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RADIATION ONCOLOGY—ORIGINAL ARTICLE

Rural Urban Differences in Receipt of Radiation Oncology Services for Breast, Prostate and Lung Cancer by Ethnicity in Aotearoa New Zealand

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ABSTRACT

Introduction: Accessing radiation therapy is a challenge for rural cancer patients. This study explored the rates of receiving radiation therapy for rural Māori and non-Māori New Zealanders with breast, prostate or lung cancer compared with their most urban counterparts.

Method: Rates of receipt of radiation therapy per 100,000 population were calculated using radiation treatment data from 2014 to 2020, obtained from the Radiation Oncology Collection and resident population estimates from StatsNZ. Rurality was assigned by the Geographical Classification for Health (GCH).

Results: For females with breast cancer, receipt of radiotherapy was lower for those over 75 living in smaller cities (U2) and for non-Māori aged 45–64 living rurally. For prostate cancer, there was higher receipt of radiotherapy by rurality in those under 65. For lung cancer, radiotherapy rates were higher in rural patients under 65, particularly females and non-Māori, but lower receipt of curative radiotherapy was observed for the most rural (R2/R3) Māori females and males over 75. Irrespective of rurality, Māori receipt of radiotherapy was lower than non-Māori in the youngest age groups for breast and prostate cancer, while Māori aged 45–74 with breast cancer, and Māori females and males with lung cancer in almost all age groups and GCH categories, had higher rates of radiotherapy than their non-Māori counterparts.

Conclusion: This study observed some rural–urban differences in receipt of radiation therapy for the three cancers studied, though with evidence of variability by age group and cancer type, and significant differences between Māori and non-Māori.

1 | Introduction

In Aotearoa New Zealand (NZ), cancer is the leading cause of mortality, accounting for nearly one third of all deaths [1]. While cancer survival rates continue to improve overall, these changes are attenuated for NZ's indigenous Māori population [2, 3].

In many countries, treatment options for rural cancer patients are constrained by difficulty accessing centralised services and the multifactorial burden of receiving treatment away from home [4, 5]. There has been substantial variation in reported rates of radiotherapy for breast cancer and for palliation when distance to travel for treatment is considered [6, 7]. Improving access by opening regional/decentralised radiotherapy sites can improve access for rural populations [8].

The specific socio-geographic situation in NZ limits the applicability of overseas data. A greater proportion of Māori live rurally (25%

vs. 18% for non-Māori) [9] and experience inequity of health service provision and poorer health outcomes [10–12]. 33% of cancers in NZ are treated with radiation, all in large urban centres, although this proportion varies according to health district [13]. This is due, in part, to a relatively lean radiation oncology workforce [14, 15]. The development of the Geographical Classification for Health (GCH) provides an opportunity to better understand differences in health status and use of services by rural New Zealanders [16]. To date, in contrast to other common causes of death, overall cancer mortality has not been demonstrated to be closely correlated with living rurally, as measured by the GCH [17].

The primary aim of this study was to explore rates of receiving radiotherapy for rural Māori and non-Māori New Zealanders with breast, prostate or lung cancer compared with their urban counterparts. These are the three most common cancers affecting Māori and are commonly treated with radiotherapy [13]. A secondary aim was to determine whether any rural–urban differences were apparent for those treated with curative or palliative intent.

2 | Methodology

This retrospective, observational, population-based study investigated the receipt of radiotherapy for breast, prostate and lung cancer in NZ between January 2014 and December 2020. All people registered for a first radiation treatment during this period were included. Those with no geographic data recorded in the database were excluded. Male patients with breast cancer were not included because of very small numbers (<1% of treatment events).

The primary outcome measures were:

The rates of radiotherapy received per 100,000 population.

Secondary outcome measures were:

The rates of radiotherapy with (i) curative and (ii) palliative intent.

Both outcome measures considered (a) breast, (b) prostate and (c) lung cancer separately.

All outcome measures compared rural and urban populations using the GCH and were analysed separately for Māori and non-Māori.

A deidentified dataset was sourced from the national Radiation Oncology Collection (ROC). This person-cancer level dataset contains all treatments received at eight of ten radiotherapy centres, including all six public and two private centres. Additionally, one private centre provided partial data for the period and one provided no data.

The GCH was used for geographic classification. It was designed and validated for use for health research and policy in NZ. It is the preferred rural–urban classification system used by Health NZ. Geographical units for the patient's residential address were obtained by linking National Health Index (NHI), a unique person identifier used throughout NZ's health system [18], with Primary Health Organisation enrolments. The meshblock is the smallest geographical unit for which data is reported by Stats NZ, while the Domicile is the Ministry of Health's specific unit of geography. The meshblock or, if missing, the Domicile was mapped to the GCH's five categories of rurality: U1 (major urban), U2 (smaller cities), R1, R2 and R3 (increasingly distant from urban centres) [16]. Due to small numbers, people living in the two most rural areas (R2 and R3) were combined into one category.

Only the first entry for each person was considered for analysis. Where a person had more than one cancer, the initial entry for any subsequent cancer was included. The denominator was estimated resident population, derived from Census 2013 and 2018 and person-years were calculated for the period 2014–2020 for each GCH category using linear interpolation and extrapolation. The Census 2018 Māori population distribution was used as the standard population.

Ethnicity data recorded in the NHI at the time of treatment was provided by the ROC. In NZ, patients can select more than one ethnicity. For this study mutually exclusive Māori and non-Māori ethnic groups were determined using a prioritisation system [19] where a patient was assigned as Māori if any of their recorded ethnicities were Māori. All other ethnicities were grouped as non-Māori.

Incidence rates of receipt of radiotherapy per 100,000 population (IR) and corresponding 95% Confidence Intervals (CIs) were estimated by GCH classification for each cancer, using the following age stratification: 0–44, 45–64, 65–74 and 75+ years. Age stratification rather than standardisation was chosen because of known rural–urban differences in mortality by age-group [17]. Because of low numbers of prostate and lung cancer in those under 45, a 0–64 year age group was used for these. Rate ratios (IRR), with corresponding 95% CIs per age group and cancer type, were calculated using Poisson regression, and represent the ratio of the population radiotherapy rate in one GCH category (U2, R1, R2/3) divided by the rate in U1 (reference category). Additional analyses were carried out for ethnicity and for curative or palliative intent.

Ethics approval was obtained from the University of Otago Human Research Ethics Committee (HD19/069) and Māori consultation was undertaken with the Ngāi Tahu Research Consultation Committee.

3 | Results

There were 48,781 treatment episodes identified, with 28.6% excluded (Figure 1), leaving 34,805 in the analytical dataset. Of these, 57.0% resided in U1, 19.7% in U2, 14.7% in R1 and 8.6% in R2/R3. There were 16,055 females with breast cancer, 10,925 males with prostate cancer and 3820 females and 4005 males with lung cancer (Table 1).

3.1 | Breast Cancer

Rates of receipt of radiotherapy for breast cancer in rural and urban areas were broadly similar (Figures 2 and 3), though there

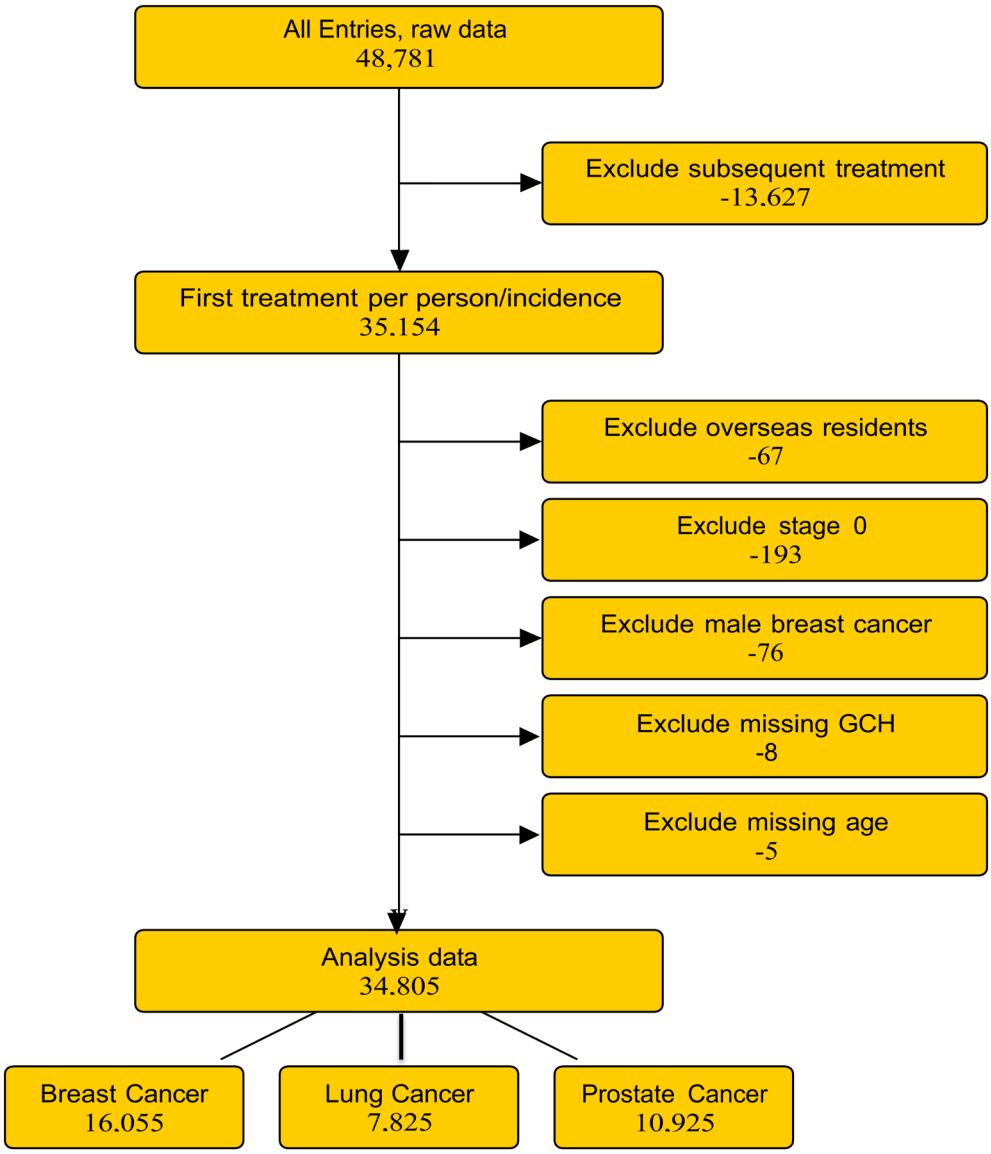

FIGURE 1 | Flowchart of data for analysis from all entries in ROC database for breast, prostate or lung cancer from 2014 to 2020.

was lower receipt of radiotherapy for those over 75 overall (IRR 0.82 [95% CI 0.73–0.92]) and for non-Māori (IRR 0.82 [95% CI 0.72–0.92]) residing in U2 compared to their counterparts living in U1 (Table S1). Ratios were also lower for non-Māori aged 45–64 in rural areas (R1: IRR 0.93 [95% CI 0.86–0.99]; R2/R3: IRR 0.90 [95% CI 0.81–0.99]).

As with the overall group, those over 75 years living in U2 had lower rates of radiotherapy with curative intent (IRR 0.86 [95% CI 0.74–0.98]) (Table S1) compared with their counterparts in U1. There were no other differences by rurality in radiotherapy rates with curative or palliative intent (Figures 4 and 5).

3.2 | Prostate Cancer

For prostate cancer, there were higher rates of receipt of radiotherapy in rural areas compared with U1 in those under 65 (U2: IRR 1.22 [95% CI 1.10–1.36]; R1: IRR 1.35 [95% CI 1.20–1.52]; R2/R3: IRR 1.47 [95% CI 1.27–1.70]) (Table S2).

In the total group under 65 with prostate cancer, compared to U1, rates of curative radiotherapy were 26% higher for those living in U2 (95% CI 1.12–1.42), 47% higher in R1 (95% CI 1.29–1.67), and 53% higher in R2/R3 (95% CI 1.30–1.80). This was independently significant for non-Māori (Figure 3). Higher rates of curative radiotherapy were also observed for non-Māori over 75 living in R2/R3 (IRR 1.50 [95% CI 1.25–1.79]). No evidence of differences was seen by rurality for palliative radiotherapy though the IRR was lower in R2/R3 in those over 75 (0.86 [95% CI 0.71–1.04]).

3.3 | Lung Cancer

For lung cancer, radiotherapy rates were higher in more rural areas for all females under 65 (U2: IRR 1.61 [95% CI 1.40–1.85], R1: IRR 1.60 [95% CI 1.36–1.87]; R2/R3: IRR 1.89 [95% CI 1.56–2.28]) than in their U1 counterparts (Table S3). This was independently significant for Māori and non-Māori, apart from Māori living in U2. Similar trends for higher receipt of radiotherapy by rurality were observed for Māori and non-Māori males

TABLE 1 | Demographics of breast, prostate and lung cancer patients receiving radiotherapy between 2014 and 2020.

	Breast		Prostate		Lung		Total	
	N	**Col %**	***N***	**Col %**	***N***	**Col %**	***N***	**Col %**
Age (years)								
0–44	1707	10.6	12	0.1	109	1.4	1828	5.3
45–64	8828	55.0	2404	22.0	2488	31.8	13,720	39.4
65–74	3607	22.5	5332	48.8	2866	36.6	11,805	33.9
75+	1913	11.9	3177	29.1	2362	30.2	7452	21.4
Gender								
Female	16,055	100	—	—	3820	48.8	19,875	57.1
Male	—	—	10,925	100	4005	51.2	14,930	42.9
Ethnicity								
Maori	2104	13.1	890	8.2	1559	19.9	4553	13.1
Non-Maori	13,951	86.9	10,035	91.9	6266	80.1	30,252	86.9
GCH								
U1	9703	60.4	5928	54.3	4211	53.8	19,842	57.0
U2	3011	18.8	2196	20.1	1648	21.0	6855	19.7
R1	2148	13.4	1744	16.0	1221	15.6	5113	14.7
R2–R3	1193	7.4	1057	9.7	745	9.5	2995	8.6
Region								
Northern	4948	30.8	3013	27.6	2472	31.6	10,433	30.0
Te Manawa Taki	3520	21.9	2518	23.1	1634	20.1	7672	22.0
Central	3675	22.9	1972	18.1	1551	19.8	7198	20.7
Te Waipounamu	3912	24.4	3422	31.3	2168	27.7	9502	27.3
Stage								
1	4683	29.2	470	4.3	954	12.2	6107	17.6
2	3312	20.6	2837	26.0	413	5.3	6562	18.9
3	1686	10.5	1651	15.1	1592	20.4	4929	14.2
4	1128	7.0	2168	19.8	2952	37.7	6248	18.0
Missing	5246	32.7	3799	34.8	1914	24.5	10,959	31.5
Intent of radiation								
Curative	13,004	81.0	7513	68.8	2524	32.3	23,041	66.2
Palliative	2241	14.0	3002	27.5	5161	66.0	10,404	29.9
Missing	810	5.1	410	3.75	140	1.8	1360	3.9

with lung cancer under 65. There were no significant findings for other age groups for females or males.

For curative radiotherapy, increasing rurality was associated with higher radiotherapy rates in females under 65 compared with U1, most markedly in R2/R3 (IRR 1.79 [95% CI 1.22–2.54]), primarily due to higher rates among non-Māori. Māori females under 65 in U2 had different rates of radiotherapy (IRR 0.79 [95% CI 0.50–1.22]) than non-Māori (IRR 1.86 [95% CI 1.34–2.55]). Higher rates were observed for Māori (IRR 2.06 [95% CI 1.19–3.49]) and non-Māori (IRR 2.05 [95% CI 1.34–3.24]) males under 65 living in R2/R3. Lower rates of curative radiotherapy by rurality for Māori over 75 were evident for females and males combined, though significant only for those living in R2/R3 (IRR 0.33 [95% CI 0.12–0.79]). Apart from Māori living in U2, receipt of palliative radiotherapy for lung cancer was higher by rurality for all females and males, Māori and non-Māori in the under 65 age group, compared with those in U1.

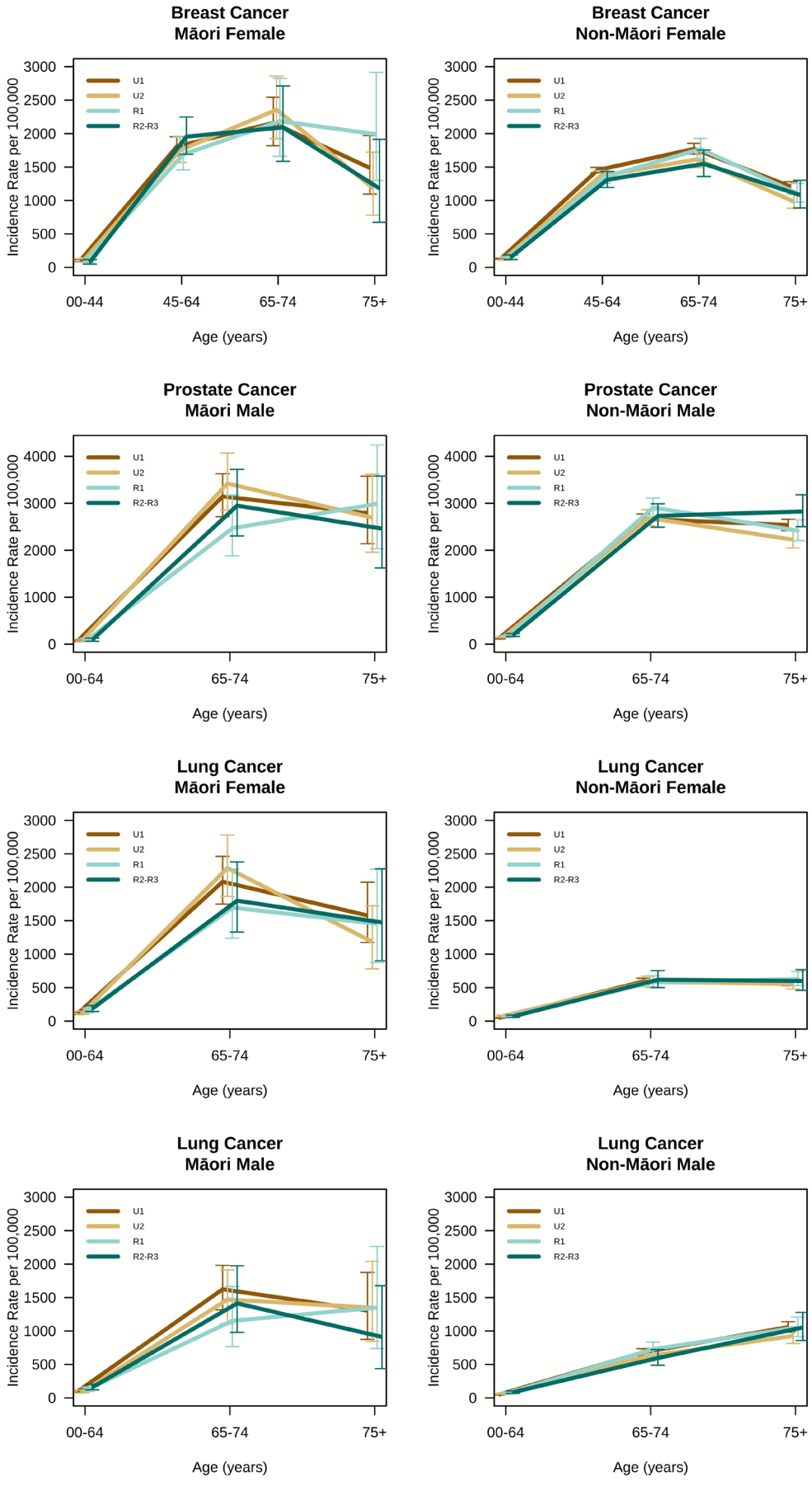

FIGURE 2 | Rates of radiotherapy for breast, prostate and lung cancers by age, sex, ethnicity and GCH.

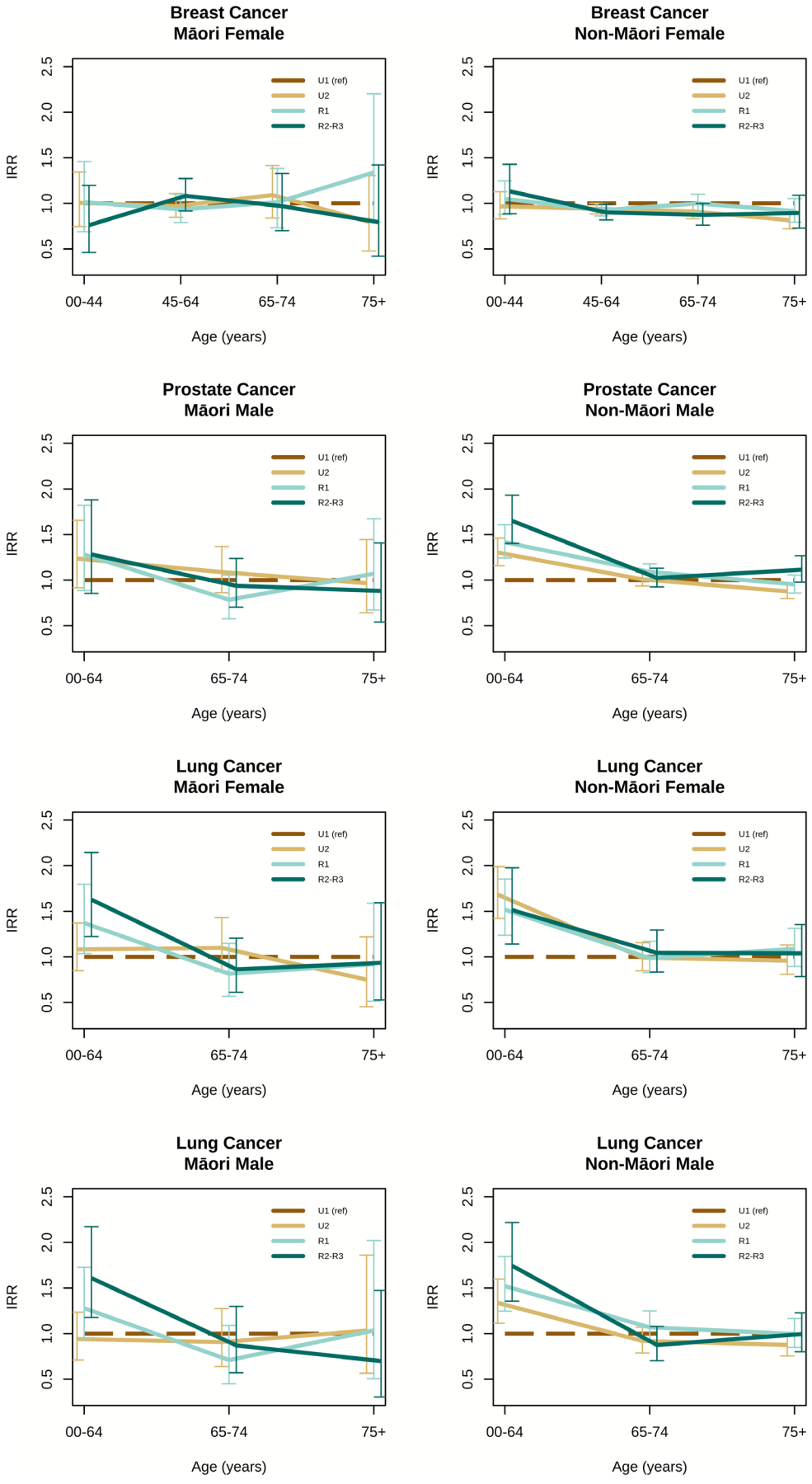

FIGURE 3 | Radiotherapy rate ratios by age, sex and ethnicity, comparing level of rurality with U1 (most urban).

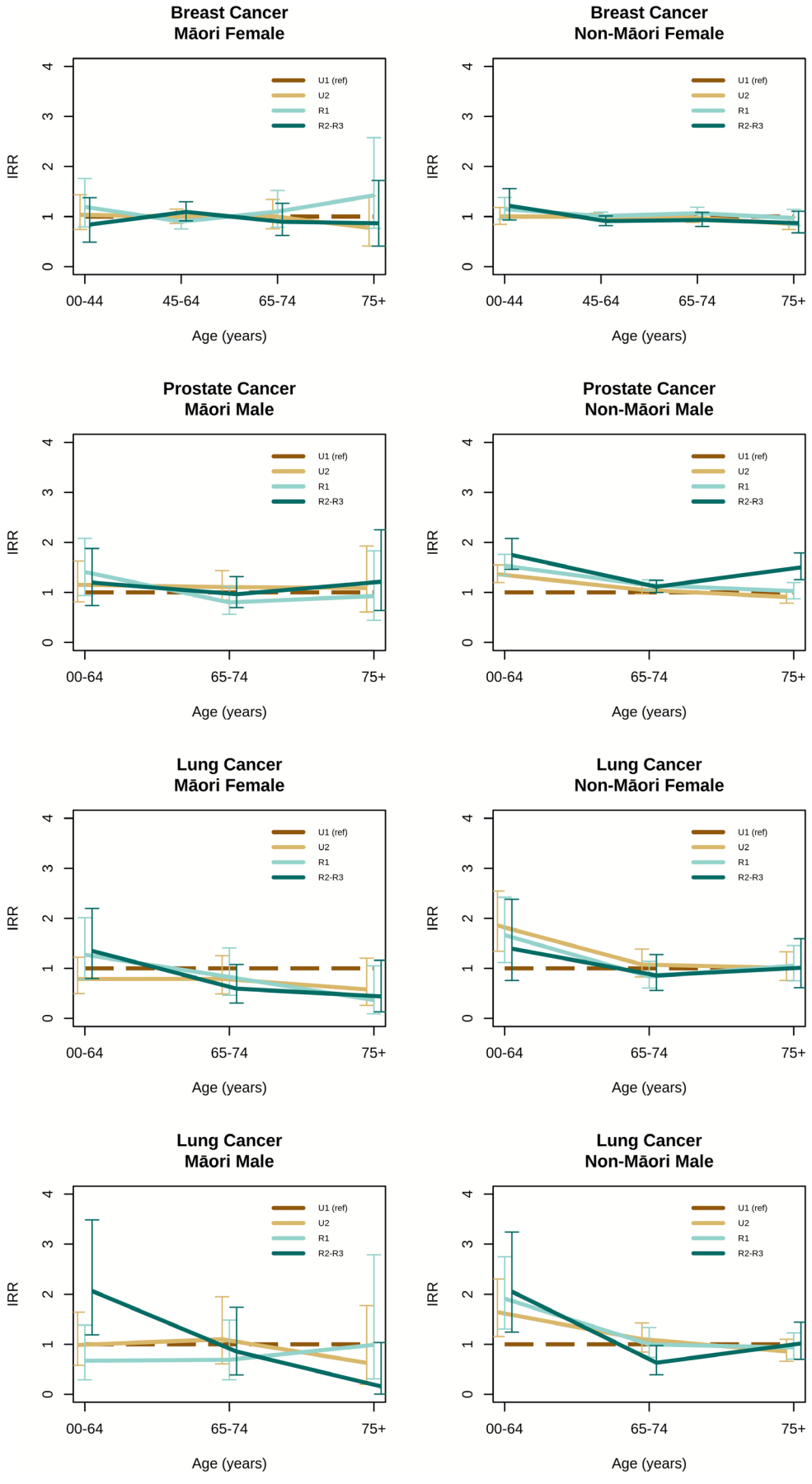

FIGURE 4 | Radiotherapy rural–urban rate ratios for those treated with curative intent.

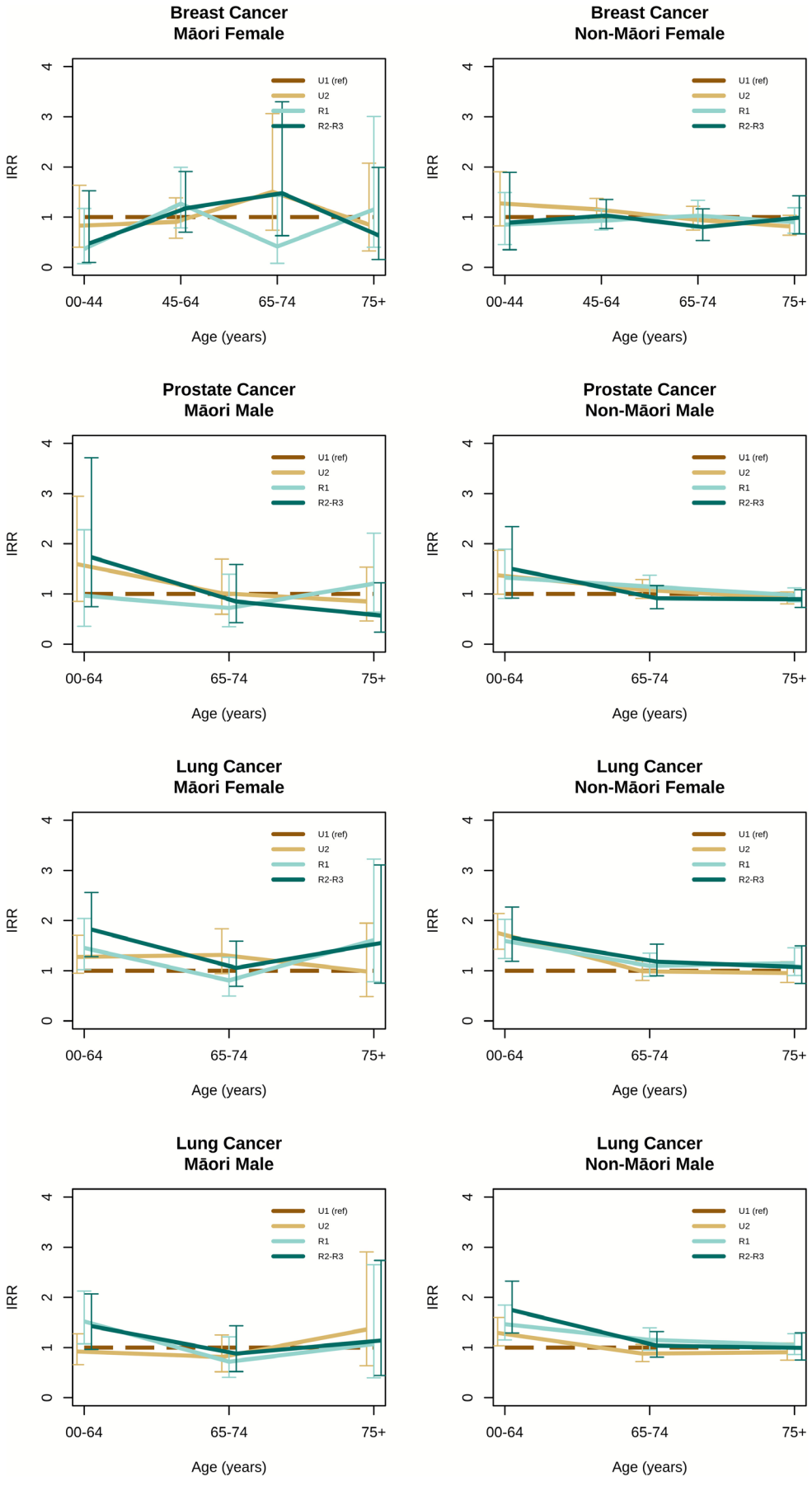

FIGURE 5 | Radiotherapy rural–urban rate ratios for those treated with palliative intent.

3.4 | Māori: Non-Māori Receipt of Radiotherapy

For breast cancer, radiotherapy rates were significantly lower for Māori than for non-Māori in those under 45, across all GCH categories, especially so for those living in R2/R3 (Māori: IR 77 [95% CI 48.3–116.8]; non-Māori: IR 148 [95% CI 116.9–185.2]) (Figure 2 and Table S1). Differences between Māori and non-Māori were reversed in the 45–64 age group for all GCH categories, particularly so in R2/R3 (Māori: IR 1954.5 [95% CI 1690.5–2248.1]; non-Māori: IR 1309.7 [95% CI 1194.2–1433.3]).

For prostate cancer, rates of radiotherapy were lower for Māori than non-Māori in every level of rurality in those under 65, most markedly in R2/R3 (Māori: IR 92 [95% CI 64–128]; non-Māori: IR 194 [95% CI 167–225]) (Table S2).

For lung cancer, rates of radiotherapy were higher for Māori than non-Māori females in every level of rurality, in all age groups. The difference was greatest in those aged 65–74 (U1: Māori IR 2083 [95% CI 1748–2462], non-Māori IR 592 [95% CI 546–640]; U2: Māori IR 2287 [95% CI 1861–2781]; non-Māori IR 586 [95% CI 513–668]; R1: Māori IR 1696 [95% CI 1237–2269], non-Māori IR 584 [95% CI 500–678]; R2/R3: Māori IR 1799 [95% CI 1331–2379], non-Māori IR 617 [95% CI 501–753]). A similar pattern between Māori and non-Māori was seen for males, though less marked (Table S3).

4 | Discussion

In this study, compared with people of similar age living in the most urban areas of NZ (U1), lower rates of receipt of radiotherapy by rurality were only observed for some subgroups with breast cancer (those over 75 living in U2 and non-Māori living in R1 and R2/R3 aged 45–64), and for curative radiotherapy for lung cancer (Māori females and males over 75 combined living in R2/R3). These differences were relatively small, though consistent with other studies highlighting rural gaps in receipt of radiotherapy for breast cancer [6, 20]. By contrast with breast cancer, rates of receipt of radiotherapy were higher for prostate cancer for males under 65 in areas of increased rurality, particularly for non-Māori, and for those over 75 living in R2/R3. Rural females and males under 65 years with lung cancer also had substantially higher rates of radiotherapy overall, and radiotherapy performed with curative and palliative intent, though this was generally more evident for non-Māori.

This variability and lack of a consistent reduction in receipt of radiotherapy by rurality across age and cancer type was unexpected. Results may be affected by differences in need for radiotherapy, notably the possibility of higher stage at diagnosis for rural people, as well as differences in choice and accessibility of radiotherapy alongside other treatment options, though it may also indicate that radiotherapy services are operating relatively well for rural New Zealanders. This stands in contrast to international literature [6, 7], though prostate cancer has been less consistently associated with lower rural radiotherapy rates [20, 21]. Attempts to support rural cancer patients through the National Travel Assistance Scheme (NTAS) and other means may be positively impacting radiation therapy use, especially for prostate and lung cancer. Nevertheless, reviews into the NTAS in 2018 noted that, while 81% of respondents said the scheme was extremely important to their treatment, there were substantial issues accessing the scheme, particularly for Māori [22, 23].

The use of a national dataset may mask regional problems. The Ministry of Health's calculator on radiation oncology 'intervention rates' for the three cancers in the period under study shows significant variability, with rates below NZ average for cancer type and intent in Northland, Taranaki, Hawkes Bay, Nelson and South Canterbury (for breast cancer) [24]. All these areas are geographically distant from radiation treatment centres.

An implicit assumption of this study is that underlying incidence is similar for these cancers across the rural–urban spectrum. Earlier reports found overall cancer rates in NZ to be lower for those living rurally under an older urban–rural classification [13], though an increased cancer incidence and mortality in small towns was noted, many of which would be regarded as having a degree of rurality under the GCH. Unadjusted risk factors for cancer, potentially differing by rurality may affect incidence. Whitehead reported higher rates of smoking in rural compared to urban areas when using the GCH classification, for both Māori and non-Māori, which may contribute to the observed increased radiotherapy rates in rural lung cancer patients under 65 [16].

This study has found differences between Māori and non-Māori in regard to receipt of radiation therapy, irrespective of rurality. Known differences in the incidence of these cancers by ethnicity may partly explain some of the observed differences in rates of radiation therapy. Robson [25] reported an age-standardised rate of incidence of breast cancer in NZ in 2002–2006 that was 28% higher for Māori than for non-Māori and mortality rates were 73% higher, consistent with the findings of higher radiotherapy rates for Māori with breast cancer aged 45–64 compared with non-Māori in this study, though significantly lower rates were observed for Māori under 45. Despite a lower reported incidence of prostate cancer for Māori [26], only in those under 65 years were radiotherapy rates—overall and for curative radiotherapy—lower for Māori than non-Māori. The reported incidence of lung cancer is over three times higher for Māori compared to non-Māori [25], though higher radiotherapy rates for Māori of this order were only observed in females aged 65–74 in this study.

This study considered differential receipt of radiotherapy by rurality and ethnicity but is unable to definitively comment whether increased radiotherapy rates for each cancer and age group are 'better'. Each of the cancers studied has a variety of treatment modalities available, including surgery, chemotherapy, immunotherapy, hormonal therapy and brachytherapy, in addition to, or instead of external beam radiation therapy. Access to these treatments may vary by rurality and ethnicity. Prostate cancer, in particular, has many possible approaches, including active surveillance, all of which may be differentially recommended to or chosen by rural New Zealanders, potentially resulting in an increase in radiotherapy receipt by rurality, because of perceived better benefit–risk ratio. There is evidence that Māori with localised prostate cancer are less likely to

undergo radical prostatectomy, and more likely to receive radiotherapy or to remain under surveillance [26].

Assessing 'optimal use' of radiotherapy would consider relative benefits and risks of different therapeutic approaches for different age groups and cancer types. Breast cancer is of particular interest. Radiotherapy may not add survival benefit over hormone therapy for breast cancer in women over 75; hence lower rates of radiotherapy for those in U2 compared with U1 in this study may be understandable. Nevertheless, breast conserving surgery (BCS) is associated with higher rates of adjuvant radiotherapy than mastectomy and making BCS more accessible to women with breast cancer is an evidence-based driver for decentralisation of radiation oncology services [8]. The lower radiotherapy rates for non-Māori females with breast cancer aged 45–64 living rurally found in this study, suggest that more of these women may be opting for, or being offered mastectomy rather than BCS because of distance to radiotherapy. Similarly, if young Māori under 45 with breast cancer have lower radiotherapy rates than their non-Māori counterparts, because mastectomy is preferentially being offered to, or taken up by them, this would warrant further investigation. Seneviratne et al. noted lower receipt of adjuvant radiotherapy for Māori females with breast cancer in the Waikato region compared with non-Māori, not attributable to tumour type or stage [27]. A recent national review of breast cancer showed Māori (and Asian) women were more likely to have mastectomy rather than BCS than NZ European women in the public system [28].

5 | Strengths and Limitations

This study employed a national dataset and utilised a new, robust geographical classification system designed and validated for use in the health sector and included stratification by ethnicity.

Māori ethnicity in the NHI has been undercounted for many years. Most recently Harris et al. [29] found that only 78.7% of people who identified as Māori in the census were recorded as Māori in the NHI. The impact of this undercount on the outcomes in this study is difficult to predict as it could result in either under-estimation or over-estimation of Māori-specific outcomes depending on the nature of the bias introduced by the undercounting.

This study did not consider the incidence or biology of the cancers under review, only the receiving of radiotherapy for them. Many studies comparing 'utilisation rates' have registered cases as a denominator, not the base population as in this study [30], hence these are not directly comparable with our data. This limits exploration of equity gaps in radiotherapy provision for Māori and for rural residents following a diagnosis with cancer.

This study does not account for change in residence over the period of treatment. The potential migration of rural people to urban centres for treatment purposes may have artefactually changed rural radiotherapy rates. Not all private radiation oncology patients were captured in these data and there might be unequal distribution of private healthcare use between rural and urban dwellers, and Māori and non-Māori. Just over 30% of NZ breast cancers were treated in private in the period under study [28].

Missing data on treatment intent was up to 5% for breast cancer and was more common in U1. Data on stage at diagnosis was missing for large numbers of patients, which limited exploration of late presentation potentially affecting radiotherapy receipt by rurality disproportionately. The effect of the COVID-19 pandemic and the stringent lockdown processes in NZ in 2020 may have disproportionately affected the provision of radiotherapy to rural people.

6 | Implications

A renewed policy focus on cancer is important and 'Faster Cancer Treatment' is one of five government health targets, which attempts to improve cancer wait-times and outcomes [31]. This, however, does not include palliative and adjuvant treatments, which contribute a large part of radiation workload and require enhanced resources. NZ's radiation workforce may be a limiting factor [15]. Upskilling regional teams to provide education and side-effect management may increase engagement and lower demand on larger centres.

Examining differences in the provision of radiotherapy at a sub-national level, and consideration of travel time to treatment, not only rurality, will help explore the potential for further decentralisation of radiation treatment centres. A new radiation oncology centre in Whangārei to cater for the underserved Northland region, is planned for mid-2026. Other regional radiotherapy centres are also planned to decrease barriers for rural people. Other practical measures that may help include improved, feedback-responsive provision of transport and accommodation, good communication with local teams and engagement with communities to better understand patient social and cultural needs. Technical initiatives, including appropriate use of hypofractionation and procedures such as simulation-free radiation therapy (SFRT), which provide part of the pathway locally (such as CT and planning), may also improve access.

Targeted strategies to reduce inequities between ethnicities are indicated, including policies to identify and mitigate gaps in access to diagnostic and treatment services for Māori and other groups that experience inequities, cultural safety programmes to address potential biases in the system and from providers and increasing the Māori workforce in radiation therapy and other cancer services.

7 | Conclusion

Surprisingly little decrease was observed in receipt of radiation therapy for rural compared with urban patients with breast, prostate and lung cancer in NZ, including those having palliative radiotherapy for whom significant travel can be more daunting. Overall, this may represent good efforts by health systems to overcome barriers to accessing radiation therapy in rural NZ, but questions remain regarding potential differences in cancer incidence and stage at diagnosis by rurality and ethnicity, sub-national differences and different therapeutic options

being taken up or offered. The observed higher rates of radiotherapy for prostate cancer in younger, rural males, especially non-Māori, may be due to a preference for this form of treatment, or a difference in offering options of treatment, though an increased incidence of prostate cancer for rural New Zealanders cannot be ruled out. Comparing utilisation of other modes of therapy in addition to radiotherapy would give a fuller picture of access to cancer therapy. Further research is recommended regarding cancer stage at diagnosis and using registered rates of cancer as a denominator to better calculate utilisation rates compared with targets and to more clearly identify inequities experienced by rural and Māori New Zealanders.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that supports the findings of this study is available in the Supporting Information material of this article.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Table S1:** Population based rates per 100,000 of first receipt of radiotherapy for female breast cancer by ethnicity and age group and rate ratios by rurality (GCH). **Table S2:** Population based rates (IR) per 100,000 of first receipt of radiotherapy for prostate cancer by ethnicity and age group and rate ratios (IRR) by rurality (GCH) compared with most urban (U1) recipients from 2014 to 2020 in Aotearoa New Zealand, subanalysed by curative or palliative intent. **Table S3:** Population based rates per 100,000 of first receipt of radiotherapy (IR) for female and male lung cancer by ethnicity and age group and rate ratios (IRR) by rurality (GCH) compared with most urban (U1) recipients from 2014 to 2020 in Aotearoa New Zealand, subanalysed by curative or palliative intent.