What are the costs of stillbirth? Capturing the direct healthcare and macroeconomic costs in Australia

Emily J. Callander PhD[1*], Joseph Thomas BA(Hons)[2], Haylee Fox MPH[3], David Ellwood PhD[4], Vicki Flenady PhD[5]

[1] Associate Professor of Health Economics, School of Medicine, Griffith University, Gold Coast, Queensland, Australia.

[2]Research Officer, Australian Institute of Tropical Health and Medicine, James Cook University, Townsville, Queensland, Australia.

[3]Senior Research Assistant, School of Medicine, Griffith University, Gold Coast, Queensland, Australia.

[4]Professor, Mater Research Institute, University of Queensland, Brisbane, Queensland, Australia.

[5]Dean of Medicine, Professor of Maternal Fetal Medicine, School of Medicine, Griffith University, Gold Coast, Queensland, Australia.

Funding: The project has received funding from the National Health and Medical Research Council through the Centre for Research Excellence (GNT1116640), and Career Development Fellowship (GNT1159536) Schemes. Funding was also received from the Griffith School of Nursing and Midwifery, and the Australian Institute of Tropical Health and Medicine.

*Contact Author:

Associate Professor Emily J. Callander
Griffith University
58 Parklands Drive
Southport QLD 4215

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/BIRT.12469

This article is protected by copyright. All rights reserved

Author Manuscript

+61 4 29 057 011

e.callander@griffith.edu.au

Word count: 3,609

Ethics approvals

Ethics approval was obtained from the Townsville Hospital and Health Service Human Research Ethics Committee (HREC) (HREC/16/QTHS/223), James Cook University HREC (H7246) and the Australian Institute of Health and Welfare HREC (EO2017-1-338). We also received Public Health Act Approval (RD007377) to waive consent for data collection.

Author Manuscript

This article is protected by copyright. All rights reserved

DR. EMILY CALLANDER (Orcid ID : 0000-0001-7233-6804)

Article type : Original Article

Author Manuscript

What are the costs of stillbirth? Capturing the direct health care and macroeconomic costs in Australia

ABSTRACT

Background

Reducing stillbirth rates is an international priority, however little is known about the cost of stillbirth. This analysis sought to quantify the costs of stillbirth in Australia.

Methods

Mothers and costs were identified by linking a state-based registry of all births between 2012 and 2015 to other administrative datasets. Costs from time of birth to two years post-birth were included. Propensity score matching was utilized to account for differences between women who had a stillbirth and those that did not. Macroeconomic costs were estimated using value of lost output analysis; and value of lost welfare analysis.

Results

Cost to government was on average $3,774 more per mother who had a stillbirth compared to mothers who had a live birth. After accounting for gestation at birth, the cost of a stillbirth was 42% more than a live birth ($p<.001$). Costs for inpatient services, emergency department services, services covered under Medicare (such as primary and specialist care, diagnostic tests and imaging), and prescription pharmaceuticals were all significantly higher for mothers who had a stillbirth. Mothers who had a stillbirth paid on average $1,479 out-of-pocket, which was 52% more than mothers who had a live birth after accounting for gestation at birth

This article is protected by copyright. All rights reserved

(p<.001). The value of lost output was estimated to be $73.8 million (95% CI: 44.0 million – 103.9 million). The estimated value of lost social welfare was estimated to be $18billion.

Discussion

Stillbirth has a sustained economic impact on society and families, which demonstrates the potential resource savings that could be generated from stillbirth prevention.

Keywords

Stillbirth; costs; resource use; economics; decision-making.

Author Manuscript

INTRODUCTION

Globally, an estimated 2.6 million stillbirths occur annually (1). Despite significant improvements in perinatal survival rates worldwide (2), stillbirth remains a significant and underemphasised problem in health systems research and policymaking (1, 3, 4), and global attention for this issue is low. Stillbirths were not included in the Millennium Development Goals and are not tracked by either the United Nations or the Global Burden of Disease – both of which count burden only after a live birth. A number of obstacles have been identified as preventing the uptake of stillbirth as a priority issue for global health policy and research. Such barriers include ingrained norms in national and international discourse and policymaking that fail to perceive a value of life lost to stillbirth as equal to that of deceased newborns or mothers (2).

Although the rates of stillbirth in high-income countries are relatively low compared to low- and middle-income countries, stillbirth is still a major health burden in Australia (5), where 7 in every 1,000 babies are stillborn (5, 6). Australia has seen a reduction in neonatal deaths (deaths within the first 28 days after birth), however, stillbirth rates have not declined in over 2 decades (1995-2014), varying between 6.7 and 7.5 per 1,000 births (5). While some small reductions have been shown in late gestation stillbirths, occuring after 28 completed weeks gestation (7, 8), Australia ranks 15th amongst developed countries with a late gestation stillbirth rate 35% higher than the best performing countries. The leading causes of stillbirth are unexplained antepartum death, congenital abnormalities, maternal conditions, and spontaneous pre-term birth (9). Despite the high prevalence of stillbirth both globally and nationally, the costs associated with stillbirth remain largely unknown, and this has been identified as a major gap in stillbirth research (10). In its series 'Stillbirths 2016: ending preventable stillbirths', The Lancet estimated that the direct financial cost of a stillbirth is 10-

This article is protected by copyright. All rights reserved

70% greater than the cost of a live birth, with the costs predominantly being met by the government (11). Existing cost estimates have rarely examined the direct costs of stillbirth during the perinatal period, nor the macroeconomic impacts (12).

This study aims to (1) identify the incremental direct costs of a stillbirth event, associated with the mother's health service use to the Australian Federal and State governments, and individuals compared to a live birth; (2) quantify the macroeconomic costs of stillbirth to the Australian economy associated with decreased gross domestic product (GDP) due to reduced capital formation as a result of the direct health care costs and a reduced labour force due to the loss of life associated with stillbirth; and (3) quantify the value of lost social utility associated with the lost life from stillbirth in Australia.

METHODS

Direct health care costs of stillbirth

To measure the direct health care costs of stillbirth we utilised Maternity1000 (13), a whole of population linked administrative dataset. Maternity1000 uses the Queensland Perinatal Data Collection to identify all women who gave birth in Queensland, and contains the records of women who gave birth between 1 July 2012 and 30 June 2015 (n=186,789), plus their resultant children (n=189,909). There were 1,271 records of babies who were stillborn during this time (0.7%). Stillbirth was identified from the Perinatal Data Collection, which defined stillbirth as being a baby born without signs of life of "at least 20 weeks gestation and/or 400 grams in weight" (14). The records of these mothers and children were then linked to their Admitted Patient Data Collection, Emergency Department Information System, Queensland Health Clinical Costing Unit, and Medicare Benefits Scheme (MBS) and Pharmaceutical Benefits Schedule (PBS) claims records. Linkage was undertaken on all women and babies identified on the Perinatal Data Collection.

The primary outcomes for this study were the total incremental cost to the Federal and State governments per stillbirth event; and the total incremental cost to the mother in the form of out of pocket health care costs per stillbirth event. Costs from the time of confinement through to 24 months postpartum were included. Incremental cost is defined as the difference in cost between mothers who had a stillbirth and mothers who had a live born baby. As the analysis was focused on identifying the costs of stillbirth, only costs associated with the health service of the mother were included in the analysis. All costs were adjusted to 2017/18 Australian dollars, based upon Consumer Price Inflation (15).

Author Manuscript

This article is protected by copyright. All rights reserved

The analysis used propensity score matching to control for the baseline differences in the population of women who had a stillbirth and women who did not. Matching on the properly estimated propensity score balances the distributions of confounding covariates between the exposure and control groups. We included in the exposure model only those variables correlated with both exposure (stillbirth) and outcome (post-event cost of health service use) (16). This approach is consistent with Rubin and Thomas (1996), who discourage the use of statistical significance as inclusion criteria in the estimation of the propensity score (17).

A logistic regression model was used to calculate each woman's propensity score. Characteristics included in the model were mother's age, body mass index at four-to-six weeks prior to conception, whether the mother had a pre-existing medical condition that was deemed to significantly affect the pregnancy or its management, smoked before 20 weeks gestation, identified as Aboriginal and/or Torres Strait Islander, area-based socioeconomic status (assigned from SEIFA quintile (18)), if the pregnancy was a singleton pregnancy, was the mother's first pregnancy, if the baby presented in a vertex position, and year of birth.

Mothers were matched 1:1 based upon their propensity score using the greedy matching (i.e., 'nearest neighbour') technique within a caliper of 0.2 times the standard deviation of the (pooled) logit of the propensity score (19). Matching produced two equal-sized cohorts of 1,125 women whose mean cost differences may thereby be attributed to stillbirth. However, some of the differences may still be attributable to unobserved factors.

Matching on the estimated propensity score should balance the underlying covariate distributions in the two groups. Post-estimation balance was assessed by comparing the standardized differences of means and prevalence between the exposure and control cohorts' baseline covariates (before and after matching). These are shown in Appendix 1 (published online only). The absolute value of the standardized differences for each covariate after matching was less than 0.1 (20) and so the groups were considered to be balanced based upon the selected covariates and thus appropriately matched. Although there has been criticism of the propensity score matching technique (21), this method was considered appropriate to control for the different characteristics in mothers who have a stillborn child and mothers who have a live born child primarily due to the large size of the dataset from which the two groups were drawn.

Descriptive statistics for the two cohorts were presented, identifying the incremental costs of stillbirth. Differences in costs were compared with generalized linear models, with cost as the

Author Manuscript

This article is protected by copyright. All rights reserved

dependent variable and gestation at birth and gestation at birth squared as independent variables. A negative binomial distribution and a log link function was specified.

Value of Lost Output

The value of lost output approach is based upon the model of economic growth independently derived by Robert Solow and Trevor Swan (12, 13) in 1956. The use of this model was proposed by the World Health Organisation in 2009 as a way to promote awareness among decision makers of the macroeconomic losses associated with disease (14). The model is described in detail in Appendix 2 (published online only). It assumes that an economy's total output is a function of capital accumulation, labour, the elasticity of output with respect to capital and labour, and total factor productivity.

In the absence of stillbirth, our counterfactual estimate of the economy's total output, was a function of the actual quantity of labour plus lives lost to stillbirth, and higher formation of fixed capital enabled by this increased output. Data used in the estimation of the Value of Lost Output secondary to stillbirth are summarised in Appendix 3 (published online only). Using the Australian Institute of Health and Welfare's stillbirth rate of 7.1 per 1000 births (22), we estimate a total of 2,193 stillbirths in Australia in the fiscal year ending June 2016. The excess out-of-pocket health costs and government expenditure estimates are taken from the first aim of this study.

Any attempt to estimate the value of lost output is sensitive to a number of inherent assumptions associated with the methodology. These core assumptions must be kept in mind when interpreting the results. It is assumed that any subsequent children born to parents who have had a stillborn child would have still been born if the stillborn child had been live born. That is, any subsequent children are not 'replacement' children. The value of lost output approach estimates the lost output in a single, closed economy, and thus also assumes that the stillborn child will not be replaced in the economy by immigrating individuals, with immigration policy being determined independently of stillbirth rates.

The underlying uncertainty of each of the value of lost output model's input parameters was tested with Monte Carlo simulations with random variation of model parameters in order to provide confidence intervals for value of lost output estimation (23). Simulations (10,000 iterations) were conducted with a uniform variation of the counterfactual population growth rate (via the stillbirth rate), private and public capital investment rate, depreciation rate, and

Author Manuscript

This article is protected by copyright. All rights reserved

output elasticity with respect to capital and labour. Selected input parameters were allowed to vary within plus or minus 25% of their base values.

Value of Lost Welfare

The value of lost welfare approach (23), models the economic consequences of disease as the present value of future social utility lost to morbidity and mortality. Following other studies that have used the value of lost welfare approach (24-27), we utilise national estimates of the ‘value of a statistical life’ and ‘value of a statistical life year’ to approximate the total social utility lost to stillbirth. Popularised by Schelling as a means to better account for social preferences in the consideration of public policy options (28), the value of a statistical life represents society’s willingness to pay to reduce the average number of deaths in a given year by one (29). The value of statistical life year may be calculated as an age-dependent function of the amount of expected life remaining, as follows:

$$VSLY = VSL\left(\frac{-r}{e^{r(current\ age\ -\ life\ expectancy)} - 1}\right) \qquad (1)$$

where VLSY is the Value of a Statistical Life Year, VSL is the Value of a Statistical Life, r is the discount rate (24). For this analysis, the expected years of life remaining is equal to life expectancy at birth, currently 82.5 years (30).

Following Aldy and Viscusi (31), we fitted Abelson’s value of a statistical life (VSL), adjusted for inflation, to an ‘inverted u-shape’ according to the following quartic function (24):

$$VSL \cdot f(a) = 19.41(0.236)^4 - 43.17(0.236)^3 + 27.65(0.236)^2 - 4.33(0.236) + 0.44 \qquad (2)$$

Research has shown that the VSL/Y of children is at least that of an adult (32) (in Alkire et al., 2015). We therefore apply the lower bound estimate produced by equation (2) (approximately $1.93m at age ~19) as the age-adjusted value of a statistical life of our target cohort. Using this value of a statistical life (VSL), we apply Equation 1 to derive a value of a statistical life year of approximately $63,000.

As the net present value of future utility lost to stillbirth, (VLW) may be expressed as

$$VLW = VSLY \cdot YLL \qquad (3)$$

Author Manuscript

This article is protected by copyright. All rights reserved

where YLL is the total years of life lost, i.e., total stillbirth incidence times life expectancy at birth. Data used in the estimation of VLW secondary to stillbirth are summarised in Appendix 4 (published online only).

The predicted VLW is strongly tied to the underlying value of a statistical life/year used in its estimation. Fitting Ableson's (33) VSL to an inverse u-shape yields a base VSL substantially lower than the original, non-fitted 'peak value'—a difference of over $77,000. We therefore present the VLW secondary to stillbirth using Ableson's unadjusted 'peak value,' as well as its corresponding lower-bound, fitted value as our estimate's upper and lower bounds, respectively.

RESULTS

Direct health care costs

Between July 1, 2012 and June 30, 2015 there were 189,909 births across Queensland. Of these, 189,811 had complete information and were included in the study population. Of these births, 1,271 (0.66%) were stillbirths, and 188,540 were live births. A total of 2,250 births were matched by their propensity score – 1,125 stillbirths and 1,125 live births.

The average cost to governments (Australian Federal and State) for the mother's health service use (covering use of services covered under MBS, PBS, and public hospital inpatient and emergency department use) from birth through to two years postpartum for mothers who had a stillbirth was $11,595; and $7,850 for mothers who had a live birth (Table 1). The average difference for the matched pairs was $3,774. After adjusting for gestation at birth, cost to governments for the health care of mothers who had a stillbirth was 42% higher than mothers who had a live birth ($p<.001$). The average cost for hospital use (inpatient and emergency department) from birth through to two years postpartum for mothers who had a stillbirth was $8,690; and $6,247 for mothers who had a live birth. After adjusting for gestation at birth, cost to government for public hospital use was 36% higher ($p=0.015$) for mothers who had a stillbirth compared to mothers who had a live birth.

The average cost for the use of health services covered under the MBS from birth through to two years postpartum for mothers who had a stillbirth was $2,905 and $1,602 for mothers who had a live birth. The average cost for the use of health services covered under the PBS from birth through to 2 years postpartum for mothers who had a stillbirth was $439, and $149 for mothers who had a live birth. After adjusting for gestation at birth, costs to government for MBS use was 72% higher ($p<.001$) and cost for pharmaceuticals under the PBS was

This article is protected by copyright. All rights reserved

Author Manuscript

139% higher (p<.001) for mothers who had a stillbirth compared to mothers who had a live birth.

For mothers who had a stillbirth, the average out of pocket expenditure for health service use from birth through to two years postpartum was $1,479, and $844 for mothers who had a live birth (Table 2). The average difference was $637. After adjusting for gestation at birth, total out of pocket fees for mothers who had a stillbirth were 52% higher than mothers who had a live birth (p<.001). The majority of this out of pocket expenditure was made up of MBS service use.

The total cost to the Federal government, State government and individual women for the health service use of mothers who had a stillbirth was $13,513 between confinement and two years post-partum, and $8,842 for mothers who had a live born baby. The incremental cost of stillbirths was $4,701, which after adjusting for gestation at time of birth was 45% higher than the costs of a live birth (p<.001).

<u>Value of Lost Output</u>

Based on an estimated 2,193 stillbirths in 2015/16, we estimate approximately $898,000 and $1,340,000 in total excess annual out-of-pocket expenditure and excess annual government expenditure secondary to stillbirth, respectively. This excess expenditure is likely to have reduced private investment in physical capital by approximately $207,000 per annum. Public investment in physical capital is likely to have been reduced by approximately $594,000. Taking into account both the loss of life and related foregone capital investment, we estimate a VLO secondary to stillbirth (2015-16) of approximately $73,800,000. Monte Carlo simulations provide the upper and lower bounds of the 95% confidence interval of the estimated VLO of $103,900,000 and $44,000,000, respectively (Table 3).

<u>Value of lost social utility</u>

Adjusting for inflation, Abelson's 'peak' VSL in Australia of approximately $4,300,000 corresponds with a VSLY of approximately $141,000. Multiplying by an estimated 180,938 YLL (years of life lost to stillbirth) yields a VLW of approximately $25.4 billion in 2015-16. Using the lower bound value of the fitted VSL of approximately $1.9m corresponds with a VSLY of approximately $63,000 and a VLW of nearly $11.5b (2015-16). The midpoint

Author Manuscript

This article is protected by copyright. All rights reserved

(mean) of these estimates represents a VLW approximately $18.4b (2015-16). Results are summarised in Table 4.

DISCUSSION

The aim of this study was to identify the costs of stillbirth, including both the direct health care costs and the macroeconomic costs in Australia. Our study has shown that there is a higher cost for a stillbirth compared with a live birth for almost all types of health service use to both the Government and to individual mothers. The average additional cost, which included those to the Governments and to individuals is $4,701 for a stillbirth event. We then estimated the follow-on macroeconomic costs that could accrue as a consequence of foregone fixed capital formation as a result of these direct health care costs, in addition to the reduced labour force due to the lost stillborn baby. This was estimated to be approximately $73.8 million annually. Due to the inherent assumptions associated with the value of lost output methodology, these estimates should be considered with caution. Finally, we sought to capture the value of lost welfare, that is, the net present value of the future earnings of individuals lost to stillbirth in a given year, which we estimated to be between $11.5 billion and $18.4 billion in 2015-16. While these figures are not additive, together they provide estimates of the range of costs incurred as a result of stillbirths in Australia.

The use of administrative data is a key strength of this study and it is a data source that has not been previously harnessed for the quantification of direct health care costs involved in this rare event. The use of administrative data allows all stillbirths within a defined population to be identified and thus included in the estimation of costs, and also reduces the potential for recall bias that can be introduced if patient surveys were utilized to identify health service use and cost (34). A key limitation of the first aim of this study was the reliance on data from one Australian state, Queensland, to make inferences about the costs of stillbirth across Australia. An additional limitation was the exclusion of some health care costs from the administrative datasets utilised. The most important costs that were excluded are those associated with post-mortem assessment, however costs associated with outpatient public hospital care are also excluded. It has been estimated in a previous study that the average cost of a stillbirth post-mortem assessment was $1,450 USD (in 2002 prices) (35). As such, our study likely underestimates the direct health care costs of stillbirth.

The findings of this study have shown that the direct health care costs of stillbirth extend beyond the time of pregnancy and birth, and out to at least two years postpartum. This could

Author Manuscript

This article is protected by copyright. All rights reserved

be explained by the higher costs associated with the management of subsequent pregnancies. Women who have had a previous stillbirth are at greater risk of stillbirth in a subsequent pregnancy (36). Care for subsequent births often entails more intensive surveillance during pregnancy and birth including more frequent ultrasounds and involvement of specialist medical practitioners, which come with greater costs. A review of the health care costs associated with stillbirth and a subsequent pregnancy in England and Wales (37) reported that women who had a previous stillbirth had higher total numbers of antenatal visits, which ultimately led to higher costs associated with stillbirth than among mothers who had a healthy baby. The extra costs rose to £4,654-5,616 per birth (10), with a total average annual cost to the National Health Service (NHS) of £943,846,000 (38).

Health policy must ensure that detailed health service use data (including costs) are collected to better understand the health service use of families affected by stillbirth. Doing so would enable the detection of inequality in access to health services and allow for better planning of health care services and resource allocation. Furthermore, knowing that the health care journey for mothers who experience stillbirth continues for at least 2 years postpartum highlights the importance of bereavement and follow up care to ensure that woman-centred care is provided well beyond the stillbirth event.

The impact that stillbirth has on the Australian economy is not widely recognised, and nowhere else have the costs been estimated. This current study has responded to this knowledge gap by demonstrating that significant costs to individuals, society and governments are experienced both through the direct costs to the health care system and the follow-on impacts on the economy. The results highlight that the costs of stillbirth go beyond the health sector and therefore require broad political attention. The sustained economic impact of stillbirth means that potential resource savings could be generated from stillbirth prevention. This study not only demonstrates the economic impact of stillbirth but raises awareness of the severity of this underemphasised health outcome. Addressing the cost of stillbirth knowledge gap is a key step towards facilitating decision-making to meet the goal outlined in the Lancet Stillbirth Series to end preventable stillbirths by 2030 (39).

REFERENCES

1. Frøen JF, Friberg IK, Lawn JE, Bhutta ZA, Pattinson RC, Allanson ER, et al. Stillbirths: progress and unfinished business.The Lancet. 2016;387:574-86.

Author Manuscript

This article is protected by copyright. All rights reserved

Author Manuscript

2. World Health Organization. Health in 2015: from MDGs, Millennium Development Goals to SDGs, Sustainable Development Goals. Geneva; 2015.

3. Frøen JF, Cacciatore J, McClure EM, Kuti O, Jokhio AH, Islam M, et al. Stillbirths: why they matter.The Lancet. 2011;377:1353-66.

4. Lawn JE, Blencowe H, Pattinson R, Cousens S, Kumar R, Ibiebele I, et al. Stillbirths: Where? When? Why? How to make the data count?The Lancet. 2011;377:1448-63.

5. Welfare AIoHa. Perinatal deaths in Australia: 2013-2014. Canberra; 2018. Contract No.: PER 94.

6. Australian Institute of Health and Welfare. Australia's mothers and babies 2016 - in brief. Canberra: AIHW; 2018.

7. Flenady V, Wojcieszek AM, Middleton P, Ellwood D, Erwich JJ, Coory M, et al. Stillbirths: recall to action in high-income countries.The Lancet. 2016;387:691-702.

8. Hilder L, Flenady V, Ellwood D, Donnolley N, Chambers GM. Improving, but could do better: Trends in gestation-specific stillbirth in Australia, 1994-2015.Paediatric and perinatal epidemiology. 2018.

9. Hilder L, Li Z, Zeki R, Sullivan E. Stillbirths in Australia, 1991–2009. . Sydney: University of New South Wales; 2014. Contract No.: 29.

10. Burden C, Bradley S, Storey C, Ellis A, Heazell AEP, Downe S, et al. From grief, guilt pain and stigma to hope and pride - a systematic review and meta-analysis of mixed-method research of the psychosocial impact of stillbirth.BMC Pregnancy and Childbirth. 2016;16.

11. ten Hoope-Bender P, Stenberg K, Sweeny K. Reductions in stillbirths--more than a triple return on investment.Lancet. 2016;387:e14-6.

12. Petrou S, Khan K, editors. Economic costs associated with moderate and late preterm birth: primary and secondary evidence. Seminars in Fetal and Neonatal Medicine; 2012: Elsevier.

13. Callander EJ, Fox H. What are the costs associated with child and maternal healthcare within Australia? A study protocol for the use of data linkage to identify health service use, and health system and patient costs.BMJ Open. 2018;8:e017816.

14. Queensland Health. Queensland Perinatal Data Collection Manual for the completion of Perinatal Data. Brisbane: State of Queensland (Queensland Health); 2015.

15. Reserve Bank of Australia. Measures of Consumer Price Inflation Online: https://www.rba.gov.au/inflation/measures-cpi.html: RBA; 2017 [

This article is protected by copyright. All rights reserved

16. Caliendo M, Kopeinig S. Some practical guidance for the implementation of propensity score matching.Journal of Economic Surveys. 2008;22:31-72.
17. Rubin DB, Thomas N. Matching using estimated propensity scores: relating theory to practice.Biometrics. 1996:249-64.
18. Australian Bureau of Statistics. Socio-Economic Indexes for Areas (SEIFA) Technical Paper ABS Cat. No. 2033.0.55.001. Canberra: ABS; 2011.
19. Austin PC. Balance diagnostics for comparing the distribution of baseline covariates between treatment groups in propensity-score matched samples.Statistics in medicine. 2009;28:3083-107.
20. Austin PC, Mamdani MM. A comparison of propensity score methods: a case-study estimating the effectiveness of post-AMI statin use.Statistics in medicine. 2006;25:2084-106.
21. King G, Nielsen R. Why propensity scores should not be used for matching.Political Analysis. 2019;27:435-54.
22. Australian Institute of Health & Welfare. Perinatal deaths in Australia 2013-2014, Cat no. PER 94. Canberra; 2018.
23. Abegunde DO, Mathers CD, Adam T, Ortegon M, Strong K. The burden and costs of chronic diseases in low-income and middle-income countries.The Lancet. 2007;370:1929-38.
24. Alkire BC, Shrime MG, Dare AJ, Vincent JR, Meara JG. Global economic consequences of selected surgical diseases: a modelling study.The Lancet Global Health. 2015;3:S21-S7.
25. Bloom DE, Cafiero E, Jané-Llopis E, Abrahams-Gessel S, Bloom LR, Fathima S, et al. The global economic burden of noncommunicable diseases. Program on the Global Demography of Aging; 2012.
26. Alkire B, Bergmark R, Chambers K, Lin D, Deschler D, Cheney M, et al. Head and neck cancer in South Asia: Macroeconomic consequences and the role of the head and neck surgeon.Head & Neck. 2016;38:1242-7.
27. Murray CJ, Vos T, Lozano R, Naghavi M, Flaxman AD, Michaud C, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010.The lancet. 2012;380:2197-223.

Author Manuscript

This article is protected by copyright. All rights reserved

28. Schelling T. The life you save may be your own. In: Chase S, editor. Problems in public expenditure Analysis Studies of Government Finance. Washington D.C.: The Brookings Institute,; 1968.
29. Viscusi WK. The value of risks to life and health.Journal of economic literature. 1993;31:1912-46.
30. Australian Bureau of Statistics. Life tables, states, territories and Australia, 2015-2017, Table 2.1, cat no. 3302.0.55.001. Canberra2018.
31. Aldy JE, Viscusi WK. Adjusting the value of a statistical life for age and cohort effects.The Review of Economics and Statistics. 2008;90:573-81.
32. Roman HA, Hammitt JK, Walsh TL, Stieb DM. Expert elicitation of the value per statistical life in an air pollution context.Risk Analysis: An International Journal. 2012;32:2133-51.
33. Abelson P. Establishing a monetary value for lives saved: issues and controversies. Canberra; 2007.
34. Dalziel K, Li J, Scott A, Clarke P. Accuracy of patient recall for self-reported doctor visits: Is shorter recall better?Health economics. 2015.
35. Michalski ST, Porter J, Pauli RM. Costs and consequences of comprehensive stillbirth assessment.American journal of obstetrics and gynecology. 2002;186:1027-34.
36. Ogwulu CB, Jackson LJ, Heazell AEP, Roberts TE. Exploring the intangible economic costs of stillbirth.BMC Pregnancy and Childbirth. 2015;15.
37. Mistry H, Heazell AE, Vincent O, Roberts T. A structured review and exploration of the healthcare costs associated with stillbirth and a subsequent pregnancy in England and Wales.BMC pregnancy and childbirth. 2013;13:236.
38. Mistry H, Heazell AEP, Vincent O, Roberts T. A structured review and exploration of the healthcare costs associated with stillbirth and a subsequent pregnancy in England and Wales.BMC Pregnancy and Childbirth. 2013;13.
39. de Bernis L, Kinney MV, Stones W, ten Hoope-Bender P, Vivio D, Leisher SH, et al. Stillbirths: ending preventable deaths by 2030.The Lancet. 2016;387:703-16.

Author Manuscript

This article is protected by copyright. All rights reserved

Table 1: Mean costs to Federal and State governments associated with mother's health service use for stillbirths and live births, Queensland, Australia 2012 – 2015.

Cost	**Stillbirth (n=1,159)**	**Live born (n=1,159)**	**Difference from matched pairs**	**Linear regression model of log transformed cost**	
	Mean±SD	**Mean±SD**	**Mean±SD**	**Parameter estimate for Stillbirth***	**p-value**
Total health service use costs	11,595±17,271	7,850±9,777	3,774±19,791	1.42	<.001
		Hospital costs			
All hospital costs	8,690±16,521	6,247±9,459	2,468±18,932	1.36	0.015
All hospital costs at birth	4,677±6,183	4,732±5,400	-34±8,149	1.04	0.818
All hospital costs year 1	2,183±11,860	772±6,256	1,413±13,454	2.13	0.007
All hospital costs year 2	1,829±5,054	742±2,737	1,089±5,675	2.56	0.003
Total inpatient costs	8,020±15,290	5,871±8,867	2,171±17,575	1.34	0.033
Total ED costs	670±2,057	375±998	297±2,261	1.54	0.070
		MBS			
All MBS costs	2,905±4,674	1,602±1,931	1,306±5,028	1.72	<.001
All MBS costs at birth	437±772	411±677	26±1,035	0.88	0.344
All MBS costs year 1	1,403±2,392	556±758	848±2,541	2.35	<.001
All MBS costs year 2	1,065±2,546	636±1,176	431±2,789	1.75	<.001
		PBS			
All PBS costs	439±3,938	149±687	290±3,987	2.39	<.001
All PBS costs at birth	14±156	8±46	7±162	0.944	0.872
All PBS costs year 1	184±1,653	67±244	118±1,672	2.65	<.001
All PBS costs year 2	240±2,552	74±584	166±2,600	2.36	0.006

*compared to live birth, adjusted for gestation at birth; exponentiated value presented.

MBS = Medicare Benefits Schedule; PBS = Pharmaceutical benefits Scheme.

Author Manuscript

This article is protected by copyright. All rights reserved

Table 2: Mean costs to mothers associated with mother's use health services covered by MBS and PBS and provided in private hospitals and funded by individuals, for stillbirths and live births, Queensland, Australia 2012 – 2015.

Cost	**Stillbirth (n=1,159)**	**Live born (n=1,159)**	**Difference from matched pairs**	**Linear regression model of log transformed cost**	
	Mean ±SD	**Mean±SD**	**Mean± SD**	**Parameter estimate for Stillbirth***	**p-value**
All OOP costs (MBS, PBS and Private Hospital)	1,479 ±3,304	844±1,479	637±3,575	1.52	<.001
MBS					
All MBS OOP costs	1,348±3,200	747±1,432	602±3,458	1.55	0.019
All MBS OOP costs at birth	289±721	409±801	-119±1,054	0.63	0.108
All MBS OOP costs year 1	562±1,632	100±297	463±1,666	4.25	<.001
All MBS OOP costs year 2	496±1,618	238±821	258±1,806	1.96	0.003
PBS					
All PBS OOP costs	132±259	97±178	35±315	1.30	0.014
All PBS OOP costs at birth	12±28	8±15	4±32	1.13	0.432
All PBS OOP costs year 1	64±136	46±92	18±165	1.34	0.023
All PBS OOP costs year 2	56±135	43±94	13±164	1.29	0.088

*compared to live birth, adjusted for gestation at birth; exponentiated value presented.

MBS = Medicare Benefits Schedule; PBS = Pharmaceutical benefits Scheme; OOP = out of pocket.

Author Manuscript

This article is protected by copyright. All rights reserved

Table 3. Value of lost output secondary to stillbirth, Australia, 2015-16

Parameter	Source	Value
Excess out-of-pocket expenditure	Results of this study	$897,892
Excess government expenditure	Results of this study	$1,340,039
Foregone private capital investment	ABS 5204.0	$206,801
Foregone public capital investment	ABS 5204.0	$593,752
Total output (observed)	ABS 5209.0	$1,659,604m
Total output (counterfactual)	ABS 5209.0	$1,659,678m
(Mean) value of lost output (VLO)	Monte Carlo	**$73,951,867**
Standard deviation	Monte Carlo	$15,295,377
Coefficient of variation	Monte Carlo	.204
VLO, lower and upper bounds		**$43,972,929 - $103,930,805**

VLO = Value of lost output

Author Manuscript

This article is protected by copyright. All rights reserved

Table 4. Value of lost welfare secondary to stillbirth, Australia, 2015-16

Parameter	Source	Value
VSL, 'peak value' (2015-16)	Abelson (2007)	$897,892
VSLY, 'peak value' (2015-16)	Abelson (2007)	$1,340,039
VSL, fitted, lower bound (2015-16)	Abelson (2007); Aldy & Viscusi (2008)	$206,801
VSLY, fitted, lower bound (2015-16)	Abelson (2007); Aldy & Viscusi (2008)	$593,752
(Mean) value of lost welfare		**$ 18,436,051,711**
VLW, lower and upper bounds		**$ 11,458,622,269 - $ 25,413,481,152**

VLW = Value of lost welfare; VSL = value of lost output; VSLY = value of lost social utility.

Author Manuscript

This article is protected by copyright. All rights reserved