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BRIEF REPORT

Survival disparities among recently diagnosed Aboriginal and Torres Strait Islander cancer patients in Australia remain

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Abstract

Purpose Australian Aboriginal and Torres Strait Islander diagnosed with cancer are known to experience poorer survival, with these survival disparities mainly restricted to the first 2 years after diagnosis. With improved accuracy and completeness of identifying Aboriginal and Torres Strait Islander peoples over the whole study period, our goal was to examine whether the survival disparity among Aboriginal and Torres Strait Islander peoples diagnosed with cancer in Queensland has changed over time.

Methods Population-based data from the Queensland Cancer Register between 1998 and 2017 for Queenslanders aged 15 years and over at diagnosis ($n = 377{,}963$; 1.6% Aboriginal and/or Torres Strait Islander) were used to determine whether this disparity has reduced over time. Flexible parametric survival models incorporating time-varying coefficients were used to examine the association between Aboriginal and Torres Strait Islander status and cancer-specific survival within 5 years of diagnosis.

Results The adjusted 5-year cancer-specific survival rate for Aboriginal and Torres Strait Islander people diagnosed with cancer increased from 60.5% (95% CI 59.2–61.9%) in 1998–2007 to 65.5% (95% CI 64.3–66.6%) in 2008–2017, with the corresponding estimates for other Queenslanders being 66.6% (95% CI 66.4–66.8%) and 70.1% (95% CI 69.9–70.3%). The survival disparity was significant only for the first 3 years since diagnosis for 1998–2007; however, it was significantly ($p \leq 0.02$) elevated for all five time intervals for 2008–2017, with similar average hazard ratios (95% CIs) over the 5-year interval after diagnosis of 1.45 (1.36–1.55) for 1998–2007 and 1.42 (1.34–1.50) for 2008–2017.

Conclusion Although survival has increased over time, the lack of improvement in the disparity in cancer survival experienced by Aboriginal and Torres Strait Islander cancer patients highlights the urgent need to better understand the multifaceted and completed factors that underlie this gap to guide targeted, evidence-based interventions and support their implementation across the health sector.

Keywords Aboriginal and Torres Strait Islander · Survival analysis · Cohort study · Intervention

Introduction

Previous studies have indicated that Australian Aboriginal and Torres Strait Islander people have lower cancer survival than other Australians and that the survival disparities are most notable in the first few years after cancer diagnosis [1–3]. For example, in Queensland during 1997–2006, Aboriginal and Torres Strait Islander peoples diagnosed with cancer faced a 50% excess mortality in the first year after diagnosis compared to other Australians, while it was near unity (3% excess mortality) at 2 years after diagnosis [1]. This excess mortality faced by Aboriginal and Torres Strait Islander cancer patients remained after adjusting for area-level characteristics of remoteness and socioeconomic

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disadvantage, the mix of cancer types, and demographics of age group and sex.

However, the interpretation of these studies was complicated by the relatively high percentage of people diagnosed with cancer for whom it is not known whether they are Aboriginal and Torres Strait Islander or not. For example, in the Queensland study [1], nearly 15% of the cohort had unknown ethnicity, compared with about 1% of the cohort that were known to be Aboriginal or Torres Strait Islander people. With studies either excluding cancer cases with unknown ethnicity [1] or including the unknowns with "other Australians" [3], it remained possible that the reported results did not actually reflect the true survival experience of all Aboriginal and Torres Strait Islander peoples diagnosed with cancer, nor the real survival disparities they faced compared with other Australians.

Previously, the status of whether people were Aboriginal or Torres Strait Islander within the Queensland Cancer Register (QCR) was determined manually based on standard notification sources (hospitals, nursing homes, and death certificates). If there were different statuses notified for an individual patient, the single status variable would be manually updated to most relevant status notification as determined by a registry coder. To improve the completeness and accuracy of this variable, in recent years, the QCR implemented a multi-stage median (MSM) algorithm [4] that combines data on Aboriginal and Torres Strait Islander status from multiple data sources including public and private hospitals and death certificates and thus provides a more accurate and complete estimate of whether a cancer patient identifies as Aboriginal or Torres Strait Islander or not.

With an additional 10 years' data now available for analysis in Queensland, along the enhanced identification of Aboriginal and Torres Strait Islander peoples, it is prudent to examine whether there are any differences in observed pattern of survival disparity faced by Indigenous Australians in Queensland and whether there have been improvements over time.

Methods

Study design and data source

Consistent with the previous study [1], our study cohort comprised all Queenslanders aged 15 years and over diagnosed with a primary invasive cancer (excluding keratinocyte cancers), including those diagnosed between 1998 and 2017. De-identified unit record data for the study were obtained from the population-based QCR in accordance with the Public Health Act (2005) [5]. Separate ethical approval was not required since there was no identifying information contained in the data extract.

Information on age (15–49, 50–59, 60–69, 70–79, and ≥ 80 years) and period (1998–2007 and 2008–2017) at diagnosis, sex, Aboriginal and Torres Strait Islander status, Remoteness Index from the Australian Bureau of Statistics (major cities, inner regional, outer regional, and remote/very remote areas) [6], and Quintiles of the 2016 Index of Relative Socioeconomic Advantage and Disadvantage [7] was obtained. In addition, given that Australian Aboriginal and Torres Strait Islander peoples typically have higher incidence rates of poor survival cancer types and lower incidence of good survival cancer types [3, 8], broad cancer type categories were generated based on the 5-year cause-specific survival estimates (very low survival (< 25%), low survival (25–49.9%), medium survival (50–74.9%), and high survival (≥ 75%)) [9]. Each cancer type was allocated into a specific category, regardless of the individual person's observed survival.

Recently, the QCR implemented a MSM algorithm [4] to ascertain whether people diagnosed with cancer were Aboriginal or Torres Strait Islander or not and applied this to all records from 1982 onward. The MSM algorithm combines data on Aboriginal and Torres Strait Islander status from multiple data sources including public and private hospitals and death certificates, thus providing more complete estimation of Aboriginal and Torres Strait Islander status [10] compared to the previous method which was used for the data reported in the earlier paper by Cramb et al. [1]. It has been estimated that this MSM algorithm approach increased the number of Aboriginal and Torres Strait Islander cancer patients by about (relative) 13% [10].

Statistical analysis

Patients were followed up to 31 December 2017 through routine matching to the National Death Index. Those still alive at the study end point or 5 years after their diagnosis, whichever came first, were censored at that date. Those who died from a cause other than cancer (ICD-O-3 code of C00-C80) were censored at the date of death, with the analysis focussing on cancer-specific survival.

The Chi-square test was used to compare the characteristics of the Aboriginal and Torres Strait Islander peoples and other Queenslanders diagnosed with cancer in Queensland.

The proportional hazard (PH) assumption for each of the variables was examined by Schoenfeld residuals within a Cox model [11]. Age at diagnosis, Aboriginal and Torres Strait Islander status, Remoteness Index from the Australian Bureau of Statistics, and broad cancer categories were found to violate the PH assumption, so they were included in the final statistical survival models as time-varying coefficients.

We used a flexible parametric survival model [12] to explore the association between cancer-specific survival up to 5 years after diagnosis and Aboriginal and Torres Strait

Islander status, adjusting for the variables of sex, age at diagnosis (using restricted cubic splines with 4 degrees of freedom), remoteness, area socioeconomic status, broad cancer type, and year of diagnosis (using restricted cubic splines with 3 degrees of freedom). In this model, we used 6 and 3 degrees of freedom, respectively, for the baseline and time-varying components. From this full model, we predicted the adjusted cancer-specific survival estimates by single calendar year of diagnosis, along with 95% confidence intervals (CIs), at 1 and 5 years after diagnosis, and whether patients were Aboriginal and Torres Strait Islander peoples or not.

In addition, corresponding stratified models (by diagnosis period) were generated, replacing the cubic splines for calendar year of diagnosis with a dichotomous variable for diagnosis period (1998–2007; 2008–2017). Interval-specific hazard ratios (HRs) and 95% CIs were calculated from these models after first splitting the data, so each row represented each individual/followup time interval combination.

All the analyses were performed with Stata/SE version 16.1 (StataCorp LP, Texas, USA) and a two-sided *p* value of < 0.05 was chosen to indicate statistical significance.

Results

A total of 391,496 invasive cancer cases were identified in the QCR. Persons with missing information for any of the covariates (*n* = 4,173, 1.1%) or Indigenous status 2,944 (0.8%) were excluded. Those who were known to have been diagnosed by death certificate, autopsy, or unknown basis were also excluded (*n* = 6,416, 1.6%). The final cohort included 377,963 (96.5%) people diagnosed with invasive cancer. Among them, 6,178 (1.6%) patients were identified as Aboriginal or Torres Strait Islander (Table 1).

Compared to other Queensland patients, there were significantly higher proportions of younger adults and females among the Aboriginal and Torres Strait Islander cohort, along with higher proportions of those diagnosed in more recent years, those diagnosed with "low-survival" cancer types, and those who lived in remote areas or areas that were socioeconomically disadvantaged (Table 1).

Overall gains in cancer survival were observed among both Aboriginal and Torres Strait Islander peoples and other Queensland cancer patients. After adjustment for all the covariates, the adjusted 5-year cancer-specific survival rate for Aboriginal and Torres Strait Islander people diagnosed with cancer increased from 60.5% (95% CI 59.2–61.9%) in 1998–2007 to 65.5% (95% CI 64.3–66.6%) in 2008–2017. Over the same period, the corresponding adjusted survival estimates for other Queenslanders diagnosed with cancer were 66.6% (95% CI 66.4–66.8%) and 70.1% (95% CI 69.9–70.3%).

Table 1 Demographic characteristics of Indigenous and non-Indigenous cancer patients in Queensland, 15 years and over, 1998–2017

Covariates	Indigenous (*n* = 6,178, 1.6%)	Non-Indigenous (*n* = 371,785, 98.4%)	*p*
Sex			
Males	2,931 (47.4)	204,801 (55.1)	< 0.01
Females	3,247 (52.6)	166,984 (44.9)	
Age (years)			< 0.01
15–49	1,707 (27.6)	59,916 (16.1)	
50–59	1,603 (26.0)	70,061 (18.8)	
60–69	1,616 (26.2)	100,439 (27.0)	
70–79	956 (15.5)	87,684 (23.6)	
≥ 80	296 (4.8)	53,685 (14.4)	
Area remoteness			< 0.01
Major cities	1,839 (29.8)	225,887 (60.8)	
Inner regional	1,162 (18.8)	86,921 (23.4)	
Outer regional	1,994 (32.3)	52,927 (14.2)	
Remote/very remote	1,183 (19.1)	6,050 (1.6)	
Area SES			< 0.01
Most disadvantaged	2,751 (44.5)	77,754 (20.9)	
Quintile 2	1,450 (23.5)	79,318 (20.6)	
Quintile 3	1,043 (16.9)	77,719 (20.9)	
Quintile 4	527 (8.5)	73,707 (19.8)	
Most affluent	407 (6.6)	63,287 (17.0)	
Cancer type group (based on 5-year survival)			< 0.01
< 25%	1,475 (23.9)	57,054 (15.4)	
25–49.9%	502 (8.1)	18,715 (5.0)	
50–74.9%	1,347 (21.8)	88,196 (23.7)	
≥ 75%	2,854 (46.2)	207,820 (55.9)	
Year of diagnosis			< 0.01
1998–2007	2,191 (35.5)	157,953 (42.5)	
2008–2017	3,987 (64.5)	213,832 (57.5)	

SES socioeconomic status

After adjustment for age at diagnosis, sex, remoteness, area-level disadvantage, and broad survival-based cancer categories, Aboriginal and Torres Strait Islander patients still had significantly lower 5-year cancer-specific survival (i.e., higher hazards) than other Queensland patients, with average HRs (95% CIs) over the 5-year interval after diagnosis of 1.45 (1.36–1.55) for 1998–2007 and 1.42 (1.34–1.50) for 2008–2017 (Table 2). The survival disparity was significant only for the first 3 years since diagnosis for 1998–2007; however, it was significantly ($p \leq 0.02$) elevated for all five time intervals for 2008–2017 (Table 2). Across the combined study period, the poorer survival experienced by Aboriginal and Torres Strait Islander peoples was evident for both males (HR = 1.34,

Table 2 Adjusted hazard ratios (Indigenous:non-Indigenous) using cancer-specific survival models among invasive cancer cases in Queensland, stratified by follow-up interval, 1998–2017

	1998–2007		2008–2017	
Time since diagnosis	HR[a] (95% CI)	*p*	HR[a] (95% CI)	*p*
0–1 year	1.57 (1.45–1.70)	< 0.01	1.44 (1.34–1.55)	< 0.01
1–2 years	1.26 (1.08–1.48)	< 0.01	1.29 (1.13–1.47)	< 0.01
2–3 years	1.35 (1.08–1.68)	< 0.01	1.37 (1.13–1.67)	< 0.01
3–4 years	1.17 (0.88–1.56)	0.28	1.37 (1.05–1.79)	0.02
4–5 years	0.89 (0.61–1.30)	0.55	1.60 (1.15–2.25)	< 0.01
Average over the 5-year followup interval[b]	1.45 (1.36–1.55)	< 0.01	1.42 (1.34–1.50)	< 0.01

[a] HR, hazard ratio; Adjusted for age group at diagnosis, sex, remoteness, area-level disadvantage, and broad survival-based cancer type categories

[b] Ignoring the time-varying component

1.26–1.42) and females (HR = 1.49, 1.39–1.58) and across all age groups, even though the magnitude of the disparity tended to decrease as age at diagnosis increased [15–49 years: 1.68 (1.52–1.86); 50–59 years: 1.41 (1.29–1.53); 60–69 years: 1.37 (1.27–1.48); 70–79 years: 1.19 (1.08–1.31); ≥ 80 years: 1.19 (1.02–1.39)].

When considering trends over calendar year (Fig. 1), while there were discernible improvements in cancer survival by calendar years over the study period for Aboriginal and Torres Strait Islander cancer patients in terms of 1- and 5-year adjusted survival, these estimates remained consistently lower than the corresponding survival estimates for other Australians. For example, for Aboriginal and Torres Strait Islander cancer patients, the modeled 1-year survival increased from 74% in 1998 to 81% in 2017, and the 5-year survival increased from 59 to 67%. Corresponding estimates for other Australians were 81% and 86% for 1-year survival and 65% and 72% for 5-year survival.

Discussion

Using more recent cancer registry data with more complete identification of Aboriginal and Torres Strait Islander peoples, our study revealed that in Queensland, on average, cancer survival among Aboriginal and Torres Strait Islander cancer patients has increased over time; however, they still experience lower survival compared to other Queensland cancer patients and that this survival disparity has expanded so it is now evident up to the fifth year after diagnosis. Thus, while the previous message of "the first year counts" [1] is still relevant, these results highlight how the subsequent

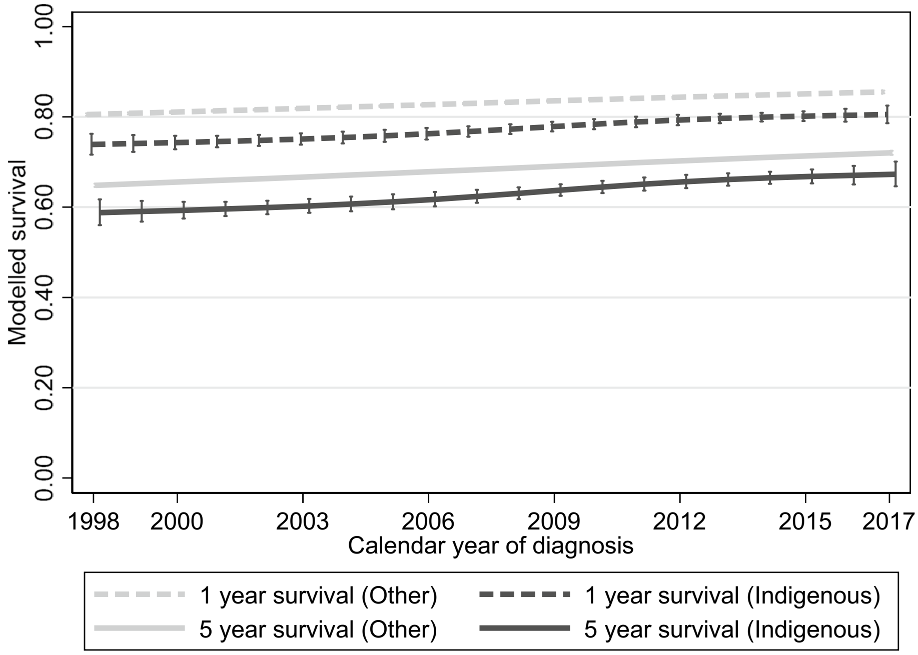

Fig. 1 Trends in modeled cancer-specific cancer survival (all types combined) by Indigenous status, Queensland, 1998–2017

follow-up years after a diagnosis of cancer also require important attention.

The lack of reduction in the disparity between Aboriginal and Torres Strait Islander cancer patients and other Queensland cancer patients over time found in this study follows on from a previous Australian report that found the corresponding disparity in 2-year cancer survival had increased for patients diagnosed between 1991 and 2005 [3]. However, the lack of any reduction in the disparity is surprising given the greater emphasis placed on reducing the gap in general health status experienced by Aboriginal and Torres Strait Islander peoples particularly in the last 10–15 years. These initiatives have included the establishment of a National Indigenous Cancer Network of Indigenous cancer survivors and other community members, health professionals and researchers, initiatives to improve cancer care in rural communities, and introduction of telemedicine to provide access to oncology specialists for patients in remote communities [3]. In addition, the Queensland government has prioritized reducing the gap in general health status experienced by Aboriginal and Torres Strait Islander peoples [13]. That the survival estimates have increased over time specifically for Aboriginal and Torres Strait Islander cancer patients may reflect some degree of success of these initiatives. However, the disparity has not decreased. It has been previously recognized that the reasons behind the survival disparity are multifaceted and completed [14], and the results of this study highlight that there remain additional factors that result in continued lower survival outcomes for Aboriginal and Torres Strait Islander peoples who are diagnosed with cancer. It remains a priority to better understand what those factors are and design effective interventions to reduce their prevalence and impact.

While we have not reported survival information by cancer type, a recent Queensland Government report using the updated identification process [15] has highlighted that the poorer survival faced by Aboriginal and Torres Strait Islander people in Queensland diagnosed with cancer is consistent across most types of cancer, particularly those typically associated with poorer survival, a results also consistent with other Australian results [3]. Although we have adjusted for broad cancer types in our analysis, it remains true that Aboriginal and Torres Strait Islander peoples are more likely to be diagnosed with these high case-fatality cancer types than other Australians.

One limitation of the study is that we were unable to adjust for cancer stage at diagnosis, however other Queensland cohort studies [2, 16] have done so and still reported a survival disparity. We adjusted for remoteness of residence and area-level disadvantage—important determinants of access to health services—however such broad area-based measures fail to account for the availability of and access to optimal and culturally appropriate cancer care for any Aboriginal and Torres Strait Islander peoples [17].

In conclusion, these analyses demonstrate that while Aboriginal and Torres Strait Islander peoples in Queensland have shared in the overall improvement in cancer survival seen in the Queensland population since 1998, there is no sign that the disparity in cancer survival is diminishing. There is an urgent need to better understand the complex and multifaceted factors that underlie this gap, including the potential role of co-morbidities, behavioral risk factors, cancer screening and diagnostic pathways, and treatment patterns to guide targeted, evidence-based interventions and to motivate the high levels of support and commitment that will be required for these interventions to be implemented across the health sector.

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Data availability The data that support the findings of this study are available on request from the corresponding author subject to receiving ethical and data custodian approval. The data are not publicly available due to privacy or ethical restrictions.

Code availability The Stata code may be requested by contacting Professor Peter Baade (peterbaade@cancerqld.org.au).

Declarations

Conflict of interest The authors declared no potential conflicts of interest.

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