

# Modelling the direct health care costs of chronic wounds in Australia

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## ABSTRACT

Chronic wounds impose large costs on health services. Information about cost is useful for raising the profile of the problem among decision makers and also provides estimates of the savings to health services if the problem is reduced. This study used published data to estimate the direct health care costs of chronic wounds: pressure ulcer, diabetic ulcer, venous ulcer and artery insufficiency ulcer. The present economic study focused on the four categories of chronic wounds. The total cost of chronic wounds was estimated at \$2.85 billion annually, with large uncertainty around this estimate. Most of the costs are incurred in the hospital system as compared to community care services, and the most expensive type of wound is pressure ulcer. These data show the costs are large and uncertain. As the elderly population grows, costs are likely to rise unless cost-effective intervention strategies are implemented as a matter of routine.

## INTRODUCTION

Chronic wounds represent a silent epidemic affecting a substantial portion of the world population and place a considerable drain on healthcare resources. In the United States, for instance, more than 6.5 million patients reportedly suffered from chronic wounds with annual treatment costs in excess of US\$25 billion<sup>1</sup>. In the United Kingdom, the costs of chronic wounds to the National Health Service (NHS) were conservatively estimated at between £2.3 and £3.1 billion per year<sup>2</sup>. In Australia, wound management procedures are among the most frequently performed in the health care system<sup>3</sup>. Yet the overall economic costs of chronic wounds to the health care system are unknown. A good understanding of the costs of a health problem provides useful information for those advocating for its reduction. Large costs can be used to get the attention of policy makers and the potential costs savings can be estimated from the use of effective treatment and prevention programmes. Of course, novel interventions will incur their own costs and these need to be balanced against cost savings. Improvements to health outcomes also need to be estimated and included in cost-effectiveness research. The objective of the

present study is to model and estimate the direct health care costs of chronic wounds in hospital and residential care settings in Australia.

The Wound Healing Society (WHS) defines a chronic wound as one that has failed to proceed through an orderly and timely reparative process to produce anatomic and functional integrity within an expected time frame<sup>4</sup>. Based on their aetiologies, WHS broadly classifies chronic wounds into four categories: pressure ulcer, diabetic ulcer, venous ulcer and artery insufficiency ulcer<sup>5</sup>. The present economic study focused on the four categories of chronic wounds.

## METHODS

We applied a probabilistic model to estimate the direct health care costs of pressure ulcer, diabetic foot ulcer, venous ulcer and artery insufficiency ulcer in hospital and residential care settings in Australia for 2010–11. Parameters for the model describe the incidences of the four types of chronic wound, and the associated direct health care costs of treatments per patient in a given health care setting. All information used was taken from a systematic review of the literature, submitted in parallel to this manuscript. To include the uncertainty for incidences and costs, the minimum and maximum values were used and fitted to a priori uniform statistical distributions. The total number of separations in either the hospital or residential care settings was used to estimate the at-risk population to whom incidence and costs were applied. Appendices 1 to 4 show the data used for all models. To propagate the uncertainties in the parameters forward to the conclusions, the modelling used a Visual Basic program to perform 10,000 Monte Carlo simulations. The output distributions were summarised to show the mean aggregate direct health care costs of a chronic wound by health care setting. A probabilistic analysis captures the uncertainty for incidences and costs and shows the range of possible economic outcomes, allowing variability to be estimated. It offers more information than a fixed value analysis that makes a single prediction.

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Table 1. Direct health care costs of pressures ulcer in all hospitals (public and private) in Australia (In 2012 \$US)

State / Territory	Public hospitals		Private hospitals	
	Cases	Costs (in 2012 US\$)	Cases	Costs
	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)
NSW	79,627 ( $\pm$ 44,038)	\$376,981,046 ( $\pm$ 243,209,038)	27,624 ( $\pm$ 15,198)	\$131,084,915 ( $\pm$ 84,386,426)
VIC	58,810 ( $\pm$ 32,553)	\$279,250,289 ( $\pm$ 181,000,563)	29,684 ( $\pm$ 16,405)	\$140,701,017 ( $\pm$ 90,423,584)
QLD	41,859 ( $\pm$ 23,188)	\$199,698,829 ( $\pm$ 129,415,283)	27,524 ( $\pm$ 15,211)	\$130,707,959 ( $\pm$ 83,887,993)
WA	22,798 ( $\pm$ 12,465)	\$108,584,142 ( $\pm$ 69,294,454)	12,417 ( $\pm$ 6,859)	\$58,857,343 ( $\pm$ 37,951,154)
SA	19,602 ( $\pm$ 10,732)	\$92,980,992 ( $\pm$ 59,676,729)	9,353 ( $\pm$ 5,122)	\$44,497,529 ( $\pm$ 28,614,277)
TAS	4,608 ( $\pm$ 2,527)	\$21,863,418 ( $\pm$ 14,026,978)	†n.p	n.p
ACT	3,924 ( $\pm$ 2,174)	\$18,778,475 ( $\pm$ 12,100,458)	n.p	n.p
NT	3,252 ( $\pm$ 1,794)	\$15,392,815 ( $\pm$ 9,913,251)	n.p	n.p
Subtotal	236,295 ( $\pm$ 129,230)	\$1,127,025,688 ( $\pm$ 718,705,938)	111,155 ( $\pm$ 61,000)	\$529,426,935 ( $\pm$ 338,165,078)
	Public and private hospitals			
Total	<b>Cases</b>		<b>Costs</b>	
	Mean ( $\pm$ SD): 345,768 ( $\pm$ 190,071)		Mean ( $\pm$ SD): \$1,640,644,160 ( $\pm$ 1,054,280,239)	

Note: The estimates were based on overnight separations for patients over  $\geq$ 15 years old, 2010–11.

†:n.p.=data not published to protect privacy

### Data for incidence of chronic wounds

We conducted systematic literature searches through electronic databases including Medline, EMBASE, CINAHL and Cochrane Library to identify the incidence and prevalence of pressure ulcer, diabetic foot ulcer, venous ulcer, and artery insufficiency ulcer in hospital and residential care settings. The data found are shown in Appendices 1a, 1d, 2a, 2d, 3a and 4a. Our searches revealed wide variation in the reported incidences of pressure ulcer between zero and 29%. To reduce modelling uncertainty, we excluded the two extreme values as outliers, and used values between 0.6% and 21.5% (Appendix 1a). Where data on incidences was unavailable, we used the prevalence and duration of the active chronic wound to derive an estimated incidence using a method reported by Rhame and Suddarth<sup>6</sup>.

### Values for the direct healthcare costs of chronic wounds

Further searches through Medline, EMBASE, CINAHL and the Cochrane Library identified Australian and international estimates of the direct health care costs of pressure ulcer, diabetic foot ulcer, venous ulcer and artery insufficiency ulcer per patient in hospital and residential care settings. The search strategy used and search outputs generated are in Appendices 1b and 1e. All estimates were converted to 2012 US dollars. Both Australian and international estimates were used for the economic modelling if the latter were comparable to the former in terms of patient population, health care setting, costing method and country setting: Appendices 1b and 1e; Appendices

2b and 2f; Appendices 3b and 3c; Appendices 4b and 4c. Where Australian data were unavailable, we relied on international estimates only for the economic modelling.

### Values for the separations from hospitals and residential care in Australia

The total number of overnight separations for patients aged 15 years and over was used for the economic modelling. Hospital separation is defined as the episode of admitted patient care, which can be a total hospital stay, or part of a hospital stay ending in a change of type of care, for example from acute care to rehabilitation. An overnight separation is when a patient is admitted to and separated from the hospital on different dates<sup>7</sup>. The data for hospital separations were sourced from the Australian Hospital Statistics 2010–2011<sup>7</sup>. The data for residential care separations were identified from the Australian residential aged care statistical review 2010–2011<sup>8</sup>. The hospital separations of diabetic patients were derived from Diabetes Hospitalisations in Australia 2003–2004<sup>9</sup> and Australian demographic statistics 2011<sup>10</sup>.

## RESULTS

### Total cases and health care costs of pressure ulcer

The total number of cases of pressure ulcer in public and private hospitals in Australia for 2010–11 was found to be 345,768 with a standard deviation of 190,071 (Table 1). The total number of cases of pressure ulcer in residential care in Australia for the same year was

Table 2. Direct health care costs of pressure ulcer in the residential care setting (long and respite) in Australia (in 2012 US\$)

State / Territory	Residential care settings (long-term and respite)	
	Cases	Costs
	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)
NSW	3,842 ( $\pm$ 606)	\$5,155,292 ( $\pm$ 1,900,120)
VIC	2,708 ( $\pm$ 424)	\$3,644,756 ( $\pm$ 1,332,490)
QLD	1,632 ( $\pm$ 256)	\$2,193,130 ( $\pm$ 807,313)
WA	786 ( $\pm$ 123)	\$1,050,385 ( $\pm$ 387,370)
SA	942 ( $\pm$ 147)	\$1,262,163 ( $\pm$ 464,208)
TAS	312 ( $\pm$ 49)	\$418,319 ( $\pm$ 153,985)
ACT	127 ( $\pm$ 20)	\$170,521 ( $\pm$ 62,407)
NT	46 ( $\pm$ 7)	\$61,772 ( $\pm$ 22,752)
Total	Mean ( $\pm$ SD): 10,397 ( $\pm$ 1,638)	Mean ( $\pm$ SD): \$13,947,536 ( $\pm$ 5,153,614)

10,397 with a standard deviation of 1,638 (Table 2). We found the total costs of pressure ulcer in public and private hospitals in 2010–11 to be US\$1.64 billion, with a standard deviation of US\$1.05 billion (Table 1). The total costs of pressure ulcer in residential care in Australia for the same year were US\$13.95 million, with a standard deviation of US\$5.15 million (Table 2). The costs of pressure ulcer in both hospital and residential care settings in Australia totalled US\$1.65 billion, with a standard deviation of US\$1.05 billion (Table 9).

#### Total cases and health care costs of diabetic ulcer

The total number of cases of diabetic ulcer in all hospitals in Australia in 2010–11 was estimated to be 12,839, with a standard deviation of 3,534. The associated total hospital care costs were US\$238.69 million, with a standard deviation of 123.98 million (Table 3). The estimated total number of cases of diabetic ulcer in residential care was 516, with a standard deviation of 141, and the associated total care costs of diabetic ulcer were US\$11 million, with a standard deviation of

US\$3.01 million (Table 4). The total health care costs of diabetic ulcer in both hospital and residential care settings amounted to US\$249.67 million, with a standard deviation of US\$124.02 million (Table 9).

#### Total cases and health care costs of venous ulcer

We estimated the total number of cases of venous ulcer in public and private hospitals in Australia in 2010–11 to be 47,299, with a standard deviation of 15,756, and the associated total hospital care costs to be US\$784.66 million, with a standard deviation of US\$307.29 million (Table 5). The total number of cases of venous ulcer in residential care was 1,739, with a standard deviation of 577, and the associated total care costs were US\$17.89 million, with a standard deviation of US\$10.26 million (Table 6). The total health care costs of venous ulcer in both hospital and residential care settings were estimated to be US\$802.55 million, with a standard deviation of US\$307.46 million (Table 9).

Table 3. Direct health care costs of diabetic foot ulcer in all hospitals in Australia (in 2012 \$US)

State / Territory	Cases and costs	
	Cases	Costs
	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)
NSW	4,146 ( $\pm$ 1,136)	\$77,545,475 ( $\pm$ 40,220,886)
VIC	3,207 ( $\pm$ 875)	\$59,595,484 ( $\pm$ 30,981,760)
QLD	2,549 ( $\pm$ 692)	\$47,584,377 ( $\pm$ 24,320,024)
WA	1,347 ( $\pm$ 368)	\$25,215,994 ( $\pm$ 12,978,363)
SA	953 ( $\pm$ 259)	\$17,757,864 ( $\pm$ 9,154,943)
TAS	296 ( $\pm$ 81)	\$5,554,936 ( $\pm$ 2,861,327)
ACT	214 ( $\pm$ 59)	\$4,005,692 ( $\pm$ 2,049,332)
NT	127 ( $\pm$ 35)	\$2,368,067 ( $\pm$ 1,214,970)
Total	Mean ( $\pm$ SD): 12,839 ( $\pm$ 3,534)	Mean ( $\pm$ SD): \$238,693,380 ( $\pm$ 123,978,571)

Note: The estimates were based on overnight separations for patients over  $\geq$ 15 years old, 2010–11.

**Total cases and health care costs of artery insufficiency ulcer**

We estimated the total number of cases of artery insufficiency ulcer in public and private hospitals in Australia in 2010–11 to be 4,712, with a standard deviation of 1,575, and the associated total health care costs to be US\$141.95 million, with a standard deviation of US\$47.46 million (Table 7). The total number of cases of artery insufficiency ulcer in residential care was 174, with a standard deviation of 58, and the associated total care costs were US\$1.78 million, with a standard deviation of US\$1.02 million (Table 8). The estimated total health care costs of artery insufficiency ulcer in both hospital and residential care settings were US\$143.73 million, with a standard deviation of US\$47.47 million (Table 9). Overall, the total direct health care costs of pressure ulcer, diabetic ulcer, venous ulcer and artery insufficiency ulcer in hospital and residential care settings in Australia in 2010–11 were estimated to be US\$2.85 billion (Table 9).

**DISCUSSION**

Although wounds are among the most frequently managed health care challenges in the Australian health care system<sup>3</sup>, no study has been conducted to assess the aggregate costs of chronic wounds to the health care system. Graves *et al.*<sup>11</sup> focused on the lost bed days to pressure ulcers among certain hospitalised patients in the public hospital setting in Australia and found the costs to be \$285 million in 2001–2002. A study by Clarke *et al.*<sup>12</sup> estimated the average costs of treating a patient with diabetic lower limb chronic ulcer in the first

and subsequent year of the event occurrence. An earlier study<sup>13</sup> looked into the hospital management costs of leg ulcers per admission. This was the first study to model the total health care costs of chronic wounds in public and private hospitals and residential care in Australia.

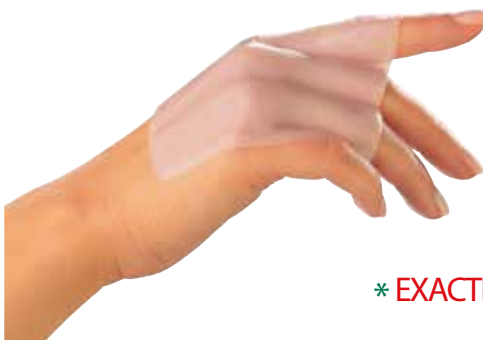
Our economic modelling showed that chronic wounds represented a significant annual burden on the health care system, with direct health care costs reaching US\$2.85 billion. This was equivalent to 2% of the total national health expenditure. A UK study showed that the costs of chronic wounds to the NHS represented 2–3% of the total national health expenditure<sup>2</sup>. The health care costs of chronic wounds in the European population accounted for 2% of the European health budget<sup>14</sup>. In the Scandinavian countries, the costs of chronic wounds comprised 2–4% of the total health care expenditure<sup>15</sup>.

The Australian estimates we present are highly uncertain as shown by the large standard deviations reported in the results tables. Both the incidences and cost estimates were characterised by large variability among the input parameters of the model. As described in the methods section, the incidence of pressure ulcer used in our economic modelling ranged between 0.6% and 21.5%, based on existing epidemiological evidence. Reported incidences varied by types of patient studies<sup>16–18</sup>, and age and other case-mix variables impacted on incidences and prevalence<sup>17,19</sup>. For example, the incidence of

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Table 4. Direct health care of diabetic ulcer in the residential care setting (long and respite) in Australia (In 2012 \$US)

State / Territory	Residential care setting (long-term and respite)	
	Cases	Costs
	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)
NSW	190 ( $\pm$ 52)	\$4,056,059 ( $\pm$ 1,105,370)
VIC	134 ( $\pm$ 36)	\$2,852,115 ( $\pm$ 774,606)
QLD	80 ( $\pm$ 22)	\$1,715,518 ( $\pm$ 470,425)
WA	39 ( $\pm$ 11)	\$830,607 ( $\pm$ 227,135)
SA	46 ( $\pm$ 13)	\$988,641 ( $\pm$ 271,029)
TAS	15 ( $\pm$ 4)	\$328,744 ( $\pm$ 90,083)
ACT	6 ( $\pm$ 2)	\$133,296 ( $\pm$ 36,363)
NT	5 ( $\pm$ 1)	\$96,208 ( $\pm$ 26,445)
Total	Mean ( $\pm$ SD): 516 ( $\pm$ 141)	Mean ( $\pm$ SD): \$10,998,764 ( $\pm$ 3,011,828)

pressure ulcer was estimated at 0.6% in a hospital patient population with a mean age of 48<sup>20</sup> as compared to 12.9% in a hospital patient population aged over 75<sup>21</sup>. We found the average age of patients with chronic wounds was over 60 years<sup>22</sup> and so our estimates may be biased downwards. With expansion of an elderly population in Australia, the economic burden of chronic wounds is likely to grow in the future.

Although the incidence of chronic wounds and associated health care costs vary significantly among different patient population groups<sup>16-21</sup> with different wound sizes<sup>23,24</sup> at different stages of the conditions<sup>25,26</sup>, and with different treatment protocols<sup>27,28</sup>, we were unable to stratify the patient population and conduct subgroup-based modelling due to lack of data for the size of different subgroup patient populations. Further research is needed to establish complete patient data so that subgroup modelling can be conducted, and the economic uncertainty

reduced. When Australian data were unavailable we relied on only international cost data for many parts of the economic modelling, or used community care-based cost data for residential care when no relevant data were available. Further research to establish Australian costs for all categories of chronic wounds in different health care settings could be useful; this would enable the total costs of chronic wounds to the health care system to be modelled with greater precision.

Our literature searches found evidence that wound management practice and care quality impacted the incidence of chronic wounds. For example, Cole *et al.*<sup>29</sup> estimated the incidence of pressure ulcer could be reduced with the use of proactive intervention, also saving resources and costs. Interventions are themselves costly and any predicted savings must be balanced against the cost increases that will arise from improving services. While estimating changes to total

Table 5. Direct health care costs of venous ulcer in all hospitals in Australia (in 2012 US\$)

State / Territory	Public hospitals		Private hospitals	
	Cases	Costs (in 2012 US\$)	Cases	Costs
	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)
NSW	10,926 ( $\pm$ 3,639)	\$181,445,782 ( $\pm$ 71,149,053)	3,744 ( $\pm$ 1,257)	\$62,031,661 ( $\pm$ 24,624,165)
VIC	8,019 ( $\pm$ 2,679)	\$133,064,357 ( $\pm$ 52,210,346)	4,083 ( $\pm$ 1,354)	\$67,709,140 ( $\pm$ 26,502,681)
QLD	5,706 ( $\pm$ 1,907)	\$94,217,175 ( $\pm$ 36,919,498)	3,773 ( $\pm$ 1,255)	\$62,448,788 ( $\pm$ 24,333,717)
WA	3,112 ( $\pm$ 1,032)	\$51,552,469 ( $\pm$ 20,247,406)	1,696 ( $\pm$ 567)	\$28,091,521 ( $\pm$ 11,090,913)
SA	2,659 ( $\pm$ 891)	\$44,074,631 ( $\pm$ 17,414,780)	1,261 ( $\pm$ 421)	\$20,940,310 ( $\pm$ 8,195,118)
TAS	631 ( $\pm$ 210)	\$10,450,961 ( $\pm$ 4,091,396)	n.p.	n.p.
ACT	541 ( $\pm$ 180)	\$8,948,083 ( $\pm$ 3,499,909)	n.p.	n.p.
NT	444 ( $\pm$ 148)	\$7,384,342 ( $\pm$ 2,899,734)	n.p.	n.p.
Sub total	32,055 ( $\pm$ 10,686)	\$532,852,264 ( $\pm$ 208,074,215)	15,265 ( $\pm$ 5,069)	\$252,856,807 ( $\pm$ 98,619,469)
Public and private hospitals				
Total	Cases		Costs	
	Mean ( $\pm$ SD): 47,299 ( $\pm$ 15,756)		Mean ( $\pm$ SD): \$784,661,109 ( $\pm$ 307,286,847)	

Note: The estimates were based on overnight separations for patients over  $\geq$ 15 years old, 2010–11.

Table 6. Direct health care costs of venous ulcer in the residential care setting in Australia (in 2012 US\$)

State / Territory	Residential care settings (long-term and respite)	
	Cases	Costs
	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)
NSW	637 ( $\pm$ 214)	\$6,536,682 ( $\pm$ 3,775,026)
VIC	453 ( $\pm$ 150)	\$4,617,879 ( $\pm$ 2,678,214)
QLD	271 ( $\pm$ 91)	\$2,791,470 ( $\pm$ 1,595,922)
WA	130 ( $\pm$ 44)	\$1,338,063 ( $\pm$ 769,137)
SA	157 ( $\pm$ 52)	\$1,606,113 ( $\pm$ 930,365)
TAS	52 ( $\pm$ 17)	\$531,382 ( $\pm$ 307,963)
ACT	21 ( $\pm$ 7)	\$216,903 ( $\pm$ 125,232)
NT	8 ( $\pm$ 3)	\$78,538 ( $\pm$ 45,280)
Total	Mean ( $\pm$ SD): 1,739 ( $\pm$ 577)	Mean ( $\pm$ SD): \$17,888,904 ( $\pm$ 10,258,507)

Table 7. Direct health care costs of artery insufficiency ulcer in all hospitals in Australia (in 2012 US\$)

State / Territory	Public hospitals		Private hospitals	
	Cases	Costs (in 2012 US\$)	Cases	Costs
	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)
NSW	1,088 ( $\pm$ 364)	\$32,782,282 ( $\pm$ 10,962,550)	378 ( $\pm$ 126)	\$11,383,983 ( $\pm$ 3,786,438)
VIC	802 ( $\pm$ 268)	\$24,176,810 ( $\pm$ 8,072,162)	405 ( $\pm$ 135)	\$12,190,471 ( $\pm$ 4,080,246)
QLD	575 ( $\pm$ 191)	\$17,332,702 ( $\pm$ 5,744,069)	376 ( $\pm$ 125)	\$11,342,417 ( $\pm$ 3,780,238)
WA	309 ( $\pm$ 103)	\$9,316,066 ( $\pm$ 3,109,837)	170 ( $\pm$ 57)	\$5,118,457 ( $\pm$ 1,707,259)
SA	267 ( $\pm$ 89)	\$8,045,817 ( $\pm$ 2,683,857)	126 ( $\pm$ 42)	\$3,806,700 ( $\pm$ 1,268,030)
TAS	63 ( $\pm$ 21)	\$1,906,171 ( $\pm$ 632,583)	n.p.	n.p.
ACT	54 ( $\pm$ 18)	\$1,630,581 ( $\pm$ 542,239)	n.p.	n.p.
NT	44 ( $\pm$ 15)	\$1,338,708 ( $\pm$ 445,870)	n.p.	n.p.
Sub total	3,206 ( $\pm$ 1,069)	\$96,598,645 ( $\pm$ 32,194,714)	1,519 ( $\pm$ 507)	\$45,756,143 ( $\pm$ 15,272,045)
Public and private hospitals				
Total	Cases	Costs		
	Mean ( $\pm$ SD): 4,712 ( $\pm$ 1,575)	Mean ( $\pm$ SD): \$141,947,337 ( $\pm$ 47,464,777)		

Note: The estimates are based on overnight separations for patients over  $\geq$ 15 years old, 2010–11.

Table 8. Direct health care costs of artery insufficiency ulcer in the residential care setting in Australia (in 2012 US\$)

State / Territory	Residential care settings (long-term and respite)	
	Cases	Costs
	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)
NSW	64 ( $\pm$ 21)	\$651,335 ( $\pm$ 376,905)
VIC	45 ( $\pm$ 15)	\$459,773 ( $\pm$ 266,621)
QLD	27 ( $\pm$ 9)	\$278,561 ( $\pm$ 161,730)
WA	13 ( $\pm$ 4)	\$133,886 ( $\pm$ 77,199)
SA	16 ( $\pm$ 5)	\$161,466 ( $\pm$ 93,415)
TAS + TAS + NT	8 ( $\pm$ 3)	\$82,833 ( $\pm$ 48,245)
Total	Mean ( $\pm$ SD): 174 (58)	Mean ( $\pm$ SD): \$1,781,967 ( $\pm$ 1,023,441)



Table 9. Total direct health care costs of chronic wounds in Australia (all states and territories)

Health care settings	Pressure ulcer Mean ( $\pm$ SD)	Diabetic foot ulcer Mean ( $\pm$ SD)	Venous ulcer Mean ( $\pm$ SD)	Artery insufficiency ulcer Mean ( $\pm$ SD)
Hospital	\$1,640,644,160 ( $\pm$ 1,054,280,239)	\$238,693,380 ( $\pm$ 123,978,571)	\$784,661,109 ( $\pm$ 307,286,847)	\$141,947,337 $\pm$ 47,464,777
Residential care	\$13,947,536 ( $\pm$ 5,153,614)	\$10,977,255 ( $\pm$ 2,993,110)	\$17,888,904 ( $\pm$ 10,258,507)	\$1,781,967 ( $\pm$ 1,023,441)
Subtotal	\$1,654,591,697 ( $\pm$ 1,054,241,633)	\$249,670,635 ( $\pm$ 124,022,869)	\$802,550,013 ( $\pm$ 307,458,206)	\$143,729,304 ( $\pm$ 47,466,504)
Total	\$2,850,541,649 ( $\pm$ 1,101,302,160)			

costs are important, the health benefits of reducing the consequences of wounds must also be considered if arguments about the cost-effectiveness of risk-reducing interventions are to be made<sup>30</sup>.

## CONCLUSION

Chronic wounds place a significant economic burden on the health care system in Australia. The burden is set to rise as the ageing population expands. Identifying and implementing effective and cost-effective intervention strategies is critically important to reducing functional impairment and improving the quality of life for patients. It is also critically important to reducing the economic burden on both the health care system and patients.

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## Appendix 1: Data used for estimating the costs of pressure ulcer.

## a: The incidence of pressure in the hospital setting

Country	Author/year		Incidence	Incidence duration within 1 year (day)
Australia	Charlier <i>et al.</i> , 2001		6.5%	7
UK	Clark <i>et al.</i> , 1994		4.03%	365
US	Schue <i>et al.</i> , 1999		6%	365
US	Whittington <i>et al.</i> , 2000		7%	5
US	Whittington <i>et al.</i> , 2004	In 2004	7%	5
		In 2003	7%	5
		In 2002	8%	5
		In 2001	7%	5
		In 2000	9%	5
		In 1999	8%	5
US	Allman <i>et al.</i> , 1995		12.9%	9
Canada	Cole <i>et al.</i> , 2004	(Baseline incidence)	17.9%	365
		Intervention phase 1	5.2%	
		Intervention phase 2	2%	
Sweden	Hunter <i>et al.</i> , 1992		0%	120
US	Jenkins <i>et al.</i> , 2010		2.8%	90
US	Schultz <i>et al.</i> , 1999		21.5%	6
Germany	Stausberg <i>et al.</i> , 2005		0.6%	180
Canada	Van DenKerkhof, 2011=	In 1998	11.2%	365
		In 2006	6.8%	
US	Fife <i>et al.</i> , 2001		12.4%	6.4
US	Gosnell <i>et al.</i> , 1992		8.4%	90
UK	Clarke <i>et al.</i> , 1988		29%	≤42
Singapore	Chan <i>et al.</i> , 2005		8.1%	7
		<i>Min</i>	0.6%	
		<i>Max</i>	21.5%	

Note: Given the wide variations in incidence, we excluded the highest and the lowest values as outliers to reduce economic uncertainty.

## b: Costs of pressure ulcer (overall) in the hospital setting as estimated by previous studies (in 2012 US\$)

Country	Author/year	Costs	Cost period within 1 year (day)
US	Kumar <i>et al.</i> , 2004	\$5,974.00	365
France	Meaume <i>et al.</i> , 2000 (protocol A)	\$7,138.91	84
France	Meaume <i>et al.</i> , 2000 (Protocol B)	\$ 2,371.12	84
Australia	Graves <i>et al.</i> , 2005		4.31
		<i>Min</i>	\$2,371.12
		<i>Max</i>	\$7,138.91

## c: Overnight separations by public and private hospital and state and territory, 2010–11

State/territory	NSW	VIC	QLD	WA	SA	TAS	ACT	NT	Total
Public hospital	727753	535855	381361	206440	178161	41996	35996	29598	2137160
Private hospital	251358	270,877	250,941	113,332	84,175	n.p†	n.p	n.p	1,013,801
Total	979111	806,732	632,302	319,772	262,336	n.p	n.p	n.p	3,150,961

Note: Overnight separations are for patients ≥15 years old. † data were suppressed for privacy protection

Data source: AIHW 2012. Australian hospital statistics 2010-11. Health services series No. 43. Cat. No. HSE 117. Canberra: AIHW. <http://www.aihw.gov.au/WorkArea/DownloadAsset.aspx?id=10737421722>



Appendix 1 (continued): Data used for estimating the costs of pressure ulcer.

**d: The incidence of pressure ulcer (all stages) in the residential care setting**

Country	Author/year	Incidence	Incidence duration
Canada	Davis <i>et al.</i> , 2001	11.7%	41
Canada	Davis <i>et al.</i> , 2001	11.6%	42
US	Frantz <i>et al.</i> , 2001	6.4%	365
	<i>Min</i>	6.4%	
	<i>Max</i>	11.7%	

**e: Costs of pressure ulcer (all stages) in the residential care setting estimated by previous studies (in 2012 US\$)**

Country	Author/year	Costs	Cost period within 1 year (day)
US	Frantz <i>et al.</i> , 2001	\$580	365
US	Xakellis <i>et al.</i> , 1996	\$2101	116
	<i>Min</i>	\$580	
	<i>Max</i>	\$2101	

**f: All separations in the residential care setting (permanent and respite) by state and territory, 2010–11**

State/territory	NSW	VIC	QLD	WA	SA	TAS	ACT	NT	Total
Separations	42,710	30,068	18124	8740	10468	3469	1408	510	115,497

Source: AIHW 2012. Residential aged care in Australia 2010-11: a statistical overview. Aged care statistics series No. 36. Cat. No. AGE 68. Canberra: AIHW. <http://www.aihw.gov.au/aged-care-data-cubes/>

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## Appendix 2: Data used for estimating the costs of diabetic ulcer.

**a: Incidence of diabetic ulcer in diabetes patients in hospital and community setting**

Country	Author/year	Incidence	Incidence duration within 1 year (day)	
US	Ramsey <i>et al.</i> , 1999	1.93% (5.8%/3) ( <b>hospital</b> )	1 year (on average)	No diabetic ulcer history
US	LeMaster <i>et al.</i> , 2008	4.5% (predicted)	1 year	No diabetic ulcer history
US	Moss <i>et al.</i> , 1992	2.4%	1 year	Diabetic population (age<30)
		2.6%	1 year	Diabetic population (age≥30)
Sweden	Borssen <i>et al.</i> , 1990	3%	1 year	(Patients with IDDM)
UK	Abbott <i>et al.</i> , 2002	2.2%	1 year	Community diabetic patients
	<i>Min</i>	1.93%		
	<i>Max</i>	4.5%		

Note: The present study only relied on the incidence of diabetic ulcer in patients without diabetic ulcer history.

**b: Costs of diabetic ulcer in the hospital setting as estimated by previous studies (in 2012 US\$)**

Country	Author/year	Costs	Costing details	Cost period within 1 year (day)
Australia	Clarke <i>et al.</i> , 2008	\$21,764	The first year costs for a man aged 60	1 year
		\$26,148	The first year costs for a man aged 70	1 year
		\$5029	A subsequent year for a man aged 60	1 year
		\$6142	A subsequent year for a man aged 70	1 year
US	Harrington <i>et al.</i> , 2000	\$5,437	Annual costs based on medicare claims	1 year
Europe	Prompers <i>et al.</i> , 2008	\$10,336	Direct costs per patient healed	1 year
US	Ramsey <i>et al.</i> , 1999	\$32,242	Treatment costs for the first year	1 year
		\$18,281	Treatment costs for the second year	1 year
	<i>Min</i>	\$5,029		
	<i>Max</i>	\$32,242		

**c: Estimated separations for hospitalisations of diabetic patients by state or territory, 2010–11**

State/territory	NSW	VIC	QLD	WA	SA	TAS	ACT	NT
15–19	461207	355460	303607	154917	105929	33922	25007	16161
20–24	499161	412439	321822	176984	114969	32369	33540	19366
25–29	522220	424771	326796	184788	112582	30416	32900	21887
30–34	498161	391582	300911	166180	101877	28501	28773	19208
35–39	508380	395169	317367	168820	106410	31872	27536	18335
40–44	497869	399129	319267	173043	114223	34669	26332	17639
45–49	498468	381719	311238	167331	115430	36056	25038	16093
50–54	485315	363797	296058	157959	114142	37577	23855	14973
55–59	432724	324689	263560	140094	103678	34917	20805	12622
60–64	403287	301135	248200	125998	99240	33388	18767	9840
65–69	316453	232523	190929	91263	76433	26024	12956	5759
70–74	242182	179811	137782	68379	58896	19593	9094	3462
75–79	191193	143065	101267	51630	47297	14770	6704	1824
80–84	153747	115211	77947	39349	39922	11343	5131	1141
85+	140748	104309	69860	34600	38038	10320	4733	693
Total	5851115	4524809	3586611	1901335	1349066	415737	301171	179003
Estimated hospital separations	138730	107283	85039	45081	31986	9857	7141	4244

Note: The estimated separations for hospitalisations of diabetic patients are based on a ratio of 2.37 separations for every 100 persons (diabetes as any diagnosis):

Source for diabetes hospital separation ratio: AIHW: O'Brien K, Thow AM & Ofei S 2006. Diabetes hospitalisations in Australia, 2003–04. Bulletin No. 47. Cat. No. 84. Canberra: AIHW; Data for Australian population ≥ 15 years old at June 2011. Data source population by State and Territory: Australian demographic statistics 2011, ABS. [http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/FEB6A31EE56FD01ACA2579CF000F9B57/\\$File/31010\\_sep%202011.pdf](http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/FEB6A31EE56FD01ACA2579CF000F9B57/$File/31010_sep%202011.pdf)

Appendix 2 (continued): Data used for estimating the costs of diabetic foot ulcer.

**d: Estimated prevalence of diabetes in the residential care setting**

People ever diagnosed with diabetes by age, Australia, 2007–08		
Age group	Number of people ever diagnosed with diabetes (all States and Territories)	Proportion with diabetes in the population (%)
65-69	127,100	15.8 %
70-74	94,300	14.8 %
75-79	76,500	14.5 %
80 and over	88,800	14.1 %
Estimated mean prevalence of diabetes in the residential care settings		14.8%

Source: Australian Institute of Health and Welfare 2011. Diabetes prevalence in Australia: detailed estimates for 2007–08. Diabetes series No. 17. Cat. No. CVD 56. Canberra: AIHW

**e: All residential separations and estimated separations of residents with diabetes**

State/territory	NSW	VIC	QLD	WA	SA	TAS	ACT	NT	Australia
All separations in the residential care setting	42,710	30,068	18124	8740	10468	3469	1408	510	115,497
Estimated separations of residents with diabetes	6321	4450	2682	1294	1549	513	208	151*	17168

Source:

(1). Prevalence of diabetes residents  $\geq 65$ : Australian Institute of Health and Welfare 2011. Diabetes prevalence in Australia: detailed estimates for 2007–08. Diabetes series No. 17. Cat. No. CVD 56. Canberra: AIHW.

(2). All separations in the residential care setting: Residential aged care in Australia 2010–11: A statistical review, AIHW

\* The prevalence of diabetes in the residential care setting in the Northern Territory was adjusted in line with the reported high prevalence of diabetes in the general population in the Territory (29.6% prevalence of diabetes was applied to estimate the separations of residents ever diagnosed with diabetes in the residential care setting)

**f: Costs of diabetic ulcer in the community setting as estimated by previous studies (in 2012 US\$)**

Country	Author/year	Costs	Costing details	Cost period within 1 year (day)
US	Lavery <i>et al.</i> , 2007	\$22,310	Costs of therapy (new treatment)	140 days
		\$20,343	Costs of therapy 2 (conventional)	1 year
			1 nurse visit a day	

Note: Due to lack of data, the health care costs of diabetic ulcer in the community setting were used for the residential care setting.



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## Appendix 3: Data used for estimating the costs of venous ulcer.

## a: Incidence of venous ulcer

Country	Author/year	Incidence	Incidence period within 1 year (day)	Settings
Unspecified	Clement, 1999	0.02-0.35%	(unspecified)	Unspecified
US	Wipke-Tevis <i>et al.</i> , 2000	1%	90	Long-term care facility
		1.3%	180	
		1.8%	270	
		2.2%	365	
UK	Margolis <i>et al.</i> , 2002	1.2/100 person-years	90	GP-based patients
		1.16/100 person-years	180	
		1.13/100 person-years	270	
	<i>Min</i>	0.02%		
	<i>Max</i>	2.2%		

Note: Due to lack of data, the incidence of venous ulcer in residential and community settings were used for estimating the healthcare costs of venous ulcer in the hospital setting.

## b: Costs of venous ulcer in the hospital setting as estimated by previous studies (in 2012 US\$)

Country	Author/year	Costs	Cost period within 1 year (day)
Australia	Gruen <i>et al.</i> , 1996	\$22,207	21
Sweden	Oien <i>et al.</i> , 2001	(Treatment group 1)	28-91
		(Treatment group 2)	
		(Treatment group 3)	
	<i>Min</i>	\$10,924	
	<i>Max</i>	\$22,207	

## c: Costs of venous ulcer in the residential care setting as estimated by previous studies (in 2012 US\$)

Country	Author/year	Costs	Cost period within 1 year (day)
France	Meaume <i>et al.</i> , 2002	(Treatment costs for protocol A)	84
		(Treatment costs for protocol B)	
		(Treatment costs for protocol C)	
	<i>Min</i>	\$2293	
	<i>Max</i>	\$18196	

## Appendix 4: Data used for estimating the costs of artery insufficiency ulcer.

## a: Estimated incidence of artery insufficiency ulcer

Country	Author/year	Incidence	Incidence period	Settings
Sweden	Ebbeskog <i>et al.</i> , 1996	0.09% (derived from prevalence rate)	Estimated on a 1-year basis	Based on the cases of artery insufficiency ulcer reported in the hospital setting
Spain	Soldevilla <i>et al.</i> , 2006	0.16% (derived from prevalence rate)	Estimated on a 1-year basis	Based on the cases of artery insufficiency ulcer reported in the community care setting

## b: Costs of artery inefficiency ulcer in the hospital setting (in 2012 US\$)

Country	Author/year	Costs	Cost period within 1 year (day)
Australia	Gruen <i>et al.</i> , 1996 (artery ulcer)	\$30127	21

## c: Costs of venous ulcer in the residential setting estimated by previous studies were used to estimate the costs of artery insufficiency ulcer in the residential setting (in 2012 US\$)

Country	Author/year	Costs	Cost period within 1 year (day)
France	Meaume <i>et al.</i> , 2002	(Treatment costs for protocol A)	\$4412
		(Treatment costs for protocol B)	\$2293
		(Treatment costs for protocol C)	\$18196
	Min	\$2293	
	Max	\$18196	



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