The health and economic value of prevention:

Assessing the benefits of reducing the prevalence of physical inactivity in Australia by 15% by 2018



Prepared for Confederation of Australian Sport
by Deakin Health Economics

September 2014

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Confederation of Australian Sport

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- Collaboration: building industry collaboration
- Advocacy: issues analysis and advocacy
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CAS will continue to foster and promote its key properties being:

- Australian Masters Games
- Australian Sport Awards

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Citation

Ananthapavan J, Magnus A, Moodie M, (2014) *The health and economic value of prevention: Assessing the benefits of reducing the prevalence of physical inactivity in Australia by 15% by 2018*. Prepared for the Confederation of Australian Sport by Deakin Health Economics. Melbourne, September 2014.

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Published by the Confederation of Australian Sport

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1. Executive summary

The Confederation of Australian Sport (CAS) has commissioned Deakin Health Economics to undertake an evaluation of the health status, economic and financial benefits that will accrue if the prevalence of physical inactivity in the Australian adult population is reduced by 15% from current levels in the 2018 adult population.

The Council of Australian Governments (COAG) has set targets for the reduction of specific disease risk factors in the adult population by 2018. The COAG target related to physical activity was to increase the proportion of adults participating in at least 30 minutes of moderate physical activity on five or more days of the week by 15 per cent from baseline by 2018 [1]. The current analysis uses the 15% target as a realistic and achievable target and aims to estimate the benefits that will accrue if the current prevalence of physical inactivity was reduced by this amount. The current prevalence of physical inactivity in Australia as estimated from the Australian Health Survey (AHS) 2011-12 is 66.9% [2][1].

1.1. Research Objective

The objective was to estimate the health status, economic and financial benefits of reducing the prevalence of physical inactivity by 15% from current levels. The 'health status' benefits were measured as changes in the future incidence of disease, deaths and Disability Adjusted Life Years (DALYs) that could be attributable to, or associated with physical inactivity. The 'economic' benefits were measured as future changes in paid workforce participation rates, prevented absenteeism and early retirements from the workforce, as well as increased days of household and leisure activities that could be associated with improvements in health status. The 'financial' benefits were defined as the dollar value (net present value) of the estimated economic benefits listed above, together with the future expenditure savings to the health sector arising from reduced incidence of diseases related to physical inactivity. Therefore these benefits represent opportunity cost savings rather than immediately realisable cash savings.

1.2. Research Methods

The Risk Factor Impact (RFI) Model is a mathematical model programed in Microsoft Excel® to estimate the multiple benefits that may accrue if the Australian population were to change behavioural risk factors by an achievable target at some point in the future. The model consists of several modules (further explained in the following chapters) and aims to estimate the health, economic and financial benefits of lowering the prevalence of behavioural risk factors. The RFI model was previously developed by Deakin Health Economics for VicHealth in 2009 [3-7] and has been adapted, improved and updated with relevant data inputs as far as practical in the time available for this analysis. Throughout the model, probabilistic multivariate uncertainty analyses were used where possible to provide uncertainty intervals around mean estimates and to improve the reliability of the primary outcome variables. Some input data were not able to be updated within the time frame of the current study.

[1] The prevalence of physical inactivity was estimated from the Australian Health Survey 2011-12. It reports that taking into account the intensity, duration and frequency of individuals' physical activity, 66.9% of Australians (over 15 years) were either sedentary or had low levels of exercise in the week prior to interview.

1.3. Results

Health status benefits

If Australia achieves the full 15% reduction in the prevalence of physical inactivity in 2018; it will result in the avoidance of over 10,000 new cases of disease, 3,000 deaths and 38,000 DALYs over the remaining life time of the Australian population in 2018.

Health benefits if physical inactivity is reduced by 15% in the 2018 Australian adult population	
DALYs (assumed at full health)	38,000
Deaths	3,000
Incident cases of disease	10,000

The sensitivity analysis conducted on DALYs, assuming each DALY averted was equivalent to less than full health (to acknowledge possibility of comorbidities at older ages), generated the following values.

Health benefits if physical inactivity is reduced by 15% in the 2018 Australian adult population	
DALYs @ 90% of a full year of good health	35,000
DALYs @ 80% of a full year of good health	31,000
DALYs @ 70% of a full year of good health	27,000
DALYs @ 60% of a full year of good health	23,000

Economic benefits

The economic benefits arising from the reductions in disease and deaths will lead to 100,000 fewer days lost due to ill health in the 15-65 year old workforce, over 1 million fewer days lost from home based production and over 2 million fewer days lost from leisure production.

Economic benefits if physical inactivity is reduced by 15% in the 2018 Australian adult population			
Rounded to ('000)		**95% confidence interval**	
	Mean	**Lower limit**	**Upper limit**
Absenteeism (days in persons 15-65 years)	100	n/a	n/a
Early retirements (persons 15-65 years)	(0)	n/a	n/a
Days out of home based production (persons 15+ years)	1,038	807	1,302
Days out of leisure production (persons 15+ years)	2,003	1,690	2,344

Notes: Numbers in brackets ( ) indicate the possibility of losses resulting from achieving the target, rather than gains.

Financial benefits

Achieving the reduced prevalence of physical inactivity in the Australian adult population will lead to total opportunity cost savings of $434 million arising from health sector expenditure savings of $190 million and total production gains (using the Friction Cost Approach) of a further $244 million.

Financial benefits if Physical inactivity reduced by 15% in the 2018 Australian adult population			
Rounded to $ million		**95% confidence interval**	
	Mean	**Lower limit**	**Upper limit**
Health sector costs	190	n/a	n/a
Workforce Production costs (FCA)	15	8	23
Workforce Production costs (HCA)	160	124	199
Recruitment and training costs	8	n/a	n/a
Leisure based production	124	92	163
Home based production	97	78	119
Total production costs (FCA)	244	197	300
Total production costs (HCA)	381	321	448

Notes: HCA: Human Capital Approach; FCA: Friction Cost Approach (preferred conservative estimate). Numbers in brackets ( ) indicate the possibility of losses resulting from achieving the target, rather than gains.

1.4. Discussion and Conclusion

The combined net present value of the future financial benefits using the FCA method is $434 million, comprising $190 million in opportunity cost savings to the health sector and $244 million in paid and unpaid production gains. Using the Human Capital Approach (HCA), the combined net present value of the future financial benefits are greater at $571 million comprising $190 million in opportunity cost savings to the health sector and $381 million in paid and unpaid production gains. We argue the FCA method better answers the research question of this study and these figures combined with the health sector savings could be viewed as the upper limit of potential investment in prevention programs to achieve the goal of lowering the prevalence of physical inactivity by 15%.

Due to the heavy reliance on cross-sectional data, there were some counterintuitive results where lowering the prevalence of physical inactivity predicted slightly higher numbers of early retirements. In this project, consistent methods were used and counterintuitive results were not adjusted. Overall positive opportunity cost savings were predicted if the 2018 Australian population achieves the target of reducing the prevalence of physical inactivity by 15% from current levels.

2. Introduction

Lifestyle risk factors have a large impact on the health, economic and financial burden in Australia, and even small decrements in the prevalence of these risk factors at the population level can have substantial benefits.

The Confederation of Australian Sports (CAS) is an organisation which advances the interests of the Australian sports community and aims to promote the social, economic and health benefits of sports participation.

The aim of this project is to estimate the health status, economic and financial benefits that will accrue if Australia reduces the current prevalence of low physical activity levels in the adult population by 15% in 2018. The 15% reduction corresponds to a target set by the National Partnership Agreement on Preventive Health [1][2]. The current prevalence is estimated from the Australian Health Survey (AHS) 2011-12 [2]. This analysis only addresses the disease risk factor of physical inactivity in adults and excludes children for several reasons. Firstly, there is a paucity of available evidence on the long term benefits for children following risk factor modification. In addition, the impact of including children in this model is likely to be insignificant following the discounting of benefits that will occur many years into the future. This predictive model, which specifically focusses on workforce and home/leisure based productivity, is unlikely to capture the benefits of importance for children in a population.

The health status benefits were measured as changes in the incidence of disease, deaths and Disability Adjusted Life Years (DALYs)[3] associated with fewer people having the risk factor. The economic benefits were measured as changes in workforce participation rates, absenteeism and early retirement from the workforce, as well as days of increased household and leisure activities that could be associated with improvements in health status. The financial benefits were defined in this project as the dollar value of the estimated economic and health benefits and represent opportunity cost savings rather than immediately realizable cash savings [3].

The Risk Factor Impact (RFI) model was originally commissioned by VicHealth in 2009 and was developed by Deakin University in collaboration with the National Stroke Research Institute. The model was developed to capture the benefits that accrue to the government, businesses and individuals from reducing the prevalence of specific modifiable risk factors (Table 1).

Table 1: Beneficiaries of reducing the prevalence of disease risk factors

Governments	Businesses	Individuals
• Reduced health care costs • Increased taxation due to increased individual incomes • Lower welfare payments (these are not captured in the current model)	• Reduced absenteeism • Reduced recruitment and training costs associated with replacing staff that die or retire prematurely due to poor health	• Increased income • Reduced absenteeism from work, home duties and leisure activities • Improved quality of life from reduced levels of ill health

[2] The National Partnership Agreement on Preventive Health set the target of reducing the prevalence of physical inactivity by 15% from 2009 baseline levels. However this analysis looks at the benefits of reducing the prevalence of physical inactivity by 15% from current level.

[3] A DALY population measure of overall disease burden. Each DALY consists of one year lost of healthy life. It consists of years of life lost (YLL) due to premature mortality and years lost due to disability (YLD) [8]

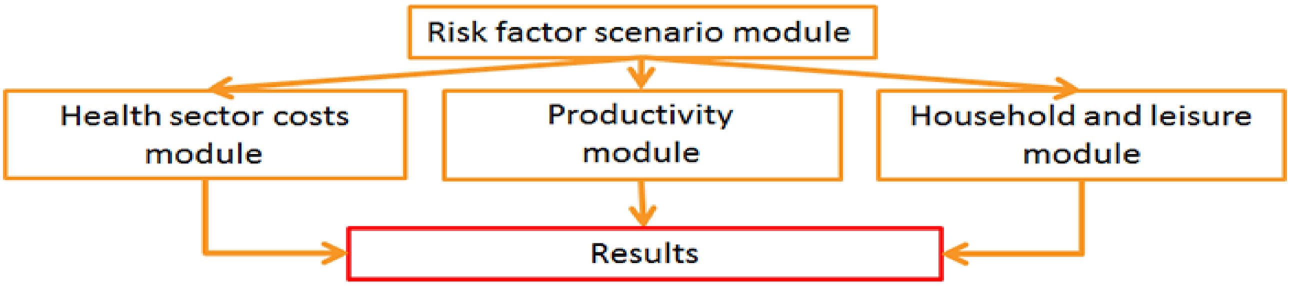
The RFI model consists of 5 different modules that work together to calculate the benefits outlined in Table 1. All benefits calculated in the model accrue over the lifetime of the Australian adult population in 2018 and have been discounted by 5% to 2013 values.

3. Methods

We modelled in Microsoft Excel® estimates of the multiple potential gains arising from targeted levels of improvement in physical inactivity in the adult population (15 years old and over). The RFI model is represented in Figure 1, identifying its main components and links. Reductions in the physical inactivity risk factor at a particular future point in time is modelled to lead to lifetime improvements in health status of the population at that time point, reductions in health sector expenditure, production of workforce gains (paid and unpaid) and leisure time gains.

The improvements in the prevalence of physical inactivity were modelled to be achieved by 2018 in the 2018 Australian adult population. These benefits were discounted back to 2013 by 5% and are presented in 2013 dollars and units.

Figure 1: Risk Factor Impact Model



3.1. Adaptations from the original RFI model

The original model on which this report is based is fully described in Cadilhac et al. [3], and widely published [4-7]. It is briefly outlined here, identifying in particular the necessary changes and improvements that have been made to the modules to address the current research question.

The main assumptions and improvements are outlined below.

1. In the risk factor scenario modules, the estimation of health status was considered sufficiently useful with its 2003 Australian mortality rates and DALY rates to be of continued value. These estimates have been updated to reflect the predicted size of the Australian population in 2018.
2. The production gains module was updated with the Australian estimated population for 2018, risk factor prevalence as at 2011-12, the target reduction in the prevalence of physical inactivity, current wage rates in 2013, workforce participation rates, taxation rates, part time and full time employment rates and hours of part time work per year.

3. The household and leisure module was updated with the current wage rates of domestic and child care workers to place a value on days of ill health to be gained or lost following the reduction in the risk factors of interest.
4. The health sector expenditure module was updated with 2008-09 costs for treating diseases associated with physical inactivity from the Australian Institute of Health and Welfare (AIHW). These costs were inflated to 2013 Australian dollars.
5. The benefits of reducing physical inactivity in the 2018 population were discounted from 2018 to 2013 in order for the costs and benefits to be represented in the same year.

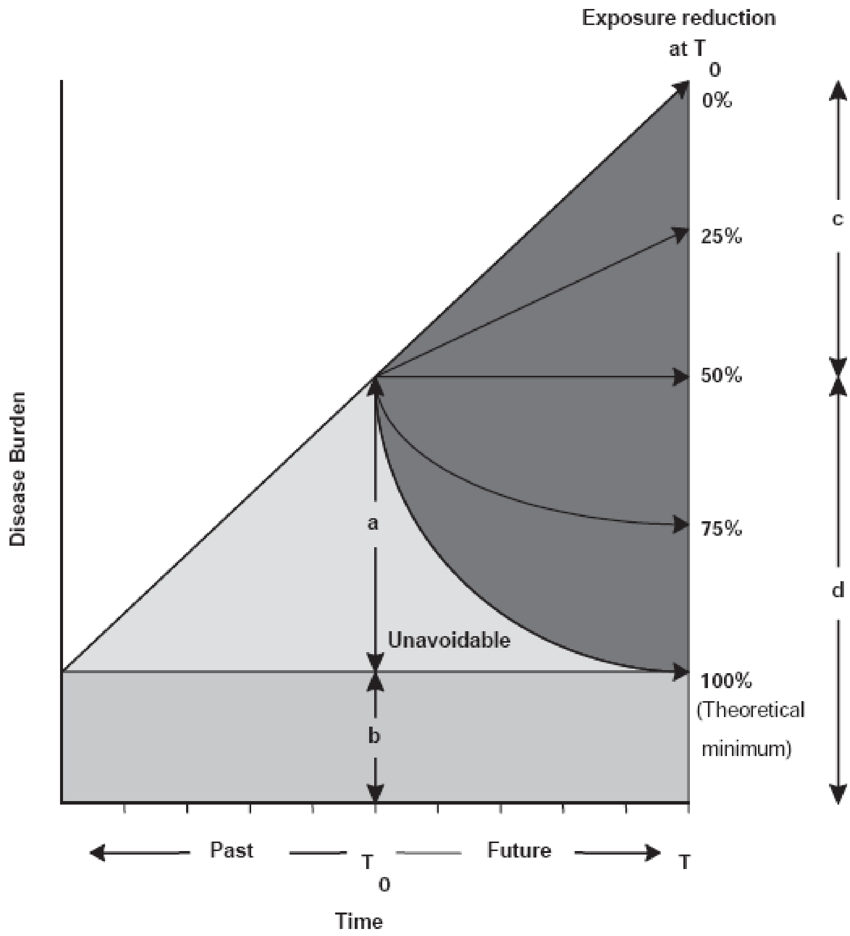
Improvements

6. To more accurately model the time use of older Australian adults, the household and leisure module was improved by the application of the time use (hours/day) of persons aged over 65 years to their remaining life expectancy, after all people in and out of the work force reached 65 years.
7. In the sensitivity analysis, the disability weight of DALYs averted was varied from the equivalent number of years of full health to 90%, 80%, 70% and 60% to acknowledge the potential for over estimation of DALYs due to the likelihood of co-morbid conditions in the elderly who benefit from reductions in physical inactivity.

3.2. Risk Factor Scenario Module- estimating health status benefits

Conceptual measurement of the potential impact of reductions in the prevalence of physical inactivity on the health, economic and financial burden in a population is represented in Figure 2. The modelling hypothesis is that the future population disease burden i.e. DALY, deaths and incidence of risk factor related disease will change following a reduction in the prevalence of a harmful risk factor in a population. We argue that health sector costs along with production and leisure gains/losses will also be altered in similar ways flowing from the reductions in deaths and incident cases of physical inactivity related disease. Without any reductions in risk factor prevalence, the burden of attributable diseases would rise into the future as the population increases and ages. We can estimate the impact of changes in risk factor prevalence from their current level to lower target levels by using known causal relationships (i.e. population attributable fractions) to identify the number of deaths and cases of disease that would be averted. The estimates in this report are based on achieving a targeted reduction of 15% in the prevalence of physical inactivity in the Australian population by the year 2018 as prescribed by the Council of Australian Governments (COAG) agreement. All benefit estimates have been discounted to 2013 values and 2013 Australian dollars. The rising line of the attributable burden into the future (Figure 2) is hypothesised to fall because of the difference between the current prevalence and the target of reducing the prevalence of physical inactivity by 15%.

Figure 2: Estimating the change in future attributable burden of a risk factor – physical inactivity



Source: Adapted from (Begg et al. 2007) [9]

The baseline population attributable fractions used in this work were based on the 2003 Burden of Disease estimates, where age and gender specific proportions of deaths and DALYs attributable to the risk factor of physical inactivity were quantified [9]. The proportion of incident cases of attributable disease were estimated as the average of the death and DALY attributable proportions and applied to the 2018 population. The list of all data sources used in the health status benefits module is provided in Table 2. By using the 2003 Burden of disease estimates we have assumed that the rates of mortality and DALYs related to physical inactivity are stable in the population and can be applied to the year under consideration in this study. Future research of this nature should aim to use more recent DALY estimates for the Australian population in 2010, available from the Institute of Health Metric Evaluation to avoid any potential bias. However, the 2010 estimates were not readily available to be applied in the current study.

Table 2 Data sources of the Health Status Model

Data	Source
Population estimates	ABS [10]
Population Attributable fractions (PAFs)	2003 BoD report [9] and results files
Target risk factor prevalence	COAG targets [1]

Note: ABS: Australian Bureau of Statistics. Population Attributable Fractions (PAFs) are used to calculate the disease burden attributable to a risk factor – in this case the risk factor of physical inactivity. BoD: Burden of Disease; COAG: Council of Australian Governments

3.3. Health Sector Expenditure Module

The Australian Institute of Health and Welfare (AIHW) routinely present an analysis of the Australian total annual health sector expenditure and the expenditure allocated to the broad disease groups adopted by the Burden of Disease publications [11]. The latest estimates by disease groups for the diseases of interest were released for the 2008-09 year and were attained with additional detail by age and gender to update the current model. We were thus able to identify the proportions of that total expenditure attributable to all cases of physical inactivity related disease by assuming the health sector expenditure in any single year approximates the lifetime cost of a new incident case of risk factor related disease. We estimated the avoidable health sector costs due to the estimated reduction in incident cases for the 2018 Australian population by multiplying the 2008-09 cost per case and converting to 2013 Australian dollars with the AIHW total health price index [12]. Details are provided in Table 3.

Table 3 Data sources of the Health Sector Expenditure module

Data	Source	Comments
Expenditure for 2008-09	AIHW	Provided by the AIHW Expenditure and Workforce Unit, Statistics and Communication Group
Population Attributable fractions (PAFs)	2003 BoD report [9] and results files	Provided by University of Queensland for original project in 2009
Population estimates	ABS [13]	ABS 2012 Table B2: Populations projections , by age and sex, Australia Series 29B
Total health price index	AIHW [12]	

Note: AIHW: Australian Institute of Health and Welfare; PAFs: Population Attributable Fractions; BoD: Burden of Disease;

3.4. Workforce Production Gains – Productivity Module

The paid workforce production gains/losses module estimates the economic impact on the workforce of fewer deaths, incident cases of disease, absenteeism due to ill health and early retirements due to ill health, that could be associated with physical inactivity (i.e. the net present value of lost production that could be averted if people who are physically inactive were to modify their behaviour and become physically active). The averted deaths and incident cases of disease estimated by age group and sex, from the health status module (described above) are linked directly in Excel into the workforce production gains module. The productivity module calculates the future lifetime income for each person in 2018, who could avoid death or disability through illness, up to retirement age at 65 years. There are two possible ways of valuing the ensuing production gains: The Friction Cost Approach (FCA) and the Human Capital Approach (HCA). We prefer the FCA since it provides conservative estimates and recognises that employed persons are often replaced within a short friction period (e.g. within 3 or 6 months) when they depart the workplace permanently. The HCA estimates the value of a human life as being the sum of future income lost due to leaving the workforce prematurely due to death or disability. As such it generates a much larger estimate of production gains by the prevention of a premature death or case of disabling disease. We present both FCA and HCA estimates since there is still debate in the literature.

The model was updated with recent participation rates, average weekly wages, and part time hours of work, together with the modelled incident cases and deaths avoided in the 2018 Australian population arising from the reduced prevalence of physical inactivity.

The rates of short term absences from the workplace were reported in the 2004-05 National Health survey (NHS) for persons who were categorised as being physically active compared to those who weren't. These values have not been updated for this work since the responses to absenteeism questions were not reported in the 2007-08 NHS Confidential Unit Record File (CURF). All parameters used are provided in Table 4.

Table 4 Technical parameters, data sources and uncertainty distributions in the Workforce Production module

Data item	Source	Values	Distribution	Comments
Australian workforce participation rate (physically active)	NHS 2007-08	Mean, n	Binomial	By 10 year age and gender groups
Australian workforce participation rate (physically inactive)	NHS 2007-08	Mean, n	Binomial	By 10 year age and gender groups
Australian absenteeism rate (physically active)	NHS 2004-05	Mean, SE	Normal	By 10 year age and gender groups. Number of days away from work in the last 2 working weeks

Australian absenteeism rate (physically inactive)	NHS 2004-05	Mean, SE	Normal	By 10 year age and gender groups. Number of days away from work in the last 2 working weeks
Days worked in a year (full time)	Assumed	240	NA	5 days multiplied by 48 weeks
Days worked in a year (part time)	ABS Census 2011 Quick stats. Available from http://www.censusdata.abs.gov.au/ census_services/getproduct/census/2011/ quickstat/2?opendocument&navpos=220	83	Cumulative	Proportions of people working across three categories of hours per week
Wage multiplier	Lower value assumed, upper value Nicholson et al [14]	0.275 1.3	Uniform	Reflects compensation for absence practices in the workplace.
Hiring and training costs	Victorian Department of Treasury and Finance Proportional estimate of annual salary by two age groups	0.175 0.425	Uniform	Halved estimates by two age groups
Australian average weekly earnings	ABS 6310.0 Aug 2013 Table 4 Employees in main job, Mean weekly earnings in main job–Selected characteristics–By full-time or part-time status in main job–By sex	Mean , SE	Normal	Australians by 10 year age groups
Real wages growth	zero		NA	
Friction period	Koopmanschap [15]	3,6 month	NA	Varied in sensitivity analysis
Discount rates	PBAC [16]	5%	NA	Base case discount rate recommended by PBAC
Retirement age	assumed	65	NA	

Australian employment status (full or part time) percentage	ABS 63100DO005_201208 Employee Earnings, Benefits and Trade Union Membership, Australia, August 2012 Table 5 Employees in main job, Selected personal and employment characteristics–By full-time or part-time status in main job–By sex	%, SE	Normal	By 10 year age and gender groups
Deaths averted by risk factor reduction	Modelled in the risk factor scenario module			By 10 year age and gender groups
Incident cases of disease avoided	Modelled in the risk factor scenario module			By 10 year age and gender groups

Notes: NHS: National Health Survey; SE: standard error; NA: not applicable; ABS: Australian Bureau of Statistics; PBAC: Pharmaceutical Benefits Advisory Committee; %: percentage

3.5. Unpaid Household Production and Leisure Module

The definitions and methods used for quantifying the household production gains/losses and the leisure time gains/losses that are expected to follow reductions in the prevalence of physical inactivity in the Australian population are provided below.

Household or home based production refers to the hours of time spent performing non-paid household duties such as cooking, shopping, cleaning, child care and maintenance. We sourced the average daily hours of participation in household activities from the Australian 2006 Time Use Survey [17] (this is the most recent Australian time use survey). We summed the hours per day spent on activities classified as domestic, childcare and voluntary work, which were reported by gender, age and labour force status. We valued all the household production hours/day at the weighted average hourly rate of domestic services and child care (formal and informal) replacement wages. The replacement cost of formal child care was based on the hourly rate of long day care because it is the most frequently used form of formal child care. The replacement wages for informal child care which is the larger component of all child care, provided by relatives and other friends, were valued the same as leisure time using gender free values. The distribution of formal and informal childcare was taken from the ABS [18].

Leisure time refers to the healthy time available for non-work related activities in pursuit of personal leisure goals and was measured (summed) by reference to the Australian 2006 Time Use Survey which identified hours per day spent on social and community interaction (attending sports events, concerts, religious and community meetings) and recreation and leisure (playing sport, games, hobbies, reading, watching TV, relaxation time, thinking, smoking and drinking alcohol). These were reported by gender, age groups and labour force status. Leisure time was valued using the opportunity cost method by using one third of the average hourly wage for males and females separately [19].

Volunteered hours per day (the smallest component of household production) were valued at the weighted average hourly rate of domestic services and child care replacement wages. See Table 5.

Table 5 Unit prices per hour for valuation of household production

	Hourly Rate $	Low $	High $	Source
Weighted average child care	10.73	7.20	12.57	Australian Government. Childcare in Australia August 2013. Available from http://www.mychild.gov.au/documents/docs/Child_Care_In_Australia.pdf Low= formal care. High = informal care
Domestic services	20.15	17.62	23.18	MA000100 - Social, Community, Home Care and Disability Services Industry Award 2010. Updated December 2013
1/3 Average hourly wages	Male 12.97 Female 8.49	8.98 5.88	17.96 11.75	Australian Bureau of Statistics # 63100DO026_201208 Employee Earnings, Benefits and Trade Union Membership, Australia, August 2012 Table 26 Populations, Mean weekly earnings in main job– State or territory of usual residence

We calculated the change due to a reduction in physical inactivity levels, in household production and leisure hours and dollars by comparing the surveyed days of workforce absenteeism due to illness and days out of role due to illness from the NHS 2004-05. The difference in days of illness (Table 6) between those who reported being physically active compared to those who reported being physically inactive was multiplied by the hours per day used to carry out household production and leisure for each workforce and age category. We argue those extra hours/year would be available for household production and leisure over the future years of life of the individuals concerned up to their life expectancy as at 2018. After people in and out of the work force reached age 65 years, we applied the relevant time use (hours per day) of persons over 65 years to their remaining life expectancy.

Table 6 Days out of role per year, due to illness by physical inactivity status, gender, age and workforce participation

	Males		Females	
	Physically inactive	**Physically active**	**Physically inactive**	**Physically active**
In the labour force	11.61	8.20	11.42	8.20
Not in the labour force	50.21	22.81	37.89	21.78
Over 65	40.68	11.23	45.53	18.99

3.6. Sensitivity analysis

DALY benefits

The risk factor model assumes that each DALY averted in a population from reduced prevalence of physical inactivity is equivalent to a full year of good health. It is acknowledged that this may be an unrealistic assumption particularly in the older age groups, where other conditions such as arthritis, osteoporosis, vision and hearing loss, dementia and some cancers are more prevalent. To adjust for the possibility of age-related comorbidities, we have more conservatively valued each DALY across a range of potential values in a sensitivity analysis (i.e. 90%, 80%, 70% and 60%).

3.7. Uncertainty analysis

In this study, multivariate probabilistic uncertainty analyses were undertaken using @RISK software version 5.7 (Palisade Corporation 2005). Uncertainty analysis was undertaken using a range of possible values whenever a piece of information was not known exactly and/or when uncertainty could be estimated. The probability distributions and parameter values around the input variables were based on survey standard errors, survey proportions, the literature, or expert advice. Simulated point estimates (minimum 4,000 iterations) were used to calculate mean, median and 95% uncertainty intervals for most of the economic and financial outcome measures. The results presented are based on differences in the exposed and unexposed mean values by age and gender group regardless of statistical significance. The standard errors at each age group were incorporated into the calculation of the uncertainty intervals to aid interpretation of and the consequent level of confidence in the reported differences in mean values.

4. Results

The Australian physical activity guidelines for adults aged 18-64 years recommend at least 150 minutes of moderate intensity or 75 minutes of vigorous intensity physical activity each week. It is difficult to ascertain what proportion of the current Australian population meet these guidelines, however it is reported that less than half of all Australian adults are active enough [20]. In this analysis we have used the AHS 2011-12 which reports that 66.9% of Australians (over 15 years) were either sedentary or had low levels of exercise in the week prior to interview [21]. This value is calculated taking into account the intensity, duration and frequency of individuals' physical activity, reported in the survey [21]. In the production module, workforce participation rates for responders to the NHS 2007-08 who report meeting recommended physical activity guidelines were compared to those who reported not meeting the recommended guidelines. The differences in the absenteeism rates of those meeting physical activity guidelines are compared with those who don't using the NHS 2004-05 survey. It is assumed that those who are categorised as meeting/not meeting the guidelines in the NHS 2004-05, NHS 2007-08 and AHS 2011-12 are all comparable.

The values of the key variables used in the model are reported in Table 7.

Table 7: Prevalence inputs for physical inactivity

Variable description	Value used in the model	Source
RFI model definition: Physically active - Exercise last week met recommended guidelines Physically inactive - Exercise last week did not meet recommended guidelines		
Population of interest	Australian population in 2018	ABS 2012 Table B9: Populations projections , By age and sex, Australia - Series 29B [13]
COAG target: Increase the proportion of adults participating in at least 30 minutes of moderate physical activity on five or more days of the week by 15 per cent from baseline by 2018.	15%	Variation to the National Partnership Agreement [1]
Baseline level of Australian adults not meeting physical activity guidelines	66.9%	AHS 2011-12 [21]
Prevalence of physical inactivity if 100% of the COAG agreed target is achieved	51.9%	Calculation

Note: RFI: Risk Factor Impact; ABS: Australian Bureau of Statistics; COAG: Coalition of Australian Governments; AHS: Australian Health Survey

4.1. Population characteristics

Workforce participation

Workforce participation rates of those who are physically inactive compared to those who meet physical activity guidelines are presented in Table 8 and

Figure 3. There were no data available from the NHS 2007-08 for the participation rate by physical activity status for persons aged 15-17 years. We assumed that the participation rate in this age group is the same for those with and without the risk factor.

Participation rates for males who are active compared to inactive are very similar across most age groups, however on average those who are inactive reported higher participation rates compared to those who are active. The exceptions to this are those aged 18-29, 45-49 and 55-59 years. Participation rates for females who are inactive are on average lower than for those who are active. The exception to this is for females aged 60-64 years, where those who are inactive have higher participation rates.

Absenteeism from paid work

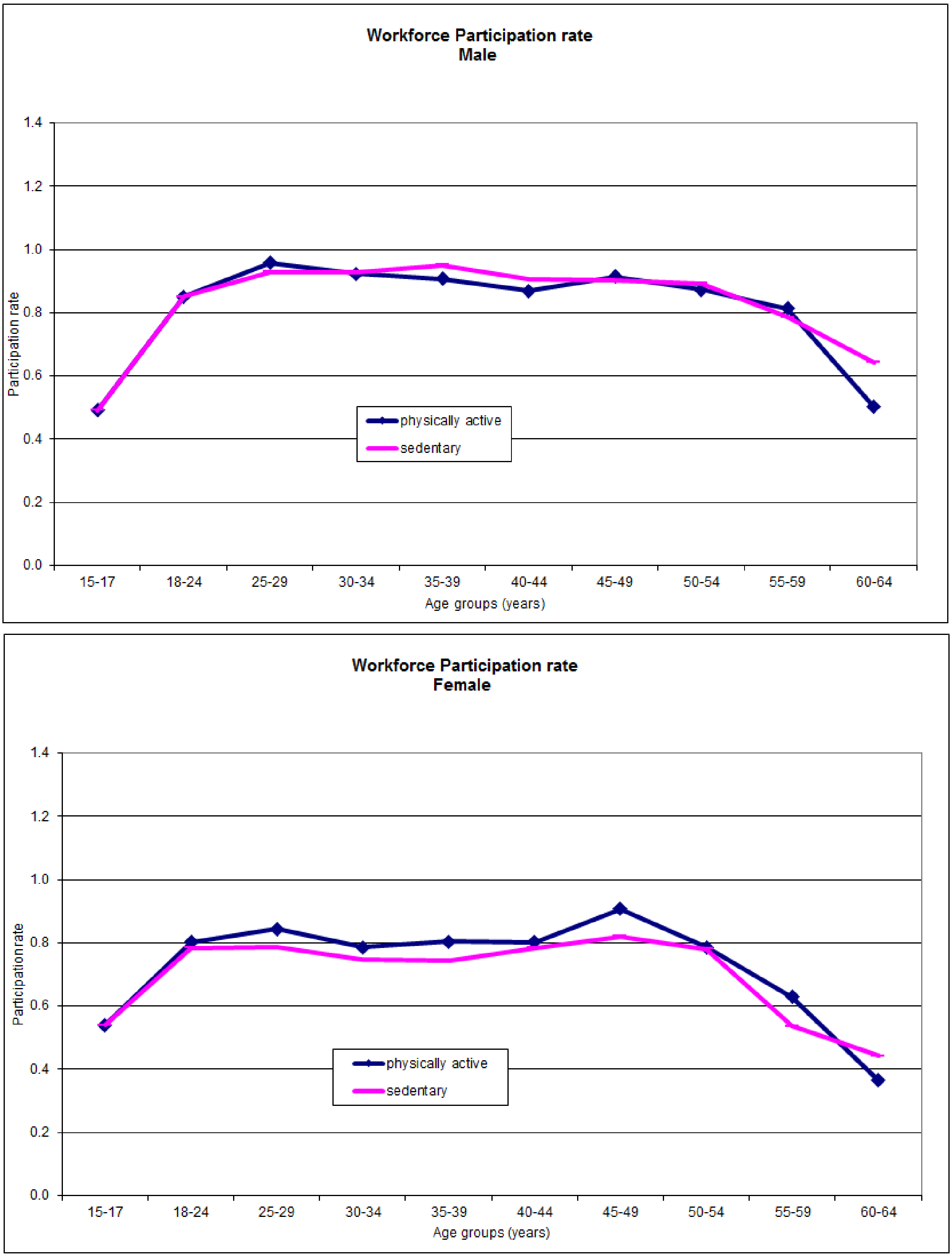
Table 8 shows the number of days taken off over a 10 day period for persons who are physically active compared to those who are inactive and Figure 4 shows absenteeism rates for different age and gender groups. Although overall males who are inactive have higher absenteeism rates compared to males who are active, there is variability across the different age groups, with the opposite being true for those aged 20-29 years. Similarly, overall females who are inactive have higher absenteeism rates compared to those who are active; however the opposite is true for those aged 15-19, 35-39 and 50-54 years.

Table 8: Participation and absenteeism rates for those who are physically active and inactive by gender

Participation rates [22]		
Males	**Mean**	**SE**
Inactive	0.86	n/a
Active	0.83	n/a
Females		
Inactive	0.73	n/a
Active	0.76	n/a
Absenteeism rates [23]		
Males	**Mean**	**SE**
Inactive	0.32	0.26
Active	0.26	0.18
Females		
Inactive	0.31	0.27
Active	0.23	0.16

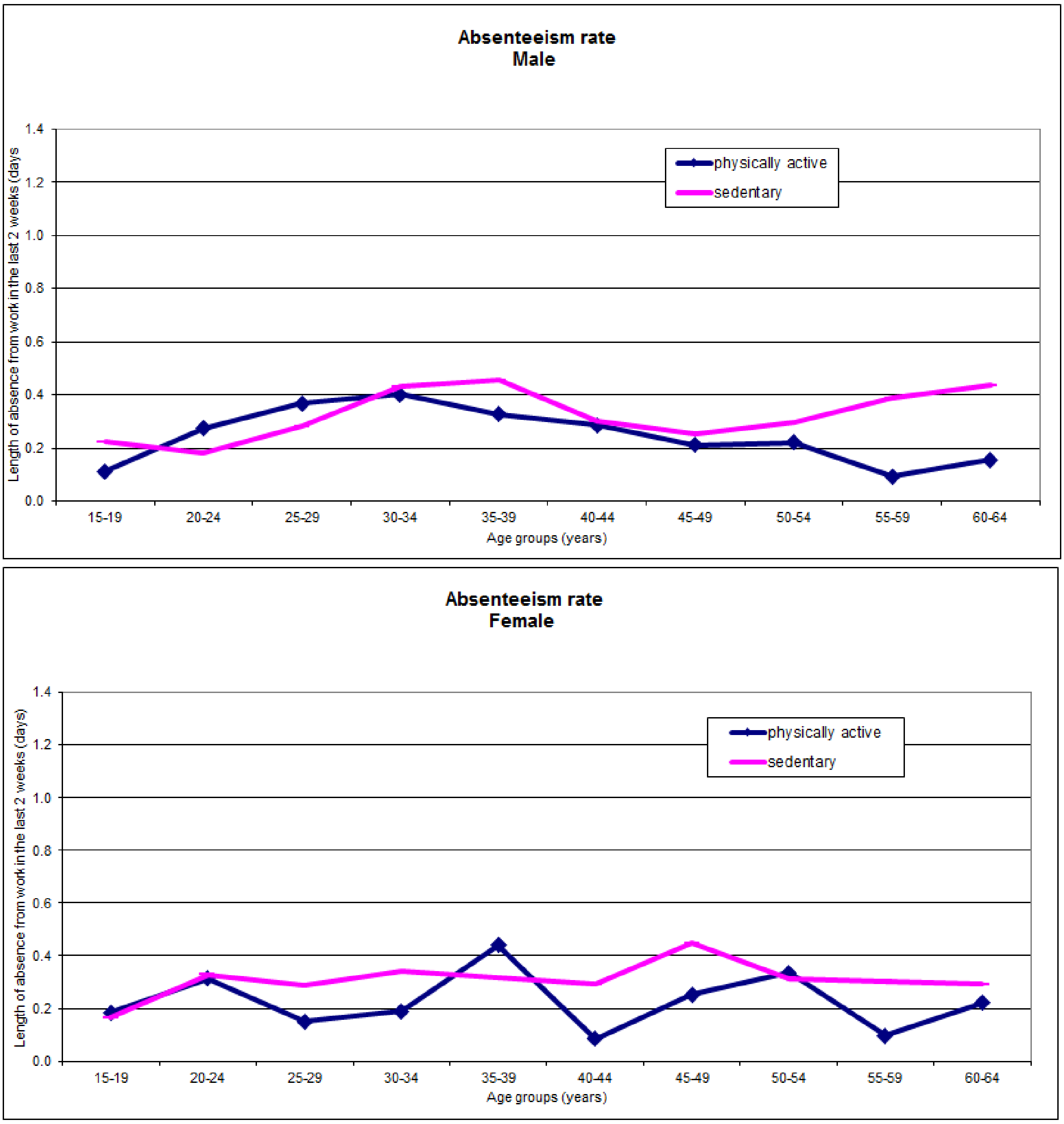
Note: The data in this table were a result of the analysis of the Confidential Unit Record File (CURF) data that was provided by the Australian Bureau of Statistics.

Figure 3: Workforce participation rates for those who are physically active and inactive by gender and age [22]



National Health Survey 2007-08. Note that the data in this table were the result of analyses of the Confidential Unit Record File (CURF) data that was provided by the Australian Bureau of Statistics.

Figure 4: Number of days off work in a 10 day working period by physical activity status, age and gender [23]



National Health Survey 2004-05. Note that the data in this table are the result of analyses of the Confidential Unit Record File (CURF) data that was provided by the Australian Bureau of Statistics.

4.2. Results - Health status, economic and financial gains and losses

The potential health gains and the economic gains including the potential reduction in days of absenteeism from paid work, lost home based production and lost days of leisure time are presented in Table 9. Table 10 shows the financial consequences of the health and economic outcomes.

Theoretically, if physical inactivity was completely eliminated from the Australian population (i.e. the entire attributable burden was eliminated), there would be 171,000 DALYs saved, with

approximately 44,000 new cases of physical inactivity related disease avoided and over 14,000 deaths averted. In addition, over the lifetime of the working population, this would save over 446,000 days of worker absenteeism. It is also estimated that there would be potentially over 8 million days of leisure and over 4 million days of home based production that could be saved. However, the model estimates that there would potentially be more premature retirements (approximately 203) if physical inactivity is reduced, since physically inactive persons in certain age and gender groups participate more in the workforce than the active.

If the target to decrease the prevalence of physical inactivity in the Australian population by 15% is achieved, some of the attributable health, economic and financial burden would not occur. It is estimated that the DALY burden would fall by 38,000 and 10,000 new cases of disease and 3,000 deaths could be averted. Over the working lifetime of the working age population it is estimated that 100,000 days of work could potentially be saved. However it is estimated that there could be slightly more premature retirements (approximately 46). Over the lifetime of adults, it is estimated that meeting the target could result in over 1 million days gained in home based production and over 2 million days of leisure gained.

If the prevalence target is achieved, the health and economic benefits translate to potential opportunity cost savings of $190 million in health sector savings and an additional $244 million in total productivity savings if calculated using the FCA and as much as $381 million using the HCA.

Table 9: Health and economic outcomes for the reduction in prevalence of physical inactivity

Attributable at current levels of prevalence			
		95% Confidence Interval ('000)	
	Mean ('000)	Lower limit	Upper limit
Health status and economic outcomes			
Per annum			
DALYs	171	n/a	n/a
Incidence of disease	44	n/a	n/a
Mortality	14	n/a	n/a
Lifetime			
Leisure (days)	8,933	7,538	10,456
Absenteeism (days)	446	n/a	n/a
Days out of home based production role (days)	4,628	3,598	5,807
Early retirement (persons)	**(0)**	**n/a**	n/a

Benefits if 15% reduction achieved			
Health status and economic outcomes			
Per annum			
DALYs	38	n/a	n/a
Incidence of disease	10	n/a	n/a
Mortality	3	n/a	n/a
Lifetime			
Leisure (days)	2,003	1,690	2,344
Absenteeism (days)	100	n/a	n/a
Days out of home based production role (days)	1,038	807	1,302
Early retirement (persons)	(0)	n/a	n/a

Notes: Disability Adjusted Life Years (DALYs), incidence of disease and mortality calculated for all age groups. Leisure and home based production calculated for persons aged 15+ years. Absenteeism and early retirement calculated for persons aged 15-64 years. LL: lower limit; UL: upper limit. Numbers in brackets ( ) indicate the possibility of losses resulting from achieving the target, rather than gains.

Table 10: Financial outcomes for the reduction in prevalence of physical inactivity, uncorrected for joint effects with other risk factors

Attributable at current levels of prevalence			
		95% Confidence Interval ($ million)	
	Mean ($million)	**Lower limit**	**Upper limit**
Financial Outcomes			
Health sector costs	847	n/a	n/a
Production Costs HCA	713	551	886
Production Costs FCA	67	36	105
Recruitment and training costs	33	n/a	n/a
Leisure based production	578	427	764
Home based production	434	348	531
Total production HCA	***1,725***	***1,452***	***2,033***
Total production FCA	***1,112***	***898***	***1,376***
Taxation effects HCA	34	23	48
Taxation effects FCA	12	2	27

Benefits if 15% reduction achieved			
Financial Outcomes			
Health sector costs	190	n/a	n/a
Production Costs HCA	160	124	199
Production Costs FCA	15	8	23
Recruitment and training costs	8	n/a	n/a
Leisure based production	124	92	163
Home based production	97	78	119
Total production HCA	***381***	***321***	***448***
Total production FCA	***244***	***197***	***300***
Taxation effects HCA	8	5	11
Taxation effects FCA	3	1	6

Notes: These financial outcomes are opportunity cost estimates and not immediately realisable cash savings. The total opportunity cost savings are the sum of the health sector offsets and the combined workforce, household and leisure production effects. The mean estimates can be added together in this way, but not the uncertainty intervals, as both the components and the total are run as independent simulations. Recruitment and training costs are included in production gains/losses using the FCA but not counted using the HCA. No probabilistic uncertainty analysis was conducted for health sector offsets. Taxation is treated as a transfer payment and should not be added to production effects or health sector offsets. HCA: Human Capital Approach; FCA Friction Cost Approach (preferred conservative estimate). Health sector, leisure and home based production estimates are based on persons 15+ years. Production gains/losses and taxation effects are based on persons 15-64 years. LL: lower limit; UL: upper limit. Values are net present value using a 5% discount rate. Numbers in brackets ( ) indicate the possibility of losses resulting from achieving the target, rather than gains.

5. Discussion

In this project we have identified the potential benefits to society if feasible reductions in the prevalence of physical inactivity could be achieved. These potential benefits were modelled for the 2018 population cohort as lifetime estimates. If the 15% prevalence reduction target could be achieved, then substantial opportunity cost savings in terms of paid and unpaid production gains of $244 million (95% confidence interval $197 million to $300 million) could be achieved. There are also opportunity cost savings of $190 million to the health sector. These potential saving have been estimated as net present values (2013) applying a 5% discount rate using the FCA method. We used conservative estimates to value total productivity effects based on common approaches in economics.

The largest potential opportunity cost savings associated with reducing the prevalence of physical inactivity will accrue to individuals in the form of saved home based production and leisure days. This is followed by savings to the health sector and then business and government. The model predicts that there are small potential losses associated with early retirement if the prevalence of physical inactivity is reduced by this target.

There continues to be debate in the literature about the best method for valuing workforce production, therefore we have presented data in this report to illustrate the magnitude of the difference between using the FCA and the alternate HCA. The HCA estimates are considerably higher than those determined using the FCA. The sizeable differences occur because of the assumption in

each method concerning the replacement of workers absent for a long time through death or disability. The HCA values the production losses as the total income stream forgone due to premature death or retirement. This approach effectively assumes the worker would not be replaced with another worker and that their forgone production is totally lost. In contrast, the FCA assumes the worker would be replaced within a short period (the "friction period") and hence the loss of production is considerably less. The adoption of one approach rather than the other for valuing workforce production has a dramatic effect upon the results, and it is therefore important to acknowledge that there are valid arguments for adopting either method. We prefer the more conservative FCA approach. The essence of our position is that we believe it is more suitable for answering the research question we were charged with – that is, for estimating actual production gains/losses in the general economy. For this question it seemed important to take into account the fact that businesses will adjust to short term and long term absences. Further, we argue that the HCA is more suited to answering a different research question – that is, placing a monetary value on human life, where the total forgone income stream due to premature death provides a sensible floor estimate. Nonetheless, we readily accept that one potential compromise is to argue that workforce production gains will fall somewhere between the HCA and FCA production estimates reported.

The main strengths of the analyses presented are the consistent use of methods and data sources, including comprehensive assessment by age, gender and workforce status to account for variation between those who are physically active compared to those who are physically inactive. Using the available evidence, we provided a comprehensive and consistent examination of the health status, economic and financial gains that may be possible if the prevalence of physical inactivity is reduced.

The main limitation of this project is the reliance on cross sectional data to identify an association between physical inactivity and reduced productivity due to ill health. In the absence of rigorous longitudinal data, we have used cross-sectional data to assess causality between the presence of the risk factor and reduced health and productivity. In the absence of detailed longitudinal data, many assumptions were required in the modelling.

The data indicated some counterintuitive findings, for example, the lower levels of workforce participation in those who are physically active in certain age groups. This likely arose due to the cross sectional nature of the data and the small numbers in certain age groups which introduced meaningless noise into the analysis.

Despite these counterintuitive findings and assumptions related to causation, we have applied a consistent methodology without any arbitrary adjustment to calculate the economic and financial outcomes. These anomalies illustrate the need for careful interpretation of the findings however they do not alter the major conclusions of this work, which establish that reducing the prevalence of physical inactivity lead to important savings to the health sector, business/government and individuals.

Another limitation arises from the reliance on self-reported survey data (from the NHS and the AHS) which is less reliable than actual measurement data, since persons exaggerate, fail to remember accurately, misunderstand questions and diseases, or simply misreport information. None of the survey responses in the NHS on which we have heavily relied to provide the results for this project were verified by actual measurement.

A third limitation is that we have assumed that changing an individual's and a population's physical activity profile in 2018 will be maintained for the rest of their life. In addition, although it is likely that the forecasted gains will occur over time in the population that have the reduced levels of physical inactivity, a quantitative assessment of when these opportunity cost savings and health status benefits would be achieved has not been undertaken.

In this analysis, the potential gains from the reductions in the prevalence of physical inactivity have been underestimated since we have adopted the view that only the incident cases of diseases related to the risk factors for the 2018 population will be reduced (i.e. looking at new cases avoided, but not health benefits among people who were already ill). For example, prevalent or existing cases of cardiovascular disease would also be likely to benefit from becoming more physically active. Another source of underestimation was that we did not measure the likely benefits in future population cohorts if reductions in physical inactivity were further reduced. Doing so could be expected to achieve important lifetime benefits for each population cohort targeted. These benefits would be marginally less than in 2018 since fewer cases in each population cohort would be physically inactive given the accrual of the health promotion impacts over time.

Uncertainty analysis was undertaken using a range of potential values wherever possible. Uncertainty analysis places point estimates (means) within an uncertainty range to assist decision-making.

The findings reported are indicative of the potential opportunity cost savings from avoidable disease burden if the prevalence of physical inactivity could be reduced by the target. However, it must be emphasised that opportunity cost savings are not estimates of immediately realisable financial savings, but rather estimates of resources, reflecting current practice that could be available for other purposes. Therefore, the results presented are broadly indicative of potential financial cost savings and should be interpreted with due regard to the width of any confidence intervals, the unspecified timing of benefits and major assumptions of the analysis. In addition, this project does not provide any information about which interventions would best be applied to achieve the prevalence reduction in physical inactivity.

6. Conclusion

We have demonstrated that reductions in the prevalence of physical inactivity by 15% from current levels in the 2018 adult Australian population will translate into substantial health status, economic and financial benefits. We have also stressed, that whilst important, the notion of 'opportunity cost savings' needs to be carefully interpreted. Opportunity cost savings are not estimates of immediately realisable financial savings, but rather estimates of resources reflecting current practice that could be available for other purposes. In the health context, they are estimates of resources devoted to the treatment of preventable disease that could be released for other activities. Therefore, the results presented are broadly indicative of potential financial savings.

Taking an incidence-based approach we have generated relevant indicative values associated with the prevention of new cases of disease. The particular value of this research was not only measuring workforce production gains, but also identifying the importance of household and leisure relative to workforce production and health sector cost savings associated with chronic disease prevention.

This provides a fuller picture for considering the potential health status, economic, and financial effects of health promotion and disease prevention approaches in Australia. Investment in disease prevention and health promotion in Australia is dwarfed by spending on treatment of disease. The findings in this project contribute important knowledge about the major impact of prevention on health sector expenditure and productivity, with productivity defined more broadly as workforce participation, household production and leisure time.

7. Appendix 1 assumptions and impact on results and conclusions

Module	Assumptions	Impact
Overall		
	The comparator group for physically inactive is physically active since the unnamed intervention is assumed to encourage physically inactive persons to become physically active	
	Self-reported NHS data are not verified and may involve under or over-reporting of days absent from work.	
	Self-reported NHS data are not verified and may involve under reporting of the presence of exposure to harmful risk factors.	
	Remaining life expectancy of the 2018 Australian population at each age was extrapolated from the rate of growth in the Australian population over the past years, assuming age specific mortality rates are held constant in future	Understates
	We have assumed causation between current risk factor exposure status and workforce participation rates, absenteeism rates and rates of days out of role.	
	We have ignored confounding from socioeconomic status or rurality on workforce participation rates, absenteeism rates and rates of days out of role	
Health benefits		
	People who are physically inactive permanently become active	Overstates
	The target of reducing the prevalence of physical inactivity by 15% is achievable with currently available affordable, sustainable interventions	
	Underlying temporal changes in risk factor prevalence are ignored i.e. the trends in physical activity levels	
	Rates of DALYs, incidence and mortality reported in the 2003 Australian population were applied to the 2018 Australian population. While rates of cardiovascular disease burden may have been falling the rates of diabetes burden have been increasing, therefore the overall impact of this is unknown.	
	We only considered the incident cases of diseases that would be reduced by	Understates

Module	Assumptions	Impact
	prevention strategies for the risk factors (benefits to prevalent cases are not included)	
	Time lags between reduction in the prevalence of physical inactivity and fewer deaths or incident cases of disease are acknowledged, but not incorporated i.e. are assumed to occur within the year.	Overstates
	The proportion of incident cases of attributable disease were estimated as the average of the proportion of attributable deaths and DALYs. Similarly the age and sex distribution of DALYs and deaths attributed to a risk factor have been used to estimate the likely age/sex distribution of incident cases of disease that can be attributed to the risk factor.	
	Disease epidemiology does not incorporate any future trends	
	The presence of multiple risk factors has not been incorporated in the evaluation.	None
	Excess risk of disease associated with exposure to risk factors is assumed reversible once exposure ceases.	
	Each DALY averted in a population from reduced prevalence of physical inactivity is equivalent to a full year of good health. This has been varied in a sensitivity analysis.	Overstates
Health sector costs		
	The proportion of DALYs attributable to a risk factor is a sound basis to identify the attributable health sector costs to the risk factor.	
	The health sector costs in 2008-09 attributed to risk factor related disease adjusted to 2013 values, approximate the future lifetime costs of incident cases of disease in the 2013 year.	
Workforce productivity		
	HCA counts all future income lost from an individual who leaves the workforce due to death and disability, whereas the FCA assumes individuals will be replaced after a specified period (3 months) and thus productivity losses to society will be less. Our stated preference is for the FCA conservative estimates.	Understates
	An important assumption of the HCA method is that there is near full	

Module	Assumptions	Impact
	employment	
	The cost of people being at work but not fully productive because of ill health are not included	
	Due to lack of adequate data, we assumed that medical appointments occurred during work time rather than out-of work time.	Overstates
	Retirement age is 65	Understates
	The proportion of work force absences covered by leave entitlements, is assumed to be zero	Overstates
	Differences in workforce absenteeism rates and participation rates at each age group are applied whether or not they were statistically significant overall. Uncertainty analysis encapsulates the degree of confidence in the estimates.	
	Replacing an absent worker with potentially a current worker, no worker, or an agency worker at higher rates, (i.e. compensation mechanisms) were incorporated by multiplying gross average salary by a factor (wage multiplier) which was varied in the uncertainty analysis between 0.275 and 1.3. The presence of compensation mechanisms in the workplace is likely to be dependent on factors such as the skill set of the absentee and his colleagues, the team based nature of the work, time sensitivity of deadlines and spare staff capacity in the workplace.	Increases width of confidence interval
	Variation in the friction period and cost of recruitment across industry are ignored. The friction period is varied in sensitivity analysis	
	Training and recruitment costs are a percentage estimate of gross wages which rises in parallel with wage rates.	
	No wages growth occurs during the year 2013	Understates
	The short term absences potentially avoided by a preventive health intervention, were measured as the difference in reported days off work that would occur if those who are physically inactive were to take days off work at the rate of those who are physically active (comparator) as reported from the NHS 2004-05.	Mixed
	No adjustments to the NHS survey data were made where those who were physically inactive had lower rates of absenteeism or higher workforce participation, than those who are physically active.	Mixed

Module	Assumptions	Impact
	We have assumed the surveyed workplace behaviours of 18 and 19 year olds, was representative of all persons aged 15 to 19 since persons under the age of 18 were not surveyed about all risk factors.	
	We assumed an 8 hour working day and 48 weeks worked per year.	
	Short term absences from the workplace are caused by ill health.	
	A reduction in ill health will lead to fewer short term absences, other factors remaining equal.	
	Short term workplace absences cover visits to both health professionals and hospital stays.	
	Workforce participation rates are related to health status. An improvement in health status will lead to higher workforce participation, other factors remaining equal.	
	Any reduction in leisure time among workers making up for absences (themselves or others) is excluded.	
	The current wage rates and structure across age and gender will be maintained into the future.	
	Current taxation rates remain constant until all beneficiaries of any health intervention reach retirement age or death.	
	The presence of multiple risk factors in employees has not been incorporated. Each risk factor has been evaluated in isolation and corrected later by an epidemiological modelling procedure (joint effects correction).	
	The age and sex specific participation rates of NHS 2008-09 are assumed representative of future years while the 2018 population cohort ages to 65 years.	
	The age and sex specific absenteeism rates of NHS 2004-05 are assumed representative of future years while the 2018 population cohort ages to 65.	
	It is assumed that the workforce participation rate is the same for 15-17 year olds with and without the risk factor of physical inactivity	
Household production		
	An improvement in health status will lead to greater participation in household and leisure activities, other factors remaining equal.	

Module	Assumptions	Impact
	Household time can be valued according to the average market price of replacement household and childcare services.	
	Leisure time can be valued by applying one third of the average weekly earnings for males and females.	
	People with risk factors who change their behaviour or exposure to the risk factor will increase their participation in household and leisure tasks to the same level as those who do not have the risk factor of interest.	
	Time delays to achieve risk reduction and benefits are not incorporated into the model. That is, in 2018 it is assumed that those people who are no longer physically inactive will not acquire the diseases associated with physical inactivity over the rest of their lifetime.	Overstates
	Benefits determined for the rest-of-life for the 2018 cohort are based on current life expectancy estimates for males and females. Life expectancy is increasing annually but is not accounted for in the model.	Understates
	Surveyed 2006 household and leisure time participation by gender and workforce status for persons under 65 years is representative of future activity only up to age 65 years. After the population reaches age 65, their remaining household and leisure time participation until death, will be represented as per persons surveyed in 2006, over 65 years.	
	Current household and leisure time participation by gender and workforce status is representative of future activity, i.e. future trends in household and leisure technology is not incorporated.	
	Individuals are assumed to not perform overlapping activities because of time constraints, e.g. watching television while minding a child or cooking while listening to a radio. In brief, about one third of every activity involves at least one other simultaneous activity [24]. Therefore, it can be difficult to estimate precisely the quantity of household production and leisure time.	Overstates
	It is likely that as leisure decreases its value rises and the one third of the wage rate estimate is likely to be a conservative estimate of the average as distinct from marginal value of leisure.	Understates

Note: NHS: National Health Survey; DALYs: Disability Adjusted Life Years; HCA: Human Capital Approach

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