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Trends and patterns of care of sentinel node biopsy in cutaneous melanoma: a population-based study in Queensland

Jessica Wong *† Julie Moore,‡ H. Peter Soyer,§¶ Victoria Mar‖** and B. Mark Smithers *†‡

*Queensland Melanoma Project, Princess Alexandra Hospital, Brisbane, Australia
†Academy of Surgery, The University of Queensland, Medical School, Herston, Queensland, Australia
‡Cancer Alliance Queensland, Princess Alexandra Hospital, Brisbane, Queensland, Australia
§Frazer Institute, Dermatology Research Centre, The University of Queensland, Brisbane, Queensland, Australia
¶Department of Dermatology, Princess Alexandra Hospital, Brisbane, Queensland, Australia
‖Victorian Melanoma Service, Alfred Health, Melbourne, Queensland, Australia and
**School of Public Health and Preventive Medicine, Monash University, Melbourne, Australia

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Correspondence
Prof. B. Mark Smithers, UQ, Southside Clinical School 4th Floor, Princess Alexandra Hospital, 199 Ipswich Rd, Woolloongabba, QLD 4102, Australia.
Email: m.smithers@uq.ed.au

J. Wong MBBS, Hons, MS, MIPH, FRACS; **J. Moore** BBsMn; **H. P. Soyer** MD, FACD; **V. Mar** MBBS, FACD, PhD; **B. M. Smithers** AM, MBBS, FRACS, FRCSEng, FRCSEd.

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Abstract

Background: Sentinel node biopsy (SNB) has evolved from offering staging and prognostication to a procedure that guides therapeutic management. The aim was to evaluate the rate of SNB for patients with high-risk melanoma and assess factors that may have impacted on the procedure being performed.

Methods: Data of patients with primary invasive cutaneous melanoma from 01 January 2009 to 31 December 2019 were obtained from the Queensland Oncology Repository. High-risk melanoma was defined as ≥0.8 mm thick or < 0.8 mm with ulceration present (AJCC eighth edition $pT1_b$–pT_4).

Results: 14 006 (33.8%) of 41 412 patients diagnosed with cutaneous invasive melanoma were in the high-risk group. 2923(20.9%) patients had SNB, with the rate increasing from 14.2% (2009) to 36.8% (2019) ($P = 0.002$), and an increasing proportion being performed in public hospitals over the 11 year period ($P = 0.02$). Older age (OR0.96 (0.959–0.964) ($P < 0.001$)), female (OR0.91 (0.830–0.998) ($P = 0.03$)), head and neck primary (OR0.38 (0.33–0.45) ($P < 0.001$)), and pT_{1b} (OR0.22 (0.19–0.25) ($P < 0.001$)) were factors associated with SNB not being performed. Travel out of the Hospital and Health Services of residence for SNB occurred in 26.2%. Although the travel rate decreased from 24.7% (2009) to 23.0% (2019) ($P = 0.04$), the absolute number increased due to the increase in SNB rate. Those most likely to travel were younger, from remote areas, or from affluent backgrounds.

Conclusion: In this first Australian population-based study, there was an increased adherence to SNB guideline, although overall SLNB rates remain low, with nearly 2/3 of eligible cases not having the procedure in 2019. Although travel rates decreased marginally, the overall number increased. This study highlights the crucial need to further improve access to SNB for melanoma surgery for the Queensland population.

Introduction

Cutaneous melanoma is the third most common cancer, and a leading cause of mortality in Australia,[1] with the incidence in Queensland being amongst the highest in the world.[2] Wide local excision provides definitive treatment of the primary melanoma, with tumour thickness and the presence or absence of ulceration being two important pathologic prognostic factors.[3] Defining the nodal status using sentinel node biopsy (SNB), offers better prognostic information and more complete staging than wide excision alone.[4] The most recent staging system from The American Joint Committee on Cancer (AJCC) is the eighth edition,[3] only included patients who had a SNB if the melanoma was 1 mm or more (T_2–T_4) for the T staging. This has provided better prognostic guidance for patients with a high-risk melanoma, given those with a positive SN were upstaged to Stage III. There are now four Stage III groups (Stages IIIA to IIID), which take into account both thickness and nodal status, with a 10-year survival rate ranging from 24% to 88%.[3]

With the proven benefit of adjuvant targeted therapy and immunotherapy for Stage III melanoma,[5,6] SNB has evolved from providing the most accurate staging and prognostic information[3,4,7] to a procedure that guides the therapeutic management of a patient. The Australian guidelines define high-risk primary disease as a melanoma ≥0.75 mm thick or the presence of ulceration if melanoma if <0.75 mm thick.[8] By reporting thickness to the higher single decimal point, this conforms with the AJCC eighth edition T stages of pT_{1b} to pT_4,[3] with T_{1b} being a melanoma 0.8–1.0 mm or any melanoma less than 0.8 mm with ulceration.[3]

Previously, in a cross-sectional study in New South Wales, between 2006–2007, the rate of SNB was reported to be 17% in patients with a melanoma >0.75 mm thick.[9] Between 2010–2014, in Queensland the SNB rate was 33% in patients with a melanoma stage T1b or greater.[10] Older age, lower socioeconomic background, head and neck primary and remoteness were factors associated with SNB not being performed.[9,10] To date there have been no population-based studies in Australia looking at the trend and patterns of nodal treatment for melanoma. Our hypothesis was that SNB was not being performed according to treatment guidelines. With the recent potential for SNB to impact on patient treatment and thus cancer outcomes, our aim was to perform a population-based study to assess the trends in the performance of SNB in Queensland, in patients with a high-risk primary melanoma. We aimed to focus on factors that may influence SNB being performed as well as evaluating access to the procedure by assessing the issue of travel outside of the patient's Hospital and Health Services region (HHS) for their SNB procedures.

Method

Following the compulsory reporting of a cancer diagnosis to the Queensland Cancer Registry, the details are submitted to the Queensland Oncology Repository (QOR), which is a secure data repository containing patients' demographic and pathology information which is linked to treatment and outcome data. Database was queried for all patients diagnosed with a cutaneous primary invasive melanoma from 1 January 2009 to 31 December 2019 from the QOR, documenting demographics, socioeconomic status (SES), geographic region at diagnosis, in-hospital treatment, pathology of the melanoma and details related to regional nodal surgery. The pathologic T stage (pT) was defined according to the AJCC eighth edition staging guidelines.[3] The AJCC eighth edition categorized melanoma to one decimal point, so that all patients with a thickness ≥ 0.75 mm were categorized as 0.8 mm.[3] AT_{1a} melanoma was melanoma up to 0.8 mm and a T_{1b} melanoma was a melanoma between 0.8 and 1 mm or if ulceration was present if the melanoma was less than 0.8 mm. The other T stages were: T_2 > 1–2 mm; T_3, >2–4 mm and T_4, >4 mm. Thus, a high-risk melanoma was defined as any patient with a melanoma of $pT1_b$–pT_4.

Individual records of all patients who underwent any regional nodal surgery were reviewed. SNB was recorded based on hospital admission summary data, operation reports and/or pathology reports. Where the pathology report or operation was reported as 'excision of lymph node' or 'a lymph node removal' and did not specify 'SNB', the procedure was presumed if the surgery is performed within 90 days of the histopathological diagnosis of their primary invasive cutaneous melanoma, and the node was not clinically diagnosed. Patients were excluded if they had: diagnostic excisional biopsy of a lymph node; presented with clinically or radiologically involved nodes or distant metastases; if they had regional lymph node dissection, including parotidectomy; and SNB for any other pathology. Where the SNB was performed at multiple sites, the case was counted as one procedure, but all the sites are recorded separately. For patients who had further primary invasive melanomas, with relevant thickness, each was treated as a separate episode for the potential to perform a SNB. Patients treated with a primary melanoma diagnosed interstate were excluded.

The HHS for each patient was as defined by the Queensland government. Figure S1 provides a HHS map for Queensland.[11] Socioeconomic status (SES) was defined by the Socio-Economic Indexes for Areas (SEIFA) developed by the Australian Bureau of Statistics, which is determined by the Statistical Areas Level 2 (SA2) geographic area of the patient residence at time of diagnosis.[12] Remoteness was defined using the Australian Statistical Geography Standard based on the SA2 of usual residence.[12] Travel was defined as travel out of the HHS of residence for SNB to be performed in a different HHS.

Statistical analysis

Continuous variables were summarized as median and interquartile range (IQR). Categorical variables were summarized as frequencies and percentages. Continuous dependent variables were assessed with Mann–Whitney *U*-test or Kruskall-Wallis H test. Categorical data were assessed using the chi-square analysis and Fischer's exact test. Trends over time were calculated using Mann-Kendall test. Logistic Regression was used to assess the impact of demographic, clinical and pathological factors on SNB rates and on the need to travel across Queensland. Significance was defined as $P \leq 0.05$ (two-sided). All analyses were performed using Microsoft Excel (v16.65, 2022) and Statistical Package of Social Sciences (SPSS) (v28.0.1, 2021).

Ethical approval for this research was granted through Metro South Human Research Ethics Committee (Reference number HREC QMS/84274) and Queensland Health (PHA 84274).

Results

There were 41 412 diagnoses of primary cutaneous invasive melanoma in Queensland during the 11-year period. A SNB was performed in 3141 patients with the rate per T stage shown in Fig. 1. With a focus on patients with a high-risk melanoma, pT_{1b}–pT_4, there were 14 006 cases with 2923 (20.9%) having a SNB (Fig. 2). The rate of SNB increased from 14.2% in 2009 to 36.8% in 2019 ($P = 0.002$) (Table 1). Overall, 49.5% of all SNB were performed in public hospitals, with an increasing proportion being performed over the time-period ($P = 0.02$) (Table 1). SNB was more commonly performed in private hospitals until 2018, when the rate increased to 55.7% in public hospitals (Table 1). In the 2923 cases, there were 3176 anatomical sites from which a SNB was taken

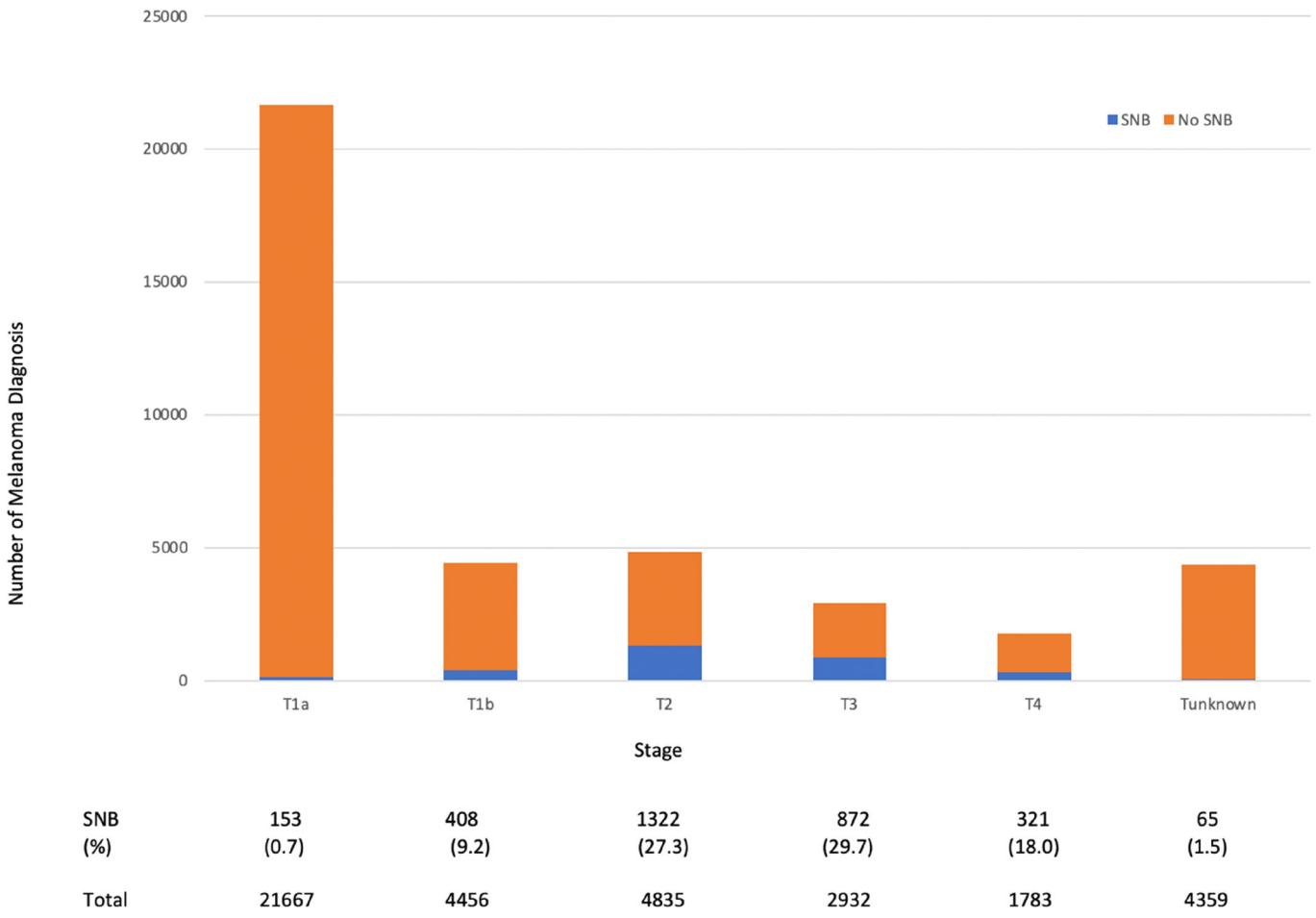
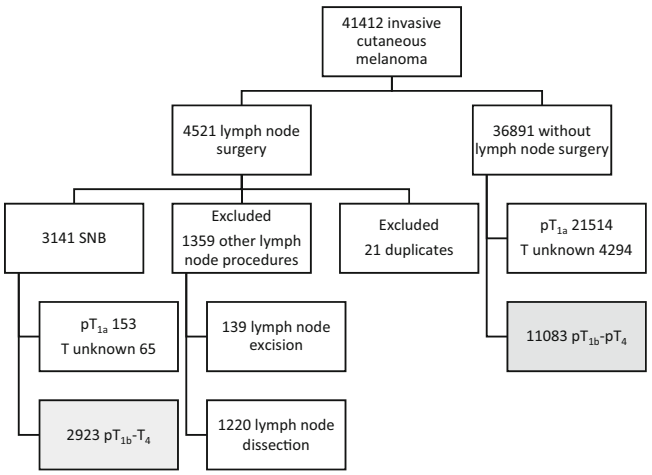


Fig. 1. Melanoma diagnosis and SNB by stage from 2009 to 2019 (AJCC eighth edition).



^High risk group ($pT1_b$ – pT_4) = 14006 patients (2923+11083)

Fig. 2. Regional Nodal treatment for Invasive Cutaneous Primary Melanoma in Queensland 2009–2019: AJCC eighth edition $pT1_b$–pT_4. High risk group ($pT1_b$–pT_4) = 14 006 patients (2923 + 11 083).

(Table 2). The most common site was the axilla (59.5%) (Table 2). There was a significant increase in inguinal ($P = 0.01$) and head and neck SNB ($P < 0.001$) SNB over the 11 years.

Table 3 outlines the demographic information and pathology used to assess the variables that may have impacted on a SNB being performed. The median age of the whole group was 66.5 years. Those having a SNB were younger (60 vs. 68 years) (OR 0.96 (0.959–0.964) ($P < 0.001$)). There were more men (59.8%) diagnosed with primary invasive cutaneous melanoma. Being female was associated with a lower rate of SNB [OR0.91 (0.830–0.998) (p = 0.03)]. The average rate of SNB was significantly lower when the primary melanoma was on the head and neck (10.1%) (OR 0.38 (0.33–0.45) ($P < 0.001$)) compared with the other sites where the rates were between 22% and 24%. The pathology staged pT_{1b} group was 32% of the high-risk group with 408 (9.2%) having a SNB, which was lower (OR 0.22 (0.19–0.25) ($P < 0.001$)) than the other pT stages. The highest rate occurred in the pT_3 (29.7%) group.

There were fewer patients in the remote group ($n = 219$, 1.6%), however there was a higher rate of SNB (32.0%) (OR 1.59 (1.16–2.18) ($P = 0.004$)) compared with the other three residential groups which had rates between 19.4% and 21.9%. Assessing SES, the rate of SNB rate was between 18.1% and 21.8% for all groups, however, was lowest in the affluent group ($P = 0.006$).

In the 11 years, 765 patients (26.2%, range 23–31.8%) travelled outside of their HHS for a SNB. The rate decreased from 24.7% in

Table 1 Number of patients with High-risk primary melanoma: SNB per year: hospital type and travel from HHS, 2009–2019

Year of primary melanoma diagnosis	Number of melanoma diagnosis T_{1b}–T_4† $n = 14\,006$	Number of SNB $n = 2923$‡ (%)	SNB performed at public hospital (%) $n = 1448$ (49.5%)	SNB outside HHS§ (%) $n = 765/2911$§ (26%)
2009	1067	152 (14.2)	65 (42.8)	37/150§ (24.7)
2010	1050	149 (14.2)	61 (40.9)	52/147§ (35.4)
2011	1153	158 (13.7)	69 (43.7)	50/157§ (31.8)
2012	1169	194 (16.6)	96 (49.5)	48/193§ (24.9)
2013	1258	211 (16.8)	94 (44.5)	62/210§ (29.5)
2014	1261	261 (20.7)	124 (47.5)	71/258§ (27.5)
2015	1370	302 (22.0)	125 (41.4)	84 (27.8)
2016	1392	296 (21.3)	127 (42.9)	77 (26.0)
2017	1379	363 (26.3)	181 (49.9)	92 (25.3)
2018	1414	287 (20.3)	160 (55.7)	66 (23.0)
2019	1493	550 (36.8)	346 (62.9)	126/548§ (23.0)

†Excludes 1359 who had other lymph node procedures and 21 duplicates.

‡Excludes 153 T1a patients and 65 with unknown T staging who had SNB.

§Unknown HHS in 12 patients.

Table 2 Anatomical site of SNB per year

Year	Number patients SNB $n = 2923$ (% of total)	Number anatomical sites SNB† $n = 3176$ (% of total)	Axilla $n = 1889$ (% per year)	Inguinal (Pelvic) $n = 672$ (% per year)	Head and Neck $n = 275$ (% per year)	Atypical‡ $n = 25$ (% per year)	Unspecified $n = 315$ (% per year)
2009	152 (5.2)	162 (5.1)	103 (63.6)	23 (14.2)	6 (3.7)	1 (0.6)	29 (17.9)
2010	149 (5.1)	169 (5.3)	109 (64.5)	18 (10.7)	10 (5.9)	1 (0.6)	31 (18.3)
2011	158 (5.4)	166 (5.2)	111 (66.9)	23 (13.9)	12 (7.2)	0 (0.0)	20 (12.0)
2012	194 (6.6)	214 (6.7)	153 (71.5)	27 (12.6)	7 (3.3)	1 (0.5)	26 (12.1)
2013	211 (7.2)	237 (7.5)	163 (68.8)	39 (16.5)	16 (6.8)	2 (0.8)	17 (7.2)
2014	261 (8.9)	290 (9.1)	169 (58.3)	56 (19.3)	26 (9.0)	2 (0.7)	37 (12.8)
2015	302 (10.3)	321 (10.1)	184 (57.3)	88 (27.4)	27 (8.4)	4 (1.2)	18 (5.6)
2016	296 (10.1)	332 (10.5)	183 (55.1)	92 (27.7)	28 (8.4)	5 (1.5)	24 (7.2)
2017	363 (12.4)	389 (12.2)	228 (58.6)	113 (29.0)	42 (10.8)	1 (0.3)	5 (1.3)
2018	287 (9.8)	306 (9.6)	180 (58.8)	77 (2) (25.8)	34 (11.1)	2 (0.7)	11 (3.6)
2019	550 (18.8)	590 (18.6)	306 (51.9)	114 (19.3)	67 (11.4)	6 (1.0)	97 (16.4)

†Each SLNB procedure may localize to multiple sites. (3176 sites in 2923 patients).

‡Atypical sites: epitrochlear, popliteal, interval/in-transit.

2009 to 23.0% in 2019 ($P = 0.04$) (Table 1). The rate decrease did not reflect the real numbers as more patients travelled as the SNB rate increase, from 37 in 2009 to 126 in 2019. Younger age, living in remote areas and being affluent were factors more likely to be associated with a patient leaving their HHS to have the SNB (Table 4). Of those who travelled, SNB was more likely to be performed at a public hospital ($P < 0.001$). Of the 15 HHS in Queensland, four do not have hospitals that can perform a SNB (North-West, Central-West, South-West, Torres and Cape) (Fig. S1 and Table S1). Excluding these health services, 723/2868 (25.2%) travelled outside of their HHS despite having a facility able to perform SNB in their HHS of residence.

Discussion

This is the first Australian population-based study to assess trends and patterns of SNB for cutaneous melanoma as we move into in the era of adjuvant systemic therapy. From 2009 to 2019, 20.9% of the patients with a high-risk primary melanoma had a SNB. There was a significant increase in adherence to SNB guidelines over this 11-year period, with the rate reaching 36.8% in 2019 from 14.2% in 2009. The rate of travel outside of the patient's HHS was 26.2%, and although there was a rate decrease from 24.7% in 2009 to 23.0% in 2019, the absolute number of patients increased due to the increased rate of SNB in that time. Factors that significantly impacted a reduced SNB rate included older age, female, head and neck primary and stage pT1b disease. Remoteness and middle class or disadvantaged backgrounds were associated with a higher rate of SNB.

Underutilization of SNB in melanoma has been reported in countries, both where universal health care is available[13] and where it is not.[14,15] Although universal health care is available in Queensland, patients may still have to travel great distances, outside of their HHS for their procedures. Similar to our findings, other studies published a lower SNB rate in older patients, those with thinner melanoma and head and neck primary.[9,13–15] The potential reasons for these groups having a lower SNB rate likely includes the impact of comorbidities in older patients, the lack of impact on patients' treatment options for the thinner melanoma, and the technical difficulties with SNB in the head and neck. With the potential to impact the patient's oncological outcome from the melanoma, there is a need to more carefully considered SNB across the age groups, and at all primary melanoma sites. Although at this time patients with a T_{1b}–T_{2a} (non-ulcerated, 1-2 mm) melanoma who are SN positive

Table 3 Clinical and pathological factors of patients with high-risk cutaneous melanoma† including univariable and multivariable analysis of factors influencing SNB being performed

		SLNB			
	Total $T_{1b–4}$ $n = 14\ 006$	Yes‡ $n = 2923$	No $n = 11\ 083$	Univariable analysis	Multivariable logistic regression odds ratio (95% CI) for SNB
Age at diagnosis (median, IQR)	66.5 (54.0–77.0)	60 (48–69)	68 (56–79)	**<0.001**	**0.96 (0.959–0.964)**
Sex, *n* (%)				**0.03**	
Male	8377 (59.8)	1696 (58.0)	6681 (60.3)		1.00 (Reference)
Female	5629 (40.2)	1227 (42.0)	4402 (39.7)		**0.91 (0.830–0.998)**
Remoteness of residence *n* (%)				**<0.001**	1.00
Major city	8678 (62.0)	1825 (62.4)	6853 (61.8)		1.00 (Reference)
Inner regional	3529 (25.2)	683 (23.4)	2846 (25.7)		0.90 (0.80–1.00)
Outer regional	1564 (11.2)	342 (11.7)	1222 (11.0)		0.99 (0.86–1.15)
Remote and very remote	219 (1.6)	70 (2.4)	149 (1.3)		**1.59 (1.16–2.18)**
Unknown	16 (0.1)	3 (0.1)	13 (0.1)		§
Socioeconomic status, *n* (%)				**<0.001**	
Affluent	1395 (10.0)	252 (8.6)	1143 (10.3)		1.00 (Reference)
Middle	9034 (64.5)	1967 (67.3)	7067 (63.8)		**1.29 (1.10–1.51)**
Disadvantaged	3560 (25.4)	701 (24.0)	2859 (25.8)		**1.21 (1.02–1.46)**
Unknown	17 (0.1)	3 (0.1)	14 (0.1)		§
Anatomic site, *n* (%)				**<0.001**	
Trunk	4289 (30.6)	957 (32.7)	3332 (30.1)		1.00 (Reference)
Upper limb	3848 (27.5)	940 (32.2)	2908 (26.2)		**1.23 (1.10–1.38)**
Lower limb	3149 (22.5)	752 (25.7)	2397 (21.6)		**1.16 (1.03–1.31)**
Head/neck	2699 (19.3)	273 (9.3)	2426 (21.9)		**0.38 (0.33–0.45)**
Unknown	21 (0.1)	1 (0.03)	20 (0.2)		§
pT Staging†, *n* (%)				**<0.001**	
1b	4456 (31.8)	408 (14.0)	4048 (36.5)		**0.22 (0.19–0.25)**
2	4835 (34.5)	1322 (45.2)	3513 (31.7)		1.00 (Reference)
3	2932 (20.9)	872 (29.8)	2060 (18.6)		**1.48 (1.33–1.65)**
4	1783 (12.7)	321 (11.0)	1462 (13.2)		0.96 (0.83–1.11)

†High-risk defined as $T_{1b–T4}$: 0.8–4.0 mm, <0.8 with ulceration.

‡Excludes 153 $T1_a$ patients and 65 with unknown T staging who had SNB.

§Excluded from analysis.

Bold indicates significant values.

(Stage IIIA) are deemed not suitable for adjuvant therapy in Australia; there remains the prognostic information, allowing for more informed patient counselling in this group if they have a SNB.

Age, comorbidities and social situations may impact on the value of a SNB but this should be an individual assessment. Age alone should not preclude patients from being counselled on the role of SNB in their management. In this study, being female was associated with a lower SNB rate ($P = 0.03$). This will partially be related to the higher number of melanomas diagnosed in men versus women (59.8% vs. 40.2%) in our study. As mentioned, SNB in patients with a head and neck primary melanoma can be more difficult, with the identification of draining nodal basins more challenging, due to the complex anatomy of lymph node drainage and radiotracer injection sites lying in close proximity to the primary lesion making identification of a node difficult, as well there maybe multiple draining sites.[14] Technically, the surgery also requires experience and potentially a different skill set for some general surgeons.

A study in Queensland reported that general practitioners and those in primary care with an interest in skin cancer diagnosed up to 80% of melanoma.[10] A 2020 New South Wales study reported that although 68% of general practitioners surveyed thought SNB played an important role in the management of melanoma, only 32% described themselves as being familiar with the guidelines for the indication for a SNB.[16] In that survey, those who discussed SNB with eligible patients, less than 40% correctly identified that SNB was recommended for patients with melanoma >1 mm thick.[16] Clearly education at this level, with respect to the guidelines and relevant patient information will have an impact on referral practices in the Australian health system.

International studies across different continents (America, Europe and Asia) found that remoteness and low SES were associated with lower percentages of patients undergoing SNB.[13,14,17] In the Queensland population, remoteness and lower SES can be associated with a reduced access to medical resources and led to a higher referral rate for a SNB. This is likely due to historic referral patterns notably to the local regional hospitals or directly to the major, tertiary hospitals, where there was likely to be a higher adherence to guidelines and a more uniform clinical practice related to SNB. This is supported by the literature, where academic facilities provided the highest rate of guideline concordant SNB management.[18] However, the rate of SNB was still low in these regions.

The significant increase in SNB rate in the public sector more recently reaching 49.5% of all SNB performed was a positive finding, however, this is still only half of those who are eligible.

As awareness grows and availability of adjuvant immunotherapy for resected melanoma increases, we anticipate a positive impact on SNB rate. Although this is a single datapoint, there appears to be a

Table 4 Clinical and pathological factors of patients who travelled out of HHS for SNB

		Travel out of HHS			
	Total† $n = 2911$ (%)	Yes $n = 765$ (%)	No $n = 2146$ (%)	Univariate analysis	Multivariate logistic regression odds ratio (95% CI) for travel
Age at diagnosis, median (IQR)	60 (48–69)	58 (46–66)	61 (49–70)	**<0.001**	0.98 (0.98–0.99)
Sex, *n* (%)				0.16	‡
Male	1690 (58.1)	461 (60.3)	1229 (57.3)		
Female	1221 (41.9)	304 (39.7)	917 (42.7)		
Remoteness of residence, *n* (%)				**<0.001**	
Major city	1818 (62.5)	418 (54.6)	1400 (65.2)		1.00 (Reference)
Inner regional	681 (23.4)	223 (29.2)	458 (21.3)		**1.76 (1.42–2.18)**
Outer regional	342 (11.7)	69 (9.0)	273 (12.7)		0.94 (0.70–1.27)
Remote and very remote	70 (2.4)	55 (7.2)	15 (0.7)		**16.12 (8.92–29.12)**
Socioeconomic status, *n* (%)				**<0.001**	
Affluent	252 (8.7)	122 (15.9)	130 (6.1)		1.00 (Reference)
Middle	1961 (67.4)	404 (52.8)	1557 (72.6)		**0.24 (0.18–0.31)**
Disadvantaged	698 (24.0)	239 (31.2)	459 (21.4)		**0.44 (0.32–0.61)**
pT staging, *n* (%)				0.09	‡
1b	408 (14.0)	94 (12.3)	314 (14.6)		
2	1317 (45.2)	371 (48.5)	946 (44.1)		
3	867 (29.8)	227 (29.7)	640 (29.8)		
4	319 (11.0)	73 (9.5)	246 (11.5)		
Anatomic site, *n* (%)				0.3	‡
Trunk	954 (32.8)	249 (32.5)	705 (32.9)		
Upper limb	935 (32.1)	240 (31.4)	695 (32.4)		
Lower limb	750 (25.8)	192 (25.1)	558 (26.0)		
Head/neck	271 (9.3)	84 (11.0)	187 (8.7)		
Unknown	1 (0.0)	‡	‡		
Hospital type				**<0.001**	‡
Public	1445 (49.6)	423 (55.3)	1022 (47.6)		
Private	1466 (50.4)	342 (44.7)	1124 (52.4)		

†Excluding 12 missing data.

‡Excluded from analysis.

Bold indicates significant values.

substantial increase in the SNB rate in 2019 (36.8%) compared with 2018 (20.3%). In December 2017, The Food and Drug Administration approved nivolumab to be used in adjuvant setting in patients with melanoma with involvement of lymph nodes and in patients with metastatic disease who have undergone complete resection.[19,20] The CHECKMATE-238 trial demonstrated a significantly reduced hazard ratio for disease recurrence or death in the nivolumab group compared with the ipilimumab group.[19] Another adjuvant monotherapy agent, pembrolizumab, was associated with significantly longer recurrence free survival compared with placebo.[21] Both trials showed similar results with halving of the risk of melanoma recurrence.[19,21] Compassionate access to these adjuvant immunotherapy drugs were available in Australia in 2018 to 2019. However, the Pharmaceutical Benefits Scheme listing for nivolumab was only officially expanded in March 2020 to include adjuvant treatment of completely resected Stage IIIB to Stage IV malignant melanoma.[22]

Although access to the procedure has improved, over one quarter of the patients needed to travel out of their HHS for a SNB. Delivery of care is especially challenging in Queensland as the population is concentrated in the South-East region of the state.[23] Brisbane Inner City has the highest population density, with 3061 persons per km^2, while Queensland - Outback has the lowest (0.1 person per km^2).[23] Difficult access is also compounded by significant travel distance even within an individual HHS. The aim should be to treat the patient as close to home as possible. An impediment to the procedure being performed in regional centres includes the need for a nuclear medicine facility, along with surgeons who have experience with the procedure. Ongoing training and investment in local surgeons, radiology, nuclear medicine and pathology are necessary to provide the population with centres that can perform the SNB procedures, reducing the need to travel. SNB is crucial not only for melanoma, but for other common cancers such as breast cancer, further justifying the need for such facilities across Queensland.

There are limitations with our study. Firstly, the potential for classification bias of the SNB procedure. We aimed to reduce this by individually reviewing the records of all patients who had regional lymph node surgery. Secondly, the eighth edition AJCC guideline was increasingly implemented towards the end of the study period. In the seventh edition, pT_{1b} was ≤1.0 mm, whereas in the eighth edition, pT_{1b} was ≤0.8 mm. This may have influenced referral patterns and consideration for SNB.[3] Additionally, mitotic rate is no longer used as a T category criterion and tumour thickness is measured to the nearest 0.1 mm, not the nearest 0.01 mm.[3] We decided to analyse the groups as per the AJCC eighth edition by including those with ≥0.75 mm thickness in the pT_{1b} group and excluding mitotic rate as a variable. However, there would be those included in the pT_{1b} group who were previously categorized as

pT_{1a} and vice versa, which might explain the 0.7% rate of SNB in pT_{1a} group (as per AJCC eighth edition) (Fig. 1). Thirdly, data was only available until 2019 at the time of this study. Nearly two-thirds of those eligible for SNB in 2019 did not have the procedure. More recent data (2020–2022) may show a further increase in SNB rate as there is increasing availability and awareness of systemic adjuvant therapy. Data on patient comorbidities was not available hence we were unable to calculate those who were high risk for surgery or those who were inappropriate surgical candidates for SNB. In this database, patient's private insurance status was unknown. Therefore, we could not formally assess whether this is a factor influencing SNB surgery or choosing to travel for their SNB surgery. Instead, we used the SES and institutional status (public versus private) as an assessment of where the SNB was performed, as surrogates. We also acknowledge that for a few patients who travelled, there would be some whose residence was located closer to a hospital in a different HHS than a hospital in their HHS of residence.

As a population-based study, the strength of this study includes the large volume of patients with good quality linkage of the pathology with the patient's treatment through the Queensland Oncology Repository. There were only few patients with missing data so that the analyses can be considered robust. As well, the results are likely applicable to other states in Australia, which may face similar barriers in the delivery of melanoma surgery.

Conclusion

This is the first Australian population-based study to assess the trends and patterns of care of SNB for cutaneous melanoma. This has become more relevant at a time period where adjuvant systemic therapies were increasingly available and are improving survival. We have shown an increased SNB rate with time. However, even in 2019, nearly two-thirds of eligible patients did not have the procedure according to the guidelines for the treatment of high-risk cutaneous melanoma. Although travel rate has decreased, the overall number of those who travelled for their SNB has increased. Today, SNB is no longer just a prognostic tool but a pathway to access systemic therapy and therefore improving access to SNB is a critical step in the delivery of care in melanoma surgery for Queenslanders diagnosed with melanoma.

Conflict of interest

H. Peter Soyer is a shareholder of MoleMap NZ Limited and e-derm consult GmbH and undertakes regular teledermatological reporting for both companies. H. Peter Soyer is a Medical Consultant for Canfield Scientific Inc., Blaze Bioscience Inc., and a Medical Advisor for First Derm.

Author contributions

Jessica Wong: Data curation; formal analysis; methodology; project administration; writing – original draft; writing – review and editing. **Julie Moore:** Data curation; project administration; writing – review and editing. **H. Peter Soyer:** Supervision; writing – review and editing. **Victoria Mar:** Supervision; writing – review and editing. **B. Mark Smithers:** Conceptualization; formal analysis; project administration; supervision; writing – original draft; writing – review and editing.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Supplementary Figure S1. Queensland Hospital and Health Service* Map (11)

Supplementary Table 1. Population in Queensland by Hospital and Health Services in 2018