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Cost-Effectiveness of a Government Policy to Incentivise Chronic Disease Management following Stroke: A Modelling Study

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Keywords
Chronic disease management · Stroke · Cost-effectiveness · Economic evaluation · Markov modelling

Abstract
Introduction: Little is known about the cost-effectiveness of government policies that support primary care physicians to provide comprehensive chronic disease management (CDM). This paper aimed to estimate the potential cost-effectiveness of CDM policies over a lifetime for long-time survivors of stroke. ***Methods:*** A Markov model, using three health states (stable, hospitalised, dead), was developed to simulate the costs and benefits of CDM policies over 30 years (with 1-year cycles). Transition probabilities and costs from a health system perspective were obtained from the linkage of data between the Australian Stroke Clinical Registry (cohort n = 12,368, 42% female, median age 70 years, 45% had CDM claims) and government-held hospital, Medicare, and pharmaceutical claims datasets. Quality-adjusted life years (QALYs) were obtained from a comparable cohort (n = 512, 34% female, median age 69.6 years, 52% had CDM claims) linked with Medicare claims and death data. A 3% discount rate was applied to costs in Australian dollars (AUD, 2016) and QALYs beyond 12 months. Probabilistic sensitivity analyses were used to understand uncertainty. ***Results:*** Per-person average total lifetime costs were AUD 142,939 and 8.97 QALYs for those with a claim, and AUD 103,889 and 8.98 QALYs for those without a claim. This indicates that these CDM policies were costlier without improving QALYs. The probability of cost-effectiveness of CDM policies was 26.1%, at a willingness-

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to-pay threshold of AUD 50,000/QALY. ***Conclusion:*** CDM policies, designed to encourage comprehensive care, are unlikely to be cost-effective for stroke compared to care without CDM. Further research to understand how to deliver such care cost-effectively is needed.

Introduction

Worldwide, stroke is a leading cause of death and disability [1] and imposes a considerable economic burden on already strained health systems [2]. There is evidence that nationwide multidisciplinary care programs, with financial incentives, could reduce mortality and morbidity and improve health-related quality of life (HRQOL) post-stroke [3]. A comprehensive care plan aimed at preventing recurrent stroke, improving functional and psychological status, and managing risk factors and comorbidities is recommended to optimise long-term care for people with stroke [4].

Since 1999, the Australian Government has been providing incentives to primary care physicians (PCPs) who deliver chronic disease management (CDM) to people with chronic conditions, such as stroke [5]. These CDM policies include Medicare Benefits Schedule (MBS) items which cover the development and review of CDM plans. The CDM plans are developed by physicians in collaboration with patients to detail the problems, management goals, actions, and services needed by the patient [5]. In 2016, 51% of survivors of stroke were provided with CDM plans [5]. Claims related to CDM policies have doubled over the last decade and are estimated to be worth nearly AUD 1 billion annually [6].

In a recent evaluation of CDM policies, compared to those without a claim for a CDM plan, those with a claim between 7 and 18 months following stroke or transient ischaemic attack (TIA) had improved survival by 26% between 19 and 30 months but increased hospitalisations by 17% [7]. Two-thirds had unplanned hospitalisations, mostly for cardiovascular disease, chest pain or collapse, and abnormal findings. From a policy perspective, it is also important to understand cost-effectiveness within the context of the current health system. In this study, we estimated the potential cost-effectiveness of government-funded CDM policies for long-term survivors of stroke or TIA over a lifetime from an Australian government funder perspective.

Methods

A cost-utility analysis was conducted using Markov modelling in accordance with the Consolidated Health Economic Evaluation Reporting Standards [8].

Data Sources and Input Parameters

Input parameters for Markov models were obtained from cohorts of two studies: Evaluation of enhanced models of primary care in the management of stroke and other chronic disease (PRECISE study) [7, 9] and Shared Team Approach between Nurses and Doctors for Improved Risk Factor Management (STANDFIRM) trial [10–12]. Transition probabilities and costs were obtained from the linkage of data between the Australian Stroke Clinical Registry (AuSCR) and government-held hospital, Medicare, and pharmaceutical claims datasets (the PRECISE study). Quality-adjusted life years (QALYs) were obtained from the STANDFIRM trial (see the online suppl. material for details; for all online suppl. material, see https://doi.org/10.1159/000536224). These are the only two cohorts in which data on claims for CDM among survivors of stroke or TIA in Australia is available (online suppl. eTable 1). Further details on the baseline characteristics of the STANDFIRM cohort (online suppl. eTable 2) and PRECISE cohort can be found elsewhere [7].

Study Groups

Primary care with ≥1 CDM claim (the CDM group) was compared to receiving primary care without a CDM claim (the non-CDM group). The Australian Government financially incentivises PCPs who provide targeted management for people with chronic diseases in the form of CDM plans [13]. A CDM plan is a care plan developed by physicians in collaboration with patients and includes problems, management goals, actions, and services needed by the patient [5]. The claims data we used lacked information about the content of CDM plans. A CDM plan (MBS item 721) can be claimed once every 12 months, and its review (MBS item 732) once every 3 months [13]. MBS items 721 and 732 were used in the PRECISE and STANDFIRM cohorts.

Costs Estimation

Direct costs were included in this study and were estimated in AUD for the reference year of 2016–17. Costs covered all-cause hospitalisations, Medicare services, and medications (painkillers, antihypertensive, antithrombotic, lipid-lowering, and anti-inflammatory agents; medications to treat anxiety, depression, arthritis, and osteoporosis). Costs of hospitalisation were calculated using the average cost of inpatient separations by diagnosis-related group obtained from all hospitals from the relevant state-held patient admission datasets [14]. Similarly, the costs of emergency department (ED) presentations were estimated using state-held ED datasets, which include ED data from public hospitals.

Medicare services included community-based services covered by the Australian Government, such as primary care, speciality care, allied health, and pathology (online suppl. eTable 3). The total fees charged by the provider for each Medicare service delivered to patients were obtained using linked MBS transactional data [13]. The costs of dispensed medications were estimated using data obtained from the Pharmaceutical Benefits Scheme and

Table 1. Parameters of cost and quality-adjusted life years for the two study groups applied to each year

	CDM group		Non-CDM group	
	stable	hospitalised	stable	hospitalised
Mean cost (SD), AUD	1,594 (1,167)	17,572 (19,987)	1,099 (924)	15,125 (16,008)
α parameter of Gamma distribution[a]	1.87	0.77	1.41	0.89
β parameter of Gamma distribution[a]	854	22734	777	16,943
Mean QALYs (SD) – a multiplicative approach	0.71 (0.23)	0.63 (0.24)	0.74 (0.24)	0.63 (0.27)
α parameter of Beta distribution[a]	1.97	1.84	1.67	1.41
β parameter of Beta distribution[a]	0.81	1.07	0.60	0.82
Mean QALYs (SD) – a complex number approach	0.88 (0.08)	0.86 (0.08)	0.88 (0.09)	0.84 (0.09)
α parameter of Beta distribution[a]	13.20	14.54	10.75	13.51
β parameter of Beta distribution[a]	1.78	2.37	1.40	2.50

AUD, Australian dollars; CDM, chronic disease management; QALYs, quality-adjusted life years; SD, standard deviation. [a]In Gamma distributions, α parameter indicates a shape parameter, whereas β parameter indicates rate parameter. In Beta distributions, α and β parameters determine the shape of the Beta distribution.

comprised both the government-subsidised amount and the amount contributed by the patient. Mean costs used in the model are shown in Table 1 and disaggregated costs in online supplementary eTable 4.

QALY Estimation

QALYs were chosen as an outcome measure because QALYs are preferred by the Australian Government [15] and patient-reported data on utilities was available by receipt of a CDM plan from the STANDFIRM cohort. We estimated QALYs using utilities converted from the AQoL-4D questionnaire [16] responses provided by participants in STANDFIRM between 12 and 24 months from the trial baseline (online suppl. eFig. 1). There was no between-group difference in the mean utilities at 12 months (β coefficient adjusted for age and sex was −0.03, 95% confidence interval −0.07, 0.02) for those with and without a CDM claim. A multiplicative approach was applied in the estimation of QALYs in a base-case analysis, where a QALY was calculated by dividing the sum of two utilities measured at 12 and 24 months by two. QALYs, estimated by the complex number method [17], were also used, in which $\text{QALY} = \left(\frac{\sqrt{1^2+\text{utility}^2}}{1.4142}\right)\text{time}$ (Table 1).

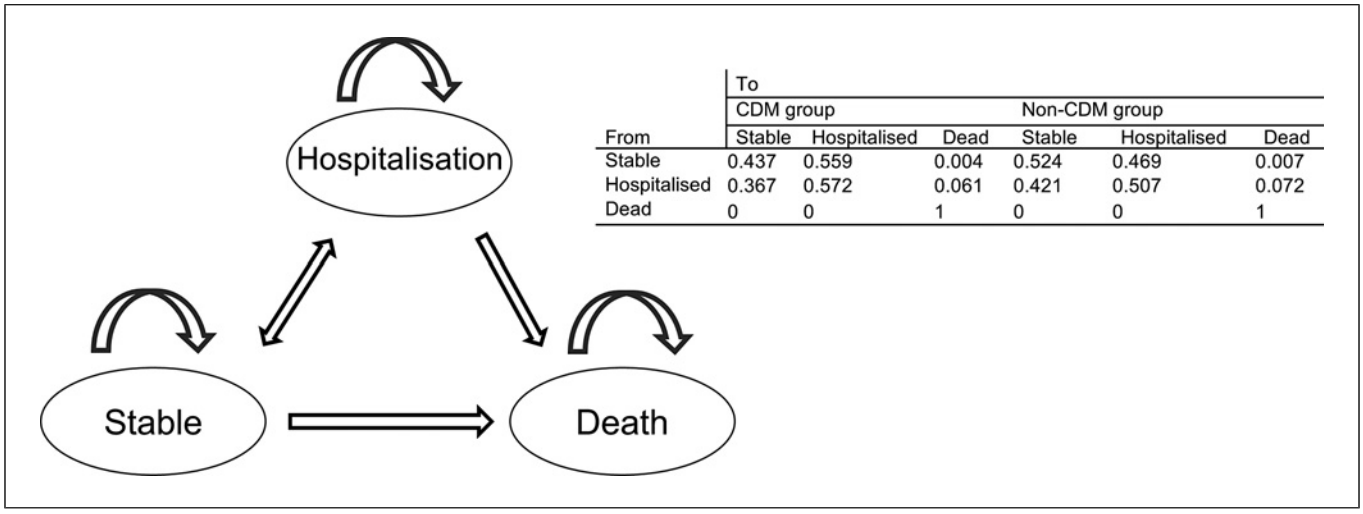
Markov Models

Markov models were constructed with 1-year cycles and a time horizon of 30 years (lifetime) to ensure all important differences in costs and outcomes were captured. Models included three health states: stable, hospitalised, and dead (Fig. 1). The initial model involved all simulated individuals being in a stable health state. Each year, individuals either remained stable, were hospitalised for any reason, or died. Transition probabilities were based on the observed proportions of patients who were hospitalised, died, or were hospitalised and died in the PRECISE study (online suppl. eTable 5). Patients who died remained in the dead state, indicating a 100% probability in the transition matrix. We assumed constant input parameters in each cycle due to the lack of data on dynamic transition probabilities, costs, and QALYs beyond 2 years, according to study groups. The life table method was used to estimate state membership, i.e., the average of membership at the start and end of the cycle [18].

Sensitivity and Scenario Analyses

A base-case analysis was represented by a deterministic cost-effectiveness analysis [19], in which both costs and QALYs were discounted at an annual rate of 3% over 30 years [20]. We performed probabilistic sensitivity analyses (PSA) using Monte Carlo simulations to characterise parameter uncertainty [21]. Beta distributions were assigned to transition probabilities and QALYs because the values of these parameters range between 0 and 1. Gamma distributions were assigned to costs because they naturally fit a rightly skewed cost distribution. The mean and standard deviation of costs and QALYs for each study group and each health state, except for the dead state, were used to calculate the shape (α) and rate (β) parameters of a relevant distribution. We set our model to generate 10,000 random samples from each assigned distribution and for each study group. The average costs and QALYs for each study group were calculated from these samples to estimate incremental cost-effectiveness ratios (ICERs).

ICERs were calculated by dividing the cost differences between the study groups by the differences in QALYs. Incremental costs and QALYs were plotted on a cost-effectiveness plane to show the degree of uncertainty relative to the assumed cost-effectiveness threshold of AUD 50,000 per QALY gained [22]. Additionally, we undertook analyses with discount rates of 0% and 5%, scenario analyses considering a time horizon of 10 years, sub-group analyses considering only ischaemic strokes, and compared care with claims for both a CDM plan and its review with care provided without claims [15]. The probability of primary care with CDM being cost-effective compared to primary care without CDM was displayed at different willingness-to-pay thresholds (WTP). Analyses were performed using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA, 2019) and STATA/MP 16.0 (StataCorp, College Station, TX, USA, 2019) for Windows 10 Enterprise.



From	To: CDM group Stable	Hospitalised	Dead	Non-CDM group Stable	Hospitalised	Dead
Stable	0.437	0.559	0.004	0.524	0.469	0.007
Hospitalised	0.367	0.572	0.061	0.421	0.507	0.072
Dead	0	0	1	0	0	1

Fig. 1. A Markov model with three health states and transition probabilities used for a cost-utility analysis. CDM, chronic disease management.

Table 2. The results of the cost-effectiveness analyses with different time horizons and discount rates

Time horizon	Discount rate, %	Type of analyses	Average per-patient costs, AUD		Incremental costs, AUD	Average per-patient QALYs		Incremental QALYs	ICER, AUD/QALY
			CDM	non-CDM		CDM	non-CDM		
30 years	3	Base-case analysis	142,939	103,889	39,050	8.97	8.98	−0.02	dominated
		PSA	141,479	103,138	38,342	8.95	8.97	−0.02	dominated
	0	Deterministic analyses	198,070	143,343	54,727	12.30	12.25	0.04	1,325,345
		PSA	192,690	145,355	47,335	12.28	12.25	0.04	1,261,323
	5	Deterministic analyses	118,974	86,677	32,297	7.52	7.56	−0.04	dominated
		PSA	117,735	86,933	30,802	7.51	7.54	−0.03	dominated
10 years	3	Deterministic analyses	77,958	58,513	19,445	5.03	5.23	−0.20	dominated
		Probabilistic analyses	78,816	58,239	20,577	5.00	4.90	0.10	205,114
	0	Deterministic analyses	88,546	66,513	22,032	5.67	5.90	−0.23	dominated
		Probabilistic analyses	89,464	65,489	23,975	5.63	5.52	0.11	218,822
	5	Deterministic analyses	72,013	54,022	17,991	4.68	4.86	−0.18	dominated
		Probabilistic analyses	73,101	53,257	19,844	4.64	4.55	0.09	228,593

AUD, Australian dollars; CDM, chronic disease management; PSA, probabilistic sensitivity analyses; QALYs, quality-adjusted life years. Dominated indicates that the CDM group had poorer outcomes and greater costs compared to the non-CDM group. There are discrepancies in calculations due to rounding.

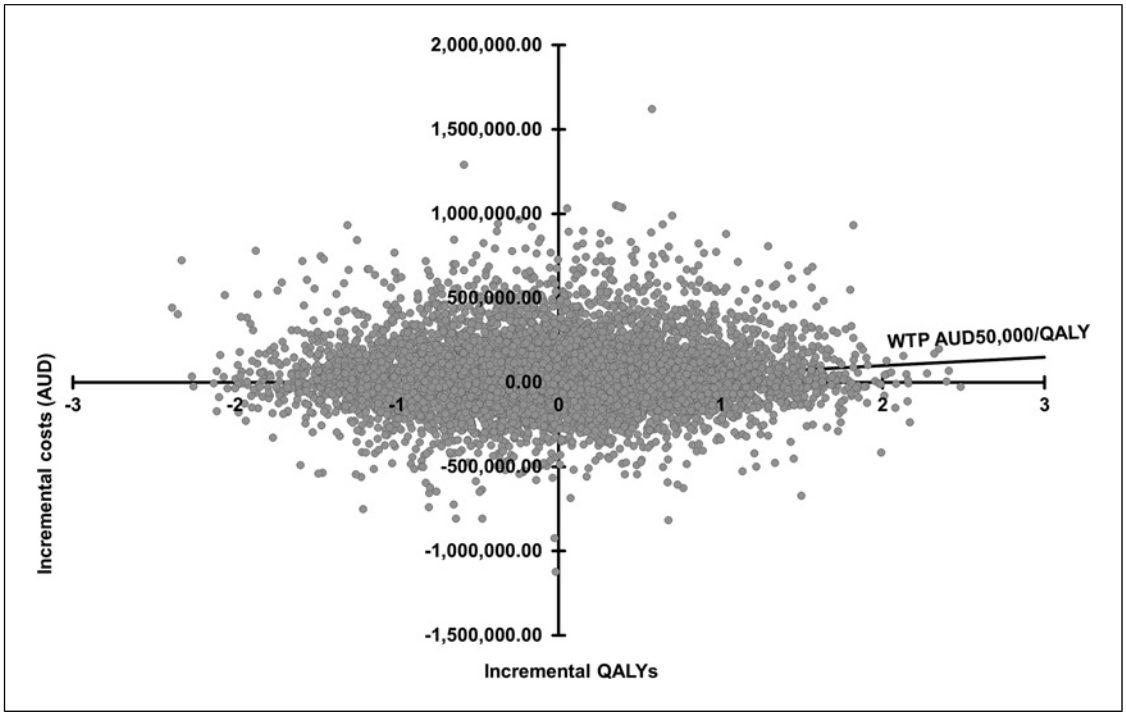


Fig. 2. Cost-effectiveness plane comparing care with and without chronic disease management (3% discounting, over 30 years). AUD, Australian dollar; QALY, quality-adjusted life year; WTP, willingness-to-pay threshold.

Results

Base-Case Analysis

The cumulative death rate was 67.7%, and the average time to death was 13 years for both study groups (online suppl. eFig. 2). The average per-patient cost was AUD 9,338 in the CDM group and AUD 7,403 in the non-CDM group for the stable state, and AUD 133,600 in the CDM group and AUD 96,486 in the non-CDM group for the hospitalised state. The average per-patient QALYs were 4.15 in the CDM group and 4.96 in the non-CDM group for the stable state, and 4.81 in the CDM group and 4.03 in the non-CDM group for the hospitalised state. The CDM group had greater average per-patient costs with slightly lower QALYs compared to the non-CDM group (Table 2).

Sensitivity Analyses

The CDM group had poorer outcomes and greater costs compared to the non-CDM group (i.e. the CDM group was dominated), with incremental costs of AUD 38,342 and incremental QALYs of −0.02. Similar results were generated using QALYs estimated by the complex number method (online suppl. eTable 6), using different discount rates and a time horizon of 10 years for all strokes (Table 2), ischaemic strokes (online suppl. eTable 7), and strokes excluding TIA (online suppl. eTable 8). Likewise, care with both a CDM plan and its review was dominated in deterministic analyses and had incremental costs of AUD 52,972 and incremental QALYs of 0.13 in PSA, resulting in an ICER of AUD 399,764/QALY.

There was considerable uncertainty with 10,000 PSA iterations scattered across all quadrants of the cost-effectiveness plane for all strokes (Fig. 2), for ischaemic strokes only, and for strokes excluding TIA (online suppl. eFig. 3). The probability of CDM policies being cost-effective at the WTP of AUD 50,000/QALY was 26.1% for all strokes, 14.1% for strokes excluding TIA, 23.4% for ischaemic strokes only, and 30.3% when both a CDM plan and its review were considered (Fig. 3). However, the cost-effectiveness probabilities were nearly two times higher over a time horizon of 10 years compared to 30 years (Fig. 4).

Discussion

We provide evidence from an Australian government funder perspective that primary care policies to support CDM are unlikely to be cost-effective in their current

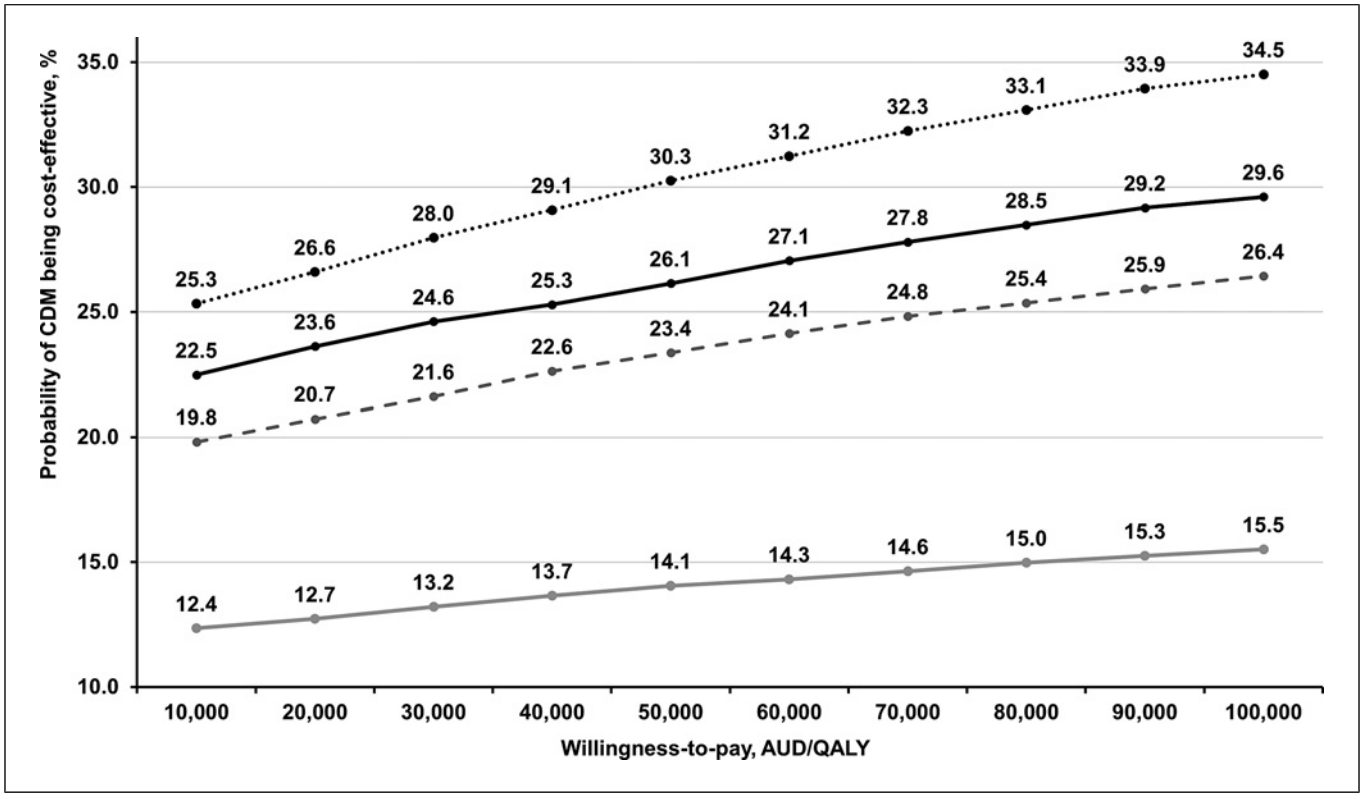


Fig. 3. Probability of CDM being cost-effective at different willingness-to-pay thresholds (3% discounting, over 30 years). All lines show the probability of care with a CDM plan being cost-effective compared to care without a CDM plan, except the black dotted line. The black solid line indicates all strokes and TIA, the grey solid line indicates strokes excluding TIA, the grey dashed line indicates ischaemic strokes only, and the black dotted line indicates care with claims for the CDM plan and its review compared to care without a CDM plan. AUD, Australian dollar; CDM, chronic disease management; QALY, quality-adjusted life year; TIA, transient ischaemic attack.

form among survivors of stroke or TIA in the community. Over a lifetime, primary care with CDM claims was more expensive and less effective than primary care where a CDM claim was not made. Results were similar when both a CDM plan and its review, or different time horizons, discount rates, or approaches to estimating QALYs, were considered, and there was considerable uncertainty around these findings. Identification of health needs, increased surveillance, and referral pathways imposed by the CDM plans likely contributed to the increased costs. A review of these policies for stroke or TIA to optimise their use may be warranted.

Our model outputs were compared to other published literature for sense checking. For example, the cumulative proportion of the simulated cohort who died over 30 years in our model was 67.7%, while 87.8% of the 2,051 people with stroke who were followed up over 30 years died in the Copenhagen City Heart Study [23]. This difference may be explained by the fact that the cohorts from which we used input parameters for the model consisted of long-term survivors of stroke or TIA (>15 months), whereas the Copenhagen City Heart Study was a population-based study. We also compared per-patient costs from the model with those published in the literature. Our estimate of the average direct per-patient cost across two study groups was AUD 120,028 for ischaemic strokes over 30 years. This is similar to the lifetime costs reported in the North East Melbourne Stroke Incidence Study (AUD 122,208 for ischaemic stroke and AUD 97,661 for intracerebral haemorrhage, converted from a reference year of 2010–2016 with annual 3% discounting). However, the lifetime costs in the NEMESIS included informal care and productivity loss, costs that we did not have available [24]. Similarly, in a recent modelling study, the medical costs of stroke over 30 years were AUD 99,690 in the reference year of 2018 and based on inputs from a very early rehabilitation trial, a clinical trial

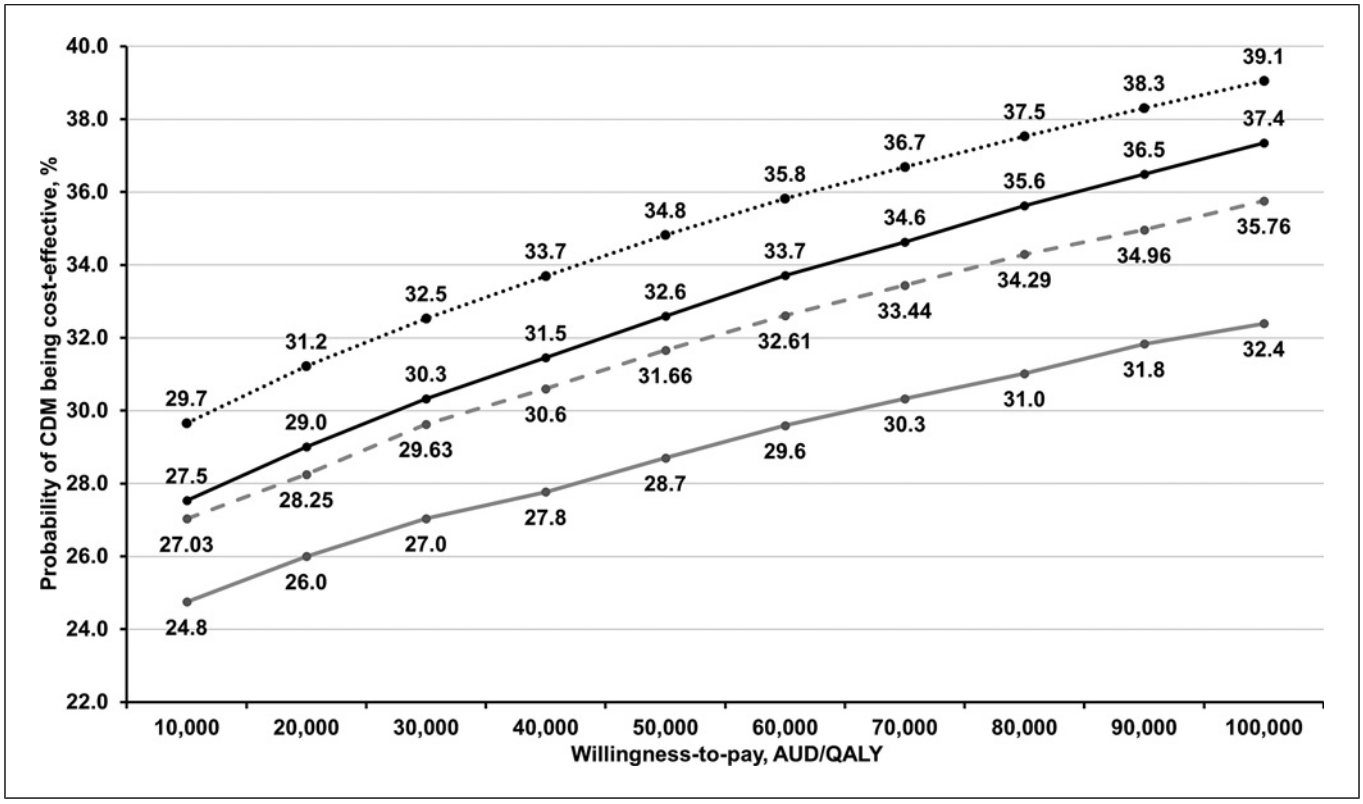


Fig. 4. Probability of CDM being cost-effective at different willingness-to-pay thresholds (3% discounting, over 10 years). All lines show the probability of care with a CDM plan being cost-effective compared to care without a CDM plan, except the black dotted line. The black solid line indicates all strokes and TIA, the grey solid line indicates strokes excluding TIA, the grey dashed line indicates ischaemic strokes only, and the black dotted line indicates care with claims for the CDM plan and its review compared to care without a CDM plan. AUD, Australian dollar; CDM, chronic disease management; QALY, quality-adjusted life year; TIA, transient ischaemic attack.

of rehabilitation following stroke [25]. Our cost estimates are within the bounds of these two studies, thereby providing some confidence in our results.

To our knowledge, there has not been a model-based cost-effectiveness analysis comparing government-funded CDM policies in primary care for stroke in Australia. Comparison to other studies is challenging because post-stroke care interventions are complex [26], and our study is novel. However, the conclusion that the policy supporting CDM was unlikely to be cost-effective is in line with those of short-term cost-effectiveness analyses of other similar interventions. Two cost-utility analyses with 1-year follow-up involving related but different types of structured interventions have been conducted, both based on randomised controlled trials [27, 28]. In one of the trials conducted in the UK (n = 800), community-based long-term stroke care incorporating structured and individualised care planning was not cost-effective compared to usual care from both health system and societal perspectives [27]. In the other trial, conducted in the Netherlands (n = 113), self-management intervention incorporating action planning was not cost-effective over education-based intervention from a societal perspective [28]. Although some aspects of these interventions are relevant to CDM, these studies were efficacy trials and, unlike PRECISE, did not include an evaluation of the population effect of an already implemented policy.

There is evidence that CDM plans used in Australia can be cost-effective for cardiovascular diseases other than stroke. Primary care with CDM plans was found to be cost-effective in coronary heart disease (CHD), with an ICER of AUD 8,081 per disability-adjusted life year (DALY) in a modelling study (reference year 2006) by Chew et al. [29]. However, these analyses were based on numerous assumptions, including a 15% reduction in CHD premature deaths and DALYs [29]. The authors referred to a 17% reduction in CHD deaths and a 15% reduction in CHD events reported in the 1998 National Health Priority Areas Report, but these estimates were

also based on assumed potential gains "through improved acute management of patients" [30]. Additionally, the long-term disability that often occurs as a consequence of stroke is likely to incur much greater costs than CHD. The greatest cost benefits for stroke are likely to be gained from prevention. Further research is warranted to fully understand the cost-effectiveness of CDM policies for patients with CHD and whether such findings can be translated to survivors of stroke.

One of the strengths of this study is that we included input parameters based on patient-level data obtained from large, well-characterised similar cohorts. In particular, costs were estimated from administrative datasets, which are considered to be more reliable than patient-reported data due to issues related to participant attrition and recall bias [31]. In addition, linking administrative data to the trial and AuSCR provided us with comprehensive clinical and socio-demographic data on the characteristics of the study groups. It is important to know the profiles of the participants in the study groups when observational data are used in economic evaluations. Moreover, we undertook a cost-utility type of economic evaluation, which enables comparison of findings across interventions and disease groups.

Some limitations of our study are worth noting. The main limitation of our study was that the input parameters for the model were limited to observational datasets. Therefore, our findings should be interpreted with caution because of potential confounding effects between the comparator groups. Additionally, input parameters were obtained from two different cohorts. The STANDFIRM cohort was derived from a trial performed within a single metropolitan region with extensive participant inclusion criteria. Furthermore, half of the STANDFIRM cohort were randomised to receive an enhanced form of CDM that is not part of standard CDM policies, which is different to what was evaluated in PRECISE using population-level CDM claims. Moreover, as we used claims data to identify the use of CDM policies, we were unable to assess the content, quality, or adherence to plans developed under the policy. Additional qualitative research is needed to explore how these plans are actually being used in primary care. Finally, estimated costs were limited to the government funder perspective, and medication costs included only prescribed medications that were subsidised by the government. Therefore, our analyses were limited to direct medical costs. A societal perspective should also be considered in future research, as this is particularly important for people living with long-term impairment following stroke.

Conclusion

We provide evidence from the perspective of an Australian government funder that CDM policies in primary care are unlikely to be cost-effective for stroke or TIA. Over a lifetime, primary care with CDM claims was estimated to be more expensive and less effective than primary care without CDM claims. CDM policies encourage PCPs to provide more comprehensive care, which increases the use of health resources. There is a need to find ways to deliver comprehensive care in a cost-effective way.

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Statement of Ethics

The Australian Institute of Health and Welfare and Monash University provided primary ethics approvals for PRECISE (EO 2018/2/449 and 12301) and STANDFIRM (EO 2016/4/325 and 2011000331) data linkage studies, including economic evaluations. Written informed consent was obtained from participants or their carers to participate in STANDFIRM.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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conduct of the study, the collection, management, analysis, and interpretation of the data, the preparation, review, or approval of the manuscript, or the decision to submit the manuscript for publication.

Author Contributions

Concept, design, and data analysis and interpretation: Orman and Kim. Acquisition of data: Andrew, Kilkenny, Olaiya, Thrift, Ung, Dalli, and Kim. Manuscript drafting: Orman, Cadilhac, Andrew, and Kim. Obtaining funding: Cadilhac, Andrew, Thrift, and Kim. Supervision: Thrift, Olaiya, and Kim. All authors provided a revision of the manuscript for critically important intellectual content. All authors read and approved the final version of the manuscript.

Data Availability Statement

The original data used in this study was obtained from multiple sources, where restrictions may apply. All data generated in the models and included in this article may be available upon reasonable request.

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