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Skin cancer has a large impact on our public hospitals but prevention programs continue to demonstrate strong economic credentials

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In today's healthcare environment, where resources are always stretched, there is a stronger policy focus on proving the effectiveness and cost efficiency of our health services. Economic evaluation has become a useful tool to assist clinical and policy decision making. Skin cancer, including melanoma and non-melanoma skin cancer (NMSC), is the most common cancer in Australia.¹ The age-standardised incidence of melanoma has increased from 27 in 100,000 in 1982 to 49 in 100,000 in 2016.¹ NMSC data have not been routinely collected in Australia and the latest estimate indicated an increase in the age-standardised rate of medical service for NMSC from 2,489 per 100,000 in 2000 to 3,174 per 100,000 in 2010.²

Public hospitals play a fundamental role in the Australian healthcare system and their funding is central to state government budgets. As one of Australia's most prevalent and costly cancers, skin cancer imposes a large cost burden, not only on the primary care system, but also on hospitals through admissions and outpatient services.³ Despite this, there is limited published literature available on the cost of skin cancer to the public sector. The most recent reports were published by the Australian Institute of Health and Welfare (AIHW), but costs were not reported on a state-by-state basis.^{3,4} The latest AIHW report on skin cancer spending indicated that, in 2014, \$9.2 million Medicare benefits claims were paid for melanoma

Abstract

Objectives: While skin cancer is still the most common cancer in Australia, important information gaps remain. This paper addresses two gaps: i) the cost impact on public hospitals; and ii) an up-to-date assessment of economic credentials for prevention.

Methods: A prevalence-based cost approach was undertaken in public hospitals in Victoria. Costs were estimated for inpatient admissions, using State service statistics, and outpatient services based on attendance at three hospitals in 2012-13. Cost-effectiveness for prevention was estimated from 'observed vs expected' analysis, together with program expenditure data.

Results: Combining inpatient and outpatient costs, total annual costs for Victoria were \$48 million to \$56 million. The SunSmart program is estimated to have prevented more than 43,000 skin cancers between 1988 and 2010, a net cost saving of \$92 million. Skin cancer treatment in public hospitals (\$9.20~\$10.39 per head/year) was 30-times current public funding in skin cancer prevention (\$0.37 per head/year).

Conclusions: At about \$50 million per year for hospitals in Victoria alone, the cost burden of a largely preventable disease is substantial. Skin cancer prevention remains highly cost-effective, yet underfunded.

Implications for public health: Increased funding for skin cancer prevention must be kept high on the public health agenda. Hospitals would also benefit from being able to redirect resources to non-preventable conditions.

Key words: skin cancer, economics, prevention, cost-effectiveness

and \$127.6 million for NMSC, but hospital care costs were excluded.¹ Total expenditure in treating NMSC was estimated to be \$367 million in 2008-09 and \$511 million in 2012. Melanoma, reported as the third most commonly diagnosed cancer in 2014, also represents a substantial cost burden to the healthcare system, with a reported \$30 million healthcare expenditure in 2001 (\$40.3 million in 2012 dollar terms).^{2,4} There is little

accurate up-to-date information on the cost impact of treating and managing skin cancer. More importantly, skin cancer is one of the most preventable cancers.^{5,6} Proven prevention programs such as the SunSmart program in Australia offer excellent potential to redirect the enormous cost burden on our hospitals each year to other non-preventable diseases.⁷⁻⁹ This study aims to estimate the cost burden of managing skin cancer as well

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as to assess the current cost-effectiveness credentials of the Victorian skin cancer prevention program. Economic information on cost, potential cost offsets and cost-effectiveness is useful for both clinical and policy assessment of where limited resources should be directed.

Methods

Cost of skin cancer

We undertook a prevalence-based approach to estimate the cost of skin cancer management within the public hospital system in Victoria. Costs were estimated separately for inpatient admission and outpatient clinic services. Quantity of service data was combined with national unit cost data to develop the cost estimates. More specifically, inpatient costs were calculated based on the number of admissions in Victorian public hospitals for 2012-13, with aggregated health service statistics sourced from Victorian Integrated Care Services (ICS). Outpatient costs were determined by the number of outpatient attendances at three public hospitals, where data were available to our study. These three hospitals are major referral centres in metropolitan areas of Victoria. All costs were valued and reported in Australian dollars for the reference year 2012-13. Where price adjustments were required, price indices published by the AIHW were applied.¹⁰

Health service utilisation

The Cancer Services Framework for Victoria is a State Government initiative and the integrated service model is promoted through eight geographically based services and one speciality-based Paediatrics Integrated Care Service (PICS).¹¹ Each of the Integrated Cancer Services (ICS) within the framework reports its services by accessing and using two main data sources: The Victorian Cancer Registry (VCR)¹² and The Victorian Admitted Episodes Dataset (VAED).¹³ Aggregated health service statistics from the ICS datasets for 2012-13 were used in our analysis. Table 1 presents the number of patients admitted to public hospitals and the number of admissions to public hospitals for melanoma and non-melanoma skin cancer treatment in each ICS. These numbers were used to estimate the cost of inpatient services incurred by Victorian public hospitals. Data on outpatient clinic services was obtained from hospital departments in charge of health informatics or operational planning that had access to their hospital's health service data. These departments/units provided counts of outpatient clinic services by type or unit of outpatient service. Due to variation in information operations at each of the three hospitals involved, the format, coverage and detail in the data provided were different but comparable. The limitations of data retrieval from each hospital information

system meant that assumptions were required to estimate outpatient attendance in a comparable fashion.

Outpatient costs were determined from outpatient attendances (see Table 1). As data on outpatient clinic services was only available from these public hospitals, extrapolation of outpatient cost to a statewide estimate was undertaken, weighted to reflect the proportion of skin cancer patients treated in each of the three hospitals. There were two steps involved: firstly, an extrapolation from the individual hospital to their ICS; and secondly, an extrapolation from the ICS level to the Victorian public hospital system.

Unit cost estimation

Unit costs were obtained from the National Hospital Cost Data Collection (NHDC). More specifically, inpatient admission from Cost Weights for Australian Refined Diagnosis-Related Groups (AR-DRG) and outpatient attendance by expenditure and occasion of service for non-admitted clinics. The national average costs per separation in the NHDC report were used as the unit costs per hospital admission, by three levels of complexity in melanoma skin cancer treatment. Hospital admissions for melanoma were distributed across these three levels of complexity according to the number of separations in the samples reported to the NHDC. The separation data was classified by AR-DRG code, which provides a useful indication of complexity.

Treatment of NMSC involves less complex procedures and consequently the average cost per NMSC admission is expected to be lower than that for melanoma. A separate unit cost for NMSC admissions was estimated based on Australian total expenditure on NMSC hospital admissions in 2008-09, divided by total NMSC cases calculated from the gender-specific NMSC hospital separation rates in 2006-07.^{3,4} Adjustment of separation rates was undertaken to reflect the trend of increase in NMSC incidence from 2006-07 to 2008-09.² The estimate was then adjusted to the reference year value (2012/2013) using AIHW inflators.¹⁰ Estimation of unit cost for NMSC admissions is presented in Table 2. Total expenditure and occasion of service data for non-admitted clinics in Victoria reported in the NHDC for the year 2008-09 were used to calculate an average cost per occasion of service for three types of

Table 1: Patients and admissions to public hospitals for skin cancer treatment and outpatient units' attendances for skin cancer at 3 public hospital, 2012-13.

ICS of Health Service	Public Hospital patients		Public Hospital Admissions ^a	
	Melanoma ^b	NMSC ^c	Melanoma ^b	NMSC ^c
Metropolitan ICS 1	243	1,267	463	1,583
Metropolitan ICS 2	432	1,183	694	1,575
Metropolitan ICS 3	706	1,753	1199	2,467
Regional ICS 1	110	655	164	838
Regional ICS 2	116	618	162	742
Regional ICS 3	87	429	110	528
Regional ICS 4	101	985	147	1,124
Regional ICS 5	100	682	147	839
Special ICS	1	4	1	5
Outpatient Unit	Melanoma		Non-Melanoma	
Hospital A ^d	1,050		879 (H), 586 (L)	
Hospital B ^d	758		1,659	
Hospital C ^d				
Medical, skin	1,349			
Radiotherapy, skin	460		319	
Surgical, skin	5,040		3,263	

a: Chemotherapy is included but radiotherapy is excluded unless it was completed as part of an inpatient episode.

b: All melanoma skin cancers including malignant, in situ and unknown or uncertain diagnosis.

c: All non-melanoma skin cancers including malignant, in situ and unknown or uncertain diagnosis.

d: To protect privacy, hospital identity is concealed.

outpatient clinic service, i.e. dermatology, radiation oncology and plastic surgery.¹⁴ Using the proportions of attendance across the three outpatient units at one of the study hospitals, average weighted costs per melanoma and per non-melanoma skin cancer outpatient attendance were estimated.

Economic evaluation framework

Economic evaluation was conducted from three perspectives: first, the government as '3rd party funder' to inform policy; second, the 'health sector' to include both government and patient impacts; and third, from a 'societal perspective' to consider productivity impacts in the broader economy. Incremental cost-effectiveness ratios (ICERs) were calculated by comparing the incremental net costs to incremental health outcomes. The Victorian skin cancer prevention program ('SunSmart'), was compared to skin cancer prevention in two populous states (New South Wales and Queensland). Based on a previous economic evaluation methodology, the present study updated the analysis with latest data in skin cancer incidence and program expenditures.⁸

The incremental intervention costs were estimated based on the difference in expenditures between Victoria and the comparator states over a specified period. The incremental cost to individuals for the intervention was estimated based on the same assumptions as in the previous economic evaluation.^{8,9} Cost offsets were measured from the number of skin cancer cases prevented, multiplied by the unit cost for treatment and management per case (Table 2). Program investment return was estimated from the government perspective by comparing the savings in cancer treatment (cost offsets) to the SunSmart program expenditure.

The effectiveness of the Victorian SunSmart program in preventing cases of melanoma was estimated by the gap between the 'predicted' and 'observed' incidence, expressed as a rate ratio (RR). The 'observed' was the actual incidence trend in Victorian between 1988 and 2007. The 'expected' skin cancer incidence was estimated by a counterfactual scenario, involving the Victorian SunSmart program modelled with lower levels of program expenditure as in the other two states. The predicted melanoma incidence for the counterfactual scenario was modelled by back calculating the Victorian incidence using the ratios of actual incidence

over projected incidence trends in another two states with lower skin cancer prevention expenditure level from 1988 to 2007. This approach assumes that, if there were no Victorian SunSmart program implemented in 1988, the melanoma incidence in Victoria would have grown in the same trend pattern as in the other two states. The effectiveness of melanoma reduction was therefore estimated by the gap between the expected and observed incidence (RR).

The methods for analysing NMSC involve analysis of BCC and SCC age-specific incidence rates across four national surveys in Australia. The national surveys were conducted in 1985, 1990, 1995 and 2004 to estimate NMSC incidence and the incidence trend.^{15,16} Available evidence from the gender specific incidence in the south regions (latitude >37°S) allowed BCC to be modelled, but not SCC. In estimating program effectiveness, 50% of the incidence reduction was attributed to the skin cancer prevention activities. This attributable fraction is in line with what has been reported in the available literature. For example, sunscreen use alone is reported to have preventable fractions of 9.3% and 14% for SCC and melanoma.¹⁷ Productivity gains/losses resulting from health impacts (i.e. cancer cases prevented and premature deaths averted), were assessed with a productivity model previously developed.¹⁸ There are two techniques available in the productivity model to assess production impacts in the general economy; the Human Capital Approach (HCA) and the Friction Cost Approach (FCA). The HCA method counts all future income lost from an individual who leaves the workforce due to premature death or illness; whereas the FCA method assumes an individual will be replaced after a specified period and the production loss to the society is temporary. We applied both methods and report results from both modelling techniques.

One-way sensitivity analysis was undertaken for key model parameters, including unit cost,

productivity estimation and the incidence reduction attribution to the program.

Results

Skin cancer cost burden to the Victorian public hospital system

In 2012-13, there were 12,700 admissions to Victorian public hospitals for the treatment of melanoma and NMSC. With three AR-DRG codes assigned to the various levels of complexity in skin cancer treatment, weighted treatment costs for melanoma and NMSC were estimated based on the numbers of admission service counts reported for each code. These public hospital admissions involved an estimated cost of \$42 million; \$13 million for melanoma and \$29 million for NMSC (Table 3).

There were about 14,000 outpatient clinic attendances for the management of melanoma and NMSC in the three reference public hospitals. These involved \$3.3 million in healthcare costs, estimated from the number of outpatient attendances in each hospital, together with the 'weighted average cost per outpatient attendance' reported by the NHCDC. Extrapolation to a statewide estimate yielded a cost of \$6 million to \$13 million, depending on the proportion of all public skin cancer patients treated in each hospital.

Total costs incurred by the Victorian public hospital system for skin cancer management, combining both inpatient admissions and outpatient clinic attendances, was estimated to be between \$49.3 million and \$55.7 million in 2012-13. Moving beyond the impact on public hospitals, the cost burden of skin cancer on the broader hospital care system is enormous. According to the aggregated hospital admission statistics reported by Victorian ICS, only one-third of skin cancer patients were treated in the public hospital system. When private hospital admissions (\$72 million) were included in addition to the

Table 2: Estimation of unit cost for NMSC admissions.

	Males	Females
NMSC hospital separations by gender, 2006-07 ⁴	47,247	32,545
Australian population, 2006-07 ²¹	10,226,268	10,443,689
NMSC hospitalisation rate per 100,000, 2006-07	462.02	311.62
NMSC hospitalisation rate per 100,000, 2008-09 by adjusting for NMSC incidence trend ²	468.69	316.12
Australian population, 2008-09 ²¹	10,443,350	10,669,628
Estimated number of NMSC hospital separations	48,947	33,729
Total expenditure of NMSC hospital admission, 2008-09 ⁵	\$224.59 million	
Average cost per NMSC separation, 2008-09	\$2,717	
Average cost per NMSC separation, 2012-13 ¹⁰	\$2,994	

public hospital care, the total annual costs in Victoria were estimated at \$121–\$127 million. These costs would be higher still if the substantial number of radiotherapy treatments carried out in non-admitted private facilities were included.

Cost-effectiveness and investment return for skin cancer prevention

The Victorian SunSmart program prevented more than 43,000 cases of skin cancer, i.e. 11,500 melanomas and 32,200 NMSCs, from 1988 to 2011. The reduction in melanomas resulted in almost 1,400 premature deaths averted, which is equivalent to 43,900 life years saved or 31,200 life years with full health Health-Adjusted Life-Years (HALYs).

From 1988 to 2011, the average SunSmart program expenditure was \$1.7 million per year, equivalent to \$0.37 per head in Victoria, compared to \$0.19 per head in the two comparator states. Total expenditure over the

1988 to 2011 period was \$42 million. The cost to individuals through purchasing sunscreen and hats in accordance with skin cancer prevention key messages was estimated at \$955 million over the same period. The cost to individuals was incurred by the private sector and was relevant to the broader 'societal' and full 'health sector' perspectives. Details of program cost, cost offsets, productivity gains and incremental net costs in respect to the different perspectives are presented in Table 4. Health sector costs of \$93.6 million were saved due to skin cancer cases prevented over the past 24 years. These cost offsets included \$65.1 million for melanomas and \$28.5 million for NMSCs.

From the government as '3rd party funder' perspective, the cost offsets were greater than the program costs, which resulted in net savings. The incremental analysis showed that the comprehensive skin cancer program in Victoria not only saved lives, but achieved

cost savings as well. In economic terminology, the intervention 'dominates' its comparator – the Victorian SunSmart program is both more effective and less costly. In terms of returns on investment, the Victorian SunSmart program achieved a return of \$2.22 on every dollar spent by the Victorian Government in the program from 1988 to 2011.

Expanding to a broader 'health sector' perspective, the incremental analysis shows an ICER of \$11,000 per LYS and \$16,000 per HALY, when cost offsets were excluded. When cost offsets were included, the ICERs were \$9,000 per LYS and \$13,000 per HALY. All these results are considered cost-effective against a value for money threshold of '<\$50,000 per QALY' commonly used in countries like Australia, the UK and Canada.

From an even broader 'societal' perspective, inclusion of productivity gains using the HCA method indicates the intervention is again dominant with an even greater incremental benefit. In contrast, a net social cost of \$337 million was estimated with productivity impacts estimated by the more conservative FCA method. With FCA, the ICERs are \$8,000 per LYS and \$11,000 per HALY from the societal perspective. Productivity gains to society result from the avoidance of premature death and early retirement, as well as from absenteeism associated with treatment activity. With the more commonly used HCA approach, the Victorian SunSmart program prevented more than \$713 million in productivity losses to the general economy over the past 24 years. Estimated productivity gains of more than \$68 million were achieved with the more conservative FCA method.

Apart from different methods used in productivity estimation, the sensitivity analysis results show that changing the unit costs and the fraction of cancer reduction attributable to the program did not alter the conclusions based on the ICERs and investment return. Accordingly, we would regard the results as robust to variation in key assumptions.

Discussion

The cost burden estimates are based on the best information currently available for public analysis. While indicative rather than comprehensive, they do provide a much clearer picture of the substantial cost impact of skin cancer on the Victorian hospital system than we have had before. When combined with information on the

Table 3: Estimated inpatient admission costs and outpatient clinic costs for the Victorian public hospital system, 2012-2013.

Inpatient admissions costs				
DRG Code	DRG description	Average cost per separation (\$)	Melanoma (\$ million)	NMSC (\$ million)
J69A	Skin Malignancy +ccc	16,183	4.25	
J69B	Skin Malignancy -ccc	10,137	7.43	
J69C	Skin Malignancy, same day	805	1.68	
Total			13.36	29.05
Outpatient clinic costs				
	Estimation for hospital (\$,000)	Estimation for ICS (\$,000)	Estimation for Victorian public hospital system (\$ million)	
Hospital A	533	1,761	10.12	
Hospital B	557	557	6.90	
Hospital C	2,386	3,874	13.32	

Table 4: Program cost and estimated cost offsets, productivity impacts, and incremental net cost in 2012/2013 reference year values from three perspectives, 1988 to 2011.

Perspectives	Government (Health System) (\$ million)	Health Sector (\$ million)	Societal (\$ million)
Program cost, intervention	42.5	42.5	42.5
Cost to individuals, intervention		954.6	954.6
Comparator cost	21.9	21.9	21.9
Cost to individuals, comparator		477.3	477.3
Cost offsets	93.6	93.6	93.6
Melanoma	65.1	65.1	65.1
NMSC	28.5	28.5	28.5
Productivity gains ^a			
HCA			712.8
FCA			68.4
Incremental net cost	-73.0	404.3	
HCA			-308.5
FCA			335.9

a: Potential productivity gains were discounted at 3.5% while the rest of costs were adjusted to reference year values but not discounted as they were incurred in the past.

high number of incidence cases; there is little doubt that skin cancer has a significant cost impact on the health care system, with NMSC alone representing the second highest healthcare expenditure among all cancers.⁴

Ironically, skin cancer is also the most preventable cancer, and efficient, affordable and effective prevention programs are available.^{7,8} The Victorian SunSmart program has demonstrated successful outcomes in changing the attitudes and behaviours in sun protection by providing multi-faceted interventions and supportive environments.^{19,20} The SunSmart program is also very cost-effective, with an estimated cost saving of \$2.20 for every dollar invested in the program. Proven prevention programs like SunSmart can impact substantially on the incidence of skin cancer. Over time, skin cancer prevention offers the important potential to redirect some of the \$56 million impact on Victorian public hospitals each year to other non-preventable diseases. Based on the present study, the cost per head incurred by skin cancer treatment in Victoria was in the range of \$9.20 (low estimate) to \$10.39 (high estimate) in 2012-13. Compared with the cost in Victoria of skin cancer prevention of \$0.37 per head, this adds weight to arguments to increase resources going into prevention.

Accurate cost studies require well-defined and complete data sources, together with rigorous analysis and associated sensitivity analysis. In this study, the data for inpatient costs (hospital admissions) was comprehensive in that we were able to obtain statewide statistics from the Victorian Integrated Cancer Service (ICS). In contrast, data available for outpatient services was less complete. We were able to obtain information from three hospitals for our ICS and statewide estimates. It is problematic whether quantity of service data from one hospital transfers readily to other hospitals with different data collection and reporting systems. More importantly, the profile of skin cancer patients differs from hospital to hospital, as does clinical practice. Extrapolation from three hospitals to the ICS and then on to the statewide estimate may overestimate the outpatient costs, as these three hospitals are major treatment centres within their ICS and complex treatment with higher costs are usually performed in the major centres. On the other hand, we adopted conservative parameters in our assumptions to help counter such biases. For example, the assumption on the number of

NMSC outpatient clinic visits for Hospital A was assumed to be 4~5 times per admitted patient, similar to Hospital C with 4.3 per admitted patient, rather than the average visit of 7.1 per admitted patient reported elsewhere.

Further, many skin cancers are treated in multiple clinics (e.g. plastic surgery and dermatology) mixed with other diseases and conditions. In Hospital B, only patients with skin cancer diagnosis (ICD code C44) who had had radiotherapy contact were included in the outpatient clinic attendance estimate due to data availability. This is certainly an underestimate of what would have occurred, as not every skin cancer, in particular NMSC, requires radiotherapy.

Our cost estimations necessarily involved assumptions. It may be worthwhile for more comprehensive sensitivity analysis to be conducted than that possible in the present paper, to fully test these assumptions. In particular, the unit costs adopted for admission for both melanoma and NMSC could be further explored. It is unclear whether the proportion of patients we used in the three levels of complexity in skin cancer malignancy admission is truly representative or not. Most people consider treatment for NMSC involves less complex procedures and would be treated in less costly GP/specialist clinic rooms. Thus it is not clear whether the NMSC cases admitted to public hospitals are in a more severe disease spectrum and therefore the cost (nearly \$3,000 per separation) is higher than usually thought. On the other hand, there are substantial costs incurred in the private settings of Australian healthcare system, including care from GPs, specialists and private hospitals, which are not reported in this paper. Our study demonstrates substantial healthcare resources consumed in managing skin cancer each year in the public hospital system only. If the costs incurred in the private sector were included, the healthcare spending would have been significantly higher.

Cost of illness studies rely on complete and reliable data sources for accuracy. The collection of incidence and prevalence for skin cancers, in particular NMSC, is lacking. As NMSC is not routinely collected by cancer registries, there is a need for an alternative data collection to facilitate economic analysis of skin cancers as well as evaluation of prevention programs. Four potential models to collect national data on the incidence of NMSC were recommended

by Australian Institute of Health and Welfare during an House of Representative Standing Committee on Health inquiry into skin cancer in Australia.¹ While collecting NMSC data is challenging, it is important to collect it at a regular intervals due to its significant burden on Australian health system.

Conclusions

Our study results demonstrate that substantial healthcare resources are consumed in managing skin cancer each year in the public hospital system, much of which was potentially preventable. In addition, there are substantial costs incurred in private settings, including care from GPs, specialists and private hospitals. Effective skin cancer prevention programs such as SunSmart are not only saving lives, they are saving substantial costs that would otherwise be incurred via treatment services. Our study suggests an investment return of \$2.20 is achieved on every dollar invested in the Victorian SunSmart program. Compared to public hospital spending on skin cancer treatment of around \$10 per head, the case for increased investment in prevention from the current level of \$0.37 per head is compelling.

Implications for public health

There is a common saying that "An ounce of prevention is better than a pound of cure". While to the economist such sayings need to be underpinned by valid economic evaluation, skin cancer is an excellent example of how true this saying can be. Currently, spending on skin cancer treatment far outweighs the investment in prevention, as indicated by our analysis and also those prevailing in the Australian health system. Skin cancer prevention programs have proven to be effective and cost-effective time after time over the past 10 years or so. Increased funding for skin cancer prevention must be kept high on the public health agenda. Hospitals would also benefit from being able to redirect resources to non-preventable conditions.

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