.

Only 39% of patients receiving EBRT and brachytherapy completed treatment within 50 days. This increased to 73.5% using the historical 56-day benchmark, which was the standard of care for much of the study period before publication of the EMBRACE-I data and so likely accounts for the better adherence to this timeframe [22]. Prolonged treatment duration remains clinically relevant, as multiple studies have demonstrated inferior local control and survival with extended overall treatment time [4, 23]. Adherence to the 56-day benchmark in our cohort was similar to the 73% reported by Chiew et al. [24] for 208 patients treated in Sydney from 2005 to 2011.

We hypothesise that delays in treatment commencement arise from cumulative post-diagnosis processes, including pathology review, specialised imaging, multidisciplinary discussion, treatment planning, workforce capacity, access to brachytherapy, scheduling constraints, and coordination between EBRT and brachytherapy services.

Distance to treatment was not clearly associated with poorer adherence to timely treatment in our study. This differs from Queensland patients with rectal cancer who have an increase in mortality with an increase in distance from the nearest radiotherapy facility [25], but is similar to lung cancer patients in Queensland who have delays in receiving radiation therapy, but not related to distance to treatment [26].

Notably, rural patients were less likely to receive brachytherapy and complete prescribed fractions. Although this did not translate into significant different survival estimates in this study, brachytherapy omission and incomplete treatment are established risk factors for poorer oncological outcomes [27]. The higher rate of treatment in private facilities among rural patients is likely attributable to the presence of private radiation therapy centres in several regional Queensland towns, without equivalent public services.

Despite suboptimal adherence with current timely quality indicators, 5-year overall survival for our cohort is similar to comparable cohorts. The international OUTBACK trial reported a 5-year overall survival of 71% (95% CI: 66%–75%) in the arm treated with standard chemotherapy with external beam radiotherapy, followed by brachytherapy [28]. This cohort included a larger proportion of early-stage patients (76% Stage I or II) compared to our cohort (52% Stage I or II). The 5-year overall survival for Australian and New Zealand patients within the OUTBACK trial was 75% (95% CI: 64%–83%) [28].

This study has several strengths. It is the first Australian study examining the impact of rurality on timely radiotherapy for cervical cancer and uses a large, population-based dataset including relevant clinical covariates, with standard follow-up for all patients. Limitations include use of diagnosis date as a proxy for referral date, which may underestimate compliance with the 6-week commencement indicator. Registry data lack information on reasons for treatment delays. The binary rurality classification may have obscured differences between inner regional and other rural/remote populations. The study did not account for travel distance to brachytherapy, which is particularly relevant in Queensland where brachytherapy is only available in Brisbane and Townsville, and may explain lower rates of brachytherapy in the rural cohort.

In conclusion, rurality was not significantly associated with inferior timeliness of treatment or survival for patients receiving primary radiotherapy for cervical cancer in Queensland. Overall adherence to quality indicator targets for timely treatment is suboptimal. Services should audit their own performance and care pathways to identify processes that can improve timeliness.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The authors have nothing to report.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Table S1:** Association between distance to treatment and timely radiotherapy commencement and treatment duration for patients with cervical cancer who received primary external beam radiotherapy, Queensland, 2015–2024.

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