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**ORIGINAL ARTICLE** MELANOMA AND SKIN CANCER

# Clinical and demographic factors influencing excision completeness in 15,000 skin cancers in South Australia: a retrospective study

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## Abstract

**Introduction:** Skin cancer is the most prevalent cancer in Australia. Known challenges affecting rural populations include delayed diagnosis, limited access to healthcare and increased burden of disease. We investigated the outcomes of skin cancer excisions, focusing on excision completeness, between rural and metropolitan patients.

**Methods:** We conducted a retrospective cohort study of melanoma and keratinocyte skin cancer excisions from August 2003 to November 2023, from a prospectively entered database. We identified 26,064 skin lesions excised in theatre. The primary outcome was the rate of incomplete excisions, defined by an involved histopathologic margin. Secondary objectives included assessing demographic and clinical factors influencing the rate of complete excisions.

**Results:** The study included 14,996 specimens from 5522 patients. Keratinocyte-based cancers made up 96.3 per cent of specimens and in 13.0 per cent of excisions, patients lived in a rural postcode. Rural patients were 34 per cent more likely to have an incomplete excision of keratinocyte skin cancers compared with metropolitan patients (OR = 1.34, $p < 0.0001$). Key factors associated with incomplete excisions included renal transplant recipients, younger age, head and neck location, and female sex. Notably, renal transplant recipients had a markedly lower risk of incomplete excision (OR = 27.6, $p < 0.05$). We found excisions in the head and neck region were significantly more prone to incompleteness, likely due to anatomical challenges and cosmetic concerns. The overall incomplete excision rate at our centre was 8.1 per cent.

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**Conclusion:** These findings demonstrate the increased risks faced by rural populations, highlighting the need for tailored surgical approaches and vigilant follow-up. Clinicians should be aware of these clinical and demographic factors and consider adjusting excision margins to reduce rates of incomplete excision.

## Introduction

Skin cancer is the most common cancer diagnosis in Australia[1] and it will affect two out of three Australians in their lifetime.[1] Annually, 1455 Australians die from melanoma and 765 from keratinocyte cancers.[1] Complete surgical excision, where possible, remains the gold standard treatment for both types of skin cancer.[2,3] Incomplete excision is associated with a higher risk of recurrence, metastasis and mortality.[4] Delays in diagnosis and treatment are responsible for tumour progression, a greater likelihood of incomplete excision and overall worse outcomes.[5]

Australia proudly hosts a uniquely large rural population and 28 per cent of Australians live in rural or remote settings.[6] Many studies demonstrate the rural disadvantage: that patients in these communities face great difficulties accessing health services, have poorer health literacy and worse health outcomes overall.[6,7] In line with this, it is the anecdotal experience of many surgeons that rural and remote patients present with a greater skin cancer burden and more advanced tumours at presentation. Several studies support these findings.[8–10]

We sought to investigate the population-level differences in skin cancer excisions between rural and metropolitan patients. Completeness of excision was thought to be a proxy of disease burden and tumour progression. A secondary aim was to assess other demographic and patient factors that confer risk of incomplete skin cancer excision. To our knowledge this is the largest dataset in the literature attempting to address these key questions.

## Methods

This study retrospectively reviewed 26,064 elective skin excisions in 5522 patients (of which 14,996 excisions were included), from August 2003 to November 2023, at the Plastic and Reconstructive Surgery Department in The Queen Elizabeth Hospital, Adelaide, South Australia. Referral basins are statewide including rural and remote patients. Cohort demographics and histopathology results were retrieved from the department's skin cancer database, which is prospectively updated and maintained. All data was de-identified and securely stored in compliance with local guidelines. This research was conducted in accordance with the ethical standards of the Central Adelaide Local Health Network (CALHN) Human Research Ethics Committee, which classified the study as an audit not requiring ethics approval. Publication endorsement was subsequently granted by CALHN before submission (CALHN Reference Number: 22134).

### Data collection

Patient and lesion-specific data were collected for this study. Patient demographics reviewed included age, sex, postcode, operation type, Indigenous background and prior history of renal transplant. Lesion factors included histopathological type, location on body and excision status (complete or incomplete). Histopathologic type was defined as keratinocyte skin cancers (basal cell carcinoma, BCC and squamous cell carcinoma, SCC) or non-keratinocyte skin cancer (melanoma). Other rare types of cutaneous malignancies were not included in this study. Postcodes were defined as either metropolitan or rural according to the Modified Monash Model.[11] Incomplete excision was defined as an involved margin by histopathologic analysis. If patients underwent excision of multiple lesions in a single theatre session, each lesion was analysed individually. Incisional biopsies were excluded from analysis. Excisions that yielded non-malignant histopathology were excluded from analysis, however, re-excisions or wide local excisions of proven malignancy were included.

### Statistical methods

Data analysis was performed by a senior statistician. Frequencies and percentages for categorical variables and mean or median analysis for continuous variables are provided in **Table 1**. Contingency tables for melanoma and keratinocyte malignancy datasets are presented in **Table 1** and **Table 2,** comparing age, sex, side of body, body part, Indigenous status and rurality.

Univariate binary logistic generalised estimating equation (GEE) models are performed for targeted outcomes for melanoma and keratinocyte malignancy datasets separately. Clustering on patients was adjusted for. For each

**Table 1. Cohort demographics for included keratinocyte and melanoma excisions at our centre over a 20-year period**

| Variable | Total (%) | Metropolitan (%) | Rural (%) | *p*-value |
|---|---|---|---|---|
| Skin excisions | 14,996 | 13,040 (87.0) | 1956 (13.0) | |
| **Cancer type** | | | | |
| Keratinocyte (SCC/BCC) | 14,440 (96.3) | 12,581 (96.5) | 1859 (95.0) | 0.0017 |
| Melanoma | 556 (3.7) | 459 (3.5) | 97 (5.0) | |
| **Age** | | | | |
| Mean age (years) | 73.29 (SD 13.68) | 73.73 (SD 13.67) | 70.36 (SD 13.35) | < 0.0001 |
| < 65 years | 4000 (26.7) | 3348 (25.7) | 652 (33.3) | < 0.0001 |
| 65–74 years | 3298 (22.0) | 2718 (20.8) | 580 (29.7) | |
| 75–84 years | 4463 (29.8) | 4053 (31.1) | 410 (21.0) | |
| ≥ 85 years | 3235 (21.6) | 2921 (22.4) | 314 (16.1) | |
| **Sex** | | | | |
| Female | 5387 (35.9) | 4786 (36.7) | 601 (30.7) | < 0.0001 |
| Male | 9609 (64.1) | 8254 (63.3) | 1355 (69.3) | |
| **Excision status** | | | | |
| Complete | 13,788 (91.9) | 12,055 (92.4) | 1733 (88.6) | < 0.0001 |
| Incomplete | 1208 (8.1) | 985 (7.6) | 223 (11.4) | |
| **Indigenous background** | | | | |
| Aboriginal and/or Torres Strait Islander | 48 (0.3) | 42 (0.3) | 6 (0.3) | 0.7207 |
| Not Aboriginal or Torres Strait Islander | 14,948 (99.7) | 12,998 (99.7) | 1950 (99.7) | |
| **Prior renal transplant** | | | | |
| Yes | 1129 (7.5) | 927 (7.1) | 202 (10.3) | < 0.0001 |
| No | 13,867 (92.5) | 12,113 (92.9) | 1754 (89.7) | |

dataset, an initial multivariable binary GEE model was performed including all predictors with *p*-value < 0.2 on univariate regression. Backwards elimination was performed until all predictors had a *p*-value ≤ 0.05. Odds ratio, 95% confidence interval (CI) and global *p*-value are calculated for each model. A binary logistic GEE model was also performed for complete status versus malignancy type. The statistical software used was SAS On Demand for Academics (SAS Institute Inc, 2021). A *p*-value ≤ 0.05 is considered statistically significant.

## Results

A total of 14,996 excision specimens from 5522 patients were included for analysis (**Table 1**). Keratinocyte malignancies contributed to 96.3 per cent of excisions and melanomas constituted the remaining 3.7 per cent. Melanoma excision numbers were similar for males (53%) and females (47%). Regarding keratinocyte cancers, a greater proportion of males had keratinocyte cancers excised than females (65% versus 35%). In 13.0 per cent of excisions, patients were from rural settings and in 0.3 per cent of excisions, patients were of Aboriginal or Torres Strait Islander descent. Renal transplant patients contributed to 7.5 per cent of all skin cancer excisions. Overall, our cohort had an 8.1 per cent incomplete excision rate, defined as an involved histopathologic margin.

### Primary outcome: rural vs metropolitan incomplete excisions

For keratinocyte skin cancers, there were 1150 (8.0%) incomplete excisions. Rural patients were 34 per cent more likely to have an incomplete excision than metropolitan patients (OR 1.34, 95% CI 1.2–1.46, $p < 0.0001$). For melanoma specimens, there were 58 (10.4%) incomplete excisions with no statistically significant difference between rural and metropolitan patients.

## Secondary outcomes

### Rural cohort comparisons

The rural keratinocyte cohort were a statistically younger cohort compared with the metropolitan cohort (33.3% vs 25.7% aged < 65 years, $p < 0.0001$) and renal transplant recipients were more likely to live in rural postcodes, compared to their non-transplant counterparts ($p < 0.0001$).

### Renal transplant recipients

Renal transplant patients contributed 7.5 per cent of our cohort. Compared with patients without a renal transplant, the transplant cohort were 27.6 times less likely to have an incomplete excision of a keratinocyte skin cancer (OR = 27.6, 95% CI 3.2–240.8, $p < 0.05$). Transplant patients were also more likely to have cancers outside the head and neck region than their non-transplant counterparts (48.1% vs 68.4%, $p < 0.0001$). Furthermore, transplant patients were also statistically younger than the non-transplant cohort (60.0% vs 23.9% aged < 65 years, $p < 0.0001$).

### Anatomic site

Skin cancers in the head and neck are associated with a higher risk of incomplete excision (**Table 2**). Keratinocyte skin cancer excisions on the head and neck have odds of incomplete excision 4.55 times that of lesions on the back (OR = 4.55, 95% CI 2.86–7.14, $p < 0.0001$), 3.55 times that of the lower limbs (OR = 3.55, 95% CI 2.59–4.85, $p < 0.0001$), 3.43 times that of the trunk (OR = 3.43, 95% CI 1.93–6.06, $p < 0.0001$) and 3.08 times that of the upper limbs (OR = 3.08, 95% CI 2.23–4.24, $p < 0.0001$). Keratinocyte skin cancer excisions on the head and neck were 1.9 times more likely to be incompletely excised (OR = 1.87, 95% CI 1.47–2.24, $p < 0.0001$). There were no statistically significant associations between rural and metropolitan cohorts, and anatomic site.

### Sex

Female patients were more likely to have an incomplete keratinocyte skin cancer excision than male patients (OR = 1.14, 95% CI 0.99–1.27). This result approached significance ($p = 0.074$). Rural patients were significantly less likely to be female compared to metropolitan patients (30.7% vs 36.7%, $p < 0.0001$)

### Multiple excisions

If a patient underwent multiple excisions during the study period, they had a high risk of an incomplete excision. This was true whether the excisions were performed simultaneously or at different theatre sessions.

For a patient with an excised melanoma, each additional excision increased the risk of an incomplete excision by 5 per cent (OR = 1.05, 95% CI 1.03–1.08, $p < 0.0001$). For keratinocyte skin cancers, adjusting for renal transplant, the risk is the same at 5 per cent (OR = 1.05, 95% CI 1.03–1.08, $p < 0.0001$).

## Discussion

A significant proportion of Australians live in rural and remote settings. Rural patients face significant disadvantages including reduced access to care, delay in presentation and overall greater mortality at a younger age.[7,12] It is known that patients from rural settings have higher rates of skin cancers on the face and a 60 per cent greater mortality than the general population from skin cancers specifically.[13] Rural patients also have a higher degree of sun exposure;[13] farmers, for example,

**Table 2. Lesion locations and laterality for keratinocyte and melanoma patients**

| Variable | Total (%) | Metropolitan (%) | Rural (%) | *p*-value |
|---|---|---|---|---|
| **Body part** | | | | |
| Back | 895 (6.0) | 773 (5.9) | 122 (6.2) | 0.7345 |
| Trunk | 433 (2.9) | 374 (2.9) | 59 (3.0) | |
| Head and neck | 9910 (66.1) | 8624 (66.0) | 1286 (65.7) | |
| Upper limb | 1950 (13.0) | 1708 (13.1) | 242 (12.4) | |
| Lower limb | 1808 (12.1) | 1561 (12.0) | 247 (12.5) | |
| **Side** | | | | |
| Left | 6137 (40.9) | 5348 (41.0) | 789 (40.3) | 0.597 |
| Right | 6082 (40.6) | 5264 (40.4) | 818 (41.8) | |
| Midline | 2777 (18.5) | 2428 (18.6) | 349 (12.6) | |

have three to eight times more ultraviolet (UV) exposure than indoor workers.[14] The anecdotal experience of many senior surgeons in our unit was that rural patients presented with a higher skin cancer burden and more advanced pathology. This study primarily looked at incomplete excision rates as a proxy for higher risk of such tumours.

We show that rural patients have a significantly higher rate of incomplete keratinocyte excision. Rural patients are also significantly more likely to be younger at presentation and to be renal transplant recipients, demonstrating that this population are more comorbid at baseline compared to metropolitan patients and have more risk factors for incomplete excisions. Our study identified several other risk factors for incomplete excisions, including head and neck location, female sex and a history of multiple excisions.

In our study, skin cancers in the head and neck region (in particular the face) showed a higher risk of incomplete excision. This is well recognised in the literature and we agree it is likely related to cosmetic concerns, as well as functional factors, such as larger tumour size, greater depth of invasion and challenging anatomy (eg, inner canthus or nose).[15,16] Cosmetic concerns may also explain why we showed that incomplete keratinocyte excision rates are higher in females. Hansen and colleagues also showed that females had a 28 per cent increased risk of incomplete excision of BCC compared with males,[15] which may be attributed to cosmetic concerns, however the broader literature is conflicting, and other studies have not replicated differences between males and females.[17,18] To help achieve balanced margins that are oncologically safe without excessive resection in these challenging anatomic and cosmetically sensitive locations, the input and experience of more senior surgeons is helpful. Good lighting and magnification should also be considered.[19,20]

In the melanoma cohort, we show that the need for multiple excisions increased the risk of incomplete excision by 5 per cent. This is true whether the excisions occurred concurrently or at separate theatre times. We also show that multiple excisions increased the risk of incomplete excisions in keratinocyte skin cancers, although this is not clinically significant and we demonstrate a 0.4 per cent increased risk. There are several hypotheses for this outcome. It may be because multiple excisions indicate patients with recurrence, satellite or metastatic disease, or in whom subclinical extension is difficult to perceive with the naked eye.[21] It may reflect patients who have higher cumulative UV exposure and thus are at greater risk of developing multiple melanomas, perhaps of subtypes that are more challenging to excise (eg, lentigo maligna melanoma).[12]

Interestingly we found that a keratinocyte malignancy was 27 times less likely to be incompletely excised if the patient had a history of renal transplant. These transplant patients are also younger and more likely to have skin cancers outside the head and neck region than non-transplant recipients. Immune suppression is a known risk factor for aggressive keratinocyte malignancy and we suspect these patients were appropriately treated more aggressively because of their demographics, irrespective of location or age. Similarly our study found no difference in rates of incomplete excisions for melanoma patients, rural or metropolitan. We hypothesise this is because melanomas are treated with more rigid protocols that ensure standardised minimum margins and thus similar excision rates. We would advocate for more aggressive surgical management of keratinocyte-based malignancies in patients with high-risk demographic factors. This involves earlier surgery, with wider margins.

A limitation of our study is that we did not directly compare histological characteristics between rural and metropolitan excision specimens. We have identified rural status as a proxy for patients who are more comorbid, with more risk factors for incomplete excision, rather than a reflection of different tumour characteristics and behaviour. Our focus is on the under-explored clinical and demographic factors, which we believe offer important insights for surgeons treating skin cancer in metropolitan and rural Australian settings.

## Conclusion

Some 15,000 skin cancer excisions were assessed to demonstrate that rural patients are at higher risk for incomplete excision of keratinocyte skin cancers. Rural patients are also younger at presentation, more likely to be transplant recipients and show patterns of skin cancer that reflect greater UV exposure. We demonstrate additional demographic risk factors of incomplete excision, including head and neck site, female sex and patients with a history of or requiring multiple excisions. Thus, when treating rural patients, or patients with high-risk demographic factors, clinicians should consider taking wider margins, increased screening and shorter follow-up, where clinically appropriate.

## Data sharing

The data that support the findings of this study are available from the corresponding author, GD, upon reasonable request.

## Conflict of interest

The authors have no conflicts of interest to disclose.

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