Estimating the magnitude and healthcare costs of melanoma in situ and thin invasive melanoma overdiagnosis in Australia

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Running Title: Magnitude and healthcare costs of melanoma overdiagnosis in Australia

Daniel Lindsay,[1,2] Katy J.L. Bell,[3] Catherine M. Olsen,[1,2] David C. Whiteman,[1,2] Thanya Pathirana[4] and Louisa G. Collins[1,2,5]

[1]Population Health Department, QIMR Berghofer Medical Research Institute, Queensland, Australia

[2]Faculty of Medicine, University of Queensland, Queensland, Australia

[3]Sydney School of Public Health, Faculty of Medicine and Health, The University of Sydney, New South Wales, Australia

[4]School of Medicine and Dentistry, Griffith University, Queensland, Australia

[5]Cancer and Palliative Care Outcomes Centre and School of Nursing, Queensland University of Technology (QUT), Queensland, Australia

Corresponding Author: Dr Daniel Lindsay

Email: Daniel.lindsay@qimrberghofer.edu.au

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Data availability: The majority of data used in this study are freely available online. Please contact the authors if you need further information on where this data can be found.

Ethics statement: This negligible risk study was exempt from formal ethics review because we analysed publicly available, non-identifiable aggregated data.

Patient consent: Not applicable.

What is already known about this topic?

- The estimated proportion of overdiagnosed melanoma is high in Australia and internationally, contributing to overtreatment, patient harms and inflated costs.

What does this study add?

- Estimates using the latest national-level data indicate that the proportion of overdiagnosed melanomas in Australia is increasing over time. Melanoma overdiagnosis may cost the Australian healthcare system over $21 million annually, largely driven by overdiagnosed melanoma in situ.

What is the translational message?

- Melanoma overdiagnosis is a significant public health issue in Australia, primarily driven by the detection of melanoma in situ. A targeted population-level intervention can minimise the harms of overdiagnosis and ensure efficient healthcare delivery

Abstract

Background: Research suggests a high proportion of melanoma *in* situ (MIS) may be overdiagnosed, potentially contributing to overtreatment, patient harm and inflated costs for individuals and healthcare systems. However, Australia-wide estimates of the magnitude of melanoma overdiagnosis are potentially outdated and there has been no estimation of the cost to the healthcare system.

Objective: To estimate the magnitude and cost of overdiagnosed MIS and thin invasive melanomas in Australia.

Methods: Using two different methods for calculating lifetime risk, we used routinely collected, national-level data to estimate overdiagnosed MIS and thin invasive melanomas (stage IA) in Australia in 2017 and 2021, separately for men and women. We multiplied the number of overdiagnosed melanomas by the estimated annual cost of a MIS or thin invasive melanoma to quantify the financial burden of melanoma overdiagnosis to the Australian healthcare system in the year following diagnosis.

Results: We estimated that between 67-70% of MIS were overdiagnosed in 2017, rising to 71-76% in 2021, contributing to between 19,829 (95%CI: 19,553 – 20,105) and 20,811 (95%CI:

20,528 – 21,094) overdiagnosed MIS. In 2021, the estimated costs in Australia ranged between $17.7 million (95%CI: $17.4 – 17.9 million) and $18.6 million (95%CI: $18.3 – 18.8 million). We estimated that 22-29% of thin invasive melanomas were overdiagnosed in 2017, rising to 28-34% in 2021, contributing to between 2,831 (95%CI: 2,726 – 2,935) and 3,168 (95%CI: 3,058 – 3,279) overdiagnosed thin invasive melanomas. In 2021, the estimated costs from thin invasive melanoma overdiagnoses ranged between $2.5 million (95%CI: $2.4 – 2.6 million) and $2.8 million (95%CI: $2.7 – 2.9 million).

Conclusions: Melanoma overdiagnosis is a growing clinical and public health problem in Australia, producing significant economic costs in the year following overdiagnosis. Limiting melanoma overdiagnosis may prevent unnecessary healthcare resource use and improve financial sustainability within the Australian healthcare system.

Introduction

In the past few decades, fair-skinned populations have experienced increasing melanoma incidence rates, with no proportional increase in mortality.[1-3] Similar epidemiological trends in other specific cancer types (prostate, breast, thyroid, kidney), while theoretically attributable to successful cancer management and prevention strategies, likely reflect increasing overdiagnosis of otherwise indolent tumours.[4] In melanoma, overdiagnosis refers to a lesion that meets the histopathology diagnostic criteria for melanoma, but would not have caused any symptoms or harm if it had remained undetected and untreated.[5]

Welch et al. (2021) described the 'cycle of melanoma overdiagnosis', where increased diagnostic scrutiny and shifts in diagnostic thresholds contribute to potentially unnecessary skin examinations and biopsies, and continued long-term surveillance.[2] Melanoma overdiagnosis can result in overtreatment, patient harm and inflated costs for individuals and healthcare systems.[6,7] Studies using different methods estimate that up to 40-60% of melanomas may be overdiagnosed.[2,6,8-10] In line with empirical evidence indicating rapid increases in melanoma *in situ* (MIS) incidence,[11] a higher proportion of MIS than invasive melanomas are likely overdiagnosed, [6,9,10] with recent estimates of 85-89% of MIS overdiagnosed in the United States.[10]

In Australia, there are no national estimates of melanoma overdiagnosis since 2012,[9] while the costs of melanoma overdiagnosis have not yet been quantified but are likely

significant. Using the latest national-level melanoma incidence data, we estimated the magnitude and cost of overdiagnosed MIS and thin invasive melanoma in Australia.

Materials and Methods

Excess lifetime risk for melanoma in Australia

Overdiagnosis can be conceptualised as the difference between the total number of melanoma diagnoses in a population, and the number that are truly destined to invade and metastasize and therefore clinically relevant (e.g. excess incidence or risk).[10] Cancer registries capture melanoma diagnoses in a population, but the proportion of all melanomas that are biologically aggressive is not quantifiable. Overdiagnosis can only be inferred indirectly using population statistics, such as excess lifetime risk of a melanoma diagnosis for current compared to past risk (when overdiagnosis was assumed to be less prevalent).[12]

Adapting the lifetime risk method,[12] we first calculated and compared current and past lifetime risks of a melanoma diagnosis by extracting routinely collected data from the Australian Cancer Database (ACD) and Australian Institute of Health and Welfare on sex- and age-specific (5-year age groups, 0-4, 5-9… 85+) counts of people with a melanoma diagnosis, melanoma mortality, all-cause mortality, and population denominators (estimated resident population).[13-15] We calculated, separately for women and men, differences in lifetime risks of being diagnosed with MIS or invasive melanoma in 2004, 2017 and 2021, assuming mortality for MIS was 0. All analyses are cross-sectional, providing individual year snapshots of estimated magnitudes and costs of melanoma overdiagnosis for 2017 and 2021 compared to 2004. We used data from these years as 2004 was the earliest year for which Australian national data on MIS incidence were available, while the ACD reports actual melanoma incidence in 2017 and projections until 2021.[13] The ACD includes primary cancer diagnoses only, and not recurrent cancer, consistent with international standards.[16]

We made the conservative assumption that there was no melanoma overdiagnosis in 2004, which is likely to underestimate overdiagnosis in future years. We assume there were no important changes in melanoma risk factors which would have changed the true age-specific incidence of MIS or stage IA melanoma over time, and that early detection activities were established for some years before the index year.[12] These assumptions may underestimate or overestimate overdiagnosis in future years.

We used two methods to calculate lifetime risk. The first method summed the estimated probabilities of a new melanoma diagnosis for each 5-year age group, adjusted for the competing risk of dying from other causes ('competing mortality' method). By including cancer and all-cause mortality rates, the competing mortality method calculates the rate of cancer deaths per person-years alive at a particular age, given the rate of non-cancer deaths per person-years alive at that same age.[17] This method estimates lifetime risk using the statistical methods described by Fay and colleagues within the Devcan 6.7.6 software of the United States National Cancer Institute (https://surveillance.cancer.gov/devcan).[17]

The second method also adjusts for competing mortality across age groups, further adjusting for the possibility of having multiple cancer diagnoses over time ('adjusted for multiple primaries' method).[18] This method assumes that the risk of developing a new primary cancer diagnosis is the same regardless of whether the person has had a previous diagnosis, essentially adjusting cancer incidence data to only consider the risk of the first diagnosis. The lifetime risk calculator used for this method was sourced from the Cancer Research UK website (https://www.cancerresearchuk.org/health-professional/cancer-statistics/cancer-stats-explained/our-calculations-explained#ref).

To account for changes in mortality between 2004 and index (2017 or 2021) years, we applied the relevant index year mortality distribution (melanoma-specific and all-cause mortality data) to the 2004 melanoma incidence data, increasing the estimated lifetime risk of a melanoma diagnosis to reflect the general increase in longevity between 2004 and 2017 or 2021.[12]

Estimating the magnitude of melanoma overdiagnosis

To estimate the number of overdiagnosed MIS or thin invasive melanomas we used the lifetime risk estimates described above. Thin invasive melanomas were defined as stage IA melanomas, classified according to the American Joint Committee on Cancer 8th guidelines for staging.[19] We multiplied the percentage of melanomas estimated to be overdiagnosed using either the competing mortality or adjusted for multiple primaries method for lifetime risk, by the incidence of melanoma reported that year. We calculated the percentage of overdiagnosed melanomas as:

$$100*(P^{2021/2017} - P^{2004}) / P^{2021/2017}$$

where P^{y} = lifetime risk of MIS or thin invasive melanoma diagnosis in year Y.

We then multiplied the proportion of overdiagnosed melanoma by the number of incident melanoma diagnoses reported for that year.

To quantify the number of thin invasive melanoma overdiagnosed, we first calculated the lifetime risk of being diagnosed with invasive melanoma (all stages) using both the 'competing mortality' and 'adjusted for multiple primaries' methods. We calculated these values for all stages of invasive melanomas because the ACD data do not stratify melanoma incidence or mortality by stage.[13] We used these lifetime risk values to estimate the proportion of invasive melanomas (all stages) that may be overdiagnosed. We then multiplied that proportion by the proportion we expect to be stage IA melanomas for females and males respectively (61% of all invasive melanomas for females, 56.5% for males) as reported by the Victorian Cancer Registry in 2022. The Victorian Cancer Registry data was considered the most comprehensive data on melanoma stage given that stage data is not routinely collected in Australian cancer registries.

Cost analyses

MIS and thin invasive melanoma are typically treated privately by community-based general practitioners and dermatologists in Australia.[20] These services are funded by the Medicare Benefits Schedule and include doctor visits, biopsy, pathology and excisions (Supplementary Table 1). The costs covered in this analysis include the contributions from Medicare for providing these services. We do not quantify hospital costs, out-of-pocket expenses incurred by patients including transportation or lost income, nor incidental health care expenses like antibiotics for infected excision sites. The financial burden of overdiagnosis measured in this study is quantified using costs incurred through out of hospital care by primary care practitioners and specialists, including biopsies, excisions, pathology, but not including in-patient hospital costs. As such, we cover only the minimum costs to the government for overdiagnosed melanoma, as opposed to all costs. The annual melanoma unit costs, which were assumed to be the same for MIS and thin invasive melanomas,[21] were multiplied by the number of overdiagnosed cases to derive the cost of overdiagnosis in the year after diagnosis. The total annual direct cost per melanoma case was $891.90 in 2023 Australian dollars.

Sensitivity analyses

We repeated our analyses using the estimated proportion of overdiagnosed cases from within a Queensland cohort of confirmed melanoma cases.[6] We also analysed the impact of adjusting the proportion of melanomas estimated to be thin invasive (0.61 or 0.565) by +/- 10%

(0.549 and 0.671 for females, 0.509 and 0.622 for males) on the magnitude and cost of overdiagnosis.

This negligible risk study was exempt from formal ethics review because we analysed publicly available, non-identifiable aggregated data.

Results

Melanoma in situ

Using the competing mortality method, 70% of MIS were estimated to be overdiagnosed in 2017 for both men and women, increasing to 75% or more in 2021. The percentage of overdiagnosed MIS was slightly lower using the adjusted for multiple primaries method, 67% of MIS for women and men in 2017, rising to above 70% in 2021 (Table 1).

Depending on method used, the total number of overdiagnosed MIS ranged between 14,685 (95%CI: 14,448 – 14,923) and 15,343 (95%CI: 15,100 – 15,585) in 2017, rising to between 19,829 (95%CI: 19,553 – 20,105) and 20,811 (95%CI: 20,258 – 21,094) in 2021. The number of overdiagnosed MIS was always higher for men than women (Table 2).

The estimated costs to the Australian healthcare system for overdiagnosed MIS ranged between $13.1 million (95%CI: $12.9 – 13.3 million) and $13.7 million (95%CI: $13.5 – 13.9 million) in 2017, increasing to between $17.7 million (95%CI: $17.4 – 17.9 million) and $18.6 million (95%CI: $18.3 – 18.8 million) in 2021 (Table 3).

Invasive melanoma

The percentage of invasive melanomas (all stages) estimated to be overdiagnosed ranged from 22% (females in 2017) to 34% (males, competing mortality method) in 2021. The competing mortality method resulted in estimates that were 6% higher for men in both 2017 and 2021 compared with the adjusted for multiple primaries method (Table 1), while estimates were the same for women across both methods (22% in 2017 and 29% in 2021).

The number of thin invasive melanomas estimated to be overdiagnosed ranged between 1,970 (95%CI: 1,883 – 2,057) and 2,269 (95%CI: 2,176 – 2,363) in 2017, rising to between 2,831 (95%CI: 2,726 – 2,935) and 3,168 (95%CI: 3,058 – 3,279) in 2021 (Table 2). Associated healthcare costs were between $1.8 million (95%CI: $1.7 – 1.8 million) and $2.0 million

(95%CI: 1.9 – 2.1 million) in 2017, increasing to between $2.5 million (95%CI: $2.4 – 2.6 million) and $2.8 million (95%CI: $2.7 – 2.9 million) in 2021 (Table 3).

Combined MIS and thin invasive melanoma

The estimated total number of overdiagnosed melanoma ranged between 16,655 (95%CI: 16,400 – 16,911) and 17,612 (95%CI: 17,350 – 17,875) in 2017, rising to between 22,660 (95%CI: 22,361 – 22,958) and 23,979 (95%CI: 23,673 – 24,286) in 2021. Associated healthcare costs for overdiagnosed melanoma were between $14,854,996 (95%CI: $14,847,365 – 14,862,627) and $15,708,442 (95%CI: $15,700,594 – 15,716,289) in 2017, increasing to between $20,210,017 (95%CI: $20,201,116 – 20,218,918) and $21,387,209 (95%CI: $21,378,052 – 21,396,366) in 2021.

Sensitivity analysis

Whiteman et al. (2022) estimated that 45% of detected MIS may be overdiagnosed (HR = 1.45, 95%CI = 1.09 – 1.92).[6] Even with this conservative estimate, this would equate to more than 12,000 overdiagnosed MIS in 2021, costing over $11 million (Supplementary Table 4). Whiteman et al. (2022) did not separate their estimates for overdiagnosed invasive melanomas by stage, finding non-significant results for their estimation of overdiagnosed invasive melanomas (HR = 1.05, 95%CI = 0.72 – 1.54), so we did not run sensitivity analyses for thin invasive melanomas.

After adjusting the proportion of thin invasive melanomas (±10%), the number estimated to be overdiagnosed ranged between 2,549 (95%CI: 2,450 – 2,648) and 3,487 (95%CI: 3,371 – 3,603) in 2021, with associated costs of between $2,273,323 (95%CI: $2,185,067 – 2,361,579) and $3,109,977 (95%CI: $3,006,750 – 3,213,204) (Supplementary Tables 5 and 6).

Discussion

We provide updated 2021 estimates of overdiagnosed early stage melanomas and their associated costs to the healthcare system. In summary, approximately 22,600 – 24,000 melanomas may have been unnecessarily diagnosed and treated in that year, with a total cost of $20.2 - $21.4 million. We found that the number of overdiagnosed melanomas increased from 2017 to 2021, indicating this is a growing problem in Australia.

The increasing number of overdiagnosed melanomas, particularly MIS, aligns with the rising incidence rates for these types of melanomas,[11] which likely reflects the high levels of opportunistic screening in the population.[22] Population-level interventions to reduce melanoma overdiagnosis may include a more targeted approach to melanoma early detection activities, with greater focus on individuals considered high risk and less for individuals considered low risk. This approach has been shown to be cost effective in breast cancer.[23] No data are yet available to support or refute this premise for melanoma screening. Additionally, some observers have advocated more stringent wait and watch approaches to excising lesions suspicious of melanoma and the potential re-labelling of MIS as a non-cancerous lesion may help reduce melanoma overdiagnosis.[24] Further research is required to assess the influence of these population-level interventions on melanoma overdiagnosis.

The high associated costs of overdiagnosis, primarily driven by MIS, contribute to a relatively high cost burden from unnecessary healthcare and inefficiency in healthcare provision. Health system efficiency is a major priority for policy makers in the face of increasing health system expenditure, with wastage of health care resources a key driver of inefficiency.[25] This inefficiency and associated opportunity costs are amplified given that general practitioners, who would manage the majority of these early stage melanomas, report high workloads and significant burn-out.[26] Redirecting costs incurred for overdiagnosis to fund skin cancer prevention programs aiming to reduce incidence might be a more cost effective use of government resources.[27,28] The Cancer Council Australia estimated that investing $20 million per year over three years could finance a multi-media sun protection awareness campaign with sufficient impact to reduce the social and economic costs related of skin cancer.[28]

Arguably, the costs of overdiagnosis are a necessary expenditure for the beneficial early detection of clinically aggressive melanomas. Excision of such lesions may prevent progression to advanced disease and death, as well as the high costs of treatments for advanced stage melanoma.[11,12] However, there are now multiple lines of evidence that MIS is not an obligate precursor of invasive melanoma.[2,11,29] Indeed, people with a MIS diagnosis appear to have an overall life expectancy longer than people in the general population.[30] Thin invasive melanomas that lack vertical growth, may also lack capacity for metastasis.[29] The magnitude and cost of melanoma overdiagnosis reported here is concerning. Being diagnosed and managed for MIS or thin invasive melanoma may contribute to ongoing medically unnecessary procedures at

significant costs to individuals and healthcare systems, opportunity costs in terms of clinician and patient time and physical harms to patients including cosmetic scarring, functional impairment and infection.[2,6,7] Additionally, being diagnosed with melanoma and labelled as someone with cancer may cause significant sociopsychological harms. For example, patient anxiety can adversely affect daily living and quality of life, including an increased fear of unavoidable sunburn and sun exposure, fear of recurrence and increasing thoughts about death.[31] There is a trade-off between too many overdiagnosed lesions versus too many missed progressive melanomas, and finding a 'balance' between these outcomes will contribute to a more effective and efficient healthcare system.

Significant challenges in the reliable detection of lesions that do and do not have malignant potential remain and such uncertainty means clinicians must continue to err on the side of caution in the fear of missing a potentially cancerous lesion.[32] Recent technological advancements such as 3D total body photography and artificial intelligence may, in the future, lead to reductions in excisions and overdiagnosis as clinicians are more able to monitor lesions clinically.[33] However, these technologies also have the potential to increase sensitivity to detect any change in a lesion, which in turn could increase overdiagnosis.[2,34] Further research on the impact of advanced technologies on melanoma overdiagnosis is required.

Strengths and limitations

We used multiple statistical methods with the most up-to-date cancer incidence data, together with sensitivity analyses, to provide a comprehensive, robust, and contemporary estimate of melanoma overdiagnosis in Australia and the first estimates of associated healthcare costs in this population. As we used aggregate-level data to estimate overdiagnosis at a national level, our lifetime risk calculations did not factor in an individual's inherent melanoma risk. We also could not compare melanoma incidence among people exposed or unexposed to melanoma screening, which would have an impact on the detection of suspicious lesions.[6] However, there have been no screening trials for melanoma, as there have been for other major cancers, so robust evidence on the impact of screening is limited. Although melanoma incidence differs by age, we did not estimate the magnitude of melanoma overdiagnosis in different age groups and this could be explored in future research.

Our estimates are likely to be conservative both in terms of numbers of overdiagnosed melanoma, and associated costs. We have likely underestimated the incidence of overdiagnosed melanoma, as it is probable that overdiagnosis was occurring before 2004.[35] National data on MIS are not available prior to that year, so we used published reports of MIS incidence from Queensland and Victoria extending back to the mid-1980s.[36,37] We extrapolated those estimates to the national population to estimate the lifetime risk for MIS in 1982, similar to other national-level cancer overdiagnosis estimates.[9] Based on those data, we estimate up to 97-98% of people with MIS were overdiagnosed in 2021, equating to nearly 27,000 overdiagnosed MIS (see Supplementary file). While we consider these estimates based on earlier data less robust, they provide an indication that melanoma overdiagnosis was likely present in 2004.

Changes in certain risk factors for melanoma over time that may have influenced true age-specific incidence (e.g. primary and secondary prevention measures to reduce ultraviolet exposure) were not accounted for in our analyses, with additional data and modelling required to adjust for temporal changes in risk factors.[12] The introduction of more advanced technologies (e.g., 3D total body photography) may have increased melanoma detection rates in more recent years compared with previous years. If these technologies contributed to beneficial detection of clinically significant melanoma, the use of cross-sectional data may have overestimated the magnitude of melanoma overdiagnosis. We did not quantify overdiagnosis of invasive melanoma that is substage IB or higher as evidence suggests that MIS and thin invasive melanoma are most likely to be overdiagnosed.[6,9,10]

We excluded potential increased healthcare use arising from management-based complications and anxiety around the diagnosis of melanoma, as well as only including services in the first 12 months following a diagnosis. Australian melanoma patients may incur relatively high out-of-pocket costs, primarily driven by costs of hospital admissions.[38] As many of these patients enter long term clinical surveillance following melanoma treatment,[39] and we covered only the minimum costs to the government and no out-of-pocket costs to the individual, the true costs of melanoma overdiagnosis are likely to be substantially larger than what we estimated.

Conclusions

Melanoma overdiagnosis represents not only a growing clinical and public health problem in Australia, but is associated with a significant economic burden. The main driver of the

overdiagnosis burden stems from the detection of MIS, with population-level interventions required to minimise the harms of overdiagnosis and ensure efficient healthcare delivery.

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Table 1. Estimated percentage of melanoma *in situ* and invasive melanoma that are overdiagnosed, stratified by sex and year

Melanoma type	Method of calculation	Female		Male	
		2017*	2021**	2017*	2021**
In situ	Competing mortality	70%	76%	70%	75%
	Adjusted for multiple primaries	67%	73%	67%	71%
Invasive	Competing mortality	22%	29%	29%	34%
	Adjusted for multiple primaries	22%	29%	23%	28%

Note: The relevant incidence and lifetime risk values for MIS and invasive melanoma are shown in Supplementary Tables 2 and 3. 2004 was used as the indicator year for all calculations.

*2004 values adjusted for 2017 mortality distribution. **2004 values adjusted for 2021 mortality distribution.

Table 2. Estimated number (95% CI) of overdiagnosed melanoma *in situ* and invasive melanoma (stage IA), stratified by sex and year

Melanoma type	Method of calculation	Female		Male		Total	
		2017	2021	2017	2021	2017	2021
In situ	Competing mortality	6,882 (6,719 – 7,044)	9,277 (9,089 – 9,466)	8,461 (8,281 – 8,641)	11,534 (11,323 – 11,744)	15,343 (15,100 – 15,585)	20,811 (20,528 – 21,094)
	Adjusted for multiple primaries	6,587 (6,428 – 6,746)	8,911 (8,726 – 9,096)	8,098 (7,922 – 8,275)	10,918 (10,714 – 11,233)	14,685 (14,448 – 14,923)	19,829 (19,553 – 20,105)
Invasive	Competing mortality	824 (767 – 880)	1,254 (1,185 – 1,324)	1,446 (1,371 – 1,520)	1,914 (1,828 – 2,000)	2,269 (2,176 – 2,363)	3,168 (3,058 – 3,279)
	Adjusted for multiple primaries	824 (767 – 880)	1,254 (1,185 – 1,324)	1,147 (1,081 – 1,213)	1,576 (1,499 – 1,654)	1,970 (1,883 – 2,057)	2,831 (2,726 – 2,935)

Competing mortality = melanoma incidence in the index year of interest (2021 or 2017) multiplied by the % of melanoma cases estimated to be overdiagnosed (lifetime risk calculated using the competing mortality method). For the invasive melanoma calculation, this value was multiplied by 0.61 for females or 0.565 for males to indicate the proportion of all invasive melanomas that were Stage IA. Adjusted for multiple primaries = same method as above but lifetime risk was calculated using the adjusted for multiple primaries method.95% confidence intervals were calculated by multiplying the square root of the estimated number of overdiagnosed melanoma by 1.96, then adding or subtracting that value from the estimated number of overdiagnosed melanoma.

Table 3. Estimated cost (AU$) (95% CI) of overdiagnosed melanoma *in situ* and invasive melanoma (stage IA), stratified by sex and year

Melanoma type	Method of calculation	Female		Male		Total	
		2017	2021	2017	2021	2017	2021
In situ	Competing mortality	$6,138,056 ($5,992,676 – 6,282,544)	$8,274,156 ($8,106,479 – 8,442,725)	$7,546,366 ($7,385,824 – 7,706,908)	$10,287,175 ($10,098,984 – 10,474,474)	$13,684,422 ($13,467,690 – 13,900,262)	$18,561,331 ($18,308,923 – 18,813,739)
	Adjusted for multiple primaries	$4,998,208 ($4,867,098 – 5,128,425)	$7,947,721 ($7,782,719 – 8,112,722)	$7,977,154 ($7,812,152 – 8,143,047)	$9,737,764 ($9,555,817 – 10,018,713)	$13,097,552 ($12,886,171 – 13,309,824)	$17,685,485 ($17,439,321 – 17,931,650)
Invasive	Competing mortality	$734,480 ($684,314 – 784,645)	$1,118,585 (1,056,677 – 1,180,494)	$1,289,540 ($1,223,069 – 1,356,011)	$1,707,293 ($1,630,809 – 1,783,776)	$2,024,020 ($1,940,744 – 2,107,296)	$2,825,878 ($2,727,479 – 2,924,277)
	Adjusted for multiple primaries	$734,480 ($684,314 – 784,645)	$1,118,585 (1,056,677 – 1,180,494)	$1,022,965 ($963,762 – 1,082,168)	$1,405,947 ($1,336,540 – 1,475,353)	$1,757,444 ($1,679,846 – 1,835,043)	$2,524,532 ($2,431,527 – 2,617,537)

Competing mortality = melanoma incidence in the index year of interest (2021 or 2017) multiplied by the % of melanoma cases estimated to be overdiagnosed (lifetime risk calculated using the competing mortality method). For the invasive melanoma calculation, this value was multiplied by 0.61 for females or 0.565 for males to indicate the proportion of all invasive melanomas that were Stage IA. Adjusted for multiple primaries = same method as above but lifetime risk was calculated using the adjusted for multiple primaries method. 95% confidence intervals were calculated by multiplying the square root of the estimated cost of overdiagnosed melanoma by 1.96, then adding or subtracting that value from the estimated cost of overdiagnosed melanomas.