The productivity gains associated with a junk food tax and their impact on cost-effectiveness

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Abstract

Objective
To estimate the productivity impacts of a policy intervention on the prevention of premature mortality due to obesity.

Methods
A simulation model of the Australian population over the period from 2003 to 2030 was developed to estimate productivity gains associated with premature deaths averted due to an obesity prevention intervention that applied a 10% tax on unhealthy foods. Outcome measures were the total working years gained, and the present value of lifetime income (PVLI) gained. Impacts were modelled over the period from 2003 to 2030. Costs are reported in 2018 Australian dollars and a 3% discount rate was applied to all future benefits.

Results
Premature deaths averted due to a junk food tax accounted for over 8,000 additional working years and a $307 million increase in PVLI. Deaths averted in men between the ages of 40 to 59, and deaths averted from ischaemic heart disease, were responsible for the largest gains.

Conclusions
The productivity gains associated with a junk food tax are substantial, accounting for almost twice the value of the estimated savings to the health care system. The results we have presented provide evidence that the adoption of a societal perspective, when compared to a health sector perspective, provides a more comprehensive estimate of the cost-effectiveness of a junk food tax.
Introduction

Overweight and obesity are well established risk factors for a number of chronic diseases including cardiovascular diseases, cancers and diabetes [1, 2]. The rise in sedentary lifestyles and the increased consumption of energy dense foods has seen worldwide obesity rates more than double since 1980, with the prevalence of chronic disease increasing globally across every region [3, 4]. As a result, overweight and obesity are increasingly recognised as being among the most important public health issues in the world today [5].

The most recent Australian Health Survey highlights that 28% of adults are now obese, with 63% classified as overweight or obese [6]. Projections suggest that by 2025, the prevalence of overweight and obesity will increase to over 70%, with approximately one third of the adult Australian population classified as obese [7]. Reflecting a similar circumstance globally, WHO member states have introduced a voluntary target to halt the rise in obesity by 2020 [8].

In addition to its significant health burden, obesity is also responsible for a substantial economic burden. The cost of illness framework provides an approach for estimating the economic burden of disease that incorporates both direct health care resource use, as well as the indirect productivity impacts of illness and death [9]. Such studies are well represented in the medical literature around overweight and obesity, and it has been reported that the direct health care costs associated with these risk factors are significant, accounting for between 2–12% of total health care budgets in developed economies [10–15]. Where these studies have considered the productivity related costs of overweight and obesity, these costs have consistently been found to outweigh the direct health care costs [16–18].

Despite these findings, studies evaluating the cost-effectiveness of public health interventions typically take a health care perspective, with estimates of potential cost savings limited to those associated with health care resource use. The cost-effectiveness outcomes reported in these studies may underestimate the total benefits to society. It follows that decisions regarding the allocation of society’s scarce resources towards improving health are often made without full information on the potential economic returns of these investments.

The aim of this study was to estimate the productivity impacts of a tax that would raise prices on unhealthy foods by 10% in an Australian setting. The selected unhealthy food categories included biscuits, cakes, pastries, pies, snack foods, confectionary and soft drinks. We refer to this intervention throughout as the ‘junk food tax’. Our secondary aim was to determine how the inclusion of productivity impacts of a junk food tax influenced the overall cost-effectiveness outcome. We applied microsimulation techniques to project the lifetime working years and income that would accrue for individuals whose premature deaths could be successfully averted under the intervention. Outcomes were modelled to the year 2030 and are presented across a number of age, sex and disease categories.

Methods

This study combines data from two previously published models in order to estimate the productivity gains associated with a junk food tax [19, 20]. Fig 1 outlines the logic pathways that guide each model and their intersections with one another. The analysis is based on an Australian adult population, aged 20 and above. Premature mortality was defined here as deaths occurring before the age of 80 years, which is close to the Australian life expectancy [21, 22].

An estimate of the number of Disability Adjusted Life Years (DALYs) averted due to the junk food tax was estimated by Sacks et al (2011) [19, 23]. The authors developed a Markov model to project the impact of changes in BMI on a number of obesity-related diseases, including: stroke, ischaemic heart disease, hypertensive heart disease, diabetes mellitus, osteoarthritis, post-menopausal breast cancer, colon cancer, endometrial cancer and kidney cancer. The
model compared two populations in separate life tables: a baseline population that was exposed to existing levels of morbidity and mortality, and an intervention population where, owing to lower average body weight, the risk of disease was reduced. Baseline consumption of unhealthy foods was based on the latest available food consumption data for the Australian adult population, from the 1995 National Nutrition Survey [24]. Changes in junk food consumption following the imposition of the junk food tax were estimated at an individual level. These changes in energy consumption were then extrapolated to project changes in mean body weight and BMI at the population level, using equations derived by Swinburn et al [25]. For the purpose of this study, we extracted estimates of the change in the number of deaths across combinations of age, sex and cause of death from the original model.

Estimates of changes in mortality due to the junk food tax were then combined with data from LifeLossMOD, a separate model developed to estimate the productivity costs associated with all-cause premature mortality [26]. LifeLossMOD was developed using individual level mortality data from the 2003 Australian Burden of Disease and Injury study [26]. The model then applied microsimulation methods to assign a counterfactual life trajectory to each individual that died in 2003. These trajectories were assumed to reflect a likely (albeit hypothetical) scenario that would occur if an individual’s premature death in 2003 had been prevented. Individuals within the model were then tracked to the year 2030, with the model annually updating data on hours worked and income earned. The model accounted for individual variability in
age, sex and socio-economic status at the time of death in estimating the counterfactual labour force participation rates, earnings, retirement ages and age at death.

A random process with replacement was used to link each death averted due to the junk food tax with an individual of the same age category, sex and cause of death in LifeLossMOD. To align with the LifeLossMOD estimates, it was assumed that the intervention commenced in the year 2003 and was sustained until the year 2030. Premature deaths could be averted at any point up to 25 years after the beginning of the intervention. A new dataset of premature deaths averted was then created, with each death averted assigned the life trajectory of an individual of the same age, sex and socioeconomic status in LifeLossMOD. Associated information on the annual number of hours worked and income earned until the year 2030 was accrued on an annual basis, with a discount rate of 3% applied to all future impacts.

It was then possible to derive estimates of the additional working years gained due to the intervention by summing the hours worked in each year following a death averted. The resulting figure was then divided by the number of hours in a standard working year (1,976 hours) to produce an estimate of the ‘full-time equivalent’ working years gained for each individual over the period 2003–2030.

To estimate the value of the productivity gains associated with the intervention, we adopted the human capital approach [27]. This method involves valuing the productivity impact of mortality as the present value of the lifetime stream of all future income that would have been earned in the event that a premature death was avoided. While other valuation methods exist, the human capital approach is the most common approach for valuing productivity losses in the cost of illness literature [28–30]. For the purpose of this study, the productivity gains associated with the intervention were therefore estimated by calculating the present value of lifetime income (PVLI) earned by each individual whose death was averted. Income was assumed to come from salary-related earnings, as well as business profits and other investments. However, transfer payments were excluded from this analysis to avoid a ‘double-counting’ of savings at the societal level. Incomes were assumed to grow at a rate of 1% per annum above inflation reflecting long term Australian wage growth trends [31]. All PVLI figures are reported in 2018 Australian dollars.

The process described above was bootstrapped 100 times to incorporate the combined uncertainty across both LifeLossMOD and the junk food tax model. The results presented here describe the mean of the 100 bootstraps, with confidence intervals calculated using the percentile method.

The estimated PVLI savings associated with a junk food tax were combined with data from a previously published cost effectiveness analysis of this intervention [19], conducted from the perspective of the health care system. The impact of productivity costs on the final cost-effectiveness outcome was assessed by comparing the results of 100 Monte Carlo simulations of the incremental cost-effectiveness ratio (ICER) under each scenario.

**Results**

There were 2,053 premature deaths averted over the first 25 years following the introduction of the junk food tax, of which 71% were among males (Table 1). This translated to 17,403 years of life gained over the period 2003 to 2030. Deaths averted due to ischaemic heart disease accounted for the greatest number of years of life gained (41%), followed by stroke, and diabetes mellitus (18% each).

The cumulative working years and PVLI gained between 2003 and 2030 were projected for each death averted (Table 2). A total of 8,656 full time equivalent working years were gained under the modelled scenario which was estimated to provide an addition $307 million in
### Table 1. Premature deaths averted and associated years of life gained due to the imposition of a junk food tax, modelled from 2003 to 2030.

| Disease                  | Male                          | Female                        | Total                          |
|--------------------------|-------------------------------|-------------------------------|--------------------------------|
|                          | Premature deaths averted | Years of Life Gained | Premature deaths averted | Years of Life Gained | Premature deaths averted | Years of Life Gained |
| Ischaemic Heart Disease  | 691                          | 6,024                         | 150                           | 1,191                      | 841                          | 7,215                        |
| 95% CI                   | 608–763                      | 5,279–6,632                   | 119–181                       | 938–1,466                   | 758–918                      | 6,455–7,815                    |
| Stroke                   | 251                          | 2,046                         | 139                           | 1,124                      | 390                          | 3,170                        |
| 95% CI                   | 230–299                      | 1,626–2,383                   | 106–172                       | 838–1,494                   | 323–455                      | 2,545–3,671                    |
| Diabetes Mellitus        | 286                          | 2,286                         | 104                           | 821                        | 390                          | 3,107                        |
| 95% CI                   | 213–339                      | 1,730–2,917                   | 86–127                        | 566–1,101                   | 323–445                      | 2,473–3,823                    |
| Colorectal Cancer        | 113                          | 1,072                         | 47                            | 441                        | 160                          | 1,513                        |
| 95% CI                   | 91–133                       | 857–1,335                     | 37–57                         | 300–561                     | 137–180                      | 1,250–1,808                    |
| Hypertensive Heart Disease | 71                           | 611                           | 46                            | 405                        | 118                          | 1,016                        |
| 95% CI                   | 59–87                        | 436–795                       | 35–56                         | 248–559                     | 99–137                       | 744–1,267                     |
| Breast Cancer            | -                             | -                             | 69                            | 649                        | 69                            | 649                           |
| 95% CI                   | -                            | -                             | 60–76                         | 547–747                     | 60–76                         | 547–747                       |
| Kidney Cancer            | 52                            | 459                           | 15                            | 122                        | 66                            | 581                           |
| 95% CI                   | 46–58                        | 329–569                       | 430–40                        | 63–182                     | 60–74                         | 484–682                       |
| Endometrial Cancer       | -                            | -                             | 18                            | 152                        | 18                            | 152                           |
| 95% CI                   | -                            | -                             | 15–21                         | 72–215                     | 15–21                         | 72–215                       |
| Total                    | 1,464                        | 12,499                        | 588                           | 4,904                      | 2,053                        | 17,403                       |
| 95% CI                   | 1,355–1,580                  | 11,514–13,340                 | 545–642                       | 4,396–5,520                 | 1,941–2,197                  | 16,456–18,415                |

CI = confidence interval

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### Table 2. Cumulative working years and PVLI gained due to the imposition of a junk food tax: 2003–2030.

| Cohort    | Premature deaths averted | Working years gained | PVLI gained ($000's) | 95% CI around PVLI gained ($000's) | PVLI as a proportion of cohort | PVLI gained per death averted ($000's) |
|-----------|--------------------------|----------------------|----------------------|-------------------------------------|---------------------------------|---------------------------------------|
| **Men**   |                          |                      |                      |                                     |                                 |                                       |
| 20–29     | 46                       | 147                  | 7,878                | 4,874–10,833                        | 3%                              | 171                                   |
| 30–39     | 173                      | 799                  | 34,298               | 26,305–43,758                       | 11%                             | 198                                   |
| 40–49     | 377                      | 2,036                | 73,403               | 61,253–84,340                       | 24%                             | 195                                   |
| 50–59     | 482                      | 2,714                | 97,510               | 82,387–117,727                      | 32%                             | 202                                   |
| 60–69     | 307                      | 889                  | 33,535               | 25,838–41,420                       | 11%                             | 109                                   |
| 70–79     | 81                       | 91                   | 1546                 | 343–3,301                           | 1%                              | 19                                    |
| Total     | 1,464                    | 6,675                | 248,170              | 220,670–272,363                     | 81%                             | 170                                   |
| **Women** |                          |                      |                      |                                     |                                 |                                       |
| 20–29     | 13                       | 43                   | 1,422                | 556–2,607                           | 0.5%                            | 109                                   |
| 30–39     | 42                       | 184                  | 5,845                | 3,800–8,108                         | 2%                              | 139                                   |
| 40–49     | 102                      | 420                  | 12,612               | 8,613–16,428                        | 4%                              | 124                                   |
| 50–59     | 176                      | 775                  | 23,074               | 18,172–29,036                       | 8%                              | 131                                   |
| 60–69     | 177                      | 481                  | 14,353               | 9,390–19,911                        | 5%                              | 81                                    |
| 70–79     | 78                       | 78                   | 1,117                | 43–2,404                            | 0.4%                            | 14                                    |
| Total     | 588                      | 1,980                | 58,424               | 49,275–73,392                       | 19%                             | 99                                    |
| **Total** | 2,053                    | 8,656                | 306,593              | 281,724–338,322                     | 100%                            | 149                                   |

PVLI = Present value of lifetime income; CI = confidence interval

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PVLI. Over half of this productivity gain was attributable to male deaths averted between the ages of 40 to 59, consistent with the proportion of years of life gained in this cohort as well as the higher relative incomes among men of this age [31]. Working years gained in those aged 65 and above were possible due to data based projections around the likelihood of individuals working beyond the traditional retirement age.

When examining the productivity impacts across disease types, the PVLI gained was broadly consistent with the number of premature deaths averted (Fig 2). Deaths averted from ischaemic heart disease had the largest impact, accounting for $148 million and close to half of the total PVLI gained. Deaths averted from diabetes ($57 million), stroke ($43 million) and colorectal cancer ($26 million) also produced relative large productivity gains.

The cost effectiveness of the junk food tax, relative to the status quo, was considered both with and without the inclusion of productivity costs. The estimated savings due to increased productivity ($307 million) amounted to approximately 50% of the savings estimated to fall within the health care system alone ($604 million). As demonstrated by the downwards shift in the ICER estimates in Fig 3 there was a significant improvement in the cost effectiveness outcome when productivity costs were included, with greater uncertainty around cost estimates.

The full datasets used in the analysis have been aggregated by age, sex and cause of death and are included as Supporting Information (S1–S3 Tables).

**Discussion**

This paper presents the results of a counterfactual analysis where a junk food tax reduces premature deaths and increases labour force participation and incomes in Australia. Results were
modelled to the year 2030. We found the intervention to be associated with a cumulative productivity gain of over 8,000 working years and $307 million in PVLI. The proportion of productivity gain across age, sex and disease categories were broadly consistent with the numbers of deaths averted in each category.

We also demonstrated the impact that the perspective taken can have on the cost effectiveness result. When a societal perspective was taken, with the inclusion of the productivity gains expected to accrue due to improved health from the intervention, the cost effectiveness result was significantly improved. Given the junk food tax was found to be cost-saving even when adopting the health system perspective, the inclusion of productivity costs did not change the overall ‘dominant’ outcome in this case (that is, the intervention was found to be both more effective and less expensive than current practice under both health care system and societal perspectives). However, the magnitude of the downward shift seen on the cost-effectiveness plane clearly demonstrates the potential for the inclusion of productivity costs to influence decisions where incremental cost effectiveness ratios (ICERs) produced under a health system perspective are above the cost effectiveness acceptability threshold.

Taxes on unhealthy foods and drinks have been implemented over the past decade in countries including Denmark, Hungary, the United Kingdom, the United States and Mexico, with promising early results [32–34]. While the longer term population impacts of these policies are yet to be observed, researchers have developed models to project both health and economic outcomes [35–37]. Our results support a growing body of evidence from modelled analyses.

Fig 3. Bootstrapped incremental cost-effectiveness ratio plots for the junk food tax relative to status quo. Dark points represent pairs of incremental costs saved and DALYs averted due the junk food tax based on a health system perspective. Light points represent these points after production gains have been included.

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based on similar underlying methods around the cost-saving nature of taxes on unhealthy foods and drinks [38–40]. While previous studies have focussed on savings to the health system, there has been relatively little published evidence on the productivity impacts. Nomaguchi et al (2017) estimated the productivity impacts of a 20% tax on sugar sweetened beverages and reported an AU $751 million potential gain within the paid employment sector [41]. The larger nature of this estimate relative to our finding may be explained by the inclusion of reductions in both morbidity and mortality in the productivity calculation. The scale of these potential savings suggests that the inclusion of productivity costs in future cost effectiveness analyses of obesity prevention interventions should be considered, particularly when the decision maker values this information.

As obesity rates increase, and more evidence comes to light regarding the impacts of obesity on the prevalence of chronic disease, estimates of the economic burden of obesity can also be expected to increase. While the direct health care costs of obesity are significant and well-recognised, there is an increasing recognition of the indirect costs, in particular those relating to lost economic productivity. A 2014 systematic review found that in studies estimating both the direct and indirect costs of obesity, the productivity related costs consistently outweighed the direct health care costs (accounting for between 51% -59% of the total costs) [16].

The analysis we have presented provides rigorous, population-based estimates of the likely gains in productivity that would accrue with a junk food tax. A key strength of our approach is the projection of long term counterfactual outcomes based on individual characteristics at the time of death. In addition, our estimates allow for projected trends in labour force participation, income levels and retirement ages.

There are some limitations to note. Firstly, this study does not account for the productivity impacts associated with reduced obesity related morbidity. These impacts were excluded due to the lack of available data, with LifeLossMOD developed to estimate to productivity costs of mortality alone. Previous studies have suggested that mortality costs represent approximately two thirds of the total productivity related costs of obesity [42, 43]. We have also excluded productivity gains associated with unpaid labour from this analysis. This is a common practice in the estimation of productivity costs of illness and reflects the definition of productivity as applied in the calculation of national Gross Domestic Product.

Health care budgets across developed countries are increasingly constrained due to the effects of population ageing and ever-advancing medical technology. There is, therefore, an imperative for governments to make decisions about the allocation of society’s scarce resources with a knowledge of the full extent of the returns on investment that can be expected. In this context, the productivity impacts of health care investment take on increased significance. There are implications for governments in considering preventive health policy interventions as a means of increasing economic productivity, as opposed to the more traditional labour market or taxation policies.

**Conclusions**

The results we present here highlight the extent of the productivity gains to society that can be achieved through investment in a junk food tax to prevent obesity. This information can be used by decision makers interested in improving both health and economic outcomes simultaneously.

**Supporting information**

S1 Table. Working years gained by age and sex. Dataset containing 100 bootstrapped estimates of working years gained from premature deaths averted due to a junk food tax, by age
and sex.

(S2 Table) Present value of lifetime income gained by age and sex. Dataset containing 100 bootstrapped estimates of present value of lifetime income gained from premature deaths averted due to a junk food tax, by age and sex.

(S3 Table) Present value of lifetime income gained by cause of death. Dataset containing 100 bootstrapped estimates of present value of lifetime income gained from premature deaths averted due to a junk food tax, by cause of death.

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References

1. Gakidou E, Afshin A, Abajobir AA, Abate KH, Abbafati C, Abbas KM, et al. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet. 2017; 390(10100):1345–422.
2. GBD Obesity Collaborators. Health effects of overweight and obesity in 195 countries over 25 years. New England Journal of Medicine. 2017; 377(1):13–27. https://doi.org/10.1056/NEJMoa1614362 PMID: 28604169
3. World Health Organisation. Obesity and overweight. WHO Factsheets2016.
4. James SL, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet. 2018; 392(10159):1789–858.
5. World Health Organisation. Global action plan for the prevention and control of noncommunicable diseases 2013–2020. Geneva: WHO, 2013.
6. Australian Bureau of Statistics (ABS). Australian Health Survey: updated results, 2011–2012. Canberra: 2013 Contract No.: ABS cat. no. 4364.0.55.003.
7. Obesity Australia. No Time to Weight 2: Obesity—Its impact on Australia and a case for action. 2015.
8. World Health Assembly. Follow-up to the Political Declaration of the High-level Meeting of the General Assembly on the Prevention and Control of Non-Communicable Diseases. Geneva, Switzerland: 2013.
9. Rice DP. Estimating the cost-of-illness. Washington, DC: US Department of Health, Education and Welfare, Public Health Service, 1966.

10. Colagiuri S, Lee CMY, Colagiuri R, Magliano D, Shaw JE, Zimmet PZ, et al. The cost of overweight and obesity in Australia. Medical Journal of Australia. 2010; 192(5):260–4. PMID: 20201759

11. Scarborough P, Bhatnagar P, Wickramasinghe K, Allender S, Foster C, Rayner M. The economic burden of ill health due to diet, physical inactivity, smoking, alcohol and obesity in the UK: an update to 2006–07 NHS costs. Journal of Public Health. 2011; 33(4):527–35. https://doi.org/10.1093/pubmed/fdr033 PMID: 21562029

12. Tsai AG, Williamson DF, Glick HA. Direct medical cost of overweight and obesity in the USA: a quantitative systematic review. Obesity Reviews. 2011; 12:50–61. https://doi.org/10.1111/j.1467-789X.2009.00708.x PMID: 20059703

13. Fry J, Finley W. The prevalence and costs of obesity in the EU. Proceedings of the Nutrition Society. 2005; 64:359–62. PMID: 16048669

14. Lévy E, Lévy P, Pen CL, Basdevant A. The economic cost of obesity: the French situation. International Journal of Obesity Related Metabolic Disorders. 1995; 19:788–92. PMID: 8589779

15. Seidell J. The impact of obesity on health status: some implications for health care costs. International Journal of Obesity Related Metabolic Disorders. 1995; 19 (suppl 6) S13–S6.

16. Dee A, Kears K, O’Neill C, Sharp L, Staines A, O’Dwyer V, et al. The direct and indirect costs of both overweight and obesity: a systematic review. BMC Research Notes. 2014; 7:242. https://doi.org/10.1186/1756-0500-7-242 PMID: 24739239

17. Trolden J, Finkelstein E, Hylands T, Dellea P, Karnal-Bahl S, Obes Rev. pp. Indirect costs of obesity: a review of the current literature. Obesity Reviews. 2008; 9:489–500. https://doi.org/10.1111/j.1467-789X.2008.00472.x PMID: 18331420

18. Popkin B, Kim S, Rusev E, Du S, Zizza C, Obes Rev. pp. Measuring the full economic costs of diet, physical activity and obesity-related chronic diseases. Obesity Reviews. 2006; 7:271–93. https://doi.org/10.1111/j.1467-789X.2006.00230.x PMID: 16866975

19. Sacks G, Veerman J, Moodie M, Swinburn B. ‘Traffic-light’ nutrition labelling and ‘junk-food’ tax: a modelled comparison of cost-effectiveness for obesity prevention. International Journal of Obesity. 2011; 35 (7):1001–9. https://doi.org/10.1038/ijo.2010.228 PMID: 21079620

20. Carter HE, Schofield D, Shrestha R. LifeLossMOD: A microsimulation model of the economic impacts of premature mortality in Australia. International Journal of Micosimulation. 2015; 7(3):33–52.

21. Australian Bureau of Statistics. Deaths, Australia. Canberra: 2003.

22. Australian Institute of Health and Welfare. Premature mortality in Australia 1997–2012 2015. Available from: http://www.aihw.gov.au/deaths/premature-mortality/.

23. Forster M, Veerman J, Barendregt J, Vos T. Cost-effectiveness of diet and exercise interventions to reduce overweight and obesity. International Journal of Obesity. 2011; 35(8):1071. https://doi.org/10.1038/ijo.2010.246 PMID: 21224825

24. Australian Bureau of Statistics (ABS). National Nutrition Survey 1995: User’s Guide. Canberra: Australian Bureau of Statistics, 1998.

25. Swinburn BA, Sacks G, Lo SK, Westerterp KR, Rush EC, Rosenbaum M, et al. Estimating the changes in energy flux that characterize the rise in obesity prevalence. The American journal of clinical nutrition. 2009; 89(6):1723–8. https://doi.org/10.3945/ajcn.2008.27061 PMID: 19369382

26. Begg S, Vos T, Barker B, Stevenson C, Stanley L, Lopez AD. The Burden of Disease and Injury in Australia 2003. Canberra: AIHW, 2007.

27. Zhang W, Bansback N, Anis A. Measuring and valuing productivity loss due to poor health: A critical review. Social Science and Medicine. 2011; 72(2):185–92. https://doi.org/10.1016/j.socscimed.2010.10.026 PMID: 21146890

28. Leal J, Luengo-Fernandez Rn, Gray A, Petersen S, Rayner M. Economic burden of cardiovascular diseases in the enlarged European Union. European Heart Journal. 2006; 27:1610–9. https://doi.org/10.1093/eurheartj/ehi733 PMID: 16495286

29. Hanly P, Pearce A, Sharp L. The cost of premature cancer-related mortality: a review and assessment of the evidence. Expert Review of Pharmacoeconomics & Outcomes Research. 2014; 14(3):355–77.

30. Akobundu E, Ju J, Blatt L, Mullins C. Cost-of-illness studies: a review of current methods. Pharmacoeconomics. 2006; 24(9):869–90. https://doi.org/10.2165/00019053-200624090-00005 PMID: 16942122

31. Australian Bureau of Statistics. Average Weekly Earnings, Australia. Canberra: Commonwealth of Australia.; 2014.
32. Backholer K, Blake M, Vandevijvere S. Sugar-sweetened beverage taxation: an update on the year that was 2017. Public health nutrition. 2017; 20(18):3219–24. https://doi.org/10.1017/S1368980017003329 PMID: 29160766

33. Silver LD, Ng SW, Ryan-Ibarra S, Tailie LS, Induni M, Miles DR, et al. Changes in prices, sales, consumer spending, and beverage consumption one year after a tax on sugar-sweetened beverages in Berkeley, California, US: A before-and-after study. PLoS medicine. 2017; 14(4):e1002283. https://doi.org/10.1371/journal.pmed.1002283 PMID: 28419108

34. Colchero MA, Rivera-Dommarco J, Popkin BM, Ng SW. In Mexico, evidence of sustained consumer response two years after implementing a sugar-sweetened beverage tax. Health Affairs. 2017; 36 (3):564–71. https://doi.org/10.1377/hlthaff.2016.1231 PMID: 28228484

35. Smed S, Scarborough P, Rayner M, Jensen JD. The effects of the Danish saturated fat tax on food and nutrient intake and modelled health outcomes: an econometric and comparative risk assessment evaluation. European journal of clinical nutrition. 2016; 70(6):681. https://doi.org/10.1038/ejcn.2016.6 PMID: 27071513

36. Veerman JL, Sacks G, Antonopoulos N, Martin J. The impact of a tax on sugar-sweetened beverages on health and health care costs: a modelling study. PloS one. 2016; 11(4):e0151460. https://doi.org/10.1371/journal.pone.0151460

37. Escobar MAC, Veerman JL, Tollman SM, Bertram MY, Hofman KJ. Evidence that a tax on sugar sweetened beverages reduces the obesity rate: a meta-analysis. BMC public health. 2013; 13(1):1072.

38. Cobiac LJ, Tam K, Veerman L, Blakely T. Taxes and subsidies for improving diet and population health in Australia: a cost-effectiveness modelling study. PLoS medicine. 2017; 14(2):e1002232. https://doi.org/10.1371/journal.pmed.1002232 PMID: 28196089

39. Lal A, Mantilla-Herrera AM, Veerman L, Backholer K, Sacks G, Moodie M, et al. Modelled health benefits of a sugar-sweetened beverage tax across different socioeconomic groups in Australia: A cost-effectiveness and equity analysis. PLoS medicine. 2017; 14(6):e1002326. https://doi.org/10.1371/journal.pmed.1002326 PMID: 28654686

40. Long MW, Gottmaker SL, Ward ZJ, Resch SC, Moodie ML, Sacks G, et al. Cost effectiveness of a sugar-sweetened beverage excise tax in the US. American journal of preventive medicine. 2015; 49 (1):112–23. https://doi.org/10.1016/j.amepre.2015.03.004 PMID: 26094232

41. Nomaguchi T, Cunich M, Zapata-Diomed B, Veerman JL. The impact on productivity of a hypothetical tax on sugar-sweetened beverages. Health Policy. 2017; 121(6):715–25. https://doi.org/10.1016/j.healthpol.2017.04.001 PMID: 28420538

42. Lal A, Moodie M, Ashton T, Siahpush M, Swinburn B. Health care and lost productivity costs of overweight and obesity in New Zealand. Australian and New Zealand journal of public health. 2012; 36 (6):550–6. https://doi.org/10.1111/j.1755-6405.2012.00931.x PMID: 22321696

43. Konnopka A, Bödemann M, König H-H. Health burden and costs of obesity and overweight in Germany. The European journal of health economics. 2011; 12(4):345–52. https://doi.org/10.1007/s10198-010-0242-6 PMID: 20401679