The long-term productivity impacts of all cause premature mortality in Australia

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Objective: To estimate the long-term productivity impacts of all-cause premature mortality in Australia by age, sex and cause of death.

Methods: Using a human capital approach, a model was developed to estimate both the working years and present value of lifetime income (PVLI) lost due to premature deaths that occurred in 2003. Outcomes were modelled on individual level data to the year 2030. A discount rate of 3% was applied and results are presented in 2015 Australian dollars.

Results: Premature deaths occurring in 2003 accounted for about 284,000 working years lost and $13.8 billion in PVLI lost when modelled to 2030. Deaths from cancer and cardiovascular disease accounted for more than half the total PVLI impact. Injuries and mental disorders were associated with the highest average PVLI loss per death.

Conclusions: The productivity-related impacts of premature mortality are substantial. This study provides an assessment of relative impact of these costs across specific age, sex and cause of death categories.

Implications: Policies and interventions that prevent premature mortality would improve both health and economic outcomes. An awareness of the productivity costs associated with all-cause mortality may assist decision makers in identifying population and disease subgroups where cost-effective health care investment can achieve the greatest economic gains to society.

Key words: economic impact, economic burden, productivity, premature mortality, all-cause mortality, human capital, Australia, microsimulation model

Premature mortality, defined here as mortality occurring before the average life expectancy, accounts for about 67,000 deaths and more than half the all-cause mortality in Australia.1 The value of productivity lost due to premature mortality has been shown to be a significant factor in the assessment of the total costs of illness.2 Historically, the productivity-related costs of mortality have been estimated by applying average earnings to the period of production lost due to premature death. This is typically referred to as the human capital approach, and has its basis in the cost of illness methodology developed by Rice et al in 1966.3 Calculation of mortality costs considers earnings over a lifetime rather than a single year since, if an individual had not died, they would have continued to be productive for a number of years according to their life expectancy.

Recent studies have applied this methodology to estimate the productivity related costs of mortality on a disease-specific basis, including for cancer,4–10 cardiovascular disease (CVD)11,12 and diabetes.13,14 Estimates of productivity costs produced by these studies have ranged from $19,000 per CVD death in the European Union,11 to $288,000 per cancer death in the US.10 However, there have been no estimates of productivity losses due to premature mortality reported in an Australian context. A literature review identified just one study that quantified the productivity impacts of all-cause mortality across all major illness categories using a consistent and rigorous methodology.15 However, the use of the friction cost method in this study, where productivity losses were valued only up to the point where an employee could be replaced,16 meant that the estimates it produced were significantly less than studies that had applied the human capital approach. Given the variation in the methods applied and the types of costs included in previous studies, it was difficult to compare results across countries and diseases.17 Reliable estimates of the relative productivity impacts of all-cause premature mortality would provide valuable information to decision makers allocating scarce resources amongst competing priorities. Australia, like most developed countries, has an ageing population. The proportion of people aged 65 and over is expected to more than double over the next few decades, resulting in economic consequences that will pose significant policy challenges. Specifically, population ageing is expected to slow Australia’s workforce and economic growth, at the very time that burgeoning demands are placed on Australia’s health and aged care systems. The Australian Government Productivity Commission’s ‘Economic Implications of an Ageing Australia’ report identified measures to raise labour force participation and productivity as a key strategy to enhance income growth and the capacity to ‘pay’ for the costs of ageing.18 Despite this focus, the potential for investment in effective health care interventions to increase the size of the
productive workforce is often overlooked in both health economic analyses and the broader policy making context.

A recent study by Schofield et al presented the results of a microsimulation model developed to estimate the productivity impacts of chronic disease in older Australians. The study reported a substantial productivity impact, with an estimated 112,000 lost productive life years caused by chronic illness in older workers in Australia between 2010 and 2030. The impact of this lost labour force participation on GDP was estimated to be $37.79 billion in 2010, increasing to $63.73 billion in 2030. The use of microsimulation methods in this study allowed for the calculation of productivity costs to be modelled on an individual basis. While the human capital approach was maintained, this technique represented a key advance over previous studies by enabling significantly greater variation and complexity to be captured. However, the model was developed specifically to assess the impact of morbidity and thus did not capture the impacts of mortality. To date, microsimulation methods have not been applied to estimate the productivity impacts of mortality in Australia or internationally.

The aim of this paper was to quantify the productivity related impacts of all-cause premature mortality in Australia by age, sex and cause of death. We developed a new microsimulation model, LifeLossMOD, to estimate the long-term impacts of premature deaths that occurred in 2003 in terms of the projected working years lost and the present value of lifetime income (PVLI) lost out to the year 2030. While previous studies have been limited to projecting the productivity related impacts of all-cause mortality were estimated using the human capital approach was developed specifically to assess the impact of morbidity and thus did not capture the impacts of mortality. To date, microsimulation methods have not been applied to estimate the productivity impacts of mortality in Australia or internationally.

We developed a new microsimulation model, LifeLossMOD, to apply a counterfactual life trajectory to each individual that died prematurely in 2003. These alternate lifespans provided a set of outcomes that were assumed to occur under a hypothetical scenario whereby an individual’s death in 2003 was prevented. The process by which LifeLossMOD was developed is described in detail in Carter et al., and is summarised below.

**Building the microsimulation model: LifeLossMOD**

LifeLossMOD was developed using two component datasets: a mortality dataset and the APPSIM microsimulation model. The mortality dataset consisted of 129,513 individual mortality records representing all registered Australian deaths in 2003, as compiled by the 2003 Australian Burden of Disease and Injury study. Given the average life expectancy of 80.1 for individuals born in 2003 (77.8 for men and 82.8 for women), we excluded all deaths occurring in individuals aged 80 and above from the analysis. This is consistent with the Australian Institute of Health and Welfare definition of premature mortality as deaths occurring before a selected age cut-off, which may be determined or informed by average life expectancy. A sensitivity analysis using 75 years as the threshold for premature death was conducted to assess the impact of uncertainty around this cut-off.

Each mortality record contained variables describing the underlying cause of death as well as the individual’s age, sex and the socioeconomic status of the suburb they resided in (as measured by the ABS’s socioeconomic index for areas (SEIFA) quintiles). However, the mortality dataset did not have information on the key economic outcomes of interest, including labour force participation and income. It was therefore necessary to assign estimates of additional variables onto the original mortality records, which was achieved using data from APPSIM.

APPSIM is a dynamic microsimulation model of the Australian population developed by the National Centre for Social and Economic Modelling to evaluate the impact of future fiscal and social policies. The model uses a one percent sample of the 2001 Australian Census (188,000 records) as its base population. Future lifetime outcomes for this population are then projected using data from large surveys including the Household, Income and Labour Dynamics in Australia (HILDA), the Longitudinal Study of Immigrants to Australia, as well as official demographic data and projections. APPSIM is also able to simulate changes to the population over time, including births, deaths and migration, as well as couple formation and separation and children leaving home.

In order to estimate the potential productivity gains forgone due to deaths occurring in 2003, each individual in the mortality dataset was matched with a similar individual existing in year 2003 of APPSIM. The resulting set of outcomes projected by APPSIM to the year 2030 were assumed to represent a series of counterfactual life trajectories for each individual that died in 2003. This process consisted of two steps. First, records in both the 2003 mortality dataset and the 2003 APPSIM population were grouped into homogenous cells, or ‘bins’, based on their combination of age, sex and SEIFA quintile. In the second step, each mortality record within a particular bin was matched at random with an individual from the APPSIM dataset that appeared in the same bin.

To allow for the effects of uncertainty in the pairing of records, the matching process was replicated 100 times to create 100 uniquely matched datasets. These 100 simulated datasets comprise LifeLossMOD. The results contained throughout this paper report the mean of the 100 datasets. Where present, 95% confidence intervals have been calculated using the percentile method.

**Estimating the economic impacts of premature mortality in 2003**

The expected labour force participation lost due to premature mortality was estimated by accumulating the number of hours worked per week between 2003 and 2030 for each individual in LifeLossMOD. The impacts of mortality on labour force participation across individuals working both full-time and part-time were generalised using a full-time equivalent working year metric. This was derived by dividing the accumulated number of hours worked by the number of hours in a standard Australian working year (1,976, or 38 hours per week for 52 weeks per year: Fair Work Act (Cth) Section 62).

In order to quantify the productivity loss due to premature mortality, an estimate of the Present Value of Lifetime Income (PVLI) was derived. The PVLI represents the potential private income forgone due to premature...
mortality in 2003, and was calculated as the accumulated annual incomes for the period between 2003 and 2030 for each individual that died in 2003.

Income was based on the median income of the APPSIM working population by age and sex in 2003, and included earnings from wages and salaries as well as income generated from other sources including business profits and investments. Transfer payments were excluded to avoid double-counting on a macroeconomic level. The modelled income was estimated on an annual basis for each individual in the mortality cohort, taking into account a range of demographic factors including the individual’s age, sex, labour force participation and life expectancy. Total income was assumed to grow at a rate of 1% per annum above inflation to reflect economic growth projections30,31 and a discount rate of 3% was applied. The resulting incomes derived from APPSIM were based on 2010 Australian dollars (AUD); these figures were inflated to AUD 2015 using the national Consumer Price Index.31

Results

Table 1 provides a summary of the total number of premature deaths in 2003 by age and sex, as well as the counterfactual years of life lost (YLL) between 2003 and 2030. Male deaths accounted for 62% of all deaths and 60% of the YLL. Deaths in the 64-80 year age category accounted for 61% of the premature mortality and 51% of the YLL.

The labour force analysis revealed that a total of 284,000 working years were lost due to premature deaths occurring in 2003. Male deaths were responsible for approximately 218,000 working years lost between 2003 and 2030, more than three times the number of working years lost due to female deaths (Figure 1). The 45 to 54 years age bracket accounted for the greatest number of working years lost for both men and women. The PVLI lost due to premature deaths in 2003 was estimated to be $13.8 billion between 2003 and 2030, with a 95% confidence interval of $13.7 billion to $13.9 billion (Table 2). Male deaths accounted for 81% of the total PVLI lost, which was a function of the higher number of premature deaths among men (15,836 more men than women died prematurely in the year 2003), their higher labour force participation (Figure 1) and their higher average incomes.32 Male deaths between the ages of 25 and 54 accounted for more than half the total PVLI impact. The PVLI lost due to premature mortality by cause of death was estimated (Table 3). Cancer was responsible for the greatest loss in PVLI (30%), followed by cardiovascular disease (19%), deaths from unintentional injuries (predominately transport accidents and falls) (15%) and deaths from intentional injuries (predominately suicide, self-harm and assault) (13%).

The most costly cause of death, per death, was intentional injuries, representing an average PVLI loss of $765,000 per death. This was followed by mental disorders ($654,000 per death) and unintentional injuries ($595,000 per death). The majority of premature deaths classified as having an underlying cause of mental disorder related to drug and alcohol dependence, but also included schizophrenia, anxiety, depression, bipolar disorder, personality disorders and eating disorders.

The diseases associated with the highest total PVLI loss for both men and women were assessed across 10 year age categories (Figure 2). For men aged 15–34, unintentional injuries resulted in the greatest total PVLI lost ($781 million), followed by intentional injuries (predominately transport accidents and falls). For women aged 55–80, unintentional injuries resulted in the greatest total PVLI lost ($1.2 billion), followed by mental disorders.

Table 1: Number of deaths and YLL in the 2003 mortality cohort.

| Age | Deaths in 2003 | YLL to 2030 | 95% CI | Deaths in 2003 | YLL to 2030 | 95% CI | Deaths in 2003 | YLL to 2030 | 95% CI |
|-----|---------------|-------------|--------|---------------|-------------|--------|---------------|-------------|--------|
| <15 | 921           | 21,497      | 21,075–22,027 | 718 | 9,006 | 8,552–9,567 | 1,639 | 30,503 | 29,906–31,182 |
| 15-24 | 1,412 | 32,623 | 31,843–33,116 | 564 | 13,147 | 12,756–13,431 | 1,976 | 45,771 | 44,908–46,376 |
| 25-34 | 2,175 | 50,313 | 49,653–51,132 | 1,199 | 27,830 | 27,316–28,406 | 3,374 | 78,143 | 77,283–79,013 |
| 35-44 | 7,445 | 163,034 | 161,648–164,340 | 4,345 | 101,780 | 100,960–102,671 | 11,790 | 264,814 | 263,127–266,356 |
| 45-54 | 24,779 | 357,102 | 354,498–359,488 | 16,244 | 272,558 | 270,250–274,770 | 41,023 | 629,661 | 626,542–633,071 |
| Total | 41,625 | 738,760 | 735,879–742,280 | 25,789 | 488,838 | 486,521–491,366 | 67,414 | 1,227,598 | 1,223,312–1,232,069 |

* YLL = years of life lost; CI = confidence interval.
* Numbers of deaths vary slightly from Carter et al (1) due to the effects of rounding at a higher level of disaggregation.
injuries ($700 million). Cancer was the most common and costly cause of death for men aged 35–80 ($2.9 billion). The PVLI associated with premature mortality from cardiovascular disease became more significant in men aged 45 and above. Diseases of the digestive system were the fifth most costly category overall.

In women, the PVLI lost due to cancer dominated the cost of all other causes of death in those aged 25–80 ($1.0 billion). The next most costly categories in terms of PVLI were cardiovascular disease, unintentional injuries, intentional injuries and nervous system and sense organ disorders.

A sensitivity analysis was performed whereby the younger age cut-off of 75 years was used to classify deaths as premature. This resulted in the exclusion of 4,932 deaths relative to our main analysis. The impact on total productivity costs was insignificant, with 0.2% fewer working years lost and a decrease of 0.1% in the total PVLI loss reported.

### Discussion

This is the first study to provide estimates of the productivity impacts of all-cause premature mortality in Australia. When projected to 2030, premature deaths occurring in 2003 accounted for a total of 295,000 working years lost and over $13.8 billion in PVLI lost. Deaths from cancer and cardiovascular diseases were the most costly overall, together accounting for almost half the total PVLI lost. This reflected the relatively large number of deaths from these diseases as a proportion of total deaths (66%).

In addition to considering the total PVLI lost, we reported the average PVLI lost per death by cause of death. Deaths from injuries, both unintentional and intentional, and mental disorders were the most costly in this regard, each accounting for a loss of more than $595,000 per death. This is reflected in our analysis of the costs of disease by age category and sex which revealed that injuries accounted for the greatest PVLI loss in men aged 15–34, a group which have the largest potential earning capacity to lose.

It should be noted that we have based our estimates on the human capital approach, which is heavily influenced by the earnings potential of individuals. This method therefore gives greater weight to conditions affecting working age men compared with women, the young, the elderly, the indigenous and other ethnic minority groups. This approach is consistent with that adopted by most recent studies in this field, but is an important consideration when interpreting our results. We have also excluded the value of care giving, household work and earnings from the informal economy in our analysis.

Our reference to ‘productivity’ costs throughout this manuscript has been adopted to reflect the common use of the term in the literature. However, we suggest that productivity costs may be the more precise term for the types of losses we describe. By definition, production is the process of combining inputs to produce output, while productivity is a measure of the efficiency of each input in producing output. It is therefore conceivable that premature mortality could lead to a scenario where overall production goes down (because fewer people are working) but productivity (the average amount produced per person) remains the same, or even improves.

There are relatively few studies evaluating the productivity impacts of premature mortality available for comparative purposes. The ‘Economic Burden of Illness In Canada 2005-2008’ (EBIC) report provided estimates of the value of lost production due to premature mortality by age, sex and cause of death. While previous EBIC reports have applied the human capital approach to measure the value of lost production, the most recent report applied the friction method. Rather than measuring the present value of an

### Table 2: PVLI lost due to premature mortality in 2003, by age and sex.

| PVLI ($) millions | 95% CI | % of total |
|------------------|--------|------------|
| Male | | |
| <15 | 163 | 153–171 | 1% |
| 15-24 | 797 | 774–821 | 6% |
| 25-34 | 1,655 | 1,607–1,697 | 12% |
| 35-44 | 2,582 | 2,544–2,625 | 19% |
| 45-54 | 3,110 | 3,063–3,164 | 23% |
| 55-64 | 2,013 | 1,975–2,045 | 15% |
| 64-80 | 884 | 858–914 | 6% |
| Total | 11,204 | 11,129–11,307 | 100% |
| Female | | |
| <15 | 312 | 299–322 | 2% |
| 15-24 | 183 | 169–195 | 1% |
| 25-34 | 293 | 279–307 | 2% |
| 35-44 | 543 | 523–563 | 4% |
| 45-54 | 677 | 655–699 | 5% |
| 55-64 | 459 | 442–480 | 3% |
| 64-80 | 153 | 143–164 | 1% |
| Total | 2,618 | 2,567–2,667 | 19% |

| PVLI = present value of lifetime income | CI = confidence interval |

### Table 3: PVLI lost due to premature mortality in 2003, by cause of death.

| Cause of death | Working years lost | PVLI lost ($) millions | 95% CI | % of total PVLI | No. of deaths | PVLI per death ($) millions |
|----------------|--------------------|------------------------|--------|----------------|---------------|-----------------------------|
| Cancer | 87,653 | 4,200 | 4,140–4,258 | 39% | 25,733 | 0.163 |
| Cardiovascular disease | 51,659 | 2,582 | 2,544–2,625 | 19% | 18,450 | 0.140 |
| Unintentional injuries | 40,942 | 2,017 | 1,968–2,058 | 15% | 3,387 | 0.238 |
| Intentional injuries | 35,056 | 1,815 | 1,780–1,846 | 13% | 2,371 | 0.165 |
| Diseases of the digestive system | 11,633 | 588 | 567–608 | 4.3% | 2,466 | 0.187 |
| Nervous system and sense organ disorders | 9,206 | 439 | 419–460 | 3.2% | 2,343 | 0.173 |
| Chronic respiratory disease | 8,110 | 377 | 359–395 | 2.7% | 2,473 | 0.088 |
| Mental disorders | 7,280 | 376 | 358–393 | 2.7% | 2,575 | 0.064 |
| Congenital anomalies | 5,160 | 201 | 189–212 | 1.5% | 570 | 0.352 |
| Infectious and parasitic diseases | 5,064 | 261 | 248–274 | 1.9% | 695 | 0.375 |
| Neonatal causes | 4,972 | 150 | 142–161 | 1.1% | 600 | 0.250 |
| Endocrine and metabolic disorders | 4,369 | 209 | 193–223 | 1.5% | 899 | 0.232 |
| Diabetes mellitus | 4,221 | 205 | 191–217 | 1.5% | 1,732 | 0.118 |
| Genitourinary diseases | 2,936 | 141 | 131–151 | 1.0% | 1,387 | 0.102 |
| Acute respiratory infections | 2,515 | 121 | 112–131 | 0.9% | 932 | 0.130 |
| Other neoplasms | 1,363 | 63 | 55–70 | 0.5% | 417 | 0.151 |
| Musculoskeletal diseases | 1,000 | 40 | 40–51 | 0.3% | 383 | 0.118 |
| Ill-defined conditions | 626 | 19 | 16–22 | 0.1% | 77 | 0.247 |
| Skin diseases | 178 | 6 | 6–11 | 0.1% | 97 | 0.086 |
| Maternal conditions | 101 | 4 | 3–6 | <0.1% | 8 | 0.499 |
| Nutritional deficiencies | 18 | 1 | 0–1 | <0.1% | 16 | 0.042 |
| Oral conditions | 10 | 0 | 0–1 | <0.1% | 3 | 0.338 |
| All | 284,072 | 13,821 | 13,740–13,945 | 100% | 67,414 | 0.205 |

PVLI = present value of lifetime income; CI = confidence interval
individual’s future lifetime earnings, this method estimated the loss in production only for the period it takes to replace the deceased worker, referred to as the ‘friction period’. This method was chosen to reflect the current state of the Canadian labour market, specifically the high unemployment rates recorded in recent years. The study reported a total mortality-related cost of $464 million (2010 Canadian dollars), significantly less than the LifeLossMOD estimate of $13.8 billion. This is unsurprising given the differences in methodology. However, the distribution of costs across age, sex and cause of death categories were closely aligned, with both LifeLossMOD and EBIC reporting the highest mortality related costs for males and individuals aged 35 to 54. In addition, both studies identified deaths from cancer, cardiovascular disease and injuries as accounting for the first, second and third highest productivity impact, respectively.

Menzin et al.33 developed a model using the human capital approach to estimate the productivity costs associated with all premature mortality across 29 selected countries, both developed and emerging. The model estimated the value of lost productivity by applying the present value of lifetime earnings (PVLE) to each death, stratified by country, age and sex. As in our results, the PVLE estimates were higher for certain subgroups, including men and younger working-age people. The average PVLE lost per death among males aged 18-34 was estimated at £590,213 in the UK and $757,640 in the US (in their respective 2009 currencies). Given the currency differences, these estimates are comparable to our finding of $1.0 million in the PVLI lost for all-cause male deaths aged 15-34.

Other recent studies have evaluated the economic impacts of premature mortality on disease specific subgroups, in particular cancer. Hanley et al.5 estimated that the...
total cost of cancer-related premature mortality in Europe in 2008 was €75 billion, equating to an average cost per premature cancer-related death of €219,241. Similarly, Bradley et al. estimated the PVLE for cancer deaths in the US, and reported an average cost of $216,701 per cancer death in 2008.

LifeLossMOD produced a comparable but slightly lower average PVLI per premature cancer related death of approximately $163,000. The difference may be explained in part by the truncation of our analysis at 2030, regardless of an individual’s modelled age and the exclusion of unpaid labour (including informal care and household work).

A 2006 study estimated the economic burden of cardiovascular disease across the European Union. CVD accounted for two million deaths in the EU, which translated to 2.18 million working-years lost. The estimated cost of CVD deaths was €24.4 billion, equivalent to around €12,200 per death. This is significantly lower than our estimate of €140,000 in lost PVLI per death, and may be explained by the truncation of the EU analysis at the traditional retirement age. LifeLossMOD allows individuals to continue earning income beyond the traditional retirement age, and accounts for the projected increase in the age at which people will retire in the future. The higher LifeLossMOD figure may also be explained by the broader scope of the PVLI estimate and its inclusion of income sources outside of wages.

The relatively large variation in the estimates of the economic burden of mortality across different studies and countries demonstrates how geographical differences in the pattern of deaths and labour force dynamics may influence the nature and size of the estimates produced. This appears to be further compounded by differences in the type of data used and the methodological approach taken. A key advance of our study is the use of a single, complete mortality dataset and a consistent methodology to generate results across deaths from all causes while maintaining the capacity to report on impacts by cause of death. This allows for highly reliable order of magnitude comparisons of the impacts of mortality across various disease groups. Because each death in our mortality dataset was assigned only to the primary cause of death, we have avoided overstating the impacts by ‘double-counting’ a death in more than one disease category. Our results further extend on the previous research by applying a microsimulation modelling technique that is able to account for significantly greater variation and complexity in generating projections. This approach builds on recent microsimulation methods developed by Schofield et al. that were applied to determine the economic impacts of illness in older Australians, and has several advantages. A key strength of this approach was its ability to impute key variables of interest onto individual level mortality records, using reliable data sources and statistically robust techniques. It was therefore possible to significantly enrich the data available for analysis. The advantage of this approach over the use of aggregate datasets is that, because individual-level data is being used, the variation and complexity in the analysis could be significantly increased. It was therefore possible to account for differences in income across individual combinations of age, sex and socio-economic status. In addition, the estimates are able to account for projected trends in wage growth, labour force participation and retirement age. A further significant advantage of the microsimulation approach is its capacity to account for a broader scope of impacts than lost wages alone, including the impacts on labour force participation and total income which includes income generated from business profits and investments.

The model is limited by the predictive ability of the covariates used to link the mortality records with similar individuals in the APPSIM microsimulation model, those being age, sex and SEIFA index. We attempted to address this uncertainty by bootstrapping the process used to assign these counterfactuals to create 100 unique simulations. The results presented here report the mean of the 100 simulations along with confidence intervals generated by the bootstrapping process. The relative narrowness of the confidence intervals indicate that our results are robust to the effects of uncertainty in the record matching process.

Our analysis of productivity impacts was based on the officially registered underlying cause of death. This is defined in accordance with the International Classification of Diseases as the disease or injury which initiated the train of morbidity events leading directly to death, or the circumstances of the accident or violence which produced the fatal injury. While this approach was necessary to avoid the double-counting of productivity impacts at an all-cause mortality level, the contribution of certain diseases to overall productivity costs may be underestimated. This is most likely evident for common comorbidities including chronic and unspecified kidney failure, diabetes, asthma, COPD, and dementia and Alzheimer disease. In interpreting our results, attention must be given to the broader cause of death categories we have applied; these are detailed in the Burden of Disease and Injury in Australia 2003 study. Australia, like most developed economies, has an ageing population. As more people move into older age groups, overall workforce participation rates are projected to drop from around 63.5% in 2003-04 to 56.3% by 2044-45, and hours worked per capita will be about 10% lower than without ageing. In this context, maximising workforce participation is increasingly being recognised as a key policy focus required to sustain economic growth. This paper highlights the significant labour force impacts associated with premature mortality, and thus the potential for investment in interventions that prevent mortality to have positive impacts on the size of the workforce.
perspective on the long-term returns of health care investment which may be used to inform priority setting.

Conclusions

The cost of premature mortality to the Australian economy is substantial, with the long-term impacts of deaths in 2003 accounting for over 284,000 full time equivalent working years lost, and $13.8 billion in the PVLI lost, to 2030. The results from this study provide an assessment of the relative productivity impacts associated with premature mortality across the major cause of death categories, as well as a comprehensive overview of the distribution of these impacts by age and sex. This information can be used by decision makers in allocating scarce resources between competing priorities and may provide valuable information to governments seeking to improve not only the health but also the productivity of a nation.

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References

1. Australian Bureau of Statistics. Deaths, Australia. Canberra (AUST): ABS; 2003.
2. Krol M, Papenburg J, Koopmanschap M, Brouwer W. Do Productivity Costs Matter? Pharmacoeconomics. 2011;29(7):561-19.
3. Rice DP. Estimating the Cost-of-illness. Washington (DC): US Department of Health, Education and Welfare, Public Health Service;1966.
4. Bradley CJ, Yabroff KR, Dahman B, Feuer EJ, Mariotto A, Brown ML. Productivity costs of cancer mortality in the United States: 2000 - 2020. J Natl Cancer Inst. 2008;100(24):1763-70.
5. Hanly PA, Sharp L. The cost of lost productivity due to premature cancer-related mortality in Europe. Int J Cancer. 2015;136(6):e136-e45.
6. Kim S-G, Hahn M-H, Choi K-S, Seung NY, Shin H-R, Park E-C. The economic burden of cancer in Korea in 2002. Eur J Cancer Care (Engl). 2008;17:136-44.
7. Ortiz-Ortiz KJ, Pérez-Irazary J, Marin-Centeno H, Ortiz AP, Torres-Bernos N, Torres-Centrón M, et al. Productivity loss in Puerto Rico’s labor market due to cancer mortality. P.R Health Sci J. 2010;29(3):241.
8. Hanly PA, Sharp L. The cost of lost productivity due to premature cancer-related mortality: An economic measure of the cancer burden. BMJ Cancer. 2014;14:224.
9. Luengo-Fernandez R, Leal J, Gray A, Sullivan R. Economic burden of cancer across the European Union: A population-based cost analysis. Lancet Oncol. 2013;14:1165-74.
10. Ekvuwe D, Guy GI, Li C, Rim S, Parelkar F, Chen S. The health burden and economic costs of cutaneous melanoma mortality by race/ethnicity-United States, 2000 to 2006. J Am Acad Dermatol. 2011;65(5 Suppl 1):133-43.
11. Leal J, Luengo-Fernandez R, Gray A, Petersen S, Rayner M. Economic burden of cardiovascular diseases from the enlarged European Union. Eur Heart J. 2006;27:1610-19.
12. Heidenreich P, Trogdon JG, Khuzoo O, Butler J, Dracup K, Ezekowitz M, et al. Forecasting the future of cardiovascular disease in the United States: A policy statement from the American Heart Association. Circulation. 2011;123(8):933-44.
13. Hex N, Bartlett C, Wright D, Taylor M, Varley D. Estimating current and future costs of Type 1 and Type 2 diabetes in the UK. Diabet Med. 2012;29(7):855-62.
14. American Diabetes Association. Economic Costs of Diabetes in the U.S. in 2012. Diabetes Care. 2013;36:1033–46.
15. Public Health Agency of Canada. Economic Burden of Illness in Canada, 2005-2008. Ottawa (CAN): PHAC; 2014.
16. Koopmanschap MA, Rutten FFH, van Ineveld BM, van Roijen L. The friction cost method for measuring indirect costs of disease. J Health Econ. 1995;14:171-89.
17. Akobundu E, Blattler J, Mullens C. Cost-of-illness studies: A review of current methods. Pharmacoeconomics. 2006;24(9):905-21.
18. Productivity Commission. Economic Implications of an Ageing Australia. Research Report. Canberra (AUST): Government of Australia; 2005.
19. Schofield DJ, Shrestha RN, Cuningham M, Tarton R, Kelly S, Passey ME, et al. Lost productive life years caused by chronic conditions in Australians aged 45–64 years, 2010–2030. Med J Aust. 2015;203(8):260.
20. Carter HE, Schofield D, Shrestha R, LifeLossMOD: A microsimulation model of the economic impacts of premature mortality in Australia. Int J Microsimulation. 2015;7(3):33-52.
21. Bergs S, Vos T, Barker B, Stevenson C, Stanley L, Lopez A. The Burden of Disease and Injury in Australia 2003. Canberra (AUST): Australian Institute of Health and Welfare; 2007.
22. Australian Bureau of Statistics, 4125.0 - Gender Indicators, Australia, Jun 2015. Canberra (AUST): ABS; 2015.
23. Australian Bureau of Statistics. Average Weekly Earnings, Australia (CAN): ABS; 2014.
24. Menz J, Marton JP, Menz JA, Willie RJ, Woodward RM, Federico V. Lost productivity due to premature mortality in developed and emerging countries: An application to smoking cessation. BMC Med Res Methodol. 2012;12:87.
25. Schofield D, Passley M, Earnest A, Percival R, Kelly S, Shrestha R, et al. HealthHxHealthMOD: A microsimulation model of the economic impacts of diseases on older workers. Int J Microsimulation. 2009;2(2):58-63.
26. World Health Organization. International Statistical Classification of Diseases and Related Health Problems [Internet]. 10th Revision. Geneva (CHE): WHO; 2003 [cited 2015 Nov 24]. Available from: http://apps.who.int/classifications/apps/icd/icd10online2003/fr/icd-10html
27. World Health Organization. Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013-2020. Geneva (CHE): WHO; 2013.
28. Vos T, Carter R, Barendregt J, Mihalopoulos C, Veerman L, Magnus A, et al. Assessing Cost-Effectiveness in Prevention: Final Report. Brisbane (AUST): University of Queensland; 2010.