Major surgery in Victoria and the United States: a comparison of hospital mortality in older patients

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ABSTRACT

Background: Knowledge is limited on how surgical outcomes compare between different geographical and health organisation settings.

Objective: To compare demographic features, surgery rates and in-hospital outcomes for 14 major types of surgery in older patients between the state of Victoria in Australia and the United States.

Methods: We obtained US Medicare data and data from the Department of Human Services Victorian Admitted Episodes Database for patients older than 65 years who underwent one of six major cardiovascular procedures or eight major cancer resections in a 5-year period (1994–1999 and 1998–2003, respectively). Data comprised patient age, sex and elective versus non-elective status, operation type, surgical volume and postoperative hospital mortality.

Results: The number of operations performed per capita was 2.6 times greater in the US system than in Victoria. Overall, postoperative hospital mortality was lower in Victoria (3.96% v 4.47%, $P<0.001$). It was also lower in Victoria for four major cardiothoracic procedures (coronary artery bypass grafting: 2.79% v 4.63% in the US, $P<0.001$; aortic valve replacement, 5.30% v 7.94%, $P<0.001$; mitral valve replacement, 6.52% v 13.24%, $P<0.001$; pulmonary lobectomy, 2.16% v 4.72%, $P=0.01$), but was higher for nephrectomy (3.59% v 2.33%, $P=0.04$) and colectomy (7.33% v 4.67%, $P<0.001$). The Victorian patients included a smaller proportion of women (35.24% v 41.23%, $P<0.001$) and people older than 75 years (39.58% v 44.48%, $P<0.001$). US patients were significantly more likely to have their admission status classified as non-elective (45.45% v 34.98% in Victoria, $P<0.001$).

Conclusions: Despite limitations on interpretation inherent in comparing outcomes from different jurisdictions, these findings suggest major differences between Victoria and the US in surgical management of patients older than 65 years. Surgical intervention rates appear lower in Victoria, particularly in patients older than 75 years. For patients who receive major cardiothoracic procedures, in-hospital mortality is lower in Victoria than in the US; for colectomy and nephrectomy, it is higher in Victoria; and for other procedures, it is similar.

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There is a growing impetus worldwide to improve quality and safety in health care.[1-5] In Australia, concern about the quality and safety of hospital care has been particularly prominent in the lay press since the 1995 Quality in Australian Health Care Study by Wilson et al[6] and the more recent uncovering of evidence of unsatisfactory surgical practices in the Queensland public health system.[7]

Of particular interest to clinicians and the public are surgical outcomes, especially in older patients undergoing complex surgical interventions, because of concern about the overall quality of care, patient safety,[8-10] and the high risk of complications.[11]

In the light of these concerns, it is important to assess whether surgical outcomes in Australia are comparable to those in other developed countries. However, it is difficult to benchmark surgical performance at a national or state level. To investigate this issue, we obtained data from the Victorian Department of Health on hospital demographics and outcomes in patients older than 65 years after 14 types of major surgical procedure. We then compared these with outcomes for the same operations obtained by Birkmeyer et al[12] in a review of surgical mortality rates in similar patients from the United States Medicare health care system.

Methods

Subjects and databases

We obtained data from the Victorian Admitted Episodes Database (VAED) for public hospitals provided by the Department of Human Services for the years 1998–2003. The dataset contains a record for each separated inpatient episode for all Victorian public hospitals and includes International Classification of Diseases (ICD) coding for each episode. We excluded patients who were under 65 years of age. The data contained in the records uses standard code sets for all data items. Data items used for this study were hospital code, age group, sex, ICD diagnosis codes (1–12), procedure codes (1–12), admission source and separation type.

The list of *International classification of diseases, 9th revision, clinical modification* (ICD-9-CM) codes used by Birkmeyer et al for each of 14 procedures was examined by health information services staff, who compiled a list of equivalent ICD-10 codes for use in this study. Patients

Table 1. Surgical volume per 5-year period and population in the United States (1994–1999) and Victoria (1998–2003)

	No. of procedures		No. per 100 000		
Procedure	United States	Victoria	United States	Victoria	Ratio US : Victoria
Coronary artery bypass grafting	90 1677	6 340	338.32	133.73	2.53
Aortic valve replacement	151 610	1 605	56.89	33.85	1.68
Mitral valve replacement	64 935	353	24.36	7.66	3.18
Carotid endarterectomy	479 289	2 180	179.84	45.99	3.91
Lower limb arterial bypass	263 580	2 797	98.9	59	1.68
Elective repair of abdominal aortic aneurysm	140 577	985	52.75	20.78	2.54
Colectomy	304 285	1 092	114.17	23.03	4.96
Gastrectomy	31 944	436	11.99	9.2	1.30
Oesophagectomy	6 337	103	2.38	2.17	1.10
Pancreatic resection	10 530	97	3.95	2.05	1.93
Nephrectomy	58 990	585	22.13	12.34	1.79
Cystectomy	22 349	210	8.4	4.43	1.90
Pulmonary lobectomy	75 563	416	28.35	8.77	3.23
Pneumonectomy	10 410	41	3.91	0.86	4.55
Overall	**2 522 066**	**17 240**	**946.32**	**363.64**	**2.60**
Population (100 000)	2665.1367[13]	47.41[14]			56.21

undergoing each of the same 14 procedures were identified using ICD-10 procedure codes.

Each of the 14 diagnostic code fields and each of the 14 operation code fields in each recorded episode were tested against the diagnosis and operation criteria. Records found to have any one of the excluded diagnosis or operation codes were excluded from the selection process. Where both included diagnosis and included operation codes were provided for a procedure, only records that had one of the diagnosis codes *and* one of the operation codes were selected.

To assess number of procedures performed per capita, population data were obtained from census sources for the United States and Victoria for the respective study periods.

Assessment of outcomes

To minimise the potential for confounding from casemix, we simulated the method of Birkmeyer et al and applied several restrictions to cohort selection. For the eight types of cancer resections, we excluded patients without an accompanying cancer diagnosis code that was related to the index procedure. Patients undergoing repair of abdominal aortic aneurysm were excluded if they had a diagnosis of aneurysmal rupture, thoracic aortic aneurysm or both. Patients undergoing coronary artery bypass grafting were excluded if they simultaneously underwent valve replacement. Our primary outcome measure was hospital mortality.

Birkmeyer et al also performed an analysis incorporating death within 30 days and undertook risk adjustment for coexisting medical conditions by compiling a Charlson score. However, as clinical information about comorbidities was not available from the Victorian database, comparisons were restricted to hospital outcome. Statistical comparisons were performed using the χ^2 test, and differences in likelihood of death are presented as odds ratios (ORs). Statistical analysis was performed using the StatView version 5.0 statistical software package (SAS Institute, Berkeley, Cal, USA, 1998).

Results

Between 1998 and 2003, 17 240 patients aged over 65 years underwent one of the 14 surgical procedures in Victorian hospitals. This was a rate of 363.6 procedures per 100 000 population over a 5-year period, compared with a rate of 946.3 procedures per 100 000 population in the US over the 5-year period 1994–1999 (Table 1).

Allowing for differences in population size, more of each of the surgical procedures were performed in the US than in Victoria, with ratios ranging from 1.1 : 1 for oesophagectomy to 4.55 : 1 for pneumonectomy. Overall, surgical volume was 2.6 times greater in the US compared with Victoria on a per capita basis.

The proportion of patients who were older than 75 years was greater in the US than in Victoria for most procedures and overall (44.48% v 39.58%; $P < 0.001$) (Table 2). The relative differences in proportion of older patients varied considerably between procedures, ranging from a 1.5%

Table 2. Characteristics of patients who underwent surgery in the United States (1994–1999) or Victoria (1998–2003)

Surgical procedure	United States		Victoria		Odds ratio	Confidence limit		χ^2	*P*	% Relative difference	% Absolute difference
	No.	%	No.	%		Low	High				
Coronary artery bypass graft	901 677		6340								
Age > 75 years	327 245	36.29	1922	30.31	0.76	0.72	0.81	97.339	< 0.001	16.48	5.98
Female	316 230	35.07	1918	30.25	0.80	0.76	0.85	64.232	< 0.001	13.74	4.82
Non-elective	545 793	60.53	2637	41.59	0.46	0.44	0.49	943.993	< 0.001	31.29	18.94
Aortic valve replacement	151 610		1605								
Age > 75 years	77 691	51.24	790	49.22	0.92	0.84	1.02	2.601	0.11	3.94	2.02
Female	65 790	43.39	720	44.86	1.06	0.96	1.17	1.389	0.24	–3.39	–1.47
Non-elective	65 756	43.37	453	28.22	0.51	0.46	0.57	148.498	< 0.001	34.92	15.15
Mitral valve replacement	64 935		353								
Age > 75 years	26 923	41.46	109	30.88	0.63	0.50	0.79	16.209	< 0.001	25.52	10.58
Female	37 963	58.46	195	55.24	0.88	0.71	1.08	1.501	0.22	5.51	3.22
Non-elective	31 452	48.44	124	35.13	0.58	0.46	0.72	24.901	< 0.001	27.48	13.31
Carotid endarterectomy	479 289		2180								
Age > 75 years	227 888	47.55	923	42.34	0.81	0.74	0.88	23.599	< 0.001	10.96	5.21
Female	210 075	43.83	741	33.99	0.66	0.60	0.72	85.363	< 0.001	22.45	9.84
Non-elective	156 560	32.67	569	26.10	0.73	0.66	0.80	42.532	< 0.001	20.11	6.57
Lower limb arterial bypass	263 580		2797								
Age > 75 years	132 666	50.33	1467	52.45	1.09	1.01	1.17	4.960	0.03	–4.21	–2.12
Female	121 834	46.22	1099	39.29	0.75	0.70	0.81	53.494	< 0.001	14.99	6.93
Non-elective	107 380	40.74	1075	38.43	0.91	0.84	0.98	6.092	0.01	5.66	2.31
Elective AAA repair	140 577		985								
Age > 75 years	60 578	43.09	431	43.76	1.03	0.91	1.17	0.176	0.68	–1.55	–0.67
Female	32 579	23.18	218	22.13	0.94	0.81	1.10	0.598	0.44	4.53	1.05
Non-elective	38 292	27.24	287	29.14	1.10	0.96	1.26	1.777	0.18	–6.96	–1.90
Colectomy	304 285		1092								
Age > 75 years	182 774	60.07	545	49.91	0.66	0.59	0.75	46.796	< 0.001	16.91	10.16
Female	169 682	55.76	526	48.17	0.74	0.65	0.83	25.446	< 0.001	13.61	7.59
Non-elective	145 761	47.90	526	48.17	1.01	0.90	1.14	0.031	0.86	–0.56	–0.27
Gastrectomy	31 944		436								
Age > 75 years	17 120	53.60	194	44.50	0.69	0.57	0.84	14.311	< 0.001	16.98	9.10
Female	13 061	40.89	165	37.84	0.88	0.72	1.07	1.649	0.20	7.46	3.05
Non-elective	13 341	41.76	120	27.52	0.53	0.43	0.65	35.912	< 0.001	34.09	14.24
Oesophagectomy	6 337		103								
Age > 75 years	1 921	30.31	20	19.42	0.55	0.34	0.91	5.715	0.02	35.93	10.89
Female	1 530	24.14	41	39.81	2.08	1.39	3.10	13.480	< 0.001	–64.91	–15.67
Non-elective	1 409	22.24	16	15.53	0.64	0.38	1.10	2.641	0.10	30.15	6.71
Pancreatic resection	10 530		97								
Age > 75 years	3 813	36.21	18	18.56	0.40	0.24	0.67	12.994	< 0.001	48.74	17.65
Female	5 171	49.11	41	42.27	0.76	0.51	1.14	1.799	0.18	13.93	6.84
Non-elective	3 992	37.91	30	30.93	0.73	0.48	1.13	1.992	0.16	18.42	6.98
Nephrectomy	58 990		585								
Age > 75 years	26 035	44.13	231	39.49	0.83	0.70	0.98	5.075	0.02	10.51	4.64
Female	25 455	43.15	229	39.15	0.85	0.72	1.00	3.790	0.05	9.27	4.00
Non-elective	15 452	26.19	112	19.15	0.67	0.54	0.82	14.913	< 0.001	26.90	7.04

AAA = abdominal aortic aneurysm.

Table 2. Characteristics of patients *continued*

Surgical procedure	United States No.	%	Victoria No.	%	Odds ratio	Confidence limit Low	High	χ^2	*P*	% Relative difference	% Absolute difference
Cystectomy	22 349		210								
Age > 75 years	9 379	41.97	66	31.43	0.63	0.47	0.85	9.492	0.002	25.11	10.54
Female	4 728	21.16	47	22.38	1.07	0.78	1.49	0.187	0.67	–5.77	–1.22
Non-elective	4 505	20.16	26	12.38	0.56	0.37	0.85	7.838	0.005	38.59	7.78
Pulmonary lobectomy	75 563		416								
Age > 75 years	25 297	33.48	104	25.00	0.66	0.53	0.83	13.362	< 0.001	25.33	8.48
Female	32 982	43.65	128	30.77	0.57	0.47	0.71	27.910	< 0.001	29.51	12.88
Non-elective	14 204	18.80	54	12.98	0.64	0.48	0.86	9.183	0.002	30.95	5.82
Pneumonectomy	10 410		41								
Age > 75 years	2 529	24.29	3	7.32	0.25	0.08	0.80	6.412	0.01	69.86	16.97
Female	2 874	27.61	8	19.51	0.64	0.29	1.38	1.340	0.25	29.34	8.10
Non-elective	2 281	21.91	2	4.88	0.18	0.04	0.76	6.940	0.008	77.73	17.03
Overall age > 75 years	**1 121 859**	**44.48**	**6823**	**39.58**	**0.82**	**0.79**	**0.84**	**166.854**	**< 0.001**	**11.03**	**4.91**
Overall female	**1 039 954**	**41.23**	**6076**	**35.24**	**0.78**	**0.75**	**0.80**	**253.667**	**< 0.001**	**14.53**	**5.99**
Overall non-elective	**1 146 178**	**45.45**	**6031**	**34.98**	**0.65**	**0.63**	**0.67**	**756.338**	**< 0.001**	**23.03**	**10.47**

relative difference for non-emergency abdominal aortic aneurysm (AAA) repair to 69.9% for pneumonectomy. All cancer-related surgery, coronary artery bypass grafting (CABG), mitral valve replacement and carotid endarterectomy had a statistically significant greater proportion of older patients in the US. Only for lower limb arterial bypass surgery was there a small but significantly greater proportion of patients older than 75 years in Victoria (52.45% v 50.33%; $P = 0.03$).

Men outnumbered women for all procedures except mitral valve replacement (both US and Victoria) and colectomy (US only). Overall, the Victorian system operated on fewer women than the US system (35.24% v 41.23%; $P < 0.001$). Only for three procedures were there relatively more women in Victoria than in the US: oesophagectomy (39.81% v 24.14%; $P < 0.001$), aortic valve replacement (44.86% v 43.39%; not significant) and cystectomy (22.38% v 21.16%; not significant) (Table 2).

Striking differences in the relative proportions of patients described as non-elective were also evident. For 10 of the 14 procedures, a significantly greater proportion of patients were recorded as non-elective in the US, ranging from a relative difference of 20.11% for carotid endarterectomy, to 77.73% for pneumonectomy (Table 2). A small and non-significant difference was evident for AAA repair and colectomy, operations for which Victorian patients were more likely to have their admission classified as non-elective.

The hospital mortality for all 14 procedures combined was 4.47% in the US versus 3.96% in Victoria (odds ratio [OR], 0.87; 95% CI, 0.81–0.94; $P < 0.001$), a relative difference of 11.45% (Table 3). Four procedures had a higher mortality rate in Victoria: colectomy (7.33% v 4.67%; $P < 0.001$), nephrectomy (3.59% v 2.33%; $P = 0.045$), lower limb arterial bypass (4.76% v 4.24%; not significant) and open AAA repair (6.50% v 5.14%; not significant). A higher mortality rate was evident in the US for the remaining 10 procedures, although this was only statistically significant for CABG (4.63% v 2.79%; $P < 0.001$), aortic valve replacement (7.94% v 5.30%; $P < 0.001$), mitral valve replacement (13.24% v 6.52%; $P < 0.001$) and pulmonary lobectomy 4.72% v 2.16%; $P = 0.01$).

Discussion

We compared hospital outcomes for 14 major cancer-related and cardiovascular operations using data obtained from the Victorian public health care system and data obtained by Birkmeyer and colleagues from the US Medicare system. Our findings suggest that surgical mortality rates in Victoria for patients aged over 65 years are, overall, at least equivalent to those in the US Medicare system. However, they also show several potential differences between the two systems. The most striking difference is the apparent markedly higher volume of surgery performed in the US Medicare system compared with the public health care system in Victoria for patients older than 65 years.

Table 3. Postoperative hospital mortality for 14 procedures in the United States and Victoria

Procedure	United States		Victoria		Odds ratio	Confidence limits		χ^2	*P*	% Relative difference	% Absolute difference
	No.	%	No.	%		Low	High				
Coronary artery bypass graft	901 677		6 340								
Hospital mortality	41 787	4.63	177	2.79	0.59	0.51	0.69	48.491	< 0.001	39.74	1.84
Aortic valve replacement	151 610		1 605								
Hospital mortality	12 041	7.94	85	5.30	0.65	0.52	0.81	15.259	< 0.001	33.25	2.64
Mitral valve replacement	64 935		353								
Hospital mortality	8 595	13.24	23	6.52	0.46	0.30	0.70	13.841	< 0.001	50.76	6.72
Carotid endarterectomy	479 289		2 180								
Hospital mortality	5 633	1.18	23	1.06	0.90	0.59	1.35	0.27	0.60	10.17	0.12
Lower limb arterial bypass	263 580		2 797								
Hospital mortality	11 170	4.24	133	4.76	1.13	0.95	1.34	1.823	0.18	–12.26	–0.52
Elective AAA repair	140 577		985								
Hospital mortality	7 231	5.14	64	6.50	1.28	0.99	1.65	3.667	0.06	–26.46	–1.36
Colectomy	304 285		1 092								
Hospital mortality	14 200	4.67	80	7.33	1.61	1.29	2.03	17.263	< 0.001	–56.96	–2.66
Gastrectomy	31 944		436								
Hospital mortality	3 046	9.54	39	8.94	0.93	0.67	1.30	0.174	0.68	6.29	0.60
Oesophagectomy	6 337		103								
Hospital mortality	937	14.79	13	12.62	0.83	0.46	1.50	0.378	0.54	14.67	2.17
Pancreatic resection	10 530		97								
Hospital mortality	1 094	10.39	7	7.22	0.67	0.31	1.45	1.042	0.31	30.51	3.17
Nephrectomy	58 990		585								
Hospital mortality	1 373	2.33	21	3.59	1.56	1.01	2.42	4.039	0.04	–54.08	–1.26
Cystectomy	22 349		210								
Hospital mortality	860	3.85	6	2.86	0.73	0.33	1.66	0.553	0.46	25.71	0.99
Pulmonary lobectomy	75 563		416								
Hospital mortality	3 567	4.72	9	2.16	0.45	0.23	0.86	6.032	0.01	54.24	2.56
Pneumonectomy	10 410		41								
Hospital mortality	1 307	12.56	3	7.32	0.55	0.17	1.78	1.022	0.31	41.72	5.24
Overall	**2 522 066**		**17 240**								
Overall hospital mortality	**112 841**	**4.47**	**683**	**3.96**	**0.87**	**0.81**	**0.94**	**12.405**	**< 0.001**	**11.45**	**0.51**

AAA = abdominal aortic aneurysm.

Other significant differences in the US Medicare system compared with the Victorian system were that patients tended to be older, included a higher proportion of women, and were more likely to have their surgery described as non-elective. Finally, all the procedures for which Victorian mortality rates were significantly lower than in the US were cardiothoracic operations.

Direct comparisons between different health care systems are difficult, given the inability of the available administrative data to accurately reflect factors such as differences in casemix. It is thus important to be cautious about drawing conclusions, but the magnitude and consistency of some findings suggest there are genuine differences between the two health care systems that influence outcomes.

There are several possible causes of the observed difference in surgical volume, but the size of the difference is difficult to fully explain. For example, disparities in the use of private health care by older patients, differences in referral patterns and differences in surgical practice and casemix (such as patient age, socioeconomic status and presence of comorbid medical conditions) are all likely to be important. Although differences in patient selection for surgical procedures are a plausible contributing factor to differences in surgical volume, it is interesting that the

largest difference in surgical rates between the two systems was for colectomy, one of the major cancer resections. Operative intervention is almost universal for colon cancer, even in frail elderly patients with significant comorbidities. The database used by Birkmeyer et al included Medicare patients aged over 65 years enrolled in fee-for-service arrangements. Reimbursement of surgeons in the Victorian public health care system generally uses a different model, which does not link the surgeon's operative caseload to remuneration so directly. With the potential financial inducement to provide surgical intervention in the US Medicare system, surgeons may be more inclined to operate. Appropriate interpretation of the apparent differences in surgical utilisation rates must also acknowledge the speculative nature of these observations, as we cannot be certain that disease prevalence and access to health care are equivalent in the two populations. Whether the higher overall surgical volume evident in the US Medicare system is of benefit to individual patients or the community is unknown.

The finding that US Medicare patients tend to be older has several possible explanations. The US Medicare data used by Birkmeyer et al for their analysis does not include patients over 65 years of age receiving care through the Veterans Affairs health care system, private payer plans or capitated Medicare management plans. The Australian federal government provides subsidies and tax incentives for individuals to maintain private health insurance. In addition, Australian armed forces veterans make up a significant proportion of patients over 65 years of age and receive additional government support that allows enhanced access to private health care. Thus, the findings that there were fewer patients aged over 75 years undergoing surgery in Victorian public hospitals may reflect a high use of the private health care system by the elderly.

To investigate this possibility further, we obtained data from the Australian and New Zealand Intensive Care Society Adult Patient Database (ANZICS APD) specifically on CABG, as this operation universally involves postoperative management in an ICU and therefore is likely to reliably contribute to the database. Because of the variation in number of private hospitals contributing data each year, it is not possible to provide exact data regarding private system CABG volume for the entire period we evaluated from the public health care system data. However, by way of example, for the year 2003 (where data were most complete), the private hospital system accounted for at least a quarter (26.98%) of total CABG volume in patients older than 65 years, and over a third (33.85%) of CABG volume in the over-75-years age group. Given that surgical volume for most operations was several-fold higher in the US than in Victoria for half the procedures, it is very unlikely that surgery in private hospitals fully accounts for the observed lower volumes of surgery in the Victorian public health system.

Another possible cause for fewer older patients having surgery and lower surgical volume overall in Victoria is patient selection. It is notable that there was a significantly increased proportion of older patients for all of the major cancer operations in the US. Victorian surgeons may be more likely to recommend non-surgical management options to their patients based on factors perceived to increase the risk of complications and postoperative mortality, such as advanced age and multiple comorbidity.

Of the differences observed between the two systems, one of the most striking is the incidence of non-elective major surgery in the US compared with Victoria, a finding that was statistically significant and of remarkable magnitude for 10 of the 14 operations. Overall, 45.45% of US patients versus 34.98% of Victorian patients were described as non-elective ($P < 0.001$). We counted as non-elective any patient coded as an emergency admission and patients admitted to hospital who were not on a surgical waiting list. The US Medicare discharge abstracts used by Birkmeyer et al contained a field describing the admission as elective, urgent, or emergent. It is likely that interpretation and coding, therefore, varies widely between both hospitals and also between the two systems, so that differences between the US and Victoria mostly represent variations in clerical interpretation of clinical situations and definitions, rather than truly reflecting differences in patient casemix. However, it seems implausible that the high rates observed for non-elective surgery in both systems and nearly all operations accurately reflects reality. In the end, perhaps it is not the differences in elective versus non-elective status between the two systems that are remarkable, but that such a high absolute rate of procedures are coded as non-elective.

Comparing mortality rates between health care systems is open to potentially valid criticism. Differences in casemix, patient selection and methods of data collection represent potential confounding factors. As already outlined, we found a marked difference in surgical volume between the two systems, a major limiting factor in making accurate performance comparisons. It is important not to make assumptions regarding each system, although US Medicare patients are likely to be older, experience greater deprivation and, consequently, have a greater burden of important medical comorbidity. The overall lower hospital death rates in Victoria should perhaps therefore be interpreted as indicating likely equivalence rather than superior overall performance, particularly in view of the different periods evaluated: 1994–1999 for the US and 1998–2003 for Victoria. Advances in medical treatment over this period

may have contributed to the lower postoperative hospital mortality in Victoria.

Nevertheless, some findings about outcomes for specific procedures are worthy of exploration. Firstly, for CABG, aortic valve replacement, mitral valve replacement, and pulmonary lobectomy — the four procedures for which Victoria was found to have a significantly lower mortality rate — surgery is conducted in specialised metropolitan tertiary referral teaching hospitals, with postoperative care routinely provided in a critical care unit, resulting in high institutional volume and a concentration of expertise.

Secondly, it is notable that, for the two procedures in which Victorian patients had a significantly higher mortality (colectomy and nephrectomy), surgery is performed at a range of hospitals throughout the state, with varying levels of surgical volume and with most patients receiving postoperative care in a non-critical care ward setting. Such findings are concordant with those of Birkmeyer et al and others, that institutional surgical volume significantly influences postoperative mortality rates, and should encourage a detailed analysis of this relationship within Victoria, as well as studies of high volume centres providing expertise in non-cardiothoracic procedures.

If the relationship between institutional volume and improved patient outcomes were confirmed, the case for trialling specialist units with a concentration of expertise would be compelling. Currently, many of the procedures we studied are performed in a wide range of hospitals, often at low or modest volumes. Operations such as elective colectomy for bowel cancer are not perceived as high-risk procedures, and these patients are usually managed on general wards across a range of hospital types. This is despite a mortality of 7.33%, substantially higher than that associated with modern coronary care-based management of acute myocardial infarction.[15] A care model that combines centres of concentrated expertise with "high-dependency"-type physiological monitoring and organ support might reduce mortality and morbidity, similarly to the effect associated with the introduction of coronary care units for managing acute coronary syndromes. While it is beyond the scope of our study to determine how many poor outcomes might in fact be preventable, a number of studies suggest that much could be achieved through strategic application of specialised resources to high-risk surgical patients.[16-18] The implications for resource allocation are considerable, and properly trialled pilot programs to explore the utility and costs of this approach are warranted.

Our analysis had several limitations. We analysed only data available for US Medicare patients and Victorian public health system patients aged over 65 years. Patients undergoing procedures in private hospitals and younger patients were not included, limiting the strength of the comparative analysis and its applicability to younger groups. This analysis relied on administrative data, which probably do not reflect characteristics such as non-elective status and may also be incomplete or incorrect in other demographic parameters. Despite the potential weaknesses of administrative data sources, no other source is as inclusive, comprehensive or accessible for analysis. Furthermore, the same data are used by health policy administrators and governments to plan resource allocation and the future structure of health care. Finally, as already discussed, the remarkable discrepancy in surgical volume between the two systems makes it impossible to draw clear conclusions in terms of mortality outcomes beyond the probable equivalent performance of the two systems. Future studies comparing local health care outcomes with other jurisdictions would be greatly strengthened by access to information that allowed adjustment for casemix and other factors.

Conclusions

In the US, significantly more surgical procedures are performed in older patients than in Victoria. The performance of each system in terms of mortality is probably equivalent in overall terms. Evidence that Victoria appeared to perform better for major cardiothoracic surgery and worse for some non-thoracic cancer surgery is significant, suggesting the possibility that hospital and surgeon procedural volume contributes significantly to operative outcome in the state. This phenomenon is consistent with experience elsewhere[19-24] and warrants further critical evaluation through an analysis of surgical outcomes for major procedures across the state. An extension of this would be the development of pilot programs of specialised care centres for other selected procedures, to evaluate the potential for improving outcomes in older patients undergoing major surgical procedures. Demonstration of a benefit would have implications for thousands of patients each year.

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