Impact of pay-for-performance for stroke unit access on mortality in Queensland, Australia: an interrupted time series analysis

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Summary

Background Stroke unit care provides substantial benefits for all subgroups of patient with stroke, but consistent access has been difficult to achieve in many healthcare systems. Pay-for-performance incentives have been introduced widely in attempt to improve quality and efficiency in healthcare, but there is limited evidence of positive impact when they are targeted at hospitals. In 2012, a pay-for-performance program targeting stroke unit access was co-designed and implemented within a clinical quality improvement network across public hospitals in Queensland, Australia. We assessed the impact on access to specialist care and mortality following stroke.

Methods We used interrupted time series analysis on linked hospital and death registry data to compare changes in level (absolute proportions) and trends in outcomes (stroke/coronary care unit admission, 6-month mortality) for stroke, and a control condition of myocardial infarction (MI) without pay-for-performance incentive, from 2009 before, to 2017 after introduction of the pay-for-performance scheme in 2012.

Findings We included 23,572 patients with stroke and 39,511 with MI. Following pay-for-performance introduction, stroke unit access increased by an absolute 35% (95% CI 29, 41) more than historical trend prediction, with greater impact for regional/rural residents (41% vs major city 24%) where baseline access was lowest (18% vs major city residents 53%). Historical upward 6-month mortality trends following stroke (+0.11%/month) reversed to a downward slope (–0.05%/month) with pay-for-performance; difference –0.16%/month (95% CI –0.29, –0.03). In contrast, access to coronary care and mortality trends for MI controls were unchanged, difference-in-difference for mortality –0.18%, (95% CI –0.34, –0.02).

Interpretation This clinician led pay-for-performance incentive stimulated significant improvements in stroke unit access, reduced regional disparities; and resulted in a sustained decline in 6-month mortality. As our findings contrast with lack of effect in most hospital directed pay-for-performance programs, differences in design and context provide insights for optimal program design.

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Keywords: Pay-for-performance; Stroke; Myocardial infarction; Stroke unit; Mortality; Clinical improvement collaboratives

Research in context

Evidence before this study

We performed a search using PubMed for relevant studies using the search terms ("pay-for-performance" OR "P4P" OR "reimbursement, incentive") AND ("hospital"). We restricted the search to controlled studies involving hospital inpatients which compared the addition of pay-for-performance to the same baseline funding method, and reported patient outcomes, clinical quality indicators, or access to healthcare. We identified a Cochrane systematic review published in 2019 which included 27 studies from 6 different pay-for-performance programs (three countries). The authors found limited evidence for possible small effects on measures of quality of clinical care, no evidence regarding access to care, and very uncertain impact on mortality. We identified 13 new publications between the Cochrane review search end (June 2, 2018) and January 21, 2023 from six programs, four of which had results included in the earlier review. Eleven studies were from the United States, and generally supported the Cochrane review conclusions with very limited new evidence for any impact on processes of care, safety, or mortality. In a study of the US Hospitals Readmission Reduction Program there was a small (1.6%) reduction in targeted readmissions for heart failure, but with increased mortality suggesting possible unintended adverse consequences. Significant improvements in mortality after hip fracture were reported in two publications regarding the English "Best Practice Tariff", which was implemented with monitoring through a national quality registry. We found no evidence to support use of pay-for-performance in stroke.

Added value of this study

This study demonstrates that a clinician led pay-for-performance incentive integrated with a clinical quality improvement collaborative stimulated significant improvements in stroke unit access, reduced regional disparities; and resulted in a sustained decline in 6-month mortality following stroke across a state-wide public health service in Australia.

Implications of all the available evidence

Pay-for-performance directed at hospitals in the area of stroke and hip fracture have resulted in a substantial impact on patient outcomes. As these findings contrast with lack of impact with most prior hospital directed pay-for-performance programs, success is likely to be dependent on design and context. Common success factors with the Queensland stroke unit and English hip fracture pay-for-performance programs included: implementation within a registry based clinical quality improvement collaborative network, choice of an evidence-based process of care target with large effect size, background Diagnosis Related Group funding model, and possibly, bonus payment for achievement of best practice indicators for individual patients. Other success factors in the Queensland scheme included: clinician co-design and leadership, a large evidence-practice gap; regional disparities in care amenable to improvement, and initial stepped achievable targets. These factors provide insights into optimal design and targets for future pay-for-performance programs.

Introduction

Globally, stroke is the second largest cause of death and the third largest contributor to disability adjusted life years lost.[1] Stroke unit care is associated with a 24% reduction in both death and death or institutional care compared to alternate care models,[2] and is applicable to all types of patients with stroke. Stroke unit care is a package of interventions, characterised by organised, specialised multi-disciplinary team care within a geographically discrete unit providing early coordinated rehabilitation, active involvement of patients and carers, and regular programs of staff education and training.[3] Despite increases in the number of stroke units over the past twenty years,[4] one quarter of Australians with acute stroke do not currently receive stroke unit care, with marked disparities in access between major cities and regional locations.[5] Historically, stroke unit access in Queensland, the Australian state with the most dispersed population, was the lowest in the country, less than 40% in 2009.[6]

Pay-for-performance is a payment system that financially rewards (or penalises) health care providers for delivering care which meets (or fails to meet) pre-defined targets for quality or efficacy indicators.[7,8] It has become widespread in healthcare, especially in the United States where it is one of the alternative payment models used by the Centres for Medicare and Medicaid Services to drive reform.[9] In England, the Commissioning for Quality and Innovation initiative links 1.25% of fixed hospital contract payments with selected quality indicators,[10] and "Best Practice Tariffs" adjust casemix based payments by adherence with agreed best practice including stroke unit care.[11] Despite this, there has been a remarkable lack of evidence supporting positive impact of pay-for-performance on patient outcomes from multiple programs targeted at hospitals,[7] and very

limited specific evidence to support their use to improve stroke care. In addition, there has been a suggestion of unintended adverse consequence with increased mortality in a program targeting readmission reduction in heart failure.[12] Recently, significant improvements in mortality were demonstrated following introduction of the Best Practice Tariffs for hip fracture in England, compared to Scottish and US Medicare controls,[13,14] suggesting that in some contexts pay-for-performance may be effective.

In 2012, the Queensland Department of Health included stroke unit access in a pay-for-performance program aimed at improving care and reducing variation in high volume clinical areas with identified evidence-practice gaps–the "Quality improvement Payment" (QIP). Queensland public hospitals are funded via an activity-based funding model using Australian "diagnosis related groups". We aimed to assess the effect of this pay-for-performance incentive on stroke unit access and patient outcomes using an interrupted time series approach.

Methods

Design of pay-for-performance incentive program

The QIP Stroke Unit Care program was collaboratively developed and implemented by the Queensland Healthcare Purchasing, Funding and Performance Management Branch and the State-wide Stroke Clinical Network ("clinical network") which is a formally convened multidisciplinary quality improvement collaborative network of clinicians and consumers.[15] Fundamental design features for the pay-for-performance program were determined by the overarching QIP parameters including the size of the available funds, and requirement for measurable targets with evidence of a direct association with better patient outcomes. The clinical network provided input into the definition of target population, distribution of available funding pool, performance targets, and implementation mechanisms including the requirement for inclusion of clinical quality measures together with performance targets. Location and geographical responsibility of stroke units were determined according to clinical network planning to situate stroke units in all large metropolitan and regional hospitals which provide specialist care to Queensland's highly dispersed population (Supplementary Fig. S1).

The resultant incentive design included biannual payments to hospitals (not directly to clinical teams) contingent on achievement of incremental performance targets for stroke unit access. Payments were made on achievement of incremental performance targets for stroke unit access; initially within stroke unit hospitals to develop capacity in these "referral hubs"; followed by health district wide access targets aimed at stimulating equity of access and integrated systems across geographical health service districts (Supplementary Table S1). In July 2015, payment was transitioned to a maintenance phase of 10% loading on the Diagnostic Related Group payment for all patients with stroke as a primary diagnosis admitted to an endorsed stroke unit. No additional funding was provided for stroke unit infrastructure or staffing.

Stroke unit access was defined as admission to a network-endorsed stroke unit for any period within the acute care episode and calculated centrally using administrative datasets and discharge diagnosis codes. All adult patients 18 years or older with primary diagnosis of acute stroke (see below) and length of stay greater than one day were included in payment calculations. Very short length of stay was excluded to avoid including administrative admissions for reasons such as delays in discharge from emergency departments; and to ensure sufficient time to allow impact of stroke unit care. Patients with intracerebral haemorrhage admitted solely under a neurosurgical unit were excluded as this is a different management pathway. There was no minimum duration in a stroke unit to qualify, but the proportion of admission time spent in a stroke unit was monitored and fed back bi-annually to monitor for gaming.

Hospital eligibility for payment required clinical network endorsement of stroke units based on review of processes against national guidelines, submission of clinical performance data on >75% of all acute stroke admissions to the Australian Stroke Clinical Registry,[16] and acceptable performance for eight indicators of quality of clinical care (Supplementary Table S2). Queensland hospitals had been participating in a network-led voluntary quality improvement collaborative for stroke from 2004, transitioning to participation in the Australian Stroke Clinical Registry with pay-for-performance introduction in 2012. This was supplemented by an externally facilitated quality improvement program delivered to individual hospitals (delivered between July 2012 and March 2014),[17] and feedback on performance integrated into ongoing bi-annual clinical network quality improvement forums.

Study population, setting and data sources

In 2012, government funded care was provided in Queensland via 39 public hospitals and 76 small rural health centres for a population of 4.6 million dispersed over an area of 1,727,000 km^2 (Supplementary Fig. S1). Public hospitals provided care for 97% of all acute stroke admissions in Queensland during the study period.

We included all patients 18 years or older, admitted for >1 day to Queensland public hospitals with a primary discharge diagnosis of either acute stroke or a non-incentivised control condition of acute myocardial infarction (MI). Patients with intracerebral haemorrhage managed solely under a neurosurgical unit, and those admitted solely to private hospitals were excluded as

they were not included in the QIP program. We excluded non-Queensland residents to ensure complete recording of deaths from the Queensland death registry. Only the first admission with either condition during the study period was included for any patient. The control condition of MI is an acute vascular event affecting a similar population to stroke, with a model of care involving admission to a geographically discrete coronary care units. No systematic changes to funding, nor financial incentives occurred in Queensland for the control condition during the study period.

De-identified hospital admissions and emergency department data were extracted by the Queensland Department of Health Research Linkage Group based on ICD 10AM primary discharge diagnosis (Supplementary Table S3), linked to the Queensland Registry of Births Deaths and Marriages, and provided to the research team in de-identified format. All diagnosis codes for the prior 5 years "look-back" period were used to calculate the Charlson Comorbidity Index, using an adaptation of the Deyo version, developed and validated for use with the Australian version of ICD-10.[18] The Accessibility/Remoteness Index of Australia (ARIA+)[19] was used to classify place of residence, stratified between major cities and regional/rural areas.

Study periods

The study includes data from three periods: (1) a pre-incentive "historical control" period from July 2009–December 2011; (2) a 12 month censored "implementation" period (January–December 2012); and (3) a "pay-for-performance" period from January 2013–June 2017.

Outcome measures

Our primary process of care measure was admission to an endorsed stroke unit for the stroke cohort, or a health department registered coronary care unit for the MI control cohort. Our primary patient outcome was all cause mortality within 6-months (180 days), chosen as nearly one half of deaths between 1 and 6 months post stroke have been attributed to the index stroke[20] and initial high mortality risk only stabilises to long term rates after 6-months following stroke.[21] Further, the impact of stroke unit care includes the effect of rehabilitation which generally extends beyond the first month post stroke. Thirty-day mortality is reported in supplementary data to align with other pay-for-performance studies.

Statistical analysis

We used interrupted time series analysis methods[22] to compare changes in outcomes before and after introduction of the pay-for-performance incentive in stroke compared to MI. We defined our expected impact model as both change in level and change in slope. We included a 12 month "implementation" interruption period in our analysis plan, as we considered delayed impact likely due to time required to develop services and change processes. One-month epochs were selected, as quarterly aggregation obscured variation present in our data and weekly aggregation produced a time-series impacted by zeroes. We fitted time series regression models to monthly data for each cohort and study period, and compared rate of change (slope) in outcomes between historical control and pay-for-performance periods in the stroke cohort, and with the MI control cohort using Linden's post estimation methods.[23] Generalized least-squares regression with a lag of 1 month, and transformation using the Prais-Winsten method was chosen to achieve best correction for autocorrelation.

To investigate any immediate change in outcomes with pay-for-performance introduction, we extrapolated trends in the historical control period to produce a counterfactual series for comparison with observed data at the beginning of intervention period (January 2013). We then compared trends in outcomes after stroke during the pay-for-performance period with trends in the historical control period to assess the extent to which pay-for-performance introduction impacted established trends in stroke. Trends in the stroke population were then compared to those in the control (MI) population during the same time periods to account for any underlying temporal trends in vascular diseases, including a difference-in-difference comparison of trend changes with pay-for-performance introduction between stroke and MI. To provide an indication of the potential overall impact of the pay-for-performance program on outcomes over the study period we compared the estimated level from extrapolated trends in the historical control period with the level from the pay-for-performance period models at the end of pay-for-performance period (June 2017). As no change was evident for any of the outcomes between the different payment structures (target-based payments vs ABF bonus), these were aggregated into a single period.

Our primary analyses were unadjusted for covariates as our data were derived from a complete population without selection. Multivariable models were developed as sensitivity analyses, including co-variates correlated with outcomes and demonstrating different change over time in stroke compared to MI cohorts (Charlson Comorbidity Index, proportion residing rural and regional areas). Subgroup analysis was performed to assess for differential change in rural and regional areas which have been identified as having low rates of access to specialist care and poorer outcomes in Australia.[24] Cases with incomplete data for covariates were excluded from sensitivity analysis (<1% for diagnostic coding for Charlson comorbidity index). Analyses were performed using STATA/MP 17 (https://www.stata.com/).

Ethical approval

Approval was provided by The Prince Charles Hospital Human Research Ethics Committee (EC00168) and approval obtained for use of public health data under the Queensland Public Health Act provisions. No individual patient consent was required as all data was de-identified.

Role of the funding source

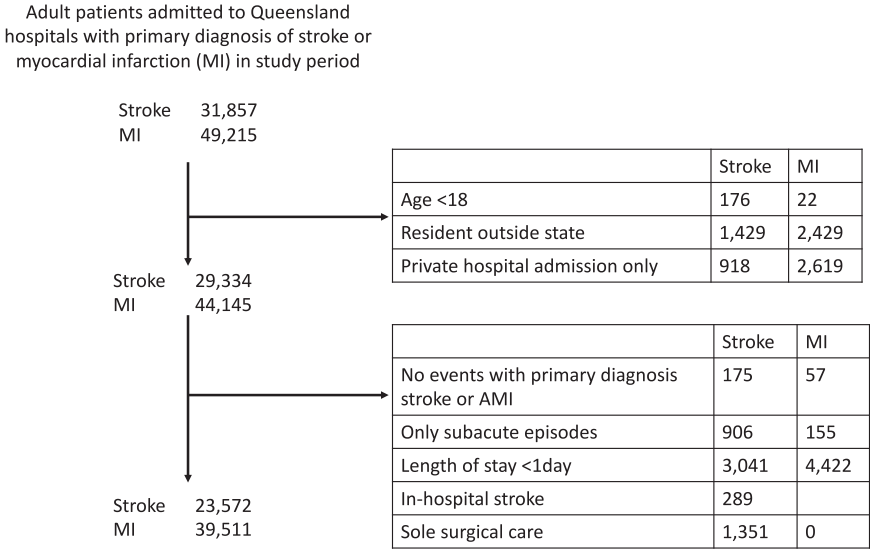
RG was supported by a Queensland Advancing Clinical Research Fellowship for this project. DAC was supported by a National Health and Medical Research Council Senior Research Fellowship (#1154273). The funder had no role in study design, data analysis, interpretation, writing of the manuscript, or decision to submit for publication.

Results

We included 23,572 patients with stroke and 39,511 with MI (Fig. 1). Patients with stroke were older, more often female, had higher Charlson Comorbidity Indexes and were slightly more likely to reside in a major city than those with MI (Table 1). There were different changes in some demographic features over time between the cohorts, with an increasing relative proportion living in major cities during the pay-for-performance period, and decreasing Charlson Comorbidity Index during the control period in the stroke compared to MI cohorts (Supplementary Fig. S2). Data were missing for diagnostic coding used for calculation of Charlson Comorbidity Index in 0.4% patients. Patients with missing data were more often from the MI cohort, younger, and less likely to die within 180 days. There were no significant seasonal trends evident in our outcome variables.

Following pay-for-performance implementation in 2012, the number of stroke units rose from seven (five in major, two in regional cities) to 20 (12 in major, eight in regional cities, Supplementary Fig. S1). During the 2012 pay-for-performance introduction year, the absolute proportion admitted to stroke units increased 35% more than predicted from control period trends (95% CI 29.1, 40.9). In comparison, there was no change in coronary care unit admission for MI during 2012 (Fig. 2, Supplementary Table S4). Changes in the proportion admitted to stroke units were much greater in patients residing in regional and rural areas compared to major cities (Fig. 2, Supplementary Table S5). Prior to pay-for-performance introduction, fewer rural/regional residents were admitted to stroke units (18% vs 53% major cities) and the increase in 2012 above baseline trend predictions was significantly greater compared to major city residents (41% vs 24% major cities; difference 17%, 95% CI 7, 26). After 2012, stroke unit access continued to improve for rural/regional residents reaching 78% at study end, but did not change for major city residents (final 83%).

Mortality at 6-months following stroke was trending non-significantly upwards during the historical control period (+0.11%/month, 95% CI –0.01, 0.24), and reversed to a statistically significant decline (–0.05%/month; 95% CI –0.09, –0.01) after pay-for-performance introduction in 2012 (Table 2, Fig. 3). This resulted in a change in mortality trend of –0.16%/month (95% CI –0.29, –0.03), which equates to a 1.9%/year reduction in mortality. Change in mortality trends after pay-for-performance introduction was significantly greater



	Stroke	MI
Age <18	176	22
Resident outside state	1,429	2,429
Private hospital admission only	918	2,619

	Stroke	MI
No events with primary diagnosis stroke or AMI	175	57
Only subacute episodes	906	155
Length of stay <1day	3,041	4,422
In-hospital stroke	289	
Sole surgical care	1,351	0

Fig. 1: Patient selection and exclusions.

Characteristic	Historical control period, Jul 2009–Dec 2011 n (%)		12-month implementation period, Jan 2012–Dec 2012 n (%)		Pay-for-performance period, Jan 2013–Jun 2017 n (%)	
	Stroke	Myocardial infarction	Stroke	Myocardial infarction	Stroke	Myocardial infarction
n	6776	12,963	2921	5105	13,875	21,443
Age, mean (sd)	72 (14)	67 (14)	72 (15)	67 (14)	72 (14)	67 (14)
Female	3167 (47)	4567 (35)	1294 (44)	1780 (35)	6349 (46)	7519 (35)
Indigenous[a]	239 (4)	752 (6)	101 (3)	319 (6)	471 (3)	1390 (6)
Stroke type						
Ischaemic	4201 (56)	–	896 (59)	–	9722 (67)	–
Haemorrhagic	1084 (15)	–	219 (14)	–	2086 (14)	–
Undetermined	2182 (29)	–	399 (26)	–	2783 (19)	–
Charlson comorbidity index, mean (sd)	2.6 (2.3)	1.6 (2.3)	2.8 (2.4)	1.6 (2.3)	3.1 (2.7)	1.8 (2.5)
Charlson comorbidity index, median (IQR)	2 (1, 3)	1 (0, 2)	2 (1, 4)	1 (0, 2)	2 (2, 2)	1 (0, 3)
Accessibility[b]						
Major city	3575 (53)	6360 (49)	1576 (54)	2434 (48)	7748 (56)	10,795 (50)
Inner regional	1849 (27)	3802 (29)	774 (27)	1495 (29)	3512 (25)	5910 (27)
Outer regional	1142 (17)	2297 (18)	479 (16)	946 (19)	2254 (16)	3897 (18)
Remote/very remote	210 (2)	504 (2)	92 (2)	230 (2)	361 (1)	841 (2)

[a]Australian aboriginal or Torres Straight Islander. [b]Based on the accessibility/remoteness index of Australia.

Table 1: **Baseline characteristics across study periods by cohorts: stroke (treatment) and myocardial infarction (MI—controls).**

for the stroke cohort than the MI control cohort (difference-in-difference, –0.18%/month; 95% CI –0.34, –0.02) in which there was a consistent non-significant downward trend across all periods. The magnitude of the initial impact of pay-for-performance introduction over 2012 was 4.0% (95% CI –0.1, 8.2) lower mortality following stroke than predicted from control period trends, compared to 0.5% (–2.1, 3.1) following MI. When extrapolated over 5.5 years of P4P, the overall impact of was a 12.5% (95% CI 1.9, 23.1) reduction in mortality compared to historical trend predictions.

Supplementary analysis with multivariable models including the Charlson comorbidity index and residence outside major cities produced similar results (Supplementary Fig. S3 and Table S6). The impact of pay-for-performance introduction on 1-month mortality followed similar patterns to 6-month mortality, but with smaller, generally non-statistically significant trends (Supplementary Fig. S4 and Table S7).

Discussion

We found a significant impact of a pay-for-performance incentive across an entire state public hospital service on stroke unit access and 6-month mortality, compared to both historical trends and a control condition of myocardial infarction. Introduction of pay-for-performance was associated with an immediate and sustained increase in proportion of patients admitted to a stroke unit, and a subsequent sustained downward trend in mortality which was significantly greater than historical upward trends. Comparison with the MI control group confirmed that these changes were likely due to the pay-for-performance incentive, and not due to underlying secular or medical trends. These trends persisted over a prolonged period, similar to the hip fracture Best Practice Tariff,[14] but in contrast to the short-lived effects on patient outcomes found in the Advancing Quality Program in England.[25]

Implementation of the QIP was integrated with an externally facilitated quality improvement program. Collection and review of clinical indicators (including stroke unit access) had been established for 8 years prior to pay-for-performance, but was enhanced by feedback of patient outcomes from the Australian Stroke Clinical Registry, and external facilitation of individual hospital quality improvement initiatives.[17] Although this program is likely to have contributed to the pay-for-performance impact, we have previously demonstrated that most improvement in quality of care indicators (14% of total 18% improvement) occurred after incentive introduction and preceded commencement of the enhanced quality improvement intervention.[17] The only other pay-for-performance program with sustained impact on mortality, the English hip fracture Best Practice Tariff was also founded on a preceding national database including quality improvement support for local teams which, in itself was associated with small but non-significant decline in mortality.[14] Integration with, and development of quality improvement networks was also identified as an important factor in the short term positive effects of the English Advancing Quality program.[26] An integrated quality improvement collaborative, therefore, is best seen as an important component of successful pay-for-performance programs, rather than a competing intervention.

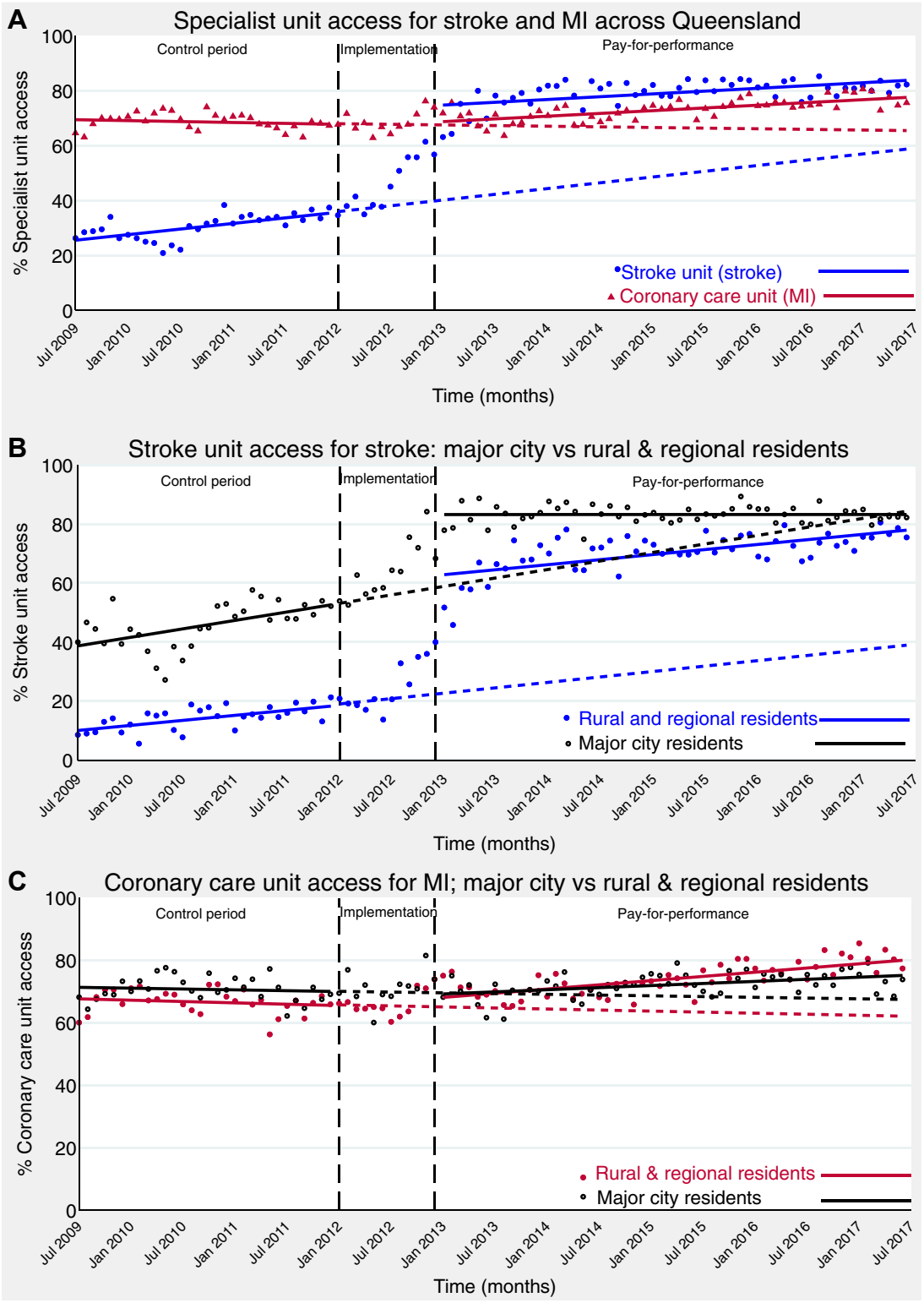


Fig. 2: Impact of pay-for-performance incentives for stroke unit access on proportion of acute stroke and myocardial infarction (MI) patients admitted to designated stroke or coronary care units: Panel A state-wide access; Panels B & C stroke unit access for stroke, and Coronary care unit access for MI in rural/regional vs major city residents.

	Stroke		Myocardial Infarction		Difference		Difference in difference	
	Level or slope	(95% CI)	Level or slope	(95% CI)		(95% CI)		(95% CI)
Level								
Start historical control period	21.8	(20.0, 23.6)	10.5	(9.3, 11.7)				
End historical control period	25.1	(22.7, 27.4)	9.4	(7.9, 10.9)				
P4P introduction effect[a]	−4.0	(−8.2, 0.1)	−0.5	(−3.1, 2.1)	−3.5	(−8.4, 1.4)		
Start P4P period	22.5	(21.1, 23.9)	8.4	(7.6, 9.2)				
End P4P period	**19.9**	**(18.8, 21.1)**	7.5	(6.9, 8.2)				
P4P overall effect[b]	**−12.5**	**(−23.1, −1.9)**	0.7	(−6.1, 7.5)	**−13.2**	**(−25.8, −0.6)**		
Rate of change (slope[c])								
Historical control period	0.11	(−0.01, 0.24)	−0.04	(−0.12, 0.04)	0.15	(0.00, 0.30)		
P4P period	**−0.05**	**(−0.09, −0.01)**	−0.02	(−0.04, 0.01)	−0.03	(−0.08, 0.02)		
Difference	**−0.16**	**(−0.29, −0.03)**	0.02	(−0.06, 0.11)			**−0.18**	**(−0.34, −0.02)**

Statistically significant values are indicated in bold ($p < 0.05$). [a]Difference between level at beginning of intervention period and predicted level from control period trends. [b]Difference between level at end of P4P period and predicted level from control period trends. [c]Slopes are expressed as change/month.

Table 2: **Change in 6-month mortality following stroke compared to myocardial infarction (control condition) with introduction of pay-for-performance (P4P) incentives for stroke unit access, interrupted time series analysis.**

As this program and the English hip fracture Best Practice Tariff are the only hospital directed pay-for-performance programs to demonstrate sustained impact on patient outcomes, it is likely that the program setting, design and implementation features were important factors in the success of the QIP program. Choice of target appears to be very important.[8,27] Both studies used a primary process of care rather than outcome target. Stroke unit care is an ideal target with substantial impact as it reflects a bundle of care incorporating adherence to multiple individual evidence-based elements, with a large effect on outcomes. Similarly, the hip fracture Best Practice Tariff also involved a bundle of multidisciplinary care with substantial impact on outcomes. Very low baseline stroke unit access and marked geographical variation were likely major factors in the success of the QIP incentive as there was substantial opportunity for improvement, especially in rural and regional areas. Other design and contextual factors of the Queensland QIP which have been linked to pay-for-performance success elsewhere[8,27] include: extensive clinician involvement in design, implementation and monitoring of the scheme; and initial absolute rather than relative targets which were simple, measurable, stepped and achievable.

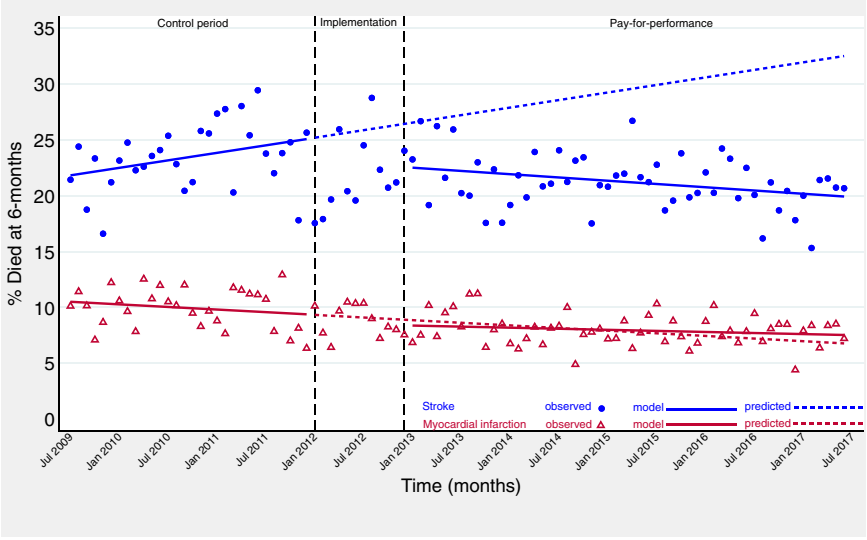


Fig. 3: Impact of pay-for-performance incentives for stroke unit access on 6-month mortality following stroke and myocardial infarction (control condition).

The second phase of the QIP payment design moved the incentive from cash bonuses for achieving targets to bonuses based on achievement of best practice for individual patients. This aligned payment structure with the English Best Practice Tariff,[11] suggesting this may be a useful model for future pay-for-performance program designs. We did not observe any change in process or outcome with change in payment structure, and it is possible that incentives were no longer having an impact as withdrawal of incentives in other programs has not been associated with decline in process of care indicators.[28] Alternately, this may represent an ongoing impact of the pay-for-performance incentive with ceiling effect from high adherence with the process of care indicator.

One of the aims of pay-for-performance programs has been to reduce disparities in health care access. The Queensland QIP was highly effective in almost abolishing marked regional disparity in health care delivery with access to stroke unit care improving significantly more in rural and regional than major city residents.

Strengths and limitations

It is possible that unrecognised systematic changes in patient characteristics or other changes in clinical care may have affected mortality risk. The major advance in stroke management during the study period has been introduction of endovascular thrombectomy for acute ischaemic stroke, introduced systematically after the publication of supporting evidence in 2015.[29] This is unlikely to have impacted our results as total cases performed in Queensland only rose from 2% to 4% of the stroke cohort in the final two years of the study. We did observe an abrupt increase in apparent severity of comorbidity in the stroke cohort, likely secondary to improved recognition and recording of comorbidities with improved quality of care in stroke units. However, if real, this would have biased our results towards the null, and our results were not affected by adjustment for patient characteristics. The lack of change in pattern of outcomes in our clinical control condition (MI) with vascular aetiology and very similar risk factors increases confidence that the observed effects on mortality were related to systematic changes in stroke clinical care through improved stroke unit access. Missing data only affected our sensitivity analyses, and as this only involved 0.4% patients, it is unlikely to have substantially impacted the results.

Conclusions

Our results have demonstrated that pay-for-performance can have an impact on both quality of care and patient outcomes. As our findings contrast with lack of impact with most other hospital directed pay-for-performance programs other than the English hip fracture Best Practice Tariff, success is likely to be dependent on design and context of the program. Success factors of the Queensland scheme included: a large initial evidence-practice gap; disparities in care amenable to improvement; choice of an evidence-based target with large effect size, stepped achievable targets; and clinician co-design and leadership within a quality improvement collaborative network. These factors provide insights into optimal design and targets for future pay-for-performance programs.

Contributors

RSG conceived the study, contributed to design, data acquisition, data analysis, interpretation of the data, and drafted the manuscript. DAC contributed to study design, data analysis, interpretation of the data, and critically revised the paper. TAC was the supervising statistician and contributed to study design, data analysis, and manuscript revision. NEA, HMD and GC contributed to study design, interpretation of the data, and critically revised the paper. ESH provided consumer input and direction throughout intervention, study design, interpretation of the data, and critically revised the paper. All authors approved the final version.

Data sharing statement

Due to legislative restrictions, person level data from this study cannot be shared, but aggregated data are available from the corresponding author on reasonable request, following approval from the relevant data custodians.

Declaration of interests

The authors declare no commercial or financial relationships that could be construed as a potential conflict of interest. RG, NEA, HMD, DAC report membership of governance committees for the Australian Stroke Clinical Registry, DAC is also data custodian. EH is consumer representative for the Queensland Stroke Clinical Network and Australian Stroke Coalition. DAC reports grants from Boehringer Ingelheim (Angel's Initiative), Moleac and Bristol Myers Squibb paid to her institution unrelated to this project.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lanwpc.2023.100921.

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