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Incremental healthcare expenditure attributable to diabetes mellitus: A cost of illness study in Tasmania, Australia

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Abstract

Aims: To quantify the incremental direct medical costs in people with diabetes from the healthcare system perspective; and to identify trends in the incremental costs.

Methods: This was a matched retrospective cohort study based on a linked data set developed for investigating chronic kidney disease in Tasmania, Australia. Using propensity score matching, 51,324 people with diabetes were matched on age, sex and residential area with 102,648 people without diabetes. Direct medical costs (Australian dollars 2020–2021) due to hospitalisation, Emergency Department visits and pathology tests were included. The incremental costs and cost ratios between mean annual costs of people with diabetes and their controls were calculated.

Results: On average, people with diabetes had healthcare costs that were almost double their controls ($2427 [95% CI 2322–2543]; ratio 1.87 [95% CI 1.85–1.91]; pooled from 2007–2017). While in the first year of follow-up, the costs of a person with diabetes were $1643 (95% CI 1489–1806); ratio 1.83 (95% CI 1.76–1.92) more than their control, this increased to $2480 (95% CI 2265–2680); ratio 1.69 (95% CI 1.62–1.77) in the final year. Although the incremental costs were higher in older age groups (e.g., ≥70: $2498 [95% CI 2265–2754]; 40–49: $2117 [95% CI 1887–2384]), the cost ratios were higher in younger age groups (≥70: 1.52 [95% CI 1.48–1.56]; 40–49: 2.37 [95% CI 2.25–2.61]).

Conclusions: Given the increasing burden that diabetes imposes, our findings will support policymakers in future planning for diabetes and enable targeting sub-groups with higher long-term costs for possible cost savings for the Tasmanian healthcare system.

KEYWORDS

Australia, cost of illness, data linkage, diabetes, record linkage, Tasmania

Barbara de Graaff and Julie A. Campbell contributed equally.

1 | INTRODUCTION

Diabetes mellitus imposes a large burden on the health and social care systems because of its chronic nature and increasing prevalence, in combination with damaging complications.[1] In Australia, 2.7 billion (2.3% total healthcare expenditure) was spent on diabetes care in 2015–2016.[2] Tasmania is an Australian state with high prevalence of chronic diseases, including diabetes. According to the Tasmanian Health Survey, diabetes prevalence in Tasmania reached 8.3% in 2019.[3] In this context, accurate information about the direct costs of diabetes care over the recent years can provide some insight on the increasing burden that diabetes imposes on the Tasmanian health system and support policymakers to take practical actions to reduce the economic burden of diabetes.

In cost of illness studies, there were two approaches that have been specifically developed to estimate different types of costs: the total cost approach and the incremental cost approach. Previous studies found that the incremental cost approach may more accurately estimate the costs incurred, compared with the total cost approach.[4,5] The incremental cost approach uses either matching algorithms or regression method to calculate the incremental costs reflecting the difference in healthcare costs between people with and without the disease.[1,6]

In Australia, there are several published papers that have estimated the incremental costs in people with diabetes. However, most of them used relatively small,[7-9] clinic-based samples[7,10] and quantified the costs incurred in either a single year[7] or short-term periods.[8-10] More importantly, until now, no data have been published on the economic burden of diabetes in Tasmania. As a result, there is an urgent need for up-to-date information related to the economic burden of diabetes in Australia in general and Tasmania in particular. To address this glaring evidence gap, we conducted this study using a matched control method to quantify the incremental direct costs (including hospital, emergency visit and pathology costs) of people with diabetes, compared to people without diabetes in Tasmania. Because diabetes is a chronic disease having long-term effects on the healthcare system, we also aimed to identify trends in the incremental costs over the 11-year period.

What is already known?

- Diabetes is a chronic disease that places a huge burden on the Tasmanian healthcare system. However, until now, no data have been published on the economic burden of diabetes in Tasmania.

What this study has found?

- On average, the incremental costs in people with diabetes were almost double those for people without diabetes, and the cost differences have increased over time. Furthermore, the impact of diabetes on costs was different by sex, age group and socioeconomic status.

What are the implications of the study?

- Our findings will motivate and support policymakers in future planning for diabetes and enable targeted interventions for those sub-groups with higher long-term costs.

2 | METHODS

2.1 | Data sources

This was a matched retrospective cohort study using a subset of a linked administrative dataset in Tasmania, an Australian state with the total area of 68,401 km^2 and a population of approximately 541,500 people. Ethics approval (with waiver of consent) for the study was obtained from the Tasmanian Health and Medical Human Research Ethics Committee (reference number H0018548).

The study population was identified from two pathology datasets: Royal Hobart Hospital Pathology (RHHPATH) and Hobart Pathology (Diagnostic Services Pty Ltd [DSPL]). Because the dataset was first developed to investigate chronic kidney disease, the study population included any individual who had a serum creatinine test between 1/1/2004 to 31/12/2017 from RHHPATH or DSPL.[11] These data were then linked to Tasmanian Public Hospital Admitted Patient Episodes (AP), Tasmanian Public Hospital Emergency Department Presentations (ED), Tasmanian Death Register and Tasmanian Coded Cause of Death (DEATH) data, the Tasmanian Cancer Registry (TCR) and the Australia and New Zealand Dialysis and Transplant Registry (ANZDATA).

RHHPATH and DSPL provided information about participants' glycaemic control (HbA$_{1c}$, fasting plasma glucose [FPG], random plasma glucose [RPG]) and other pathology tests (Appendix 1); admitted patient data included information about hospital episodes (International Statistical Classification of Diseases and Related Health problems 10th Revision Australian Modification

[ICD-10-AM] codes, Australian Refined Diagnosis-Related Groups [AR-DRGs], number of admissions and length of hospital stay); ED data included information about ED presentations (primary diagnosis codes, urgency-related groups [URGs], number of presentations and length of ED stay); DEATH provided information about cause of death and date at death; while TCR and ANZDATA provided information about comorbidities.

The dataset was linked by the Tasmanian Data Linkage Unit, Menzies Institute for Medical Research, the University of Tasmania. Details about the linkage process were published elsewhere.[11] The dataset included approximately 87% (355,622) of the adult population in Tasmania (409,729) during 2013–2017.[11]

2.2 | Participant selection

From the initial dataset that comprised any individual that had a serum creatinine test, people with diabetes were defined as those people who satisfied at least one of the following criteria between 01/01/2004 to 31/12/2017.

1. ≥1 HbA_{1c} test ≥48 mmol/mol (6.5%).
2. ≥1 FPG tests ≥7.0 mmol/l (126 mg/dl).
3. ≥1 RPG test ≥11.1 mmol/l (200 mg/dl).
4. ICD-10-AM diagnosis code (primary or other) in the E10–E14 ranges recorded in either AP or ED.
5. A primary or underlying ICD-10-AM coded cause of death in the E10–E14 ranges recorded in DEATH.

Criteria 1–3 were based on diabetes diagnostic criteria published by the Australian Diabetes Society,[12] while using ICD codes to identify people with diabetes (criteria 4,5) was widely used in studies based on administrative data.[7,10]

The corresponding controls were sourced from the remaining individuals. Matching was based on age decile, sex, Statistical Areas Level 4 (SA4) of residence, year of first serum creatinine test in RHHPATH or DSPL and follow-up time (years) in the datasets, with a ratio of 1 case to 2 controls. Follow-up time for each person was calculated from the first and the last records during the study period. Exact matching was made on categorical variables (age decile, sex and SA4 of residence) with the nearest neighbour scoring for year of first appearance and follow-up time.

There were 54,623 cases and 109,245 controls identified. After excluding those who died or had the latest records before the inclusion date for the cost analysis (1 January 2007), and participants with missing data; 51,324 cases and 102,648 controls were included in the cost analysis (Figure 1).

2.3 | Estimation of healthcare costs and the incremental costs

Within the dataset, hospital episodes with similar levels of resource consumption were classified into AR-DRGs. Each AR-DRG was allocated a cost, sourced from the Independent Hospital Pricing Authority (IHPA).[13] Similarly, each emergency department presentation was classified into an URG, with costs extracted from validated IHPA sources.[13] In terms of pathology costs, unit costs for each test were sourced from the Medicare Benefits Schedule (MBS).[14] Because of data availability, only cost data for tests conducted on the same day as the serum creatinine test were included. The costs were aggregated for each year, then adjusted to 2020–2021 Australian dollars using the price index for Government Final Consumption Expenditure (GFCE) on hospitals and nursing homes index. This index was chosen because of its appropriateness for healthcare expenditure analysed in our cost analysis.[15] For years that were not included in the index, the corresponding inflators were calculated using the average increase of the included years (Appendix 2).[16]

For ED presentations with missing URGs (146,219 records; 3.5% of total records), mapping the primary diagnostic codes with the corresponding URGs was undertaken. The proportion of each URG during the study period was also considered to generate the average cost weight for each group. The cost analysis was performed from the healthcare system perspective and considered hospital, ED and pathology costs.

The incremental costs were expressed as the absolute difference and the cost ratio between mean annual costs of people with diabetes and their controls. To investigate the impact of diabetes on costs in different sub-groups, we stratified the incremental costs by sex, age group and Index of Relative Socioeconomic Disadvantage (IRSD) score. This was assigned based data from the Australian Bureau of Statistics, which assigns socioeconomic levels based on the residential address of participants (Statistical area level 2).[17] We divided the IRSD score into five categories reflecting the socioeconomic levels of participants, with level 1 is the most disadvantaged level and level 5 is the least disadvantaged level.

The incremental costs were then multiplied by the prevalence of diabetes in Tasmania and the total number of Tasmanians in 2017 to estimate the incremental direct healthcare expenditure in people with diabetes in Tasmania. The same methods were applied to estimate the incremental costs in Australia.

2.4 | Method of analysis

Our analyses focused on the arithmetic mean of costs because it has been considered the most informative

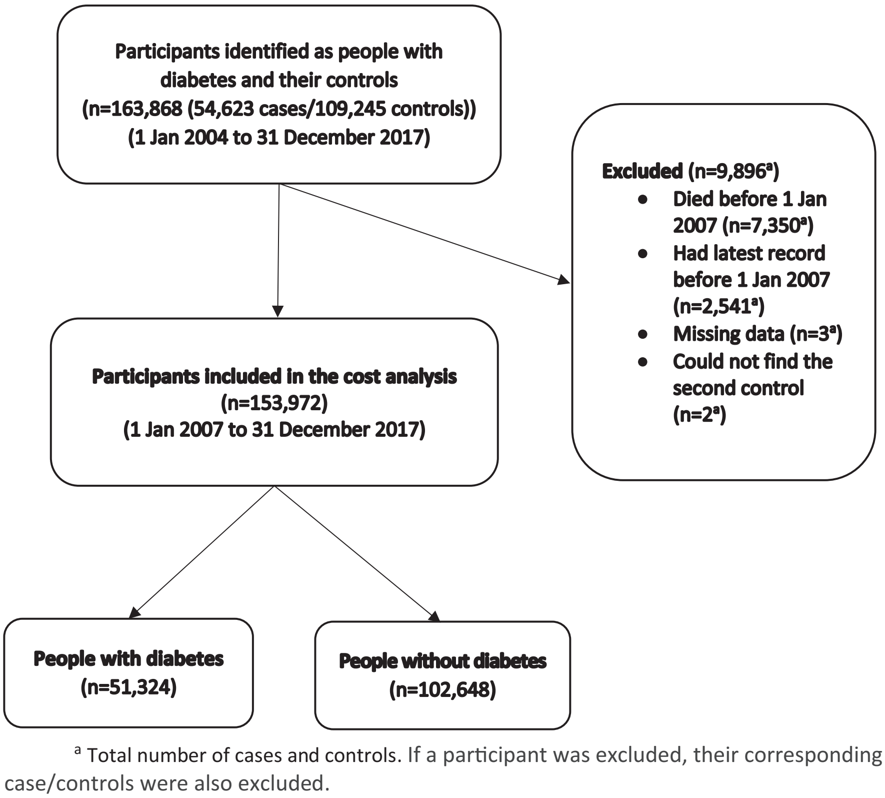

FIGURE 1 Flow of participants into the study. [a]Total number of cases and controls. If a participant was excluded, their corresponding case/controls were also excluded

TABLE 1 Matched cohort size by follow-up years

Follow-up year	People with diabetes *n* (%)	People without diabetes *n* (%)	Total
0	41,011 (33.3)	82,179 (66.7)	123,190
1	42,629 (33.0)	86,438 (67.0)	129,067
2	43,359 (32.9)	88,555 (67.1)	131,914
3	43,398 (32.8)	88,954 (67.2)	132,352
4	43,067 (32.7)	88,613 (67.3)	131,680
5	42,625 (32.6)	87,955 (67.4)	130,580
6	41,848 (32.6)	86,572 (67.4)	128,420
7	40,815 (32.6)	84,523 (67.4)	125,338
8	39,464 (32.7)	81,335 (67.3)	120,799
9	37,587 (33.1)	75,869 (66.9)	113,456
10	33,144 (34.6)	62,727 (65.4)	95,871

measure for policymakers.[18,19] Although our costs data were right skewed, we used t-tests to compare mean annual costs between people with diabetes and their controls because it has been proven that with sufficiently large samples, t-test still perform well regardless of the non-normal distribution of the data.[20] We calculated two-tailed p values, and $p \leq 0.05$ was considered statistically significant. The confidence intervals of mean annual costs per person, the incremental costs and the cost ratio between people with diabetes and their controls were calculated using a bias-corrected bootstrapping method with 1000 resamples.

One limitation of AR-DRG costing is that it is based on national average costs; therefore, potential differences in length of hospital stay between different patient groups such as those with diabetes versus those without are not reported. To account for that, we conducted a sensitivity analysis using a costing method that was based on the exact length of hospital stay. We replaced the cost buckets (ward medical, ward nursing, non-clinical salaries, allied, pharmacy, ward supplies and hotel) calculated by average length of stay (ALOS) in each AR-DRG by the corresponding cost buckets calculated using the exact length of stay (LOS) for each hospitalisation recorded in our dataset. To do that, we first calculated the unit cost (costs for a one day stay) for each cost bucket by dividing the total costs of each bucket by the ALOS, both of which are published by the IHPA.[13,21] The resulting unit cost was then multiplied by the actual LOS recorded for each individual patient's hospital admission.

To deal with coding errors that happen when physicians make a coding of diabetes if there is only an indication for diabetes or an incorrect coding is made, we conducted a second sensitivity analysis excluding 1610 people with diabetes who were identified with only a single coding of ICD diabetes.

All statistical analyses were conducted using Stata version 17. The matching process was performed using R version 4.0.3. Joinpoint software version 4.9.0.0 was used for analysing cost trends during the study period.[22]

3 | RESULTS

In 2017, there were 33,144 people with diabetes identified from our dataset (Table 1). This corresponds to a crude prevalence of 6.3% and an age/sex standardised prevalence of 5.7% (based on direct standardisation method using the Australian age and sex distribution in 2017).[23]

The characteristics of participants in our study are described in Table 2. In both groups, 55.6% were men, and the mean age was approximately 59 years. As anticipated, people with diabetes had a higher rate of deaths (20.1% vs. 12.9%; $p < 0.001$), more hospitalisations (6.0 ± 34.1 vs. 3.2 ± 22.0; $p < 0.001$), ED presentations (3.8 ± 7.8 vs. 2.6 ± 5.0; $p < 0.001$), longer length of hospital stay (5.0 ± 12.6 days vs. 4.4 ± 15.1 days; $p < 0.001$) and ED stay (405 ± 373 min vs. 352 ± 401 min; $p < 0.001$) than people without diabetes.

Table 3 illustrates the incremental costs in people with diabetes in terms of the absolute and relative differences. On average, the annual costs of people with diabetes ($5209 [95% confidence interval (CI) 5112–5317]) were almost double those of their counterparts without diabetes ($2782 [95% CI 2738–2826]; difference: $2427 [95% CI $2322–2543]; ratio 1.87 [95% CI 1.85–1.91]; $p < 0.001$). When standardised based on the Australian age and sex distribution in 2017,[23] these correspond to $2397 (95% CI 2057–2745). Most of the costs were related to hospital admission costs ($2190; 90.2%); with ED presentations and pathology tests only accounting for small proportions (ED: $162, 6.7%; pathology: $75; 3.1%, respectively). Extrapolating annual mean direct costs using our prevalence estimate, this corresponds to $173 million for total costs and $80 million of incremental costs due to diabetes in Tasmania in 2017. In the same year, approximately 1.2 million Australians were living with diabetes,[24] this corresponds $2.9 billion of incremental costs due to diabetes.

Both the incremental costs and the cost ratio were higher in women (by 8.8% and 11.2%, respectively). In terms of age, trends in incremental costs were found in people aged over 40. Although the incremental costs were higher in older age groups (e.g. ≥70: $2498 [95% CI 2265–2754]; 40–49: $2117 [95% CI 1887–2384]), the cost ratios were higher in younger age groups (≥70: ratio 1.52 [95% CI 1.48–1.56]; 40–49: ratio 2.37 [95% CI 2.25–2.61]). Regarding socioeconomic status, while the relative impact of diabetes decreased by the disadvantaged status (most disadvantaged: ratio 1.69 [95% CI 1.57–1.80]; least disadvantaged: ratio 2.13 [95% CI 2.01–2.19]), no pattern was observed for the absolute difference.

An upward trend in both mean annual costs and incremental costs in people with diabetes over the study period was observed (Figure 2a and b). The annual percent change (APC) of the incremental costs was significantly different from zero (APC = 5.13, $p < 0.05$) (Appendix 3). While in the first year of follow-up, on average, people with diabetes had medical costs that were $1643 (95% CI 1489–1806) more than their controls, these incremental costs increased to $2480 (95% CI 2265–2680) in the final year.

Results of sensitivity analyses were presented in Appendix 4. The first sensitivity analysis indicated that if the actual LOS was considered, the incremental costs would increase to $2868 (95% CI 2723–3024). Although there was similar upward trend, the APC of the excess costs was lower (3.68, $p < 0.05$). The incremental costs obtained from the second sensitivity analysis ($2385 [2280–2503]) were slightly lower than our main analysis.

4 | DISCUSSION

Diabetes prevalence estimated from our study (year 2017: 5.7%) was higher than results from the Australian health survey (5.4%)[24] but lower than estimate from the Tasmanian health survey (year 2016: 8.1%).[3] This might be mostly because of the differences in sample size and diabetes definition. It is likely that we captured the vast majority, if not all people with diabetes in Tasmania.

By using matched controls in a large sample of the Tasmanian population, we have demonstrated that people with diabetes require substantially greater healthcare expenditure than people without diabetes of similar age, sex and residential area. Health service utilisation in people with diabetes was higher compared to people without diabetes, both in terms of the number of hospital visits and the LOS, which also led to considerable increases in costs.

Our results not only quantified the substantial increase in healthcare expenditure in people with diabetes but also

TABLE 2 Characteristics of participants

Characteristics	People with diabetes $n = 51{,}324$	People without diabetes $n = 102{,}648$	p
Sex			
Men	28,524 (55.6)	57,048 (55.6)	
Women	22,800 (44.4)	45,600 (44.4)	
Age (years)[a]	59.1 ± 15.5	58.7 ± 15.6	
Age groups (years)[a]			
0–39	5286 (10.3)	10,755 (10.5)	
40–49	7273 (14.2)	14,616 (14.2)	
50–59	12,102 (23.6)	24,706 (24.1)	
60–69	13,493 (26.3)	26,768 (26.1)	
≥70	13,170 (25.7)	25,803 (25.1)	
IRSD			
1 (most disadvantaged)	10,601 (20.7)	15,940 (15.5)	
2	9829 (19.2)	17,778 (17.3)	
3	10,810 (21.1)	21,073 (20.5)	
4	9901 (19.3)	22,409 (21.8)	
5 (least disadvantaged)	10,183 (19.8)	25,448 (24.8)	
Number of hospital admissions[b]	6.0 ± 34.1	3.2 ± 22.0	<0.001[d]
Median (IQR)	2 (0, 5)	1 (0, 3)	
Length of hospital stay (days)[c]	5.0 ± 12.6	4.4 ± 15.1	<0.001[d]
Number of ED presentations[b]	3.8 ± 7.8	2.6 ± 5.0	<0.001[d]
Median (IQR)	2 (0, 5)	1 (0, 3)	
Length of ED stay (minutes)[c]	405 ± 373	352 ± 401	<0.001[d]
Number of deaths	10,318 (20.1)	13,229 (12.9)	<0.001[e]
Follow up time (years)	8.0 ± 3.2	8.1 ± 3.1	

Note: Data are presented as mean ± standard deviation or n (%) unless otherwise stated.

Abbreviations: IRSD, index of relative socioeconomic disadvantage, calculated using statistical area level 2 (SA2) of residence; IQR, interquartile range; ED, emergency department.

[a]Calculated from recorded age at date of the first pathology recorded.

[b]Calculated for the whole study period.

[c]Average length of stay per admission.

[d]Derived from two-sample t-test.

[e]Derived from Chi-square test.

demonstrated the upward trend over time. More importantly, this trend was more noticeable from the year 3–4 of the follow-up period that corresponds to year 2010–2011 (2007–2010: APC 0.71, $p > 0.05$; 2010–2017: APC 6.44; $p < 0.05$). This is most likely due to the activity-based funding (ABF) agreement between the Commonwealth and Australian states in 2011,[25] which led to the establishment of the IHPA. Based on the national hospital cost data collection, the IHPA determined the national efficient price to estimate the costs of hospital services to support ABF. This reform might have led to more careful clinical coding and AR-DRG assignment, resulting in higher costs being assigned for each hospital admission.

Our findings also highlighted the interaction between diabetes and age. While the incremental costs indicate the absolute difference in costs between people with and without diabetes, the cost ratios enable comparing the relative effect of diabetes in different age groups. The fact that the lower incremental costs in younger age groups corresponded to the higher relative increase in costs demonstrated that the impact of diabetes on health status might be even more devastating in younger age groups. Similar trends were reported in other international studies. A study conducted in Germany found that the cost ratio was approximately 3.3 in people aged <50 years, much higher compared with a cost ratio of 1.6 in those aged >80 years.[26]

TABLE 3 Mean annual costs of people with diabetes and their controls, by participants' characteristics and health service

	People with diabetes n = 51,324 Mean AUD (95% CI)[a]	People without diabetes n = 102,648 Mean AUD (95% CI)[a]	p[b]	Incremental costs AUD (95% CI)[a]	Cost ratio AUD (95% CI)[a]
Sex					
Men	5300 (5157–5424)	2964 (2907–3031)	<0.001	2336 (2182–2496)	1.79 (1.74–1.88)
Women	5096 (4947–5268)	2555 (2493–2609)	<0.001	2541 (2388–2710)	1.99 (1.89–2.07)
Age group (years)[c]					
0–39	4598 (4244–4986)	1871 (1771–1968)	<0.001	2727 (2352–3150)	2.46 (2.28–2.64)
40–49	3665 (3411–3911)	1547 (1459–1656)	<0.001	2117 (1887–2384)	2.37 (2.25–2.61)
50–59	4077 (3903–4279)	1737 (1679–1803)	<0.001	2339 (2162–2544)	2.35 (2.26–2.44)
60–69	5251 (5061–5431)	2835 (2741–2922)	<0.001	2416 (2224–2638)	1.85 (1.79–1.92)
≥70	7306 (7083–7543)	4808 (4699–4911)	<0.001	2498 (2265–2754)	1.52 (1.48–1.56)
IRSD					
1 (most disadvantaged)	5849 (5612–6104)	3457 (3340–3587)	<0.001	2392 (2132–2684)	1.69 (1.57–1.80)
2	6019 (5784–6300)	3448 (3334–3560)	<0.001	2570 (2285–2876)	1.75 (1.63–1.87)
3	5318 (5130–5510)	3063 (2956–3183)	<0.001	2255 (2028–2469)	1.74 (1.68–1.79)
4	4741 (4560–4997)	2485 (2397–2567)	<0.001	2256 (2049–2485)	1.91 (1.83–1.99)
5 (least disadvantaged)	4104 (3915–4304)	1924 (1858–2002)	<0.001	2180 (1970–2399)	2.13 (2.01–2.19)
Health service					
Hospital	4590 (4497–4693)	2400 (2359–2442)	<0.001	2190 (2091–2297)	1.91 (1.89–1.95)
ED	423 (416–430)	261 (259–265)	<0.001	162 (154–170)	1.62 (1.60–1.66)
Pathology	196 (194–199)	121 (120–122)	<0.001	75 (73–78)	1.62 (1.60–1.64)
Total	5209 (5112–5317)	2782 (2738–2826)	<0.001	2427 (2322–2543)	1.87 (1.85–1.91)

Abbreviations: AUD, Australian dollars; IRSD, index of relative socioeconomic disadvantage; ED, emergency department.

[a]95% confidence interval, derived by bootstrapping method.

[b]Derived by two-sample t-test.

[c]Calculated from recorded age at date of the first pathology recorded.

Another study in Italy even found more remarkable difference, with cost ratio 7.1 in people <45 years and 1.7 in people >74 years.[27]

Previous studies in Australia reported the annual incremental costs per person with diabetes as ranging from $1861 to $2534 in 2020–2021 values (ratio 1.22–2.08).[7,9,10] Our results were higher than a study performed in Queensland in 1999 that estimated the incremental costs at $1861 ($1006 in 1998–1999 values).[10] Although using the same costing method as ours, this Queensland study focused on hospital costs in people with type 2 diabetes only and did not include ED and pathology costs. Our estimate was also higher than a study that reported incremental costs of $2342 ($1559 in 2004–2005 values). This study used a bottom-up approach, partly based on self-reported diabetes and only included adults aged ≥30 years.[9] As a result, it is likely that the majority of participants in this study had type 2 diabetes who have lower incremental costs than patients with type 1 diabetes.[27] However, our results were lower than another Australian study that reported incremental costs of $2534 ($2105 in 2012–2013 values).[7] These differences may be due to (1) the fact that their participants were recruited from hospital admissions versus our broad population-based participant inclusion including ED presentations that did not result in admissions so were likely to be more unwell than our cohort and (2) the study was based on a bottom-up approach, while our study used a case mix approach for costing hospital and ED admissions.

Results from international studies have likewise demonstrated the profound impact of diabetes on direct healthcare costs. In these studies, the cost ratios of people with diabetes versus people without diabetes ranged from 1.3 to 4.1.[26-31] Although some of them reported a cost ratio that was relatively close to our estimate,[28,29,31] detailed

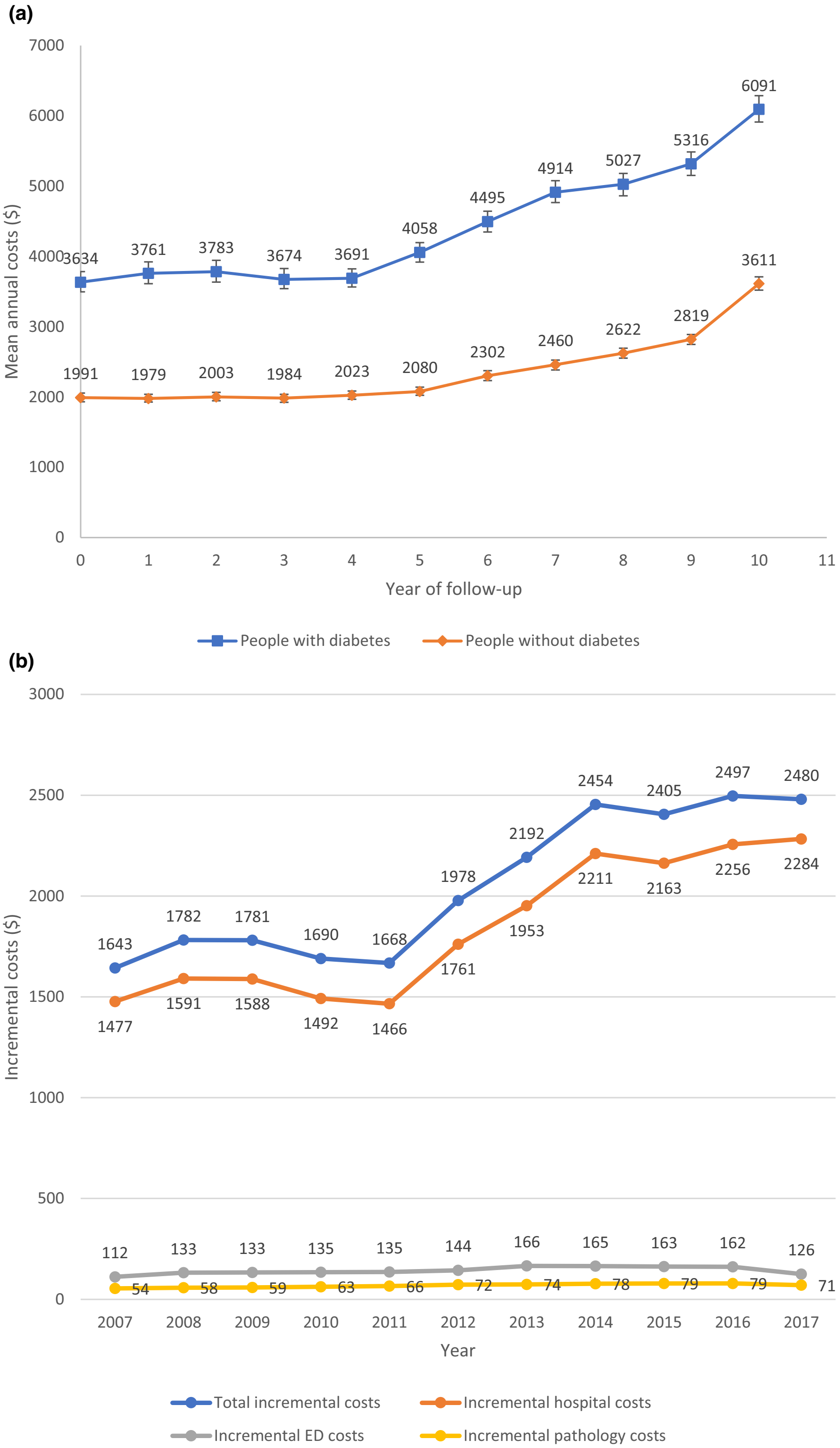

FIGURE 2 (a) Trend in mean annual costs in people with and without diabetes. Costs were expressed as mean (95% confidence interval). The differences in costs were statistically significant at all time points ($p < 0.001$, two-sample t-test). (b) Trend in incremental costs in people with diabetes. The differences in costs were statistically significant at all time points ($p < 0.001$, two-sample t-test). 95% confidence intervals were omitted for clarity. ED, emergency department

comparison is problematic due to the discrepancies in healthcare systems and costs between countries.

The strengths of this study included the large sample size and a long study period. Additionally, the availability of pathology results supported by diagnostic codes allowed the accurate identification of people with diabetes and their counterparts without diabetes. However, there were some limitations. First, the dataset was originally developed to investigate chronic kidney disease. Therefore, participants were only included in the cohort if they had a serum creatinine test. This could have led to a selection or overrepresentation of people with kidney disease, or people with long-standing diabetes that already had diabetes related complications. Costs of pathology tests during the study period were only captured if they were performed on the same day as serum creatinine test, leading to a potential underestimation of the costs of pathology tests in our study. However, as serum creatinine tests are common routine blood test, we believe that this limitation does not considerably affect our cost estimates. Second, our dataset did not contain MBS or Pharmaceutical Benefits Scheme data, so information on costs of medical practitioner consultations, physiotherapy, eye and vision therapy and medication costs were not included in our study. Furthermore, as we adopted the healthcare system perspective, we did not include patient out-of-pocket expenses. In addition, we were not able to calculate indirect costs due to absenteeism, presenteeism, premature death and early retirement. Because it is challenging to ascertain when exactly people developed diabetes using administrative data, our sample could have included a number of people with prediabetes in some period of the study. Finally, because of the differences between type 1 and type 2 diabetes, these two types should have been reported separately. However, we could not distinguish between type 1 and type 2 diabetes because this information was not available.

The incremental costs estimated in our study may be valuable information to support policymakers to assess the costs potentially saved by implementing diabetes prevention strategies, as well as optimal diabetes management. It is anticipated that these incremental costs will continue increasing over time, and policymakers should consider this information when planning future budgets and to allocate resources adequately and effectively. Our findings not only highlight the economic burden of diabetes, but also identify sub-groups with higher costs. This may allow decision makers to target these groups with suitable interventions to lower these costs, for example older age groups. However, because of their shorter remaining lifetime, people with diabetes diagnosed at older ages had lifetime costs that are less than younger people.[32] Although implementing programs targeting older age groups could gain immediate benefit, focusing on prevention and treatment of diabetes in younger age groups may be more beneficial in the long run, because the relative impact of diabetes is higher in younger age groups, and they also have higher long-term healthcare costs.

Most of the incremental costs associated with diabetes identified in this study may be due to complications. Future research could identify the complications that lead to higher incremental costs and further explore the most important underlying factors that are associated with long-term incremental costs, such as frequency of hospitalisations or intensity of treatment.[10] Furthermore, estimating the incremental costs before and after diagnosis in people with diabetes in an Australian setting will also provide more evidence to help identify cost-effective interventions for preventing diabetes.

In conclusion, this study used linked data to determine that the incremental direct medical costs due to hospitalisation, ED visits and pathology tests in people with diabetes were almost double their counterparts without diabetes in Tasmania, Australia. These cost differences have increased over time, most likely due to changes in funding models rather than to changes in management or hospitalisation rates. Additionally, we determined the different impact of diabetes on costs by sex, age group and socioeconomic status. Our cost estimates will be useful information for full economic evaluations and will support policymakers in allocating resources effectively for possible long-term cost savings.

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CONFLICT OF INTEREST

MJ is a member of the Australia and New Zealand Dialysis and Transplant Registry (ANZDATA) Executive Committee.

DATA AVAILABILITY STATEMENT

Due to ethical concerns, the data that support the findings of this study cannot be made available openly.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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