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Quality Indicators for Non-Small Cell Lung Cancer in Queensland, Australia, 2012–2021

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ABSTRACT

Background: Quality indicators for non-small cell lung cancer (NSCLC) have been implemented in Queensland, Australia, to assess performance across 28 elements relating to diagnosis, access, treatment, and outcomes.

Methods: Linked data were sourced from the population-based Queensland Oncology Repository. Eligible people were diagnosed with NSCLC between 2012 and 2021, with follow-up on treatment and mortality available to 31 December 2022. For each indicator, changes between 2012–2016 and 2017–2021 were assessed by fitting a multivariable Poisson regression model. Results from the models were expressed in terms of the relative likelihood (RL) using 2012–2016 as the reference period.

Results: Records were included for a total of 20 449 individuals. Significant improvements over the study period were observed for several indicators, including: review by a multidisciplinary team (RL = 1.05, 95% CI 1.03–1.07); any anticancer treatment received (RL = 1.04, 95% CI 1.03–1.06); radiation therapy for inoperable early-stage NSCLC (RL = 1.06, 95% CI 1.01–1.11); concurrent chemo-radiotherapy for stage III disease (RL = 1.35, 95% CI 1.24–1.47); and intravenous systemic therapy (IVST) for metastatic NSCLC (RL = 1.18, 95% CI 1.13–1.22). Two-year survival from the time of surgery increased from 85% to 90% ($p < 0.001$). In contrast, fewer people had their performance status documented following MDT review during the latter period (RL = 0.95, 95% CI 0.94–0.96), and there was a decrease in people from rural/remote areas who received their first treatment within 30 days of diagnosis (RL = 0.89, 95% CI 0.81–0.97).

Conclusions: The endorsed suite of quality indicators offers essential benchmarking to enable ongoing monitoring of and improvement in the quality of lung cancer care in Queensland.

Abbreviations: CI, confidence interval; IVST, intravenous systemic therapy; LUCiD, Lung Cancer (internet-based) Delphi; MDT, multidisciplinary team; NSCLC, non-small cell lung cancer; QNSCLCQI, Queensland Non-Small Cell Lung Cancer Quality Index; QOR, Queensland Oncology Repository; RL, relative likelihood; TNM, tumor, node, metastasis.

1 | Introduction

Lung cancer is the leading cause of cancer-related deaths both globally [1] and in Australia [2]. In 2020, there were an estimated 2.2 million new cases of lung cancer and 1.8 million deaths due to lung cancer worldwide [1]. Up to half of all NSCLC cases present after the tumor has metastasized (stage IV) [3–5].

The most common type of lung cancer is non-small cell lung cancer (NSCLC), which accounts for approximately 85% of all lung cancer cases [3, 6]. NSCLC thus represents a significant public health challenge in terms of both morbidity and mortality. It can be further classified into three main histological subtypes: adenocarcinoma (40% of NSCLC cases), squamous cell carcinoma (25%–30%), and large cell carcinoma (5%–10%) [6, 7]. Each of these subtypes has its own distinctive set of pathological features and behaviors [8], such as the usual site of origin within the lung.

While options for clinicians and patients have improved with the introduction of immunotherapy and targeted therapy, treatment for metastatic NSCLC remains mostly palliative with limited curative possibilities [9]. Earlier detection, along with advances in multidisciplinary patient management for those with early-stage NSCLC (i.e., stages I–III), is therefore crucial to improve survival outcomes.

The value of implementing and regularly reporting key indicators within the healthcare setting, leading to quality improvement initiatives, is becoming increasingly recognized [10]. Monitoring of quality indicators over time, or for making comparisons between patient groups, can assist with assessing the performance of healthcare systems, guiding clinical decision-making, and ensuring patient-centered care. As the landscape of oncology continues to change with the incorporation of novel treatment modalities, including immunotherapies and targeted therapies, particularly for early-stage disease with the aim to cure, the use of robust quality indicators is likely to assume heightened importance. For example, the implementation of quality indicators for the diagnosis and treatment of lung cancer in regional New South Wales has led to the establishment of a multidisciplinary clinic to improve access to services [11].

We present here the main findings of a set of quality indicators specific to NSCLC, across the four dimensions of diagnosis, access, treatment, and outcomes. In particular, changes in the indicator values over the last decade were examined.

2 | Methods

2.1 | Development and Content of the Indicators

The Queensland Non-Small Cell Lung Cancer Quality Index (QNSCLCQI) is a tool for reviewing and comparing information on the safety and quality of cancer treatment and outcomes, designed to assist clinicians and administrators to improve patient care. It was developed by the lung cancer subcommittee of the Queensland Cancer Control Safety and Quality Partnership. Membership of the subcommittee comprises lead clinicians and a consumer representative, supported by the Cancer Alliance Queensland team. Indicators included in the QNSCLCQI were directly adopted or adapted from existing national clinical practice guidelines for the diagnosis and treatment of lung cancer [12] and the recently published Australasian clinical quality indicators from the Lung Cancer (internet-based) Delphi (LUCiD) [13]. A total of 28 quality indicators were accepted for inclusion in the QNSCLCQI, using a pragmatic approach directed by the data that were available (see Table 1).

2.2 | Data Sources and Definitions

A retrospective, population-based cohort study was performed using unit record data from the Queensland Oncology Repository (QOR). Data were obtained in accordance with Section 82 of the Hospital and Health Boards Act (2011); therefore, this study is exempt from human research ethics committee approval.

The repository compiles data from a wide range of sources, encompassing the Queensland Cancer Register, private and public hospital admissions data, pathology reports, treatment information from hospital clinical data systems, QOOL (a web-based tool that supports data collection by multi-disciplinary teams), and the Registry of Births, Deaths, and Marriages. A detailed linkage and data cleaning process is then used to bring together all information pertaining to the same person. Note that data on *oral* systemic therapy (chemotherapy, tyrosine kinase inhibitors, etc.) are not currently available through the repository, but *intravenous* systemic therapy (IVST) was recorded (including chemotherapy, immunotherapy, and biologic therapies).

Cancer notification is a statutory requirement throughout Australia, and so it is expected that data from the QOR covers all people diagnosed with cancer, apart from non-melanoma skin cancers. People included in the study cohort were Queensland residents diagnosed with NSCLC between January 1, 2012, and December 31, 2021 (i.e., the most recent 10 years for which cancer incidence data were available). Follow-up on treatment and mortality was available up to December 31, 2022. People diagnosed with NSCLC based on autopsy or death certificate only were excluded.

Cancer stage summarizes the extent to which the disease has spread at the time of diagnosis and was assigned using the 7th edition of the TNM (tumor, node, metastasis) system [14, 15] for cases diagnosed between 2012–2017 and TNM version 8 [16, 17] for 2018–2021. An audit of unstaged cases diagnosed from 2017 onwards was conducted as part of the study, and stage was manually assigned where possible. If multiple stage notifications were received for the same person, a single category was allocated using a hierarchical approach that prioritized information deemed to be of better quality.

Other key variables of interest included First Nations status, remoteness of residence, area-based socio-economic status, number of comorbidities, hospital type, and hospital size. First Nations status describes whether a person self-identifies as being of Aboriginal or Torres Strait Islander origin and is routinely collected in administrative health data and clinical information systems throughout Australia. Remoteness of residence

TABLE 1 | Quality indicators for non-small cell lung cancer.

Indicator	Domain	Description	Numerator	Denominator
1.1	Diagnosis	Histological diagnosis	People with a pathological diagnosis of NSCLC	People diagnosed with NSCLC
1.2	Diagnosis	Evidence of multidisciplinary team review	People with NSCLC who were reviewed at a MDT meeting	People diagnosed with NSCLC
1.3	Diagnosis	Evidence of documented stage	People diagnosed with NSCLC who have a documented stage	People diagnosed with NSCLC
1.4	Diagnosis	Evidence of documented performance status	People diagnosed with NSCLC who were reviewed at a MDT meeting and had performance status documented	People diagnosed with NSCLC who were reviewed at a MDT meeting
2.1	Access	Received first treatment within 30 days of diagnosis	People diagnosed with NSCLC who received their first treatment within 30 days of diagnosis	People with NSCLC who received their first treatment within 365 days of diagnosis
2.2	Access	Received first surgery within 30 days of diagnosis	People diagnosed with NSCLC who received their first surgery within 30 days of diagnosis	People diagnosed with NSCLC who received their first surgery within 365 days of diagnosis
2.3	Access	Received first radiation therapy within 30 days of diagnosis	People diagnosed with NSCLC who received their first radiation therapy within 30 days of diagnosis	People diagnosed with NSCLC who received their first radiation therapy within 365 days of diagnosis
2.4	Access	Received first IV systemic therapy within 30 days of diagnosis	People diagnosed with NSCLC who received their first IV systemic therapy within 30 days of diagnosis	People diagnosed with NSCLC who received their first IV systemic therapy within 365 days of diagnosis
2.5	Access	Received first treatment within 30 days of diagnosis for people aged ≥ 75 years	People aged ≥ 75 years diagnosed with NSCLC who received first treatment within 30 days of diagnosis	People aged ≥ 75 years diagnosed with NSCLC who received first treatment within 365 days of diagnosis
2.6	Access	Received first treatment within 30 days of diagnosis for First Nations people	First Nations people diagnosed with NSCLC who received first treatment within 30 days of diagnosis	First Nations people diagnosed with NSCLC who received first treatment within 365 days of diagnosis
2.7	Access	Received first treatment within 30 days of diagnosis for people from socioeconomically disadvantaged areas	People from socioeconomically disadvantaged areas diagnosed with NSCLC who received first treatment within 30 days of diagnosis	People from socioeconomically disadvantaged areas diagnosed with NSCLC who received first treatment within 365 days of diagnosis
2.8	Access	Received first treatment within 30 days of diagnosis for people from rural/remote areas	People from rural/remote areas diagnosed with NSCLC who received first treatment within 30 days of diagnosis	People from rural/remote areas diagnosed with NSCLC who received first treatment within 365 days of diagnosis
3.1	Treatment	Received any anticancer treatment	People diagnosed with NSCLC who received any treatment (surgery, radiotherapy, IV systemic therapy) within 365 days of diagnosis	People diagnosed with NSCLC

(Continues)

TABLE 1 | (Continued)

Indicator	Domain	Description	Numerator	Denominator
3.2	Treatment	Surgical resection for stage I and II NSCLC	People diagnosed with stage I and II NSCLC who received surgery within 365 days of diagnosis	People diagnosed with stage I and II NSCLC
3.3	Treatment	Radiation therapy for stage I and II NSCLC without surgery	People diagnosed with stage I and II NSCLC, who did not receive surgery, and received radiation therapy within 365 days of diagnosis	People diagnosed with stage I and II NSCLC who did not receive surgery
3.4	Treatment	Surgery or radiation therapy for stage I and II NSCLC	People diagnosed with stage I or II NSCLC who received either radiation therapy or surgery within 365 days of diagnosis	People diagnosed with stage I or II NSCLC
3.5	Treatment	Neoadjuvant or adjuvant IV systemic therapy for stage IIA–IIIA NSCLC	People diagnosed with stage IIA–IIIA NSCLC neoadjuvant or adjuvant IV systemic therapy	People diagnosed with stage IIA–IIIA NSCLC who received surgery within 365 days of diagnosis
3.6	Treatment	Concurrent chemoradiotherapy for stage III NSCLC	People diagnosed with stage III NSCLC who did not receive surgery and received concurrent chemoradiation	People diagnosed with stage III NSCLC who did not receive surgery
3.7	Treatment	IV systemic therapy for stage IV NSCLC	People diagnosed with stage IV NSCLC who received IV systemic therapy	People diagnosed with stage IV NSCLC
4.1	Outcomes	Length of stay ≥ 12 days after surgery	People diagnosed with NSCLC who received surgery and whose length of stay was ≥ 12 days after surgery	People diagnosed with NSCLC who received surgery within 365 days of diagnosis
4.2	Outcomes	In-hospital mortality	People diagnosed with NSCLC who received surgery and died during surgical admission	People diagnosed with NSCLC who received surgery within 365 days of diagnosis
4.3	Outcomes	30-day mortality	People diagnosed with NSCLC who received surgery and died within 30 days of last surgery	People diagnosed with NSCLC who received surgery within 365 days of diagnosis
4.4	Outcomes	90-day mortality	People diagnosed with NSCLC who received surgery and died within 90 days of last surgery	People diagnosed with NSCLC who received surgery within 365 days of diagnosis
4.5	Outcomes	One-year surgical survival	People diagnosed with NSCLC who received surgery and were alive 1 year after surgery	People diagnosed with NSCLC who received surgery within 365 days of diagnosis
4.6	Outcomes	Two-year surgical survival	People diagnosed with NSCLC who received surgery and were alive 2 years after surgery	People diagnosed with NSCLC who received surgery within 365 days of diagnosis
4.7	Outcomes	30-day mortality for curative intent radiation therapy	People diagnosed with NSCLC who received curative intent radiation therapy and died within 30 days of last treatment	People diagnosed with NSCLC who received curative intent radiation therapy within 365 days of diagnosis

(Continues)

TABLE 1 | (Continued)

Indicator	Domain	Description	Numerator	Denominator
4.8	Outcomes	30-day mortality following last IV systemic therapy	People diagnosed with NSCLC who received IV systemic therapy and died within 30 days of last treatment	People diagnosed with NSCLC who received IV systemic therapy within 365 days of diagnosis
4.9	Outcomes	14-day mortality following last IV systemic therapy	People diagnosed with NSCLC who received IV systemic therapy and died within 14 days of last treatment	People diagnosed with NSCLC who received IV systemic therapy within 365 days of diagnosis

Abbreviations: IV, intravenous; NSCLC, non-small-cell lung cancer.

was defined according to the Australian Statistical Geography Standard, Edition 3 [18], and categorized as major city, inner regional, outer regional, and remote/very remote. The index of relative socio-economic advantage and disadvantage [19] was used to determine socio-economic status depending on the area where the person lived and was grouped into disadvantaged (deciles 1 and 2), middle (deciles 3–8), and advantaged (deciles 9 and 10). A count of comorbidities for each person was ascertained from hospital admissions data using the Quan algorithm [20], and limited to conditions included in the Charlson Comorbidity Index [21] (except for second primary cancers) that were coded in any hospital admission within Queensland between 12 months before and 12 months after the date of NSCLC diagnosis. Hospital type was either public, private, or mixed public/private partnership, and hospital size was categorized into very large, large, medium, small, and day facilities, depending on a combination of the number of beds and the services provided [22].

2.3 | Data Analyses

To investigate changes in the quality indicators over time, people with NSCLC were grouped into two 5-year periods according to their year of diagnosis, namely 2012–2016 and 2017–2021. For each quality indicator, the percentage of people with the elements of interest for each time period was calculated. The exception was Indicator 4.6 (2-year surgical survival); not all people with NSCLC who underwent surgery had the required follow-up time; therefore, the Kaplan–Meier method was used to estimate all-cause survival after 2 years.

Differences in the distribution of the quality indicators (apart from Indicator 4.6) by period of diagnosis were assessed using chi-square tests. A multivariable Poisson regression model with a robust error variance was then fitted to test for changes in the quality indicators over time, adjusted for each of the key variables of interest listed above. Because most of the outcomes were framed in the positive sense, results were expressed in terms of the relative likelihood (RL) rather than relative risk, using 2012–2016 as the reference period. The difference in 2-year surgical survival was assessed using a flexible parametric survival model.

Point estimates are presented along with 95% confidence intervals (95% CIs) and p values where relevant. Results were deemed to be statistically significant where $p \leq 0.05$.

3 | Results

3.1 | Study Cohort

A total of 20 449 Queensland residents were diagnosed with NSCLC between 2012 and 2021. The majority of these diagnoses were based on histological findings ($n = 18\,527$, 91%).

Several differences were observed in the composition of the study cohort by time period of diagnosis (Table 2). Overall, the majority were males ($n = 11\,810$, 58%), although this percentage decreased from 59% to 56% between the two time periods

TABLE 2 | Key sociodemographic and clinical characteristics of the NSCLC study cohort by time period of diagnosis, Queensland, 2012–2021.

	2012–2016 (*N* = 9309)		2017–2021 (*N* = 11 140)	
Characteristic	***n***	**Col %**	***n***	**Col %**
Sex ($p < 0.001$)				
Males	5535	59.5	6275	56.3
Females	3774	40.5	4865	43.7
Age group at diagnosis ($p < 0.001$)				
< 50 years	301	3.2	339	3.0
50–59 years	1285	13.8	1350	12.1
60–69 years	2864	30.8	3231	29.0
70–79 years	3126	33.6	4161	37.4
> = 80 years	1733	18.6	2059	18.5
First nations status[a] ($p = 0.02$)				
Aboriginal/ Torres Strait Island people	296	3.2	421	3.8
Other Queensland residents	9010	96.8	10 715	96.2
Residential location ($p = 0.04$)				
Major city	5788	62.2	6919	62.1
Inner regional	2246	24.1	2650	23.8
Outer regional	1040	11.2	1341	12.0
Remote/very remote	235	2.5	230	2.1
Area-based socioeconomic status ($p = 0.89$)				
Advantaged	744	8.0	907	8.1
Middle SES	5701	61.2	6831	61.3
Disadvantaged	2864	30.8	3402	30.5
Stage at diagnosis ($p < 0.001$)				
Stage I	1493	16.0	2349	21.1
Stage II	679	7.3	782	7.0
Stage III	1108	11.9	1628	14.6
Stage IV	4398	47.2	5157	46.3
Unknown	1631	17.5	1224	11.0
Number of comorbidities[b] ($p = 0.23$)				
None	4246	45.6	5064	45.5
One	2822	30.3	3288	29.5
Two or more	2241	24.1	2788	25.0

[a]First Nations status was not specified for 7 people.
[b]Comorbidities include clinical conditions that have the potential to significantly affect prognosis, coded in any admission episode between 12 months before and 12 months after the date of cancer diagnosis.

($p < 0.001$). Age at diagnosis ranged from 10 to 101 years old. More than half of all people with NSCLC were aged 70 years or older at diagnosis ($n = 11\,079$, 54%), increasing from 52% in 2012–2016 to 56% in 2017–2021 ($p < 0.001$). The proportion of Aboriginal and/or Torres Strait Islander people rose slightly from 3% to 4% ($p = 0.02$). There was little variation over time in the distribution of residential location ($p = 0.04$) and area-based socio-economic status ($p = 0.89$), with 14% of people living in either outer regional or remote/very remote localities and 31% in disadvantaged areas, irrespective of the period of diagnosis. The percentage of people with NSCLC who had at least one comorbidity also remained steady over time (54% in 2012–2016 and 55% in 2017–2021; $p = 0.24$). Although there was significant variation over time in stage at diagnosis for NSCLC, with the percentage of people diagnosed at stage I increasing from 16% to 21% ($p < 0.001$), it should be noted that the two results will be inherently different due to cases with unknown stage being audited from 2017 onwards, hence decreasing from 18% to 10%.

3.2 | Diagnosis, Staging, and Case Review

Evidence of multidisciplinary team (MDT) review and documented stage both improved over time (from 56% to 62% and from 82% to 89%, respectively) and were estimated to be 5% more likely to be recorded for people with NSCLC diagnosed between 2017 and 2021 compared to 2012–2016 after multivariable adjustment (both $p < 0.001$—see Table 3). Further, the percentage of people undergoing MDT review varied by stage, ranging from 60% for stage IV NSCLC to 82% for stage III disease between 2017 and 2021 (results not shown). In contrast to the overall increase in MDT review, there was a decrease over time in evidence of documented performance status, from 93% to 88% (adjusted RL = 0.95, 95% CI 0.94–0.96; $p < 0.001$).

3.3 | Access

Median time from diagnosis to treatment for NSCLC was 34 days for both periods and was higher for stages I–III combined compared to stage IV (40 days and 28 days, respectively). Although the percentage of people with NSCLC who received their first treatment within 30 days of diagnosis remained steady at 46% in both periods (Table 3), the modeled results for this indicator revealed that people aged 70–79 and 80 years and over were 14% (adjusted RL = 0.86, 95% CI 0.81–0.90) and 22% (adjusted RL = 0.78, 95% CI 0.73–0.83) less likely to receive their first treatment within 30 days of diagnosis than those aged 50–59, respectively (both $p < 0.001$; results not shown).

After accounting for the covariates, particularly stage at diagnosis, receiving first radiation therapy within 30 days of NSCLC diagnosis was more likely for people diagnosed between 2017 and 2021 (adjusted RL = 1.08, 95% CI 1.03–1.14; $p = 0.002$). There was no significant difference in receiving first surgery or first IVST within 30 days of diagnosis by period of diagnosis, nor any apparent changes in access to first treatment for NSCLC within 30 days for people aged 75 years and older, Aboriginal and/or

TABLE 3 | Diagnosis, access, and treatment quality indicators for NSCLC by the time period of diagnosis, Queensland, 2012–2021.

	2012–2016		2017–2021			
Quality indicator	***n***	**%[a]**	***n***	**%[a]**	**Adjusted RL[b,c] (95% CI)**	***p***
Diagnosis						
1.1 Histological diagnosis	8371	89.9	10156	91.2	0.99 (0.99–1.00)	0.01
1.2 Evidence of multidisciplinary team review	5252	56.4	6903	62.0	1.05 (1.03–1.07)	< 0.001
1.3 Evidence of documented stage	7678	82.5	9916	89.0	1.05 (1.04–1.06)	< 0.001
1.4 Evidence of documented performance status	4892	93.2	6078	88.0	0.95 (0.94–0.96)	< 0.001
Access						
2.1 First treatment within 30 days	3137	46.3	3951	45.7	1.03 (1.00–1.07)	0.06
2.2 First surgery within 30 days	974	53.8	1193	50.7	0.98 (0.92–1.03)	0.43
2.3 First radiation therapy within 30 days	1339	41.7	1679	41.2	1.08 (1.03–1.14)	0.002
2.4 First IVST within 30 days	916	44.8	1229	45.0	1.05 (0.99–1.11)	0.13
2.5 First treatment within 30 days for people aged ≥ 75 years	747	43.4	1110	43.2	1.03 (0.97–1.10)	0.36
2.6 First treatment within 30 days for First Nations people	79	38.3	118	37.9	1.04 (0.83–1.30)	0.72
2.7 First treatment within 30 days for disadvantaged areas	873	43.6	1078	41.5	1.04 (0.97–1.10)	0.29
2.8 First treatment within 30 days for rural/remote areas	424	49.5	502	44.3	0.89 (0.81–0.97)	0.01
Treatment						
3.1 Received any anticancer treatment (within 365 days)	6769	72.7	8641	77.6	1.04 (1.03–1.06)	< 0.001
3.2 Surgical resection for stage I and II NSCLC	1387	63.9	1930	61.6	0.97 (0.93–1.01)	0.10
3.3 Radiation therapy for stage I and II NSCLC without surgery	599	76.3	973	81.0	1.06 (1.01–1.11)	0.02
3.4 Surgery or radiation therapy for stage I and II NSCLC	1986	91.4	2903	92.7	1.01 (1.00–1.03)	0.09
3.5 Neoadjuvant or adjuvant IVST for stage IIA–IIIA NSCLC	287	55.7	374	54.0	0.97 (0.88–1.07)	0.57
3.6 Concurrent chemoradiotherapy for stage III NSCLC	380	40.6	721	52.8	1.35 (1.24–1.47)	< 0.001
3.7 IVST for stage IV NSCLC	1924	43.7	2569	49.8	1.18 (1.13–1.22)	< 0.001

Abbreviations: IVST, intravenous systemic therapy; NSCLC, non-small-cell lung cancer; RL, relative likelihood.
[a]Denominators vary by indicator.
[b]RL used 2012–2016 as the reference category and was adjusted for sex, age group at diagnosis, First Nations status, residential location, area-based socioeconomic status, stage at diagnosis, number of comorbidities, hospital size, and hospital type, as relevant.
[c]Note that for all the indicators in this table, an adjusted RL that is significantly more than 1 designates a favorable result for people diagnosed between 2017–2021 compared to 2012–2016, whereas an adjusted RL that is significantly less than 1 designates an unfavorable result for 2017–2021 compared to 2012–2016.

Torres Strait Islander people or those from socioeconomically disadvantaged areas.

However, the percentage of people from rural/remote areas who received their first treatment within 30 days of diagnosis fell from 49% in 2012–2016 to 44% between 2017 and 2021 (adjusted RL = 0.89, 95% CI 0.81–0.97; $p = 0.01$). This decrease was only observed for people with NSCLC from rural/remote areas who were treated at public hospitals, among whom first treatment within 30 days of diagnosis dropped from 48% for 2012–2016 compared to 36% for 2017–2021, whereas this indicator remained stable for those treated at private hospitals (64% compared to 67%; data not shown). It was further noted that people living in rural/remote areas were more likely to receive their first treatment for NSCLC at a public hospital than people from urban areas (75% versus 67%, respectively; $p < 0.001$).

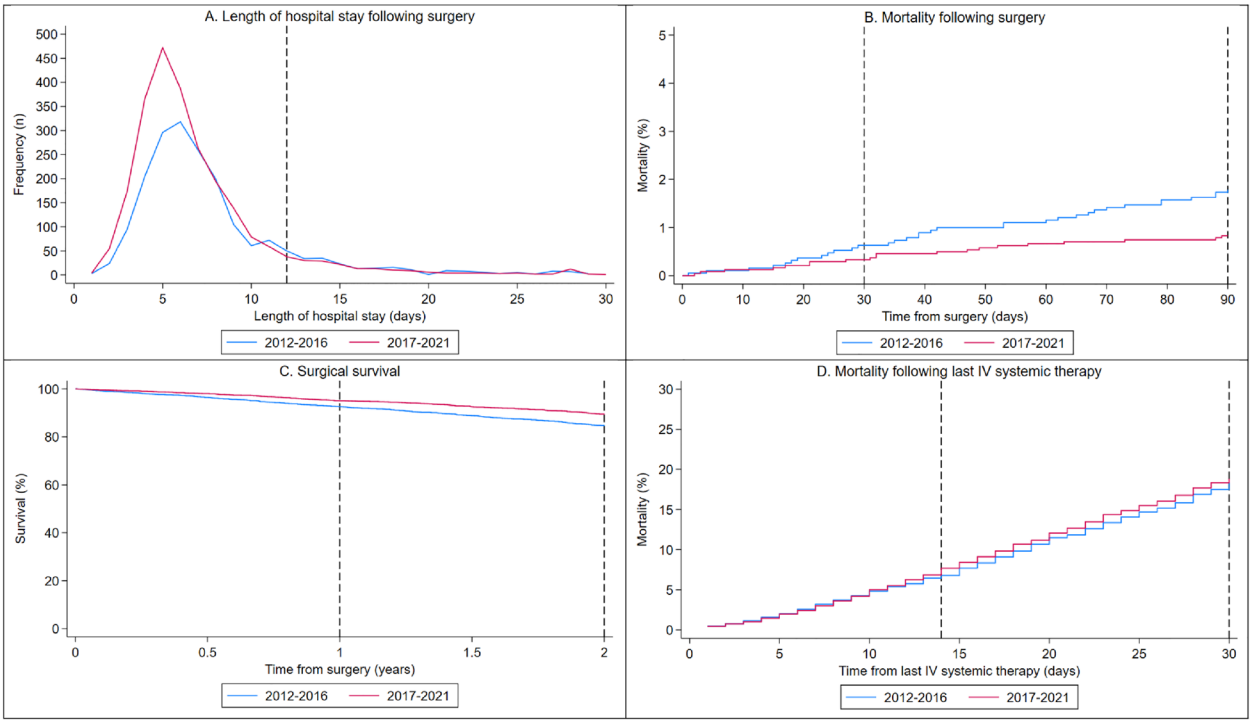

FIGURE 1 | Outcome quality indicators for NSCLC by the time period of diagnosis, Queensland, 2012–2021. Mortality following last IVST excludes people who commenced their last IVST after 31 Dec 2022.

3.4 | Treatment

Several of the quality indicators relating to treatment for NSCLC were associated with a significant improvement between 2012–2016 and 2017–2021 (Table 3). Specifically, increases between the two time periods were observed for: receiving any anticancer treatment, including surgery, radiotherapy, or IVST (73% compared to 78%, adjusted RL = 1.04, 95% CI 1.03–1.06; $p < 0.001$); undergoing radiation therapy for stage I or II NSCLC when surgery was not performed (76% compared to 81%, adjusted RL = 1.06, 95% CI 1.01–1.11; $p = 0.02$); having concurrent chemoradiotherapy for stage III NSCLC (41% compared to 53%, adjusted RL = 1.35, 95% CI 1.24–1.47; $p < 0.001$); and receiving IVST for stage IV NSCLC (44% compared to 50%, adjusted RL = 1.18, 95% CI 1.13–1.22; $p < 0.001$). There was no discernible change in surgery and/or radiation therapy for stage I and II NSCLC, nor was there a difference over time in IVST for stage IIA–IIIA disease.

3.5 | Outcomes

The percentage of people with NSCLC who stayed in hospital for 12 or more days after surgery decreased from 14% for those diagnosed between 2012 and 2016 to 9% between 2017 and 2021 (adjusted RL = 0.71, 95% CI 0.60–0.85; $p < 0.001$) – see Figure 1 and Table 4. The corresponding median lengths of stay following surgery for the two time periods were 7 and 6 days, respectively ($p < 0.001$). Two-year surgical survival also improved from 85% (95% CI 83%–86%) to 90% (95% CI 88%–91%; $p < 0.001$). Few people (< 2%) with NSCLC died within 90 days of surgery in both time periods. There were also no significant changes over time for 30-day mortality following either curative intent radiation therapy or last IVST, although it was noted that the percentage of people treated with IVST within 30 days of death remained consistently high at an average of 18% over the entire study period.

4 | Discussion

This study encompasses multiple phases of the healthcare delivery process for people with NSCLC. Implementation of the QNSCLCQI has allowed us to highlight areas where the health system is doing well and also to identify, understand, and prioritize aspects that require further attention so that plans can be developed to drive ongoing quality improvement.

4.1 | Diagnosis, Staging, and Case Review

We observed an apparent alteration over time in stage at diagnosis, with the percentage of people having stage I NSCLC increasing in the latter period. Rather than representing an actual move toward an earlier stage at diagnosis, it seems reasonable to attribute the increase in stage I NSCLC to the higher percentage of cases with assigned stage between 2017 and 2021, coinciding with the introduction of more specific staging guidelines for lung cancer [17] along with an audit of unstaged cases from 2017 onwards. As such, the 2017–2021 cohort is likely to be more representative of the true stage distribution. Staging documentation should improve in the future as the focus on advancing cure rates shifts to earlier-stage disease, where formal staging dictates the subsequent multi-modal choice of therapy.

A recent meta-analysis [23] of 22 international studies concluded that people with NSCLC who received management

TABLE 4 | Outcome quality indicators for NSCLC by the time period of diagnosis, Queensland, 2012–2021.

Quality indicator	2012–2016		2017–2021		Adjusted RL[b,c] (95% CI)	*p*
	n	%[a]	*n*	%[a]		
Outcomes						
4.1 Length of stay ≥ 12 days after surgery	268	14.1	224	9.3	0.71 (0.60–0.85)	< 0.001
4.2 In-hospital mortality	9	0.5	6	0.2	0.52 (0.17–1.61)	0.26
4.3 30-day mortality	12	0.6	9	0.4	0.64 (0.26–1.58)	0.33
4.4 90-day mortality	35	1.8	22	0.9	0.61 (0.36–1.06)	0.08
4.5 1-year surgical survival	1765	92.7	2297	95.1	1.02 (1.00–1.03)	0.05
4.6 2-year surgical survival[d]	1765	84.7	2297	89.5	1.35 (1.12–1.63)	< 0.001
4.7 30-day mortality for curative intent radiation therapy[e]	53	3.7	58	2.5	0.72 (0.49–1.06)	0.10
4.8 30-day mortality following last IVST[e]	655	17.7	846	17.9	1.01 (0.92–1.10)	0.85
4.9 14-day mortality following last IVST[e]	285	7.7	395	8.4	1.08 (0.94–1.25)	0.29

Abbreviations: IVST, intravenous systemic therapy; NSCLC, non-small-cell lung cancer.
[a]Denominators vary by indicator.
[b]RL used 2012–2016 as the reference category and was adjusted for sex, age group at diagnosis, First Nations status, residential location, area-based socioeconomic status, stage at diagnosis, number of comorbidities, hospital size, and hospital type, as relevant.
[c]Note that for all of the indicators in this table except for 4.5 and 4.6, an adjusted RL that is significantly less than 1 designates a favorable result for people diagnosed between 2017–2021 compared to 2012–2016, whereas an adjusted RL that is significantly more than 1 designates an unfavorable result for 2017–2021 compared to 2012–2016. The opposite interpretation applies for Indicators 4.5 and 4.6.
[d]The Kaplan–Meier method was used to calculate the estimates for two-year surgical survival (Indicator 4.6), with the difference between the two time periods assessed using flexible parametric survival modeling.
[e]Excludes people who commenced their last curative intent radiation therapy or IV systemic therapy more than 365 days after diagnosis.

by an MDT were more likely to survive longer. They also experienced a range of improved secondary outcomes, such as a higher rate of staging to guide treatment and reduced time from diagnosis to completion of treatment [23]. Our results show that the proportion of people with NSCLC in Queensland who underwent an MDT review increased to 62% between 2017 and 2021, although still well below the LUCiD standard of ≥ 85% prior to treatment commencing [13]. In this study, MDT data is incomplete, with some private MDTs not contributing data to QOR. MDT review in Queensland peaked at 82% for those with stage III disease. This is similar to the MDT review of stage III NSCLC occurring for 83% of people in a population-based study from Victoria, Australia, between 2012 and 2019 [24], but lower than the 95% reported in a study of seven hospitals from the Netherlands between 2015 and 2019 [25].

Improvement in MDT review was offset by a decrease in documenting performance status, which was measured using the Eastern Cooperative Oncology Group (ECOG) scale [26]. This scale evaluates a person's level of functioning in terms of aspects such as their ability to care for themself, level of daily activity, and physical capacity. Recording performance status for NSCLC is important because it can be used to determine fitness for various treatments, such as whether chemotherapy is appropriate for people with advanced disease [27, 28]. It is recommended that performance status be documented for ≥ 95% of people with NSCLC following MDT review [13], however, this indicator fell from 93% to 88% across our study period. The observed decrease most likely reflects a lapse in recording performance status. If so, follow-up is warranted to ensure that all required details from MDT meetings are routinely recorded.

4.2 | Access

Longer intervals from diagnosis to treatment have generally been shown to adversely impact survival for people with NSCLC, particularly resection for earlier-stage disease [29–31]. Median time from diagnosis to treatment was 39 days for stages I–III in the United States in 2013 [30] and 47 days for stage I and II NSCLC in the Netherlands between 2014 and 2019 [31], compared to 40 days for non-metastatic disease in Queensland.

The most notable change in access to treatment from the current study was the decrease among people from rural/remote areas receiving their first treatment within 30 days of NSCLC diagnosis. This result was unexpected, given that additional sites delivering radiotherapy and chemotherapy services have opened throughout Queensland during the last decade, potentially enabling people from rural and remote areas to be treated closer to home and in a timelier manner, especially those with unresectable tumors. Ongoing monitoring and further investigation into our findings are therefore required to address any other underlying factors. For example, people with NSCLC who live outside of major cities may experience a range of barriers that cause delays between initial diagnosis and commencement of treatment. These include delays with organizing referrals and scheduling specialist appointments, as well as extended waiting times for diagnostic procedures, pathology, and molecular testing to adequately stage before MDT discussion [32]. They were

also less likely to be treated at a private hospital, which are concentrated in urban areas and generally have shorter times from diagnosis to first treatment [33].

4.3 | Treatment

The main positives from our study in terms of quality indicators for recommended treatments included increases over the last decade in the percentage of people with NSCLC in Queensland who received: radiation therapy for inoperable early-stage disease; concurrent chemo-radiotherapy for stage III cancers; and IVST for metastatic NSCLC. A study from three institutions in New South Wales, Australia, reported that 76% of people with inoperable stage I or II NSCLC who were diagnosed between 2008 and 2014 received either curative or palliative radiotherapy [34], equivalent to the result in Queensland for the earlier time period (2012–2016) which subsequently rose to 81% between 2017 and 2021. Less than one-third of Victorians diagnosed with unresectable stage III NSCLC between 2012 and 2019 received concurrent chemo-radiotherapy [24], considerably lower than the overall result of 48% in Queensland, with a large increase from 41% to 53% observed across our study period.

As recently as two decades ago, very few people with stage IV disease received active treatment [35]; this is changing, however, with newer therapies prolonging survival and reducing symptoms for advanced disease [36, 37]. One in four people with metastatic NSCLC in Ontario, Canada, (diagnosed 2010–2015) were treated with systemic therapy (mostly oral) [35], while the proportion in the United States was estimated to be 39% in 2015 [38]. This compares to 44% receiving IVST in Queensland between 2012–2016 and 50% between 2017–2021, compliant with the LUCiD standard that at least half of people with stage IV NSCLC should receive any systemic therapy [13] while also illustrating how attitudes toward treatment for metastatic disease have altered over time.

4.4 | Outcomes

Commensurate with our finding that post-surgery survival for people with NSCLC has improved significantly in Queensland over the study period, results from Iceland [39] revealed a large rise in one-year survival from 75% to 88% between 1991 and 2014. A cohort of people with NSCLC from France [40] diagnosed between 2005 and 2012 showed a more modest increase in three-year surgical survival, from 80% to 82%. Gains in survival following surgery were attributed to a combination of advances in surgical techniques and improved preoperative staging, along with more people being diagnosed with earlier-stage disease [39, 40].

More than one in six Queenslanders with NSCLC who had ever received IVST continued to receive it within 30 days of death. Although this includes immunotherapy, it nonetheless exceeds the recommendation that less than 10% of patients should receive systemic therapy 30 days prior to death [13] and suggests possible overuse of treatments nearing end of life in Queensland. Prolonging chemotherapy for terminally ill people can cause unnecessary physical, psychological, and financial distress and delay hospice care if needed [41, 42]. Informed decision-making and open communication between people with NSCLC and healthcare providers about the benefits and risks of continuing therapy until close to death must therefore remain central to treatment choices. Palliative care has an important role in helping patients and caregivers to navigate the most appropriate choice depending on their circumstances; indeed, early referral to palliative care services following NSCLC diagnosis has been demonstrated to improve quality of life and possibly even prolong survival and is now part of many oncology guidelines [43, 44].

4.5 | Strengths and Limitations

Clear strengths of this study are the provision of data from the QOR, allowing population-based research using a well-established linked dataset containing expansive patient and clinical information, as well as the use of quality indicators that were determined through a clinician-and consumer-led process. There are also some limitations to consider when interpreting changes in the indicators between the two time periods. Information on oral anticancer therapy was missing, which would have been more prevalent prior to the widespread introduction of IVST for patients diagnosed and treated more recently. Data for MDT review is not complete as it is reliant on the provision of data from hospitals to QOR. MDT activity captured in QOR favors public hospitals, with minimal contribution from private hospital MDTs.

5 | Conclusions

The QNSCLCQI provides essential baseline measurements for ongoing monitoring of the high standard of lung cancer care in Queensland. It is intended that the set of current quality indicators for NSCLC will be expanded as further feedback is obtained from providers of cancer services and the community and as more data items become available. Future analysis may focus on small-cell lung cancer, mesothelioma, screening, molecular testing, immunotherapy, recurrence, and end-of-life care.

Author Contributions

All authors had full access to the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Conceptualization: Margot Lehman, Morgan Windsor, Alison Bolton, Jasotha Sanmugarajah, Bryan Chan, Tracey Guan and Danica Cossio. Data curation: Tracey Guan and Danica Cossio. Formal analysis: Artika Nath and Danny Youlden. Funding acquisition: Danica Cossio. Methodology: Nathan Dunn and Danny Youlden. Project administration: Tracey Guan. Supervision: Danica Cossio, Jasotha Sanmugarajah and Bryan Chan. Visualization: Nathan Dunn and Artika Nath. Writing – original draft: Danny Youlden. Writing – review and editing: Tracey Guan, Bryan Chan, Jasotha Sanmugarajah, Margot Lehman, Alison Bolton, Morgan Windsor, Artika Nath, Nathan Dunn and Danica Cossio.

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Disclosure

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The datasets generated during and/or analyzed during the current study are not publicly available due to confidentiality restrictions but may be available from the corresponding author upon reasonable request.

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