Keratinocyte carcinomas, area-level socioeconomic status and geographic remoteness in Tasmania: cross-sectional associations and temporal trends

Author

Ragaini, Bruna S, Blizzard, Leigh, Baade, Peter, Venn, Alison

Downloaded from

http://hdl.handle.net/10072/428269

Griffith Research Online

https://research-repository.griffith.edu.au

Keratinocyte carcinomas, area-level socioeconomic status and geographic remoteness in Tasmania: cross-sectional associations and temporal trends

Bruna S. Ragaini,[1] [iD] Leigh Blizzard,[1] Peter Baade,[2] [iD] Alison Venn[1]*[iD]

[1]Menzies Institute for Medical Research, University of Tasmania, Hobart, Australia
[2]Cancer Council Queensland, Brisbane, Australia

Abstract

Objective: This article aims to examine cross-sectional associations and assess temporal trends in keratinocyte carcinoma (KC) incidence by area-level socioeconomic status (SES) and geographic remoteness in Tasmania, Australia.

Methods: KCs—basal cell carcinoma (BCC) and cutaneous squamous cell carcinoma (SCC)—registered by the Tasmanian Cancer Registry were assigned to area-level SES and remoteness area. Incidence rate ratios (2014–2018) were estimated using Poisson regression. Average annual percentage changes (2001–2018) were estimated using the Joinpoint Regression Program.

Results: BCC incidence increased with increasing area-level advantage (p value for trend <0.001), but no trend was found for SCC. SCC incidence was higher in rural than urban areas (p value <0.001), and BCC incidence was slightly lower in rural than urban areas for males (p value = 0.026), but not for females (p value = 0.381). BCC and SCC incidence increased between 2001 and the mid-2010s, when it peaked across most areas.

Conclusions: Associations were found between BCC and higher area-level SES, and between SCC and geographic remoteness. The findings suggest differences in sun exposure behaviours, skin cancer awareness and access to services, or ascertainment bias.

Implications for public health: Efforts to control and deliver KC services in Tasmania should consider targeting populations with specific area-level characteristics.

Key words: skin cancer, basal cell carcinoma, squamous cell carcinoma, public health, cancer epidemiology

Introduction

Keratinocyte carcinomas (KCs)—comprised of basal cell carcinoma (BCC) and cutaneous squamous cell carcinoma (SCC)—are the most common cancers in fair-skinned populations, and Australia has the highest incidence in the world.[1] During 2011–2014, 3.9% of Australians had at least one KC excised.[2] These common cancers pose a substantial burden on our nation's healthcare system and on individuals, with an estimated $1.2 billion in direct and indirect costs in 2020.[3]

It is well documented that area-level socioeconomic status (SES) and geographic remoteness can influence health outcomes, including the incidence rate of cancer.[4–6] Although there are exceptions, such as melanoma, prostate cancer and breast cancer, Australians living in areas of higher socioeconomic disadvantage and in inner and outer regional areas generally have higher incidence rates than their counterparts in more advantaged or urban areas.[5,7] This has been largely explained by differences in behavioural risk factors across the socioeconomic and geographic spectrum.[5] Further, those living in more regional and remote areas tend to have poorer access to healthcare services, including screening and diagnostic services, and are generally more socioeconomically disadvantaged than those living in urban areas.[8–11]

It is unclear whether the incidence of KCs varies by area-level SES and geographic remoteness in Australia. Population-based studies conducted in Europe have consistently shown that people living in

areas of high socioeconomic advantage have the highest incidence rates of KCs,[12–19] while the evidence for variation by geographic remoteness is mixed.[14,16,20] Moreover, evidence from a population-based Dutch study suggested that, over time, KCs have changed from a disease of the socioeconomically disadvantaged to a disease of the socioeconomically advantaged.[19]

Despite the high burden of KCs, the lack of Australian studies is largely attributable to KCs not being notifiable diseases by law and, therefore, not reported by most population-based cancer registries. The Tasmanian Cancer Registry is the only one in Australia that periodically registers KCs diagnosed within its jurisdiction.

In Tasmania, the incidence rate of KCs has substantially increased since the 1980s, with almost a third of the population in 2018 estimated to be diagnosed with a KC by age 75 years.[21] Further, it has been estimated that 33% of Tasmanians with a first diagnosis experience a subsequent KC within 5 years.[22] Identifying the socioeconomic and geographic characteristics of the populations at higher risk of KCs can contribute to the development of more effective public health initiatives and promote health equity.

This study had two aims. First, to examine whether the cross-sectional associations between the person-based incidence rate of KCs, area-level SES and geographic remoteness in the Tasmanian population are consistent with what is reported internationally. Second, to assess whether the temporal trends previously reported for the whole of Tasmania varied by area-level SES and geographic remoteness.

Methods

Study design and population

This is a population-based study conducted in the Australian island state of Tasmania, which has a population of approximately 540,000 people and the oldest age distribution of any Australian state or territory.[23]

This study included registrations of histologically confirmed BCC or SCC by the Tasmanian Cancer Registry between 1 January 2001 and 31 December 2018. Details about the data, including compilation of the dataset, coding practices and quality measures, have been described previously.[21] Briefly, coding was conducted in accordance with the convention of the International Classification of Diseases for Oncology, Third Edition (ICD-O3).[24] Cancers with a skin site (C44), behaviour code 3 (malignant, primary), and morphology codes 805-808 or 809-811 were ascertained as SCCs or BCCs, respectively. Only one cancer of each histological type was registered and coded per person per year of diagnosis regardless of the site, and recurrent lesions, where stated in the pathology report, were excluded. Stage at diagnosis is seldom used for KCs, especially BCCs, and is not recorded by the Registry.

The usual residential address at each year of diagnosis for each person was coded to a Statistical Area Level 2 (SA2) according to the 2016 Australian Statistical Geography Standard (ASGS). Area-level SES and geographic remoteness information at the SA2 level were sourced from the Australian Bureau of Statistics. For area-level SES, we used the Socio-economic Indexes for Areas 2016, specifically the Index of Relative Socio-economic Advantage and Disadvantage.[25] For geographic remoteness, we used the ASGS 2016 Remoteness Structure.[26] The Index of Relative Socio-economic Advantage and Disadvantage was grouped into five categories (based on quintiles of

the Tasmanian population) and the Remoteness Structure was grouped into two categories: "urban" (i.e., "inner regional") or "rural" (i.e., "outer regional, remote and very remote"). Tasmania does not have an area categorised as a "major city."

Statistical analysis

Summary statistics (percentages and frequencies) described the characteristics of the population for categories of area-level SES and geographic remoteness for the latest 5-year study period between 1 January 2014 and 31 December 2018.

Annual person-based age-standardised incidence rates over the whole study period (2001–2018) were calculated using the Australian 2001 population.[27]

Fully adjusted Poisson regression models compared annual person-based incidence rates while controlling for area-level SES, geographic remoteness and age group. The models included the log of the population as the offset variable. Results were reported as fully adjusted incidence rate ratios (IRR) and 95% confidence intervals (CI).

Temporal trends in the annual person-based age-standardised incidence rates between 1 January 2001 and 31 December 2018 were modelled using the Joinpoint Regression Program[28] and assessed using a logarithmic transformation to estimate average annual percentage changes (AAPCs). The model of best fit was selected using the Bayesian Information Criterion and a maximum of one joinpoint was allowed in each model, since preliminary analysis including more joinpoints showed the same overall patterns but with more random fluctuation.

The test for parallelism was used to examine whether the slope in temporal trends differed between categories of area-level SES and geographic remoteness. A p value of 0.05 was considered statistically significant.

Preliminary analysis indicated that associations with area-level SES and geographic remoteness differed by histological type (p value for interaction terms <0.001). Associations with geographic remoteness further differed by sex in both BCC (p value for interaction term =0.030) and SCC models (p value for interaction term =0.002). Therefore, all results are presented in strata of sex and histological type.

Results

Characteristics of the cohort

Between 2014 and 2018, 32,828 persons (40% females) were diagnosed with BCC and 19,318 persons (40% females) were diagnosed with SCC. Of those diagnosed with BCC, 57% were aged between 60 and 79 years and 20% were aged above 80 years. Those diagnosed with SCC had an older age profile: 55% were aged between 60 and 79 years and 33% were older than 80 years.

Among the cohort diagnosed with BCC, 30% lived in the most advantaged areas and almost 70% lived in urban areas (Table 1). The cohort diagnosed with SCC was more equally distributed across socioeconomic areas (22% lived in the most advantaged areas) and 62% lived in urban areas. Distributions were similar for males and females.

Table 1: Numbers, age-standardised[a] incidence rates (ASR) and adjusted incidence rate ratios[b] (IRR) of person-based annual keratinocyte carcinomas in Tasmania by sex, histological type, area-level socioeconomic status[c] and geographic remoteness, 2014–2018.

	Basal cell carcinoma					Squamous cell carcinoma				
	n	ASR	(95% CI)	IRR	(95% CI)	n	ASR	(95% CI)	IRR	(95% CI)
Males										
Area-level socioeconomic status										
1 (most disadvantaged)	3,242	1,005	(971-1,040)	1.00	(ref)	2,187	669	(641-697)	1.00	(ref)
2	3,293	1,008	(974-1,043)	1.04	(0.99-1.09)	2,408	721	(693-750)	1.05	(0.98-1.11)
3	3,699	1,074	(1,039-1,109)	1.10	(1.05-1.16)	2,293	673	(646-701)	0.98	(0.92-1.04)
4	3,411	1,145	(1,106-1,184)	1.16	(1.10-1.21)	2,207	732	(701-762)	1.11	(1.05-1.18)
5 (most advantaged)	5,960	1,506	(1,468-1,543)	1.51	(1.44-1.58)	2,589	648	(623-672)	1.01	(0.95-1.07)
p-value for trend				**<0.001**					0.304	
Geographic remoteness										
Urban	13,274	1,241	(1,220-1,262)	1.00	(ref)	7,175	660	(645-675)	1.00	(ref)
Rural	6,331	1,020	(995-1,046)	0.96	(0.92-0.99)	4,509	728	(706-749)	1.11	(1.06-1.16)
p-value				**0.026**					**<0.001**	
Females										
Area-level socioeconomic status										
1 (most disadvantaged)	2,221	608	(582-634)	1.00	(ref)	1,552	388	(369-408)	1.00	(ref)
2	2,203	656	(628-684)	1.07	(1.00-1.14)	1,508	412	(391-433)	0.95	(0.88-1.02)
3	2,459	691	(663-719)	1.13	(1.07-1.20)	1,490	394	(374-414)	0.96	(0.89-1.03)
4	2,326	730	(700-760)	1.20	(1.13-1.27)	1,405	402	(381-423)	1.05	(0.97-1.12)
5 (most advantaged)	4,014	931	(901-960)	1.53	(1.45-1.61)	1,679	350	(333-367)	0.96	(0.90-1.03)
p-value for trend				**<0.001**					0.906	
Geographic remoteness										
Urban	9,150	761	(745-777)	1.00	(ref)	4,807	357	(347-367)	1.00	(ref)
Rural	4,073	675	(653-696)	1.02	(0.98-1.07)	2,827	446	(430-463)	1.25	(1.18-1.32)
p-value				0.381					**<0.001**	

CI: confidence intervals. Bold indicates statistically significant with p less than 0.05.
[a] 2001 Australian standard population.
[b] estimated using Poisson regression models and adjusting for area-level socioeconomic status, geographic remoteness and age group.
[c] based on quintiles of the Tasmanian population according to the Index for Relative Socioeconomic Advantage and Disadvantage.[25]

Associations with area-level socioeconomic status and geographic remoteness

For BCC, age-standardised incidence rates increased with increasing area-level socioeconomic advantage and were higher in urban than rural areas for both males and females (Table 1).

Fully adjusted IRRs for BCC increased with increasing area-level socioeconomic advantage and were just over 50% higher in the most advantaged group compared with the most disadvantaged group for both males (p value for trend <0.001) and females (p value for trend <0.001) after controlling for age group and geographic remoteness (Table 1). For males, the fully adjusted IRRs were 4% lower in rural than urban areas (p value =0.026), while for females, there was no evidence of an association with geographic remoteness after controlling for area-level SES.

The area-level socioeconomic gradient in incidence rates of BCC was more pronounced among younger age groups and generally weaker, but still statistically significant, with increasing age (p value for interaction terms <0.001 for males and females). Among those aged 0–49 years, incidence rates of BCC for the most advantaged group were 74% higher compared with the most disadvantaged group for males (p value for trend <0.001) and 110% higher for females (p value for trend <0.001) (Supplementary file 1).

For SCC, age-standardised incidence rates were higher in rural than urban areas for both males and females but distributed more evenly across socioeconomic areas (Table 1).

Fully adjusted IRRs for SCCs in rural areas were 11% higher for males (pvalue <0.001) and 25% higher for females (p value <0.001). There was no statistically significant socioeconomic gradient for SCC.

The difference in incidence rates of SCC between urban and rural areas was more pronounced among younger persons and generally decreased but remained statistically significant, as age increased (p values for interaction terms <0.001 for males and =0.001 for females). Those aged 0–49 years who lived in rural areas had adjusted incidence rates 52% higher for males (p value <0.001) and 77% higher for females (p value <0.001) than their urban counterparts (Supplementary file 2).

Temporal trends

Although several trends were different (i.e., test of parallelism rejected; Supplementary file 3), most temporal trends in the age-standardised incidence rates followed a similar pattern between 2001 and 2018, where they increased sharply until around the mid-2010s then reached a peak and plateaued or declined in more recent years (Figure 1).

Age-standardised incidence rates of SCC for males living in areas of relative disadvantage (category 2), and for males and females living in the most advantaged areas (category 5), had not yet plateaued in 2018 (Figure 1). But AAPCs between 2001 and 2018 for these groups were overall slightly lower compared with other groups (Table 2).

Figure 1: Temporal trends in the annual person-based age-standardised (Australian 2001) incidence rates of basal cell carcinoma (BCC) and squamous cell carcinoma (SCC) in Tasmania by sex, area-level socioeconomic status and geographic remoteness, 2001–2018. Area-level socioeconomic status is based on quintiles of the Tasmanian population according to the Index of Relative Socioeconomic Advantage and Disadvantage.[25]
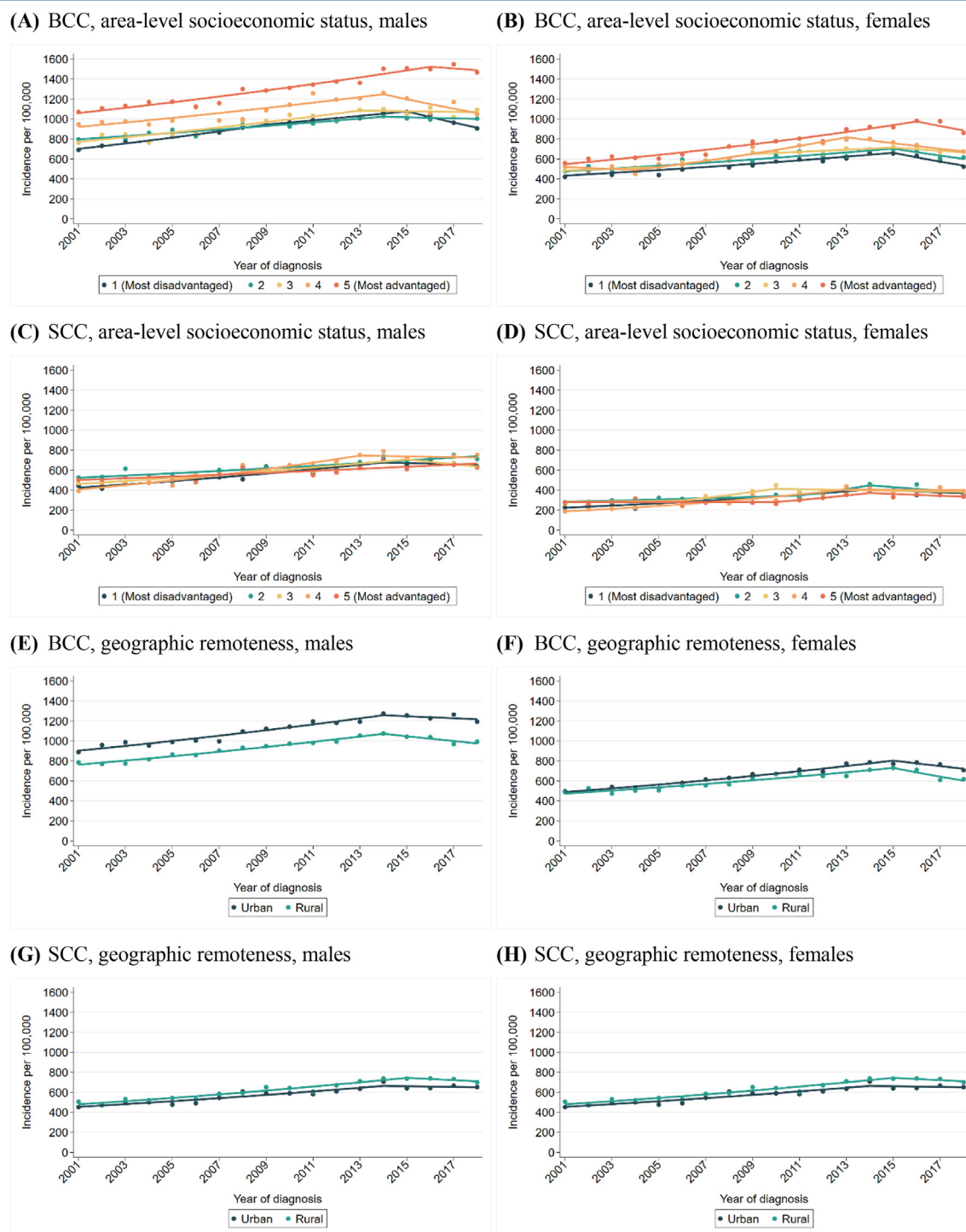
Throughout the study period, age-standardised incidence rates of BCC were consistently higher for areas of most socioeconomic advantage and urban areas (Figure 1).

AAPCs across most geographic areas were generally higher for SCC than BCC and for females than males (Table 2).

Discussion

This study aimed to examine the cross-sectional associations (2014–2018) and assess temporal trends (2001–2018) in the person-based incidence rates of KCs by area-level SES and geographic remoteness in the Tasmanian population. Stark differences were

Table 2: Average annual percentage changes (AAPC) in the person-based annual age-standardised[a] incidence rates of first annual keratinocyte carcinomas in Tasmania by sex, histological type, area-level socioeconomic status[b], geographic remoteness and calendar period, 2001–2018.

	Calendar period	AAPC	(95% CI)	Calendar period	AAPC	(95% CI)
Basal cell carcinoma						
Males						
Area-level socioeconomic status						
1 (most disadvantaged)	2001-2015	3.1	(2.7, 3.4)	2015-2018	-6.3	(-9.1, -3.3)
2	2001-2014	1.9	(1.5, 2.4)	2014-2018	-0.6	(-2.7, 1.6)
3	2001-2013	2.9	(2.0, 3.8)	2013-2018	-0.3	(-2.9, 2.4)
4	2001-2014	2.4	(1.4, 3.3)	2014-2018	-4.0	(-8.5, 0.7)
5 (most advantaged)	2001-2016	2.5	(2.0, 2.9)	2016-2018	-1.1	(-8.5, 6.9)
Geographic remoteness						
Urban	2001-2014	2.6	(2.1, 3.0)	2014-2018	-0.8	(-3.0, 1.4)
Rural	2001-2014	2.6	(2.3, 3.0)	2014-2018	-2.3	(-4.0, -0.5)
Females						
Area-level socioeconomic status						
1 (most disadvantaged)	2001-2015	3.1	(2.3, 3.9)	2015-2018	-6.9	(-13.8, 0.6)
2	2001-2015	2.8	(1.9, 3.8)	2015-2018	-5.1	(-13.0, 3.5)
3	2001-2013	3.5	(2.7, 4.3)	2013-2018	-1.1	(-3.4, 1.3)
4	2001-2014	4.4	(3.3, 5.5)	2014-2018	-4.9	(-9.6, 0.1)
5 (most advantaged)	2001-2016	3.9	(3.4, 4.5)	2016-2018	-4.8	(-14.2, 5.8)
Geographic remoteness						
Urban	2001-2015	3.6	(3.2, 4.1)	2015-2018	-3.5	(-7.4, 0.5)
Rural	2001-2015	3.2	(2.4, 3.9)	2015-2018	-6.2	(-12.3, 0.4)
Squamous cell carcinoma						
Males						
Area-level socioeconomic status						
1 (most disadvantaged)	2001-2014	3.7	(2.7, 4.6)	2014-2018	-0.9	(-5.3, 3.7)
2	2001-2018	2.1	(1.5, 2.6)	-	-	-
3	2001-2015	3.1	(2.5, 3.7)	2015-2018	-3.5	(-8.0, 1.2)
4	2001-2013	5.2	(3.8, 6.6)	2013-2018	-0.6	(-4.1, 3.1)
5 (most advantaged)	2001-2018	1.7	(1.1, 2.3)	-	-	-
Geographic remoteness						
Urban	2001-2014	3.0	(2.3, 3.7)	2014-2018	-0.5	(-3.7, 2.8)
Rural	2001-2015	3.2	(2.6, 3.8)	2015-2018	-1.6	(-6.2, 3.2)
Females						
Area-level socioeconomic status						
1 (most disadvantaged)	2001-2014	4.7	(3.3, 6.1)	2014-2018	-2.4	(-8.6, 4.2)
2	2001-2016	3.2	(2.3, 4.1)	2016-2018	-7.6	(-23.2, 11.3)
3	2001-2010	5.1	(2.9, 7.3)	2010-2018	-0.4	(-2.4, 1.6)
4	2001-2013	6.7	(5.1, 8.3)	2013-2018	-0.4	(-4.3, 3.7)
5 (most advantaged)	2001-2018	1.8	(1.0, 2.7)	-	-	-
Geographic remoteness						
Urban	2001-2014	3.5	(2.9, 4.1)	2014-2018	-1.5	(-4.4, 1.5)
Rural	2001-2016	4.1	(3.2, 4.9)	2016-2018	-8.3	(-21.7, 7.3)

[a]2001 Australian standard population.
[b]based on quintiles of the Tasmanian population according to the Index for Relative Socioeconomic Advantage and Disadvantage[25]; CI: confidence intervals.

observed between the two histological types. BCCs were more strongly associated with area-level SES, and SCCs were associated with geographic remoteness with no evidence of an independent association with area-level SES.

People living in areas of higher area-level socioeconomic advantage had, on average, a higher incidence of BCC, regardless of geographic remoteness. This finding supports European population-based studies that consistently found a higher risk of BCC in areas of high SES.[12,14–17,19] Exposure to solar ultraviolet (UV) radiation is the biggest contributor to skin cancer, and BCCs specifically have been associated with intermittent UV exposure and sunburns.[29–31] Areas of relatively high socioeconomic advantage tend to have a higher percentage of residents in white-collar occupations.[32] It is plausible that white-collar indoor workers engage in intermittent patterns of sun exposure where weekends may be spent outdoors, and holidays may be spent in destinations closer to the equator where UV levels are high. One study conducted in Queensland (closer to the equator than Tasmania) found no association between weekend sunburns and area-level socioeconomic advantage,[33] but the findings might not be generalisable to the Tasmanian setting due to substantial differences in UV levels and lifestyle between the two states.

The incidence rate of SCC was consistently higher in rural than urban areas. Evidence from other population-based studies is mixed. In Denmark, increasing rates of BCC and SCC were found with increasing and decreasing urbanisation, respectively,[20] while rates for both histological types were higher in urban than rural areas in Ireland.[14,16] Farmers in Australia, Europe and the United States have been shown to have the highest levels of UV exposure among outdoor workers and suboptimal levels of skin protection.[34] Given this finding and the link between SCC and cumulative sun exposure,[35,36] the higher incidence rates of SCC in the more rural areas of Tasmania could be due, at least in part, to a larger proportion of workers in agriculture residing in these areas.

The associations between BCC and area-level SES, and SCC and geographic remoteness, were more pronounced among younger persons and generally weakened as age increased. Similar findings for BCC and area-level SES have been reported in European countries.[12,19] A possible explanation is that people at high risk of developing KCs tend to do so at a younger age and in association with factors that more clearly differ by SES and geographic location.

Our findings suggest that differences in the age-standardised incidence rates of BCC between urban and rural areas are largely explained by differences in area-level SES between these areas. In Tasmania, as for the rest of Australia, persons living in urban areas are generally more socioeconomically advantaged than persons living in more regional and remote areas.[8–11] It appears that it is this socioeconomic advantage that is driving slightly higher incidence rates of BCC in urban compared to rural areas.

Temporal trends for BCC indicated that areas of most socioeconomic advantage sustained the highest age-standardised incidence rates throughout the study period between 2001 and 2018. Similar results were reported in a population-based study from Scotland, where the incidence of BCC was consistently higher in areas of least socioeconomic deprivation between 1978 and 2004.[17] In Ireland, a population-based study found diverging temporal trends between 1990 and 2004, a period in which the incidence of BCC increased by 6% in areas of high SES and decreased by 7% in areas of lower SES.[19] Our findings suggest that the contributors to the area-level socioeconomic gradient in the age-standardised incidence rate of BCC—possibly including differential sun exposure patterns and use of clinical skin examination services—may not have changed substantially in Tasmania for the past two decades.

Ascertainment bias could explain some of our findings. We cannot exclude the possibility that the higher incidence rates of BCC we observed among people living in areas of more socioeconomic advantage are the result of increased surveillance among these groups. Individuals in these strata of the population are generally more educated about the risks associated with sun exposure and the early signs of skin cancer, and more likely to self-examine their skin and seek medical advice.[37] BCCs are generally considered indolent cancers; therefore, active surveillance may result in increased diagnosis. In terms of completeness of the Tasmanian Cancer Registry's data, a previous quality assurance process indicated a very high level of reporting of histologically confirmed KCs by pathology laboratories and hospitals in the state.[21] That is, differences by area-level SES are unlikely to be due to differences in ascertainment by the Registry. The extent to which persons who live in areas of lower SES—who also tend to live in more regional and remote areas[11]—have access to and make use of skin cancer-related health services determines whether these cancers get diagnosed and registered in the first place.

The increased diagnosis of indolent cancers due to increased surveillance may lead to overdiagnosis—that is, the diagnosis of asymptomatic cancers that would never have caused harm. For melanoma, which is a more aggressive type of skin cancer, it has been estimated that 54% of cancers are overdiagnosed in Australia.[38] Because KCs are substantially more common and less aggressive than melanoma, it is likely that a substantial proportion of cancers are overdiagnosed.[39] While we cannot quantify it, overdiagnosis may vary by area-level SES and geographic remoteness and may contribute to the differences observed in this study.

Age-standardised incidence rates for BCC and SCC increased substantially between 2001 and the mid-2010s, when they peaked for most geographic areas, consistent with previously reported trends for the whole Tasmanian population during the same period.[21] Although the temporal trends for some area-level socioeconomic groups had not yet peaked by 2018, these groups experienced some of the slowest rates of increase in the age-standardised incidence rates throughout the whole study period. Although this indicates that there are no socioeconomic nor geographic remoteness areas of particular concern in Tasmania, future studies should continue to monitor these trends to ensure that incidence rates continue to decline across all areas.

This study has two main strengths. It is the first whole-of-population, cancer-registry-based study in Australia to examine the associations between KCs, area-level SES and geographic remoteness. Further, due to our registry-collected data that register BCC and SCC separately, we were able to demonstrate how these associations differed between the two histological types. This study has three main limitations. First, the KC counts exclude lesions that were not sent to a pathology laboratory for histological confirmation, such as lesions that were not biopsied before being treated using destructive therapies or topical creams. Second, this study compares the incidence rates by SES at the area rather than individual level, which makes it susceptible to the ecological fallacy in that not everyone living in an area will share the average socioeconomic characteristics of all persons living in the same area. Lastly, because only one cancer of each histological type was registered and coded per person per year of diagnosis, we underestimated incidence rates of lesions when we consider that it is common for people to be diagnosed with multiple lesions.[22,40] But since our aim was to estimate the person-based incidence rates, ascertainment of total lesions was not required. Further research could consider linking Registry data to the Medicare Benefit Schedule and public hospital data to enhance our understanding and provide more insights, particularly on the health economics of KCs in Tasmania.

Conclusions and implications for public health

In Tasmania, higher area-level socioeconomic advantage was associated with increased risk of BCC and living in rural areas was associated with increased risk of SCC, especially among the younger population. These disparities may reflect differences in sun exposure behaviours, awareness of skin cancer and access to, and use of, skin cancer clinics and services across socioeconomic and geographic remoteness areas, but ascertainment bias may also play a role. Further research is required to elucidate the causes more clearly.

Although trends in the incidence rates of BCC and SCC have plateaued or started to decline across most socioeconomic and

geographic remoteness areas in recent years, rates remain high. Efforts to reduce the burden of KCs in Tasmania through prevention programs should continue. Targeted strategies for reaching high risk groups should consider their socioeconomic advantage and age, and tailor age-appropriate information and resources according to a diverse range of literacy levels. Lastly, our findings have implications for service planning, especially given the higher incidence rates of SCC in rural areas.

Funding

Ethics approval

This study was approved by the Tasmanian Health and Medical Human Research Ethics Committee (reference H0018089).

Data accessibility

The data that support the findings of this study are available from the Tasmanian Cancer Registry, but restrictions apply to the availability of these data, which were used under licence for the current study, and so are not publicly available.

Acknowledgements

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author ORCIDs

Bruna S. Ragaini https://orcid.org/0000-0002-3603-2544
Peter Baade https://orcid.org/0000-0001-8576-8868
Alison Venn https://orcid.org/0000-0001-7090-1398

References

1. Olsen CM, Pandeya N, Green AC, Ragaini BS, Venn AJ, Whiteman DC. Keratinocyte cancer incidence in Australia: a review of population-based incidence trends and estimates of lifetime risk. *Public Health Research & Practice* 2022; **32**(1):1–8.

2. Pandeya N, Olsen CM, Whiteman DC. The incidence and multiplicity rates of keratinocyte cancers in Australia. *Med J Aust* 2017;**207**(8):339–43.

3. Sanofi. *The burden of non-melanoma skin cancer (NMSC) in Australia*. NSW, Australia. 2020. Available from: https://www.sanofi.com.au/dam/jcr:c4b262a8-cae0-401a-848b-5a569026190f/NMSC%20report_18%20September%202020.pdf.

4. Australian Institute of Health and Welfare. *Social determinants of health*. Canberra: *Australian institute of health and welfare*. 2020. Available from: https://www.aihw.gov.au/reports/australias-health/social-determinants-of-health.

5. Australian Institute of Health and Welfare. *Health across socioeconomic groups*. Canberra: *Australian institute of health and welfare*. 2020. Available from: https://www.aihw.gov.au/reports/australias-health/health-across-socioeconomic-groups.

6. Wilkinson R, Marmot M, World Health Organization. *Social determinants of health: the solid facts*. 2nd ed. Copenhagen: World Health Organization. Regional Office for Europe; 2003.

7. Australian Institute of Health and Welfare. *Cancer in Australia 2021*. Canberra: *Australian institute of health and welfare*. Available from: https://www.aihw.gov.au/reports/cancer/cancer-in-australia-2021.

8. Australian Bureau of Statistics. *Education and work, Australia, may 2018*. Canberra: *Australian Bureau of statistics*. Available from: https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/6227.0Main+Features1May%202018?OpenDocument.

9. Australian Bureau of Statistics. *Labour force, Australia, detailed, February 2022*. Canberra: *Australian Bureau of statistics*. Available from: https://www.abs.gov.au/statistics/labour/employment-and-unemployment/labour-force-australia-detailed/latest-release#content.

10. National Rural Health Alliance. *A snapshot of poverty in rural and regional Australia*. Canberra: *national Rural Health Alliance*. 2013. Available from: https://www.ruralhealth.org.au/sites/default/files/documents/nrha-policy-document/policy-development/rural-poverty-snapshot-11-october-final.pdf.

11. National Rural Health Alliance. *Income inequality experienced by the people of rural and remote Australia*. Canberra: *national Rural Health Alliance*. 2014. Available from: https://www.ruralhealth.org.au/sites/default/files/documents/nrha-policy-document/submissions/sub-income-inequality-inquiry-15-oct-2014.pdf.

12. Aarts MJ, van der Aa MA, Coebergh JWW, Louwman WJ. Reduction of socioeconomic inequality in cancer incidence in the South of The Netherlands during 1996-2008. *Eur J Cancer* 2010;**46**(14):2633–46.

13. Anna M, Sonja T, Tina Z, Katarina L, Vesna Z. Socioeconomic inequalities in cancer incidence in Europe: a comprehensive review of population-based epidemiological studies. *Radiol Oncol* 2020;**54**(1):1–13.

14. Carsin AE, Sharp L, Comber H. Geographical, urban/rural and socioeconomic variations in nonmelanoma skin cancer incidence: a population-based study in Ireland. *Br J Dermatol* 2011;**164**(4):822–9.

15. Corazza M, Ferretti S, Scuderi V, Borghi A. Socioeconomic status and skin cancer incidence: a population-based, cohort study in the province of Ferrara, northern Italy. *Clin Exp Dermatol* 2021;**46**(7):1285–9.

16. Deady S, Sharp L, Comber H. Increasing skin cancer incidence in young, affluent, urban populations: a challenge for prevention. *Br J Dermatol* 2014; **171**(2):324–31.

17. Doherty V, Brewster D, Jensen S, Gorman D. Trends in skin cancer incidence by socioeconomic position in Scotland, 1978–2004. *Br J Cancer* 2010; **102**(11):1661–4.

18. Eberle A, Luttmann S, Foraita R, Pohlabeln H. Socioeconomic inequalities in cancer incidence and mortality—a spatial analysis in Bremen, Germany. *J Public Health* 2010;**18**(3):227–35.

19. Van Hattem S, Aarts M, Louwman W, Neumann H, Coebergh J, Looman C, et al. Increase in basal cell carcinoma incidence steepest in individuals with high socioeconomic status: results of a cancer registry study in The Netherlands. *Br J Dermatol* 2009;**161**(4):840–5.

20. Steding-Jessen M, Birch-Johansen F, Jensen A, Schüz J, Kjær S, Dalton SO. Socioeconomic status and non-melanoma skin cancer: a nationwide cohort study of incidence and survival in Denmark. *Cancer epidemiology* 2010; **34**(6):689–95.

21. Ragaini BS, Blizzard L, Newman L, Stokes B, Albion T, Venn A. Temporal trends in the incidence rates of keratinocyte carcinomas from 1978 to 2018 in Tasmania, Australia: a population-based study. *Discover Oncology* 2021;**12**(1):1–11.

22. Ragaini BS, Blizzard L, Venn A. Risk of subsequent keratinocyte carcinomas after a first diagnosis in Tasmania, Australia. *Australas J Dermatol* 2022; **64**(1):101–17.

23. Australian Bureau of Statistics. *National, state and territory population*. Australian Bureau of Statistics. 2021. Available from: https://www.abs.gov.au/statistics/people/population/national-state-and-territory-population/latest-release#content.

24. Fritz A, Percy C, Jack A, Shanmugaratnam K, Sobin L, Parkin DM, et al. *International classification of diseases for Oncology*. 3rd ed. World Health Organization; 2013.

25. Australian Bureau of Statistics. *Census of population and housing: socio-economic Indexes for areas (SEIFA), Australia, 2016*. Canberra: Australian Bureau of Statistics; 2018. Available from: https://www.abs.gov.au/ausstats/abs@.nsf/mf/2033.0.55.001.

26. Australian Bureau of Statistics. *Australian statistical Geography standard (ASGS): volume 5 - remoteness structure, july 2016*. Canberra: Australian Bureau of Statistics; 2018. Available from: https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1270.0.55.005Main+Features1July%202016?OpenDocument=.

27. Australian Bureau of Statistics. *3101.0 - Australian demographic statistics. Dec 2019*. Available from: https://www.abs.gov.au/Ausstats/abs%40.nsf/ca79f63026ec2e9cca256886001514d7/35ca51458e2fe133ca2568a900143aa5!OpenDocument.

28. Joinpoint Regression Program. *Statistical methodology and applications branch, surveillance research program*. National Cancer Institute; April 2020., Version 4.8.0.1.

29. Green A, Battistutta D, Hart V, Leslie D, Weedon D. Skin cancer in a subtropical Australian population: incidence and lack of association with occupation. *Am J Epidemiol* 1996;**144**(11):1034–40.

30. van Dam RM, Huang Z, Rimm EB, Weinstock MA, Spiegelman D, Colditz GA, et al. Risk factors for basal cell carcinoma of the skin in men: results from the health professionals follow-up study. *Am J Epidemiol* 1999;**150**(5):459–68.

31. Savoye I, Olsen CM, Whiteman DC, Bijon A, Wald L, Dartois L, et al. Patterns of ultraviolet radiation exposure and skin cancer risk: the E3N-SunExp study. *J Epidemiol* 2018;**28**(1):27–33.

32. Australian Bureau of Statistics. *Census of population and housing. TableBuilder. Findings based on use of ABS TableBuilder data*. Canberra: Australian Bureau of Statistics; 2016.

33. Green AC, Marquart L, Clemens SL, Harper CM, O'Rourke PK. Frequency of sunburn in Queensland adults: still a burning issue. *Med J Aust* 2013;**198**(8):431–4.

34. Smit-Kroner C, Brumby S. Farmers sun exposure, skin protection and public health campaigns: an Australian perspective. *Preventive Medicine Reports* 2015; **2**:602–7.

35. Rosso S, Zanetti R, Martinez C, Tormo MJ, Schraub S, Sancho-Garnier H, et al. The multicentre south European study 'Helios'. II: different sun exposure patterns in the aetiology of basal cell and squamous cell carcinomas of the skin. *Br J Cancer* 1996;**73**(11):1447–54.

36. Ramos J, Villa J, Ruiz A, Armstrong R, Matta J. UV dose determines key characteristics of nonmelanoma skin cancer. *Cancer Epidemiol Biomarkers Prev* 2004; **13**(12):2006–11.

37. Seité S, Del Marmol V, Moyal D, Friedman AJ. Public primary and secondary skin cancer prevention, perceptions and knowledge: an international cross-sectional survey. *J Eur Acad Dermatol Venereol* 2017;**31**(5):815–20.

38. Glasziou PP, Jones MA, Pathirana T, Barratt AL, Bell KJ. Estimating the magnitude of cancer overdiagnosis in Australia. *Med J Aust* 2020;**212**(4):162–8.

39. Esserman LJ, Thompson IM, Reid B, Nelson P, Ransohoff DF, Welch HG, et al. Addressing overdiagnosis and overtreatment in cancer: a prescription for change. *Lancet Oncol* 2014;**15**(6):e234–42.

40. Flohil SC, van der Leest RJ, Arends LR, de Vries E, Nijsten T. Risk of subsequent cutaneous malignancy in patients with prior keratinocyte carcinoma: a systematic review and meta-analysis. *Eur J Cancer* 2013; **49**(10):2365–75.

Appendix A Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.anzjph.2023.100067.