B Literature review

B.1 Previous multivariate studies of hospital efficiency

A summary of the methods and data used in previous overseas and Australian multivariate studies of hospital efficiency is given in table B.1. The table is organised according to the type of function (cost or production) and modelling techniques used (data envelopment analysis (DEA), stochastic frontier analysis (SFA), stochastic distance function (SDF) or other). Studies that employed more than one modelling technique (such as Webster, Kennedy and Johnson 1998) are therefore reported more than once.

Table B.1 **Selected literature review — benchmarking studies**

Author(s) and year published	*No. of hospitals and year(s)*	*Dependent variable*	*Independent variables*	*External factors*	*Quality or patient safety*
Cost function – Stochastic frontier analysis					
Herr (2008)	1594 German public, not-for-profit private, and for-profit private hospitals, 2001-2003.	Total (adjusted) costs.	No. of cases, no. of weighted cases, unit prices for doctors, nurses, other staff, no. of beds, surgery ratio, total adjusted costs per bed, total adjusted costs per weighted case.	No subsidies dummy, East dummy, female ratio, 75+ ratio.	Occupancy rate, nurse-bed ratio, average length of stay (ALOS), mortality rate.
Yaisarwang and Burgess (2006)	131 US Vets Affairs hospitals, 2000.	Total (adjusted) costs.	Medical, nursing and other salaries, no. of operating beds, outpatient services, inpatient services, access indicators (occupancy rate, waiting days, market penetration).	Intensive care unit intensity index, urban, teaching and psychiatric hospital status.	In-hospital mortality rate, readmission rate, length of stay for readmissions, average days to readmit.
Jacobs (2001)	232 UK National Health Service hospitals, 1995-96.	Cost Index (actual cost divided by expected cost).	Emergency room (ER) visits, casemix weight, index of unexpected ER visits, occasions of outpatient services.	Transfers to and from a hospital, patients under 15, patients over 60, female patients, teaching, market forces factor.	None.

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Table B.1 (continued)

Author(s) and year published	*No. of hospitals and year(s)*	*Dependent variable*	*Independent variables*	*External factors*	*Quality or patient safety*
Wang and Mahmood (2000a)	113 NSW public hospitals (in two peer groups – large and small) 1997-98.	Total variable cost.	Inpatient casemix index, occasions of service, ER visits, input price of medical staff, average non-medical costs, average available beds, percentage sameday separations.	Dor and Farley index, inpatient casemix index.	ALOS of acute separations.
Yong and Harris (1999)	35 large Victorian acute public hospitals for 1994-95.	Total operating expenditure, admitted patient cost.	Weighted-inlier equivalent separations (WIES), occasions of service, emergency services, average medical wage, nursing wage, other staff wage, hotelling wage, medical support staff wage, size (number of beds).	Metropolitan hospital, teaching status.	Occupancy rate, staff per WIES.
Rosko and Chilingerian (1999)	195 Pennsylvania acute care hospitals, 1989.	Total costs.	Inpatient separations, outpatient visits, wage rate, average price of capital, casemix index.	Severity of illness index, teaching variables, Herfindahl index.	None.
Linna (1998)	Finnish hospitals from 1988 to 1994.	Net operating cost.	Inpatient admissions, accident and emergency visits, hourly wage index, index on local government expenditure, time dummy.	Research and development variable, teaching dummy.	Readmission rate.
Webster, Kennedy, Johnson (1998)	280 Australian private hospitals in 1994-95.	Total operating expenditure.	Bed unit costs, materials unit costs, staff unit costs, revenue (output), occupied bed days, squared and cross terms.	None.	None.
Zuckerman, Hadley and Iezzoni (1994)	1600 US hospitals in 1984 and 1985.	Total operating cost.	Medicare admissions, Medicare post admission days, non-Medicare admissions and non-Medicare post-admission days, outpatient visits, average salary per FTE (full-time equivalent), average capital cost per bed.	Percent male patients, percent older patients, scores for disease status, plus a large number of factors describing characteristics of hospitals.	Transfers from another hospital, mortality rates of certain patients.
Vitiliano and Toren (1994)	443 US nursing homes for 1987 and 1990.	Total costs.	Patient days, admissions and transfers, per cent low care patients, wages of medical aids, registered nurse wages, property expenses (per square feet).	Voluntary, public, corporate, proprietorship, partnership.	None.

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Table B.1 (continued)

Author(s) and year published	*No. of hospitals and year(s)*	*Dependent variable*	*Independent variables*	*External factors*	*Quality or patient safety*
Cost function – Ordinary least squares					
Dor and Farley (1996)	500 US acute non-federal general hospitals.	Total variable (operating) cost.	Inpatient discharges, casemix index, outpatient services, surgery share, ER visits, average salary, average capital price.	Severity of illness index, source of hospital funding.	None.
Butler (1995)	121 Queensland public hospitals and 35 private hospitals.	Average cost per casemix-adjusted separation.	ALOS, occupancy rate, case flow rate, no. of beds.	None.	None.
Scott and Parkin (1995)	76 Scottish acute hospitals for 1992-93.	Total variable cost.	No. of acute discharges, no. of other discharges, acute length of stay (LOS), other LOS, outpatient and ER visits, beds.	None.	None.
Granneman, Brown and Pauly (1986)	867 US hospitals in 1982.	Total annual cost.	No. of acute inpatient, sub-acute, and intensive care days and discharges, accident and emergency visits, outpatient and other visits, wage rates for four categories.	Revenue sources, location dummies, per capita income of region, teaching status and presence of particular facilities.	None.
Single output production function – Stochastic frontier analysis					
Herr (2008)	1594 German public, non-profit private, and for-profit private hospitals, 2001–2003.	No. of cases, no. of weighted cases.	No. of doctors, no. of nurses, no. of other staff, no. of beds, total adjusted costs per bed, total adjusted costs per weighted case.	No subsidies dummy, East dummy, female ratio, 75+ ratio, surgery ratio.	Occupancy rate, nurse-bed ratio, ALOS, morality rate.
Mangano (2006)	116 Victorian public hospitals, 1992-93 to 1995-96.	Total WIES, total inpatients treated.	No. of FTE nurses, no. of FTE medical support staff, no. of admin and clerical staff and no. of FTE hotelling staff, average no. of available beds.	Teaching and metropolitan location status.	None.
Brown (2003)	20 per cent sample of hospitals in 17 US states, 1992 to 1996.	Inpatient separations.	No. of FTE employees, no. of beds, capital expenses, casemix index.	Share of admissions enrolled in health management organisations, share enrolled in preferred provider organisations, teaching dummy, public & for-profit status.	None.

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Table B.1 (continued)

Author(s) and year published	*No. of hospitals and year(s)*	*Dependent variable*	*Independent variables*	*External factors*	*Quality or patient safety*
Webster, Kennedy, Johnson (1998)	300 private hospitals for 1994-95.	Revenue, composite of occupied bed days.	No. of FTE staff, no. of beds, cost of materials, (plus squared and cross terms).	Technology dummies.	None.
Multi-output production function – Data envelopment analysis					
Chua, Palangkaraya and Yong (2009)	123 Victorian public hospitals between 2003-04 and 2004-05.	Total WIES	No. of FTE doctors, no. of FTE registered and other nurses, no. of FTE admin, domestic and other staff, no. of beds, expenditures on drug, medical and surgical supplies.	Second-stage Tobit regression testing for the effects of hospital competition.	Risk-adjusted unplanned readmissions (output).
Vitikainen, Street and Linna (2009)	40 Finnish public acute hospitals in 2005.	Casemix-adjusted inpatient admissions (episodes, days and cases), outpatient visits and ER visits	Hospital operating costs.	None.	None.
Nayar and Ozcan (2008)	53 non-federal hospitals in Virginia in 2003.	Casemix-adjust. separations, outpatient visits (including accident and emergency).	No. of total staff, no. of beds, costs (excluding payroll and costs), total assets.	Teaching FTEs (as an output).	Percent of patients receiving: ant biotics; oxygenation; and aged 65+ given pneumococcal vaccination.
Mangano (2006)	100 Victorian public hospitals, 1992-93 to 1995-96.	WIES, total inpatients treated.	No. of FTE non-medical staff, average no. of available beds.	None.	None.
Harrison and Sexton (2006)	Between 471 and 480 not-for-profit hospitals for 1998 and for 2001.	Admissions, outpatient visits.	No. of FTE staff, no. of beds, operating expenses, no. of services.	None.	None.
Queensland Department of Health (2004)	Queensland public hospitals for 2000-01 to 2002-03.	Weighted separations, outpatient occasions of service, other admitted care .	No. of FTE staff, non-labour costs and gross asset values	None.	None.
Biørn et al (2003)	Unspecified no. of Norwegian hospitals between 1992 and 2000.	Casemix-adjusted separations, fee-weighted outpatient visits .	No. of FTE physicians, no. of other FTE staff, medical costs, total expenses.	Dummies for funding source, university affiliation and location.	None.

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Table B.1 (continued)

Author(s) and year published	*No. of hospitals and year(s)*	*Dependent variable*	*Independent variables*	*External factors*	*Quality or patient safety*
Hofmarcher, Paterson, and Riedel (2002)	93 Austrian hospitals between 1994 and 1996.	Patient days, no. of discharges, LDF points.	No. of medical staff, no. of para-medical staff, no. of admin. staff, no. of beds, no. of wards, Index of casemix complexity.	None.	None.
Al Shammari (1999)	15 Jordanian hospitals, 1991–1993.	Patient days, minor operations, major operations.	No. of physicians, no. of health personnel, no. of bed days.	None.	None.
Wang and Mahmood (2000b)	113 NSW public hospitals for 1997.	Inpatient casemix index, inpatient admissions, outpatient visits, ER visits.	No. of doctors, no. of nurses, no. of non-medical staff, no. of beds, other expenses.	None.	ALOS of acute separations.
Webster, Kennedy, Johnson (1998)	301 private hospitals for 1994-95.	Inpatient days, surg. days, non-patient services, nursing home days, surgery procedures, inpatient separations, ER visits, comp. output.	No. of FTE medical staff, contract value of visiting medical officers, no. of FTE nurses, no. of FTE other staff, no. of beds, cost of materials.	None.	None.
Burgess and Wilson (1998)	2420 US hospitals with 100+ beds, 1985 to 1988.	Acute inpatient days, casemix-adjusted discharges, long-term care days, no. of outpatient visits, ambulatory surgeries, inpatient surgeries.	No. of registered nurses, no. of practice nurses, no. of other clinical staff, no. of non-clinical staff, no. of acute beds, no. of long-term beds, casemix index.	None.	None.
O'Neill (1998)	40 Philadelphia and Pittsburgh hospitals (27 urban and 13 teaching) with 300+ beds in 1992.	Casemix-adjust. inpatient medical separations, casemix-adjust. inpatient surgical separations, casemix-adjust. outpatients, no. of trained residents.	No. of FTE staff, no. of beds, operational expenditure (excluding payroll and capital).	Capital intensity index for specialist units.	None.
SCRCSSP (1997)	109 Victorian public hospitals for 1994-95.	Three categories of WIES outputs.	No. of FTE non-medical staff, no. of FTE medical staff, all FTE staff, non-salary costs, medical salaries, total salaries.	None.	Unplanned readmission rates.
Ferrier and Valdmanis (1996)	360 US rural hospitals for 1989.	No. of acute days, subacute days, no. of intensive days, no. of surgeries, discharges, outpatients	No. of FTE staff, no. of beds, size, regional location, ownership.	None.	Occupancy rate.

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Table B.1 (continued)

Author(s) and year published	*No. of hospitals and year(s)*	*Dependent variable*	*Independent variables*	*External factors*	*Quality or patient safety*
Morey and Dittman (1996)	105 North Carolina hospitals in 1978.	No. of patient days for persons aged under 14, patient days for persons aged 14 to 65, patient days for persons aged over 65.	Cost of nursing services, cost of ancillary services, cost of administration and general services.	No. of intensive-care beds, acute beds and other beds, percent each of intensive-care patient days, intensive or acute-care patient days, capital value of hospital.	None.
Bedard and Wen (1990)	58 New York and West Pennsylvania hospitals, 1974 to 1979.	No. of inpatient separations, no. of surgical operations, no. of outpatient visits.	No. of FTE staff, no. of beds; cost of labour, non-payroll expenditure.	None.	None.
Färe, Grosskopf and Valdmanis (1989)	39 Michigan hospitals with 200+ beds in 1982.	No. of acute care patients, no. of ICU patients, no. of emerg. patients, and no. of surgeries.	No. of doctors, no. of FTE non-doctor staff, no. of admissions, no. of beds.	None.	None.
Borden (1988)	52 New Jersey hospitals, 1979 to 1984.	No. of cases treated for high most common diagnosis-related groups (DRGs), all other DRG separations combined.	No. of total FTE staff, no. of FTE nurses, no. of beds, other non-payroll expenses.	None.	None.
Multi-output production function with some outputs defined as undesirable – Data envelopment analysis					
Clement et al. (2008)	667 hospitals from 10 US states for 2000.	No. of births, outpatient surgeries, ER visits, outpatient visits, casemix-adjusted admissions.	No. of FTE registered nurses, no. of FTE practice nurses, no. of other FTE staff, no. of beds, and capital.	None.	Risk-adjusted acute myocardial infarction (AMI), congestive heart failure, stroke, gastrointestinal haemorrhage, pneumonia.
Multi-output production function – Stochastic distance function					
Ferrari (2006)	52 Scottish public hospitals for 1991-92 to 1996-97.	Inpatients index, outpatients and other services index.	No. of medical staff, no. of nursing staff, no. of other staff, no. of beds, capital.	None.	None.

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Table B.1 (continued)

Author(s) and year published	*No. of hospitals and year(s)*	*Dependent variable*	*Independent variables*	*External factors*	*Quality or patient safety*
Siciliani (2006)	17 Italian hospitals between 1996 and 1999.	No. of discharges, surgical discharges, medical discharges.	No. of physicians and nurses, no. of other personnel, no. of beds.	None.	None.
Paul (2002)	223 NSW public hospitals in 1995-96.	No. acute inpatient seps, non- and sub-acute bed-days, occasions of service, Inpatient seps separated into public and private, and were unweighted.	No. of FTE staff, no. of beds, capital, cost of materials, no. of services, no. of diagnoses.	Research, rurality, index of education and occupation, teaching.	Standardised mortality ratio.
Löthgren (2000)	26 Swedish county hospitals, 1989–1994.	No. of operations, no. of physician visits, no. of inpatient admissions.	Cost expenditure, no. of beds.	None.	None.
Gerdtham, Löthgren, Tambour and Rehnberg (1999)	26 Swedish county hospitals, 1989–1995.	No. of operations, no. of physician visits, no. of inpatient admissions.	Cost expenditure, no. of beds.	Reimbursement mechanism, university hospital status, patient age.	None.
Grosskopf, Margaritis and Valdmanis (1995)	108 not-for-profit and public hospitals in California and New York in 1982.	No. of acute patient days, no. of intensive care inpatient days, no. of inpatient and outpatient surgeries, no. of ER visits.	No. of physicians, no. of FTE non-medical staff, net plant assets.	None.	None.
Malmquist productivity change (including when some outputs are undesirable)					
Weng et al. (2009)	65 Iowa hospitals between 2001 and 2005.	Average speeds of: treatment per case, swing bed service, no. of admitted patients, no. of swing bed patients.	No. of staff members, no. of available beds.	None.	None.
Arocena and Garcia-Prado (2007)	20 Costa Rican public hospitals between 1997–2001.	No. of casemix-adjusted discharges, no. of casemix-adjust. outpatient services.	No. of FTE physicians, no. of FTE nurses, no. of beds, expenditure on goods and services.	None.	No. of casemix-adjusted hospital readmissions.
Chen (2006)	40 Taiwanese public and private hospitals.	No. of seps, no. of surgeries, no. of intensive cares, no. outpatient visits.	No. of doctors, no. of nurses, no. of beds, cost of other medical supplies, no. of doctors and nurses per department.	Second stage regression of public status, severity of illness, Herfindahl index.	ALOS and occupancy rate in a second-stage regression.
Sola and Prior (2001); Prior (2006)	8 private and 12 public hospitals for 1990–1993.	No. of acute days, no. of long stay days, intensive days, no. of visits.	No. of FTE health staff, no. of FTE other staff, no. of beds, cost of materials.	None.	No. of infections.
Maniadakis and Thanassoulis (2000)	75 Scottish hospitals for 1991-92 to 1995-96.	No. of ER patients, no. of inpatients, no. of day cases, no. of outpatients.	No. of doctors, no. of nurses, no. of other staff, no. of beds, cubic metre floor space.	None.	None.

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Table B.1 (continued)

Author(s) and year published	*No. of hospitals and year(s)*	*Dependent variable*	*Independent variables*	*External factors*	*Quality or patient safety*
Webster, Kennedy, Johnson (1998)	280 private hospitals for 1991-92 to 1994-95.	No. of occupied bed days.	No. of FTE staff, no. of beds, cost of materials.	None.	None.
Linna (1998)	Finnish hospitals from 1988 to 1994.	No. of inpatient admissions, no. emergency visits.	Hourly wage index, index on local government expenditure, time.	R and D variable, teaching dummy.	Readmission rate.
Färe, Grosskopf, Lindgren and Poullier (1997)	19 OECD countries from 1974 to 1989.	No. of bed days, no. of discharges.	No. of physicians, no. of beds; No. of physicians per person, beds per person.	None.	Life expectancy for women over 40, reciprocal of infantry mortality rate.
Burgess and Wilson (1995)	1545 profit, non-profit, Veterans Affairs and Local Govt hospitals for 1985–1988.	No. of inpatient days, no. of casemix separations, no. of long stay days, no. of outpatients, no. of ER surgeries, no. of inpatient surgeries.	No. of registered and practice nurses, no. of other clinical staff, no. of non-clinical staff, no. of acute and long-term beds, value of capital, casemix severity.	None.	None.

B.2 Previous studies on the relationship between hospital efficiency and quality

Table B.2 **Selected literature review — hospital volume and mortality**

Author	*Sample*	*Procedure or condition*	*Dependent variable*	*Independent variables*	*Results*
Aujesky et al. (2008)	15 531 hospital patients in Pennsylvania, between Jan. 2000 and Nov. 2002.	Pulmonary embolism.	In-hospital mortality, 30 day mortality, time to hospital discharge	Hospital region, hospital teaching status, race, insurance status, severity of illness according to the pulmonary embolism severity, administration of thrombolytic therapy.	In hospitals with a high volume of cases, pulmonary embolism was associated with lower short-term mortality.
Birkmeyer et al. (2002)	U.S. Medicare patients — 2.5 million procedures, between 1994 and 1999.	Six cardiovas-cular procedures, eight types of cancer resection.	Mortality.	Age group, sex, race (black or non-black), year, urgency of admission (elective, urgent or emergency), coexisting conditions and mean income from Social Security.	Mortality decreased as volume increased for all 14 types of procedures, but the relative importance of volume varied markedly according to the type of procedure.

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Table B.2 (continued)

Author	*Sample*	*Procedure or condition*	*Dependent variable*	*Independent variables*	*Results*
Birkmeyer, Dimick and Staiger (2006)	U.S. Medicare patients, between 1994 and 1997.	Major resections for lung, oesophagel, gastric, liver or pancreatic cancer.	Risk-adjusted 30 day mortality.	Age group, sex, race (black or non-black), year, urgency of admission (elective, urgent or emergency), cancer type, comorbidities.	Procedure volume explained 50 per cent of variation in mortality for pancreatic cancer resection, but only 26 per cent for abdominal aortic aneurysm repair and 9 per cent for coronary artery bypass graft surgery. (Sample size for oesophageal cancer resection too small.)
Finlayson, Goodney and Birkmeyer (2003)	All patients in U.S. National Inpatient Sample undergoing target procedures (195 152 procedures), 1995-1997.	8 cancer resections.	Risk-adjusted in-hospital mortality.	Age group, sex, race (black or non-black), year, urgency of admission (elective, urgent/emergent), comorbidities and median Social Security income.	Statistically significant volume–outcome relationship for oesophagectomy, pancreatic resection and pulmonary lobotomy. Insignificant relationship for other procedures. Volume most important for older, higher-risk patients.
Glance et al. (2007)	243 000 patients in California, between 1998 to 2000.	Impact of regionalising delivery of three procedures based on volume.	Risk-adjusted mortality.	Disease stage, age, gender, transfer status, admission type (elective or non-elective).	Selective referral to high-volume centres reduces the number of hospitals treating these conditions by 70–99 per cent and would reduce mortality by 2–20 per cent. Selective avoidance of low quality hospitals also reduces mortality by 2–6 per cent.
Kahn et al. (2006)	20 241 patients in 37 hospitals	Non-surgical patients receiving mechanical ventilation.	Intensive care unit mortality and in-hospital mortality.	APACHE II score (includes patient's age, comorbidities, physiological condition)	High-volume hospitals are associated with improved survival in the ICU and in the hospital.
Khuri et al. (1999)	68 631 operations in U.S. Veterans' Affairs hospitals, between Oct. 1991 and Dec. 1993.	Eight major surgical procedures in vascular, orthopaedic, non-cardiac thoracic and general surgery.	Risk-adjusted 30-day mortality rate (30-day stroke rate for one procedure — carotid endarte-rectomy)	Emergency status, age, race and a range of comorbidities.	No association between procedure or specialty volume and mortality rate (or stroke rate for carotid endarterectomy)
Urbach and Baxter (2004)	31 632 patients in Ontario, between April 1994 to March 1999.	Five complex surgical procedures, including major lung resection and oeso-phagectomy.	Death within 30 days.	Age, sex, comorbidity.	Volume–outcome association for lung resection and abdominal aortic aneurysm repair, but not for oesophagectomy, pancreaticoduodenectomy or colorectal resection.

Table B.3 Selected literature reviews and meta-analyses — hospital volume and mortality

Author	*Number of relevant studies (number of patients)*	*Procedure or condition*	*Increased volume associated with reduced mortality — hospitals*	*Increased volume associated with reduced mortality — doctors*	*Other findings*
Chowdhury, Dagash and Pierro (2007)	1075 studies of which 163 fulfilled entry criteria (9.9 million patients).	42 surgical procedures.	No.	Yes (surgeons).	Surgeon specialization associated with improved patient outcomes.
Gandjour, Bannenberg and Lauterbach (2003)	552 studies of which 76 fulfilled entry criteria.	34 diagnoses and interventions.	Yes.	Yes.	None.
Gruen et al. (2009)	137 studies (1.1 million patients).	Surgery for five types of cancer.	Yes, for short-term mortality, in two-thirds of studies (i.e. significant but not robust).	Insufficient evidence	Only 8 per cent of studies accounted sufficiently for confounders in estimating the size of the volume effect.
Halm, Lee and Chassin (2002)	272 studies of which 135 fulfilled entry criteria.	27 procedures and conditions.	Yes, in 71 per cent of studies. Studies which conducted risk-adjustment with clinical data \were less l kely to find a significant association.	Yes, in 69 per cent of studies.	Magnitude of the volume–outcome association varies greatly between studies. Unexplained case-mix differences may account for the observed relationships.

Table B.4 Other relevant studies — hospital volume and mortality

Author(s) and year published	*Focus of the study*	*Number of relevant studies (number of patients)*	*Results*
Devereaux, Choi et al. (2002)	Comparison of mortality in private for-profit and private not-for-profit hospitals.	805 studies of which 15 fulfilled entry criteria (38 million patients, 26 000 hospitals).	Lower risk of mortality in private not-for-profit centres (compared to private for-profit centres).
Devereaux, Schünemann et al. (2002)	Comparison of mortality in private for-profit and private not-for-profit haemodialysis centres.	779 studies of which 8 fulfilled entry criteria (500 000 patients, 11 000 hospitals).	Lower risk of mortality in private not-for-profit centres (compared to private for-profit centres).

Table B.5 **Selected patient-level mortality-related studies**

	No. of hospitals and year(s)	*Dependent variables*	*Independent variables*
Chua, Palangkaraya and Yong (2008)	130 Victorian public and private hospital admitted patients with heart disease, 2000-01 to 2004-05.	Aggregate index of standardised hospital mortality rate	No. of episodes of care, proportion with: heart disease, admissions via emerg. department, old, with high Charlson score, and with private health insurance. Dummies for hospital location and status
Jensen, Webster and Witt (2007)	130 Victorian public and private hospitals admitted patients with heart disease, 1996 to 2005.	Readmission for AMI within 6 months, or death within 30 days of admission, mortality within 30 days of an unplanned 6-month readmission.	Charlson comorbidity index, gender, country of birth, Indigenous status, marriage status, SEIFA index, hospital status (private, public teaching, public non-teaching).
Dormont and Milcent (2004)	36 French public hospitals, 1994–1997.	Average cost per stay, for acute myocardial infarction	Gender, age profile, length of stay, hospital admission, home admission, methods of treatment.