Burden of disease and injury in Australia in the new millennium: measuring health loss from diseases, injuries and risk factors

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ABSTRACT

Objective: To describe the magnitude and distribution of health problems in Australia, in order to identify key opportunities for health gain.

Design: Descriptive epidemiological models for a comprehensive set of diseases and injuries of public health importance in Australia were developed using a range of data sources, methods and assumptions. Health loss associated with each condition was derived using normative techniques and quantified for various subpopulations, risks to health, and points in time. The baseline year for comparisons was 2003.

Main outcome measures: Health loss expressed as disability-adjusted life years (DALYs) and presented as proportions of total DALYs and DALY rates (crude and age-standardised) per 1000 population.

Results: A third of total health loss in 2003 was explained by 14 selected health risks. DALY rates were 31.7% higher in the lowest socioeconomic quintile than in the highest, and 26.5% higher in remote areas than in major cities. Total DALY rates were estimated to decline for most conditions over the 20 years from 2003 to 2023, but for some causes, most notably diabetes, they were projected to increase.

Conclusion: Despite steady improvements in Australia's health over the past decade, there are still opportunities for further progress. Significant gains can be made through achievable changes in exposure to a limited number of well established health risks.

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Information on the magnitude and distribution of health problems in a population is important for health policy decision making. Popular epidemiological measures such as mortality, incidence and prevalence are available for many health problems, but can not be compared across causes as indicators of population-level health. Summary measures of population health, on the other hand, extend the utility of descriptive epidemiology by combining information on mortality and non-fatal health problems into a common measure that can be used to provide a comprehensive picture of the health status of a population.[1]

We present here a reanalysis of a large body of work that used summary measures to describe the health of Australians in the new millennium.[2] The research on which it is based follows a comparable study for the year 1996 reported in the Journal in 2000.[3] Both studies use a particular summary measure — the "disability-adjusted life year" (DALY) — to quantify health loss from a comprehensive set of diseases, injuries and health risks of public health importance in Australia. The DALY, in turn, has its origins in an assessment of global health for the World Bank.[4,5] One DALY is equivalent to one lost year of healthy life and represents the gap between current health status and an ideal situation of the whole population living into old age in full health. This gap is referred to here as "health loss", rather than the less accurate but more commonly used term "burden of disease".

The DALY combines the descriptive epidemiology of each health condition of interest with a multidimensional numerical weighting for the severity of that condition. As the weighting given to each dimension implies a judgement about its relative importance to the total measure, the DALY has obvious normative characteristics that make it not necessarily compatible with other classifications of health (eg, the World Health Organization's *International classification of functioning, disability and health*[6]). For this reason, others have highlighted the importance of limiting interpretation of the DALY to the specific purposes for which it is being used[7] — which, in this case, is as a comparative measure of health loss.

Our article provides an assessment of the magnitude and distribution of health problems in Australia in order to identify key opportunities for health gain. Our specific objectives were to calculate:

- DALYs by cause, age and sex for the year 2003;
- DALYs attributable to past and current exposure to major modifiable health risks;
- Differentials in DALY rates between subpopulations (eg, between state and territory jurisdictions, socioeconomic groups, and remoteness categories); and
- DALYs projected 10 and 20 years beyond 2003.

METHODS

Health loss was estimated for a comprehensive set of diseases and injuries of public health importance in Australia, using DALYs as the outcome measure. Diseases and injuries were the smallest reported unit of disaggregation, and are referred to here as "specific causes" or "conditions". Each is mutually exclusive and belongs to one of 22 "broad cause groups", most of which correspond to chapter-level headings of the International classification of diseases.[8] Each broad cause group, in turn, belongs to one of three broad clusters: (a) communicable, maternal, neonatal and nutritional conditions; (b) non-communicable diseases; and (c) injuries. Further details on methods and assumptions are provided elsewhere.[2]

Baseline models

Baseline models describing the epidemiology of each specific cause for Australia in 2003 were developed using a range of data sources, methods and assumptions. Typical inputs included prevalence (from surveys), incidence (from disease registers), case fatality (from cohort studies), remission (from cohort and intervention studies), clinical judgement, and information about changes over time in any of these variables. Complete and internally consistent cross-sectional epidemiological models were derived from three of these inputs using modelling software.[9]

Epidemiological trends

Trends in observed cause-specific mortality over the period 1979–2003 were analysed and projected to 2023 using a combination of regression techniques. Transition hazards for conditions that cause mortality were extrapolated from baseline using assumptions about the relative contribution of incidence and case fatality to changes in cause-specific mortality. For non-fatal conditions, incidence

1 Health loss, by broad cause group, Australia, 2003

Broad cause group	Rate/1000 people (%)		
	Non-fatal health loss*	Fatal health loss†	Total health loss‡
Cancers	4.4 (6.5%)	20.7 (32.2%)	25.1 (19.0%)
Cardiovascular disease	5.3 (7.7%)	18.6 (28.9%)	23.8 (18.0%)
Mental disorders	16.5 (24.2%)	1.2 (1.8%)	17.6 (13.3%)
Neurological and sense organ disorders	13.0 (19.1%)	2.7 (4.2%)	15.7 (11.9%)
Chronic respiratory diseases	5.8 (8.5%)	3.6 (5.6%)	9.4 (7.1%)
Injuries	2.2 (3.2%)	7.1 (11.0%)	9.3 (7.0%)
Diabetes mellitus	5.6 (8.2%)	1.6 (2.5%)	7.2 (5.5%)
Musculoskeletal diseases	5.0 (7.3%)	0.4 (0.5%)	5.3 (4.0%)
Genitourinary diseases	2.1 (3.0%)	1.2 (1.9%)	3.3 (2.5%)
Other	8.3 (12.3%)	7.3 (11.4%)	15.6 (11.7%)
Total	68.1 (100.0%)	64.3 (100.0%)	132.4 (100.0%)

* Calculated as incidence × severity weight (range, 0–1) × average duration in years (discounted at 3%) and referred to as years lost due to disability (YLD).
† Calculated as deaths × global standard expectation of life at age of death in years (discounted at 3%) and referred to as years of life lost (YLL).
‡ Calculated as YLD + YLL and referred to as disability-adjusted life years (DALYs). ◆

was the only transition hazard for which extrapolations were made. Estimates for each specific cause through time were calculated in a model that accounted for changes in all-cause mortality as well as changes in incidence and case fatality (where appropriate) at all points throughout the study period. Absolute numbers of incident and prevalent cases were derived by applying the population rates from these analyses to Australian Bureau of Statistics population projections.[10]

DALY estimates

DALYs were calculated by applying severity weights (range, 0–1) to the estimated number of incident cases and average duration for each condition. Weights were derived from two sources,[4,11] with extrapolations based on alternative methods in some cases. Adjustments were made to account for the possibility of two or more conditions occurring simultaneously in the same person, either by chance or because the conditions are related. These corrections were achieved by determining numbers of people for every combination of causes of ill health as measured by various surveys and hospital admission data.

Health risk assessment

Past and current exposure to 14 selected risk factors (listed in Box 3) were analysed for their contribution to health loss in 2003. Analyses were based on the theoretical framework developed for the WHO-initiated Comparative Risk Assessment project.[12] This approach incorporates a "hypothetical minimum" as the alternative exposure distribution against which health loss is calculated, and uses continuous rather than categorical measures of exposure where appropriate. Results were also calculated for the combined effect of health risks.

Health differentials

Health differentials were assessed by comparing subpopulation-specific age-standardised DALY rates derived from disaggregated national DALY estimates. Disaggregation was achieved in two stages, whereby condition-specific estimates of incidence and mortality were first apportioned to states and territories and then to a 15-cell matrix of subpopulations. The matrix was composed of three remoteness categories (major cities, regional areas and remote areas) by five socioeconomic quintiles within each jurisdiction.

To disaggregate conditions with a predominantly fatal impact, preference was given to mortality data. For the remaining conditions, preference was given to the data source on which the baseline model was based (eg, hospital data, health survey data). Condition-specific estimates of prevalence and duration for each subpopulation were derived from subpopulation-specific incidence and all-cause mortality rates, as well as national assumptions regarding remission and case fatality. Subpopulation-specific DALYs were calculated using comorbidity-corrected national severity weights.

RESULTS

Key findings are presented here at two levels of aggregation: "broad cause groups" and "specific conditions". Both levels are referred to as "causes" and are ranked in terms of "leading" causes compared with others at the same level of aggregation.

Leading broad cause groups

Total health loss in Australia in 2003 was 2.63 million DALYs or 132 DALYs lost per 1000 people. Fifty-one per cent of the loss was from non-fatal causes. Over 75% was

2 Ten leading specific causes of health loss,* by sex, Australia, 2003

Rank	Males		Females	
	Specific cause	Rate/1000 people (%)	Specific cause	Rate/1000 people (%)
1	Ischaemic heart disease	1.5 (11.1%)	Anxiety and depression	1.3 (10.0%)
2	Type 2 diabetes	0.7 (5.2%)	Ischaemic heart disease	1.1 (8.9%)
3	Anxiety and depression	0.7 (4.8%)	Stroke	0.7 (5.1%)
4	Lung cancer	0.6 (4.0%)	Type 2 diabetes	0.6 (4.9%)
5	Stroke	0.5 (3.9%)	Dementia	0.6 (4.8%)
6	Chronic obstructive pulmonary disease	0.5 (3.6%)	Breast cancer	0.6 (4.8%)
7	Adult-onset hearing loss	0.4 (3.1%)	Chronic obstructive pulmonary disease	0.4 (3.0%)
8	Suicide and self-inflicted injuries	0.4 (2.8%)	Lung cancer	0.3 (2.7%)
9	Prostate cancer	0.4 (2.7%)	Asthma	0.3 (2.7%)
10	Colorectal cancer	0.4 (2.5%)	Colorectal cancer	0.3 (2.3%)

* Expressed as disability-adjusted life years lost per 1000 people. ◆

accounted for by the six leading broad cause groups: cancer, cardiovascular disease, mental disorders, neurological and sense organ disorders, chronic respiratory diseases, and injuries (Box 1).

Broad cause groups, by age

DALY rates increased steeply with age, apart from small but significant peaks in infancy and early adulthood. Injuries (particularly in males) and mental disorders accounted for the majority of DALYs in early adulthood, after which cancer, cardiovascular disease, and neurological and sense organ disorders were more prominent. The contribution from cancer peaked at age 70 years then declined, leaving cardiovascular disease as the major cause of DALYs in the very old.

Leading specific conditions, by sex

Ischaemic heart disease was the leading specific cause of health loss in males, followed by type 2 diabetes, anxiety/depression, lung cancer and stroke. For females, anxiety/depression was the leading specific cause of health loss, followed by ischaemic heart disease, stroke, type 2 diabetes and dementia (Box 2).

Risks to health, by broad cause group

The 14 selected risk factors together explained almost a third of health loss (expressed as total DALYs). Ten risk factors explained 32.9% of cancer-related health loss, tobacco use being the most important. Twelve risk factors explained 69.3% of health loss from cardiovascular disease, with high blood pressure and high blood cholesterol levels being the largest contributors. Four risk factors explained 26.9% of health loss from mental disorders, with alcohol and illicit drug use contributing in roughly equal proportions. Seven risk factors explained 31.7% of injury-related health loss, alcohol consumption being the dominant risk. Two risk factors explained 60.1% of health loss from type 2 diabetes, high body mass being the largest contributor (Box 3).

Health differentials

Age-standardised DALY rates were 31.7% higher in the lowest socioeconomic quintile than in the highest, and 26.5% higher in remote areas than in major cities. Age-standardised DALY rates in the Northern Territory were 88.7% higher than in the Australian Capital Territory, these jurisdictions having the highest and lowest rates, respectively (Box 4).

Past, present and future health loss

Age-standardised DALY rates declined from 151.0/1000 people to 132.4/1000 people over the period 1993–2003, and are projected to decline by 0.8% per year to 111.4/1000 people by the year 2023. Over the period 2003–2023, age-standardised DALY rates associated with cardiovascular disease are expected to experience the greatest annual rate of decline (–2.5%), followed by cancer (–1.4%), injuries (–1.1%) and chronic respiratory conditions (–0.9%). On the other hand, age-standardised DALY rates associated with diabetes are projected to grow by 1.8% a year over the period 2003–2023. Age-standardised DALY rates for other broad cause groups are likely to experience much smaller changes over this period (Box 5).

DISCUSSION

Our findings emphasise that, despite steady improvements in Australia's health over the past decade, significant opportunities for

3 Health loss* attributable† to 14 selected risk factors, by selected broad cause group, Australia, 2003

	Broad cause group					
	Cancers	CVD	Mental disorders	Injuries	Diabetes mellitus	All causes
Total health loss (DALYs lost/1000 people)	25.1	23.8	17.6	9.3	7.2	132.4
Attributable† health loss — individual (%)‡						
Tobacco use	20.1%	9.7%	na	0.5%	na	7.8%
High blood pressure	na	42.1%	na	na	na	7.6%
High body mass	3.9%	19.5%	na	na	54.7%	7.5%
Physical inactivity	5.6%	23.7%	na	na	23.7%	6.6%
High blood cholesterol levels	na	34.5%	na	na	na	6.2%
Alcohol consumption	3.1%	–4.7%	9.7%	18.1%	na	2.3%
Low consumption of fruit and vegetables	2.0%	9.6%	na	na	na	2.1%
Illicit drug use	na	< 0.1%	8.0%	3.6%	na	2.0%
Occupational exposures and hazards	3.1%	0.4%	na	4.7%	na	2.0%
Intimate partner violence	0.5%	0.3%	5.5%	2.5%	na	1.1%
Child sexual abuse	< 0.1%	< 0.1%	5.8%	1.4%	na	0.9%
Urban air pollution	0.8%	2.7%	na	na	na	0.7%
Unsafe sex	1.0%	na	na	na	na	0.6%
Osteoporosis	na	na	na	2.4%	na	0.2%
Attributable† health loss — combined (%)§	32.9%	69.3%	26.9%	31.7%	60.1%	32.2%

CVD = cardiovascular disease. DALY = disability-adjusted life year. na = not applicable.

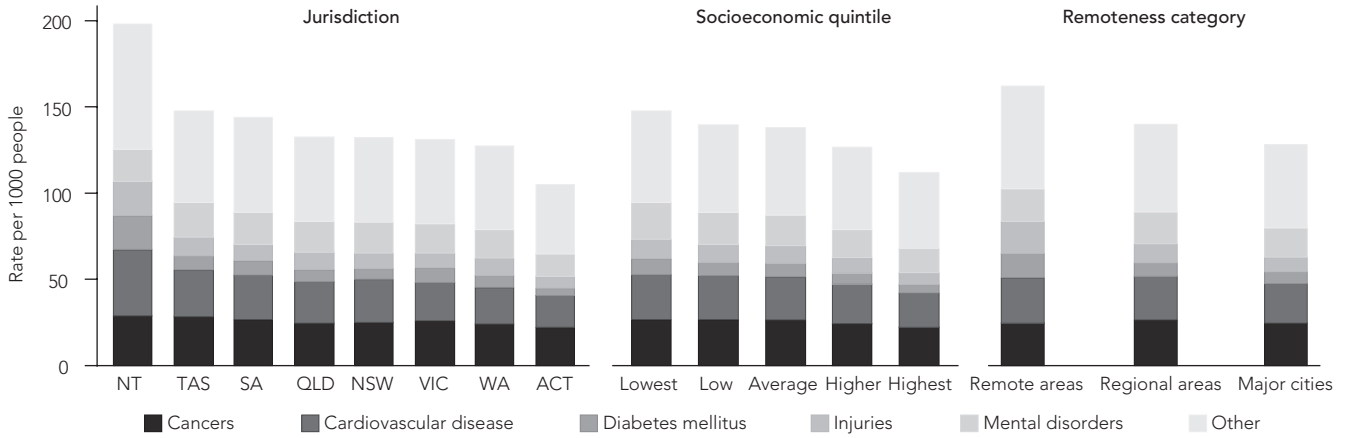
* Expressed as DALYs lost per 1000 people.

† "Attributable" health loss is health loss that is explained by past and current exposure to health risks. This is distinct from "avoidable" health loss, which is health loss that might be averted through future changes in exposure to a health risk.

‡ Attributable health loss within each column is expressed as a percentage of total DALY rates for that column.

§ Figures for combined effects are not necessarily column totals because risk factors can share common causal pathways. ◆

4 Age-standardised* DALY rates per 1000 people, by jurisdiction, socioeconomic quintile and remoteness category, for selected broad cause groups, Australia, 2003



ACT = Australian Capital Territory. DALY = disability-adjusted life year. NSW = New South Wales. NT = Northern Territory. QLD = Queensland. SA = South Australia. TAS = Tasmania. VIC = Victoria. WA = Western Australia.

* Standardised to the age structure of the Australian population (males and females combined). ◆

further progress remain at the beginning of the 21st century.

The strength of our analysis is that it is based on an internally consistent assessment of the incidence, prevalence, duration and mortality for a mutually exclusive and comprehensive set of diseases and injuries of importance in Australia. Health loss from these causes was quantified for different periods, subpopulations and risks to health using methods that incorporate fatal and non-fatal health outcomes and include adjustments to account for individuals who simultaneously experience multiple conditions. Health loss is likely to be over-estimated without such corrections, as the severity weights used to derive DALYs were originally determined for health states in isolation, without reference to coexisting conditions.[13]

A potential limitation is that the severity weights used in our analysis were derived from international sources[4,11] and applied without evidence of their validity in Australia. However, studies conducted elsewhere suggest that there are only minor variations across populations in the values people ascribe to different health states.[4]

We have not quantified uncertainty in our analysis, although a qualitative assessment suggests it is unlikely to be excessive. Overall, about half of the total estimated health loss is due to mortality, for which estimates are fairly robust. Of the remainder, half is due to non-fatal outcomes from conditions for which reasonably good data are available (including cardiovascular disease, cancers, diabetes, common mental disorders and injuries), leaving a quarter with varying and probably higher levels of uncertainty. Precision varies between causes, with estimates for hearing loss, neurological conditions, osteoarthritis and cirrhosis being the most inaccurate.

Our results are not directly comparable with previous DALY estimates for Australia,[3] owing to the different methods used. First, a number of the epidemiological models in our analysis benefit from more accurate inputs, particularly the cardiovascular disease models, which incorporated linked data from Western Australia. Second, unlike in the previous analysis, the comorbidity adjustments here capture the dependent nature of certain health states (eg, diabetes increases the risk of heart disease). Third, the current risk attribution methods incorporate a number of methodological advances absent from previous health risk analyses.[3,14,15] Because of this lack of comparability, we back-calculated estimates for 1993 based on methods that were consistent with estimates for 2003.

5 Past and projected future changes in health loss,* by selected broad cause group, Australia, 1993–2023

	Proportion of total (%)				Standardised rate/1000 people†			
Broad cause group	1993	2003	2013	2023	1993	2003	2013	2023
Cancers	18.8%	19.0%	18.9%	18.2%	29.5	25.1	21.8	18.2
Cardiovascular disease	22.3%	18.0%	15.4%	13.1%	36.5	23.8	17.1	12.0
Mental disorders	13.2%	13.3%	12.9%	11.9%	17.8	17.6	17.8	17.7
Neurological and sense organ disorders	9.6%	11.9%	13.9%	16.4%	15.1	15.7	16.1	16.3
Chronic respiratory diseases	7.1%	7.1%	6.8%	6.9%	10.6	9.4	8.4	7.7
Injuries	7.7%	7.0%	6.3%	5.4%	10.6	9.3	8.4	7.3
Diabetes mellitus	4.1%	5.5%	7.0%	8.7%	6.3	7.2	8.4	9.8
Musculoskeletal diseases	3.4%	4.0%	4.5%	4.9%	5.2	5.3	5.4	5.5
Other	13.8%	14.2%	14.1%	14.4%	19.5	18.9	17.7	16.8
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**151.0**	**132.4**	**121.1**	**111.4**

* Expressed as disability-adjusted life years lost per 1000 people.

† Standardised to the age structure of the Australian population (males and females combined). ◆

Several implications for policy are worth emphasising. All of the health risks examined here are amenable to modification through intervention, and together explain a large proportion of health loss in Australia. In addition, the large health differentials between subpopulations are due, in part, to differential exposure to these risks. Significant health gains are likely to be achieved through realistic changes to future levels of exposure to health risks, given that even small changes in distribution of exposures can lead to substantial reductions in population-level risk.[16]

The predicted strong growth in DALY rates associated with diabetes is notable in that it is mostly due to increasing body mass. Given that current strategies have failed to mitigate this risk, new approaches are critical. The impact of increasing diabetes incidence will be magnified by reductions in case fatality from cardiovascular disease through successful strategies to reduce smoking and lower cholesterol levels and blood pressure.[2,17] Increased survival will result in a greater number of people with diabetes developing other health conditions such as renal failure, retinopathy, neuropathy and peripheral vascular disease. Notwithstanding the apparent intractability of diabetes, further reductions in cardiovascular disease could be achieved, given that most of the health loss from this condition continues to be explained by exposure to known health risks.

The much higher DALY rates in the NT compared with other jurisdictions are largely explained by a higher concentration of Indigenous people in the NT. Health loss in this particular population is considered elsewhere.[18,19]

Several areas for further research flow from this work. First, health loss and expenditure under a "business as usual" approach to health risk management have been projected into the future,[2,20] and such analyses could usefully be extended to include various "what if?" risk-reduction scenarios. Second, simulation methods have been used elsewhere to quantify uncertainty in DALY estimates,[21] and would enhance interpretability if applied to these findings. Third, developments in health state valuation methods could, if applied in Australia, increase confidence in the use of the DALY as a valid comparative measure of health loss.

Finally, our analysis is undermined, to some degree, by significant gaps in Australia's health information infrastructure. In particular, there is limited information on mental disorders, neurological conditions, hearing loss, chronic respiratory diseases and musculoskeletal disorders. Even more importantly, Australia, unlike other countries, has no mechanism for regularly collecting measurement data on biomedical indicators such as body mass, blood pressure, and blood glucose and cholesterol levels. Better and more frequent monitoring in each of these areas would strengthen future comparative assessments of health in Australia, thus enhancing their value for policy and program development.

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COMPETING INTERESTS

None identified.

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