

Supplementary data

Table 1. Study characteristics

Number, author, year • Key findings	Study design	Country	Period	Data source	Patients	Unit	Low	High	Outcomes	Reported data
1. Browne, 2009 • Higher hospital volume is not associated with mortality, but it is with nonfatal morbidity and length of stay +/- • Higher surgeon volume is associated with decreased mortality +	RCS	USA	1998–2002	NIHS	97,894	Hospital Surgeon	< 57 < 7	> 132 > 15	In-hospital mortality, complications Some as above	OR OR
2. Castronuovo, 2011 • Higher hospital volume is not associated with mortality –	PCS	Italy	2006	RHD	6,896	Hospital	≤ 45	> 200	30-day mortality	HR
3. Elkassabany, 2016 • Higher case volumes are associated with lower rates of readmission and mortality +	RCS	USA	2007–2009	RHD	458,526	Hospital	< 13	> 175	Readmission to an acute care hospital for any cause within 30 days, death at 30 days, readmission at 30 days	OR
4. Flood, 1984 • No association between hospital volume and mortality –	PCS	USA	1972	CPHA	52,368	Hospital	≤ 44.8	> 44.8	In-hospital mortality	SMR
5. Forte, 2010 • Only the highest volume hospitals showed an inpatient mortality benefit +	PCS	USA	2000–2002	MPA	192,365	Hospital Surgeon	1–17 1–4	≥ 79 ≥ 18	In-hospital mortality, 30/60/90-day mortality In-hospital mortality, 30/60/90-day mortality	RR RR
6. Franzo, 2005 • High hospital volume was associated with worse outcomes + (inverse)	RCS	Italy	1996–2000	DR	6,629	Hospital	< 45	> 400	In-hospital mortality, 6 months, 1 year mortality	OR
7. Genuario, 2008 • Moderate volume had the lowest odds of death, LOS was shortest in high volume, complication rates were similar +/-	RCS	USA	1997–2003	NTDB	9368	Hospital	1–23	> 60	In-hospital mortality, complications, LOS	OR
8. Guida, 2016 • No association between hospital volume and mortality –	CSS	Italy	2014	NOE	69,134	Hospital	–	–	(continuous) 30-day mortality	Spearman
9. Hamilton, 1997 • Higher volume is associated with higher probability to live +	PCS	Canada	1991–1993	DR	7383	Hospital	< 34	> 71	In-hospital mortality, LOS	MR
10. Hamilton, 1998 • Hospitals performing more surgeries experienced no significant improvements in outcomes –	PCS	Canada	1990–1993	DR	7483	Hospital	≤ 32	≥ 73	In-hospital mortality, LOS	MR
11. Hentschker, 2015 • Higher case volumes have on average a significant lower probability to die +	PCS	Germany	2007	DR	7980	Hospital	10–58	151–387	In-hospital mortality	OR
12. Hughes, 1988 • Mutual causality between volume of hip fracture patients and outcomes +	PCS	USA	1982	CPHA	44,905	Hospital	–	–	(continuous) In-hospital mortality, LOS	Coefficient
13. Kristensen, 2014 • Patients admitted to high-volume centers had higher mortality rates, lower quality and longer LOS + (inverse)	PCS	Denmark	2011–2011	DMHFR	12,065	Hospital	≤ 151	≥ 351	30-day mortality, time to surgery, LOS, quality indicators	OR
14. Lavernia, 1998 • Higher surgeon volume was significantly associated with LOS +	PCS	USA	1992	DR	5,604	Surgeon	≤ 10	> 30	In-hospital mortality, LOS, complications	p-value
15. Maceroli, 2016 • High-volume centers are associated with lower mortality and complication rates +	RCS	USA	2000–2010	SPARCS	3,986	Hospital	< 47	> 171	30-day/1-year mortality, 90-day complication rate	HR
16. Metcalfe, 2016 • Time to operation and LOS were prolonged in low-volume centers, no differences in clinical outcomes +/-	16 RCS	USA	2007–2011	DR	91,401	Hospital	< 20	> 215	In-hospital mortality, LOS, complications	OR
17. Nimptsch, 2018 • No relation between volume and outcome observed –	RCS	Germany	2009–2014	DR	710,962	Hospital	< 64	≥ 283	In-hospital mortality	OR

Table 1 continued

Number, author, year • Key findings	Study design	Country	Period	Data source	Patients	Unit	Low	High	Outcomes	Reported data
18. Okike, 2017 • Hospital volume did not influence observed rates of mortality and postoperative morbidity –	PCS	USA 2013	2010–	KPHFR	14,294	Hospital	< 125	≥ 187	30-, 90-, 1-year mortality, postoperative morbidity (lifetime reoperation, 90-day medical complications, and 30-day unplanned readmission)	OR
• Mortality and postoperative morbidity rates did not differ by surgeon volume –						Surgeon	< 14	≥ 62	Some as above	OR
19. Riley, 1985 • The results indicate an association between higher surgeon volume and mortality +	PCS	USA 1980	1979–	HCFA	20,161	Surgeon	< 4	> 9	60-day mortality	Coefficients
20. Shah, 2005 • Low-volume hospitals were associated with prolonged LOS and higher complication rates +	PCS	USA 2000	1988–	NIHS	173,508	Hospital	1–19	≥ 62	In-hospital mortality, complication rates, LOS OR	
• Low-volume surgeons were associated with higher mortality and prolonged LOS +						Surgeon	1–3	≥ 12	Same as above	OR
21. Sund, 2010 • There are no indications that patients benefit from high-volume centers –	PCS	Finland 2001	1998–	FHCR	22,857	Hospital	–	–	(continuous) 4-month mortality	Graphical
22. Takahashi, 2011 • Patients treated in higher-volume hospitals have shorter length of postoperative hospital stay +	PCS	Japan	2006	DR	8,920	Hospital	< 28	≥ 28	Postoperative LOS	OR
23. Treskes, 2017 • High hospital volume is associated with fewer operations and surgical site infections +	PCS	The Netherlands 2013	2010–	TR	4,552	Hospital	< 96	> 170	Complications	OR
• Surgeon volume is not associated with fewer operations and surgical site infections –						Surgeon	< 15	> 25	Complications	OR
24. Van Laarhoven, 2015 • Level II centers had shorter time to operation, shorter LOS, complication rate was lower and mortality was lower +	RCS	The Netherlands	2008– 2012	DR	1,629	Hospital	–	–	In-hospital mortality, c omplications, time to operative treatment	p-value

Abbreviations:
CPHA = Commission of Professional Hospital Activities
CSS = cross-sectional study
DR = discharge register
FHCR = Finnish Health Care Register
HCFA = Health Care Financing Administration
KPHFR = Kaiser Permanente Hip Fracture Registry
LOS = Length of stay
MPA = Medicare provider analysis
NIHS = nationwide inpatient sample database
NOE = National Outcome Evaluation Program Edition
NTDB = National Trauma Data Bank
PCS = prospective cohort study
RCS = retrospective cohort study
RHD = regional hospital discharge
SMR = standardized mortality ratio
SPARCS = Statewide Planning and Research Cooperative System
TR = Trauma Registry

Study	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1. Browne	+	+	+	+	-	+	+	+	+	-	+	+	+	+	-	-
2. Castronuovo	+	-	+	+	+	+	+	-	+	-	+	+	+	+	+	+
3. Elkassabany	+	-	+	+	-	+	+	-	+	-	+	+	+	+	+	+
4. Flood	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	+
5. Forte	+	+	+	+	-	+	+	+	+	-	+	+	+	+	-	+
6. Franco	+	-	+	+	+	+	+	-	+	-	+	+	+	+	-	+
7. Genuario	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+
8. Guida	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
9. Hamilton 1997	+	-	+	+	-	+	-	-	-	-	-	-	-	-	-	+
10. Hamilton 1998	+	-	+	+	-	+	+	-	+	-	+	+	+	+	-	+
11. Hentschker	+	+	+	+	+	+	+	-	+	-	+	+	+	+	-	+
12. Hughes	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
13. Kristensen	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	-
14. Lavernia	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-
15. Maceroli	+	-	+	+	+	+	+	-	+	-	+	+	+	+	+	+
16. Metcalfe	+	-	+	+	+	+	+	-	+	-	+	+	+	+	+	+
17. Nimptsch	-	+	+	+	+	-	+	-	-	+	+	+	+	+	-	+
18. Okike	+	-	+	+	-	+	+	-	+	-	+	+	+	+	+	+
19. Riley	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-
20. Shah	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+
21. Sund	-	+	+	+	-	-	-	-	-	-	-	-	-	-	+	+
22. Takahasi	+	+	+	+	-	+	+	-	+	-	+	+	+	+	-	+
23. Treskes	+	-	+	+	+	+	+	+	+	-	+	+	+	+	+	+
24. Van Laarhoven	+	-	+	+	+	-	-	-	-	-	-	-	-	-	+	-

A.	Inclusion and exclusion criteria clearly described?
B.	Nationwide?
C.	Population-based?
D.	Total number of hip fracture patients reported?
E.	Number of patients per volume group reported?
F.	Cut-off volume groups clearly reported?
G.	OR/HR hospital-volume reported?
H.	OR/HR surgeon-volume reported?
I.	OR/HR reported + 95% confidence intervals?
J.	Crude ORs/HRs reported?
K.	Adjust ORs/HRs reported?
L.	All confounders used in adjusted OR/HR clearly reported?
M.	Adjust for patients demographic characteristics?
N.	Adjust for comorbidity?
O.	No conflict of interest declared?
P.	Funding sources identified?

Search strategy

Search results January 30, 2018

	Total	Removed duplicated
Embase.com	2,681	2,622
Medline Ovid	2,615	677
Web of science	2,979	1,374
Cochrane CENTRAL	706	527
Google scholar	200	163
Total	9,181	5,363

Embase.com

('high volume hospital'/exp OR 'low volume hospital'/exp OR (((volume*) NEAR/3 (high OR low OR surg* OR hospital* OR critical-patient* OR severe-patient* OR trauma-patient* OR emergen*-patient* OR centre* OR center*)) OR ((number-of) NEXT/1 (critical-patient* OR severe-patient* OR trauma-patient* OR emergen*-patient*)) OR ((high* OR low*) NEXT/1 exposure*) OR (size NEAR/3 (department* OR hospital* OR centre* OR center*)) OR caseload* OR case-load* OR (volume* NEAR/3 outcome*) OR patient-volume* OR 'volume of patients':ab,ti) AND ('emergency'/de OR traumatology/exp OR 'emergency care'/de OR 'emergency health service'/exp OR 'emergency patient'/exp OR 'emergency ward'/exp OR 'emergency medicine'/exp OR burn/de OR 'burn unit'/de OR 'fracture'/exp OR accident/exp OR 'accidental injury'/exp OR injury/mj OR 'blunt trauma'/exp OR 'penetrating trauma'/exp OR 'crush trauma'/de OR 'multiple trauma'/de OR 'head and neck injury'/exp OR 'limb injury'/exp OR 'sport injury'/exp OR 'thorax injury'/de OR 'abdominal injury'/de OR 'nervous system injury'/exp OR ((emergen* NEAR/3 (centre* OR center* OR ward* OR patient* OR admitt* OR department* OR room*)) OR trauma* OR neurotrauma* OR multitrauma* OR burn* OR fracture* OR accident* OR (acute* NEAR/3 care) OR ((accidental OR blunt OR penetrating OR crush OR multiple OR head OR neck OR limb OR sport* OR athlet* OR thora* OR abdom* OR brain*) NEAR/3 injur*) OR (ED NEAR/3 patient*)):ab,ti) AND ('treatment outcome'/exp OR 'hospital admission'/exp OR 'hospital discharge'/de OR hospitalization/de OR 'mortality'/exp OR 'fatality'/exp OR 'survival'/exp OR 'length of stay'/de OR 'convalescence'/de OR (outcome* OR (admiss* NEAR/3 ('intensive care' OR icu OR icus OR hospital*)) OR mortalit* OR fatal* OR surviv* OR discharge* OR ((length OR duration* OR long* OR short*) NEAR/6 stay) OR recover* OR convalescen* OR hospitalization* OR hospitalisation* OR ((treat* OR management* OR therap*) NEAR/3 (fail* OR succes*)):ab,ti) NOT ([animals]/lim NOT [humans]/lim) NOT ([Conference Abstract]/lim OR [Letter]/lim OR [Note]/lim OR [Editorial]/lim) AND [english]/lim

Medline Ovid

("Hospitals, High-Volume"/ OR "Hospitals, Low-Volume"/ OR (((volume*) ADJ3 (high OR low OR surg* OR hospital* OR critical-patient* OR severe-patient* OR trauma-patient* OR emergen*-patient* OR centre* OR center*)) OR ((number-of) ADJ3 (critical-patient* OR severe-patient* OR trauma-patient* OR emergen*-patient*)) OR ((high* OR low*) ADJ3 exposure*) OR (size ADJ3 (department* OR hospital* OR centre* OR center*)) OR caseload* OR case-load* OR (volume* ADJ3 outcome*) OR patient-volume* OR "volume of patients".ab,ti,kf.) AND (exp "Emergencies"/ OR traumatology/ OR "Emergency Treatment"/ OR exp "Emergency Medical Services"/ OR "Emergency Medicine"/ OR exp burns/ OR "Burn Units"/ OR exp "Fractures, Bone"/ OR exp accidents/ OR * "Wounds and Injuries"/ OR "Wounds, Nonpenetrating"/ OR exp "Wounds, Penetrating"/ OR "multiple trauma"/ OR exp "Cranio-cerebral Trauma"/ OR "Neck Injuries"/ OR "Extremities"/in OR "Athletic Injuries"/ OR exp "thorax"/in OR exp "Abdominal Injuries"/ OR exp "Trauma, Nervous System"/ OR ((emergen* ADJ3 (centre* OR center* OR ward* OR patient* OR admitt* OR department* OR room*)) OR trauma* OR neurotrauma* OR multitrauma* OR burn* OR fracture* OR accident* OR (acute* ADJ3 care) OR ((accidental OR blunt OR penetrating OR crush OR multiple OR head OR neck OR limb OR sport* OR athlet* OR thora* OR abdom* OR brain*) ADJ3 injur*) OR (ED ADJ3 patient*)):ab,ti,kf.) AND (exp "treatment outcome"/ OR exp hospitalization/ OR exp "mortality"/ OR mortality.xs. OR "Fatal Outcome"/ OR exp "survival"/ OR "length of stay"/ OR "convalescence"/ OR (outcome* OR (admiss* ADJ3 ("intensive care" OR icu OR icus OR hospital*)) OR mortalit* OR fatal* OR surviv* OR discharge* OR ((length OR duration* OR long* OR short*) ADJ6 stay) OR recover* OR convalescen* OR hospitalization* OR hospitalisation* OR ((treat* OR management* OR therap*) ADJ3 (fail* OR succes*)):ab,ti,kf.) NOT (exp animals/ NOT humans/) NOT (letter OR news OR comment OR editorial OR congresses OR abstracts).pt. AND english.la.

Cochrane CENTRAL

(((((volume*) NEAR/3 (high OR low OR surg* OR hospital* OR critical-patient* OR severe-patient* OR trauma-patient* OR emergen*-patient* OR centre* OR center*)) OR caseload* OR case-load* OR (volume* NEAR/3 outcome*) OR patient-volume* OR 'volume of patients':ab,ti) AND (((emergen* NEAR/3 (centre* OR center* OR ward* OR patient* OR admitt* OR department* OR room*)) OR trauma* OR neurotrauma* OR multitrauma* OR burn* OR fracture* OR accident* OR (acute* NEAR/3 care) OR ((accidental OR blunt OR penetrating OR crush OR multiple OR head OR neck OR limb OR sport* OR athlet* OR thora* OR abdom* OR brain*) NEAR/3 injur*) OR (ED NEAR/3 patient*)):ab,ti) AND ((outcome* OR (admiss* NEAR/3 ('intensive care' OR icu OR icus OR hospital*)) OR

mortalit* OR fatal* OR surviv* OR discharge* OR ((length OR duration* OR long* OR short*) NEAR/6 stay) OR recover* OR convalescen* OR hospitalization* OR hospitalisation* OR ((treat* OR management* OR therap*) NEAR/3 (fail* OR succes*)):ab,ti

Web of science

TS=(((volume*) NEAR/2 (high OR low OR surg* OR hospital* OR critical-patient* OR severe-patient* OR trauma-patient* OR emergen*-patient* OR centre* OR center*)) OR ((number-of) NEAR/1 (critical-patient* OR severe-patient* OR trauma-patient* OR emergen*-patient*)) OR ((high* OR low*) NEAR/1 exposure*) OR (size NEAR/2 (department* OR hospital* OR centre* OR center*)) OR caseload* OR case-load* OR (volume* NEAR/2 outcome*) OR patient-volume* OR "volume of patients")) AND (((emergen* NEAR/2 (centre* OR center* OR ward* OR patient* OR admiss* OR admitt* OR department* OR room*)) OR trauma* OR neurotrauma* OR multitrauma* OR burn* OR fracture* OR acci-

dent* OR (acute* NEAR/2 care) OR ((accidental OR blunt OR penetrating OR crush OR multiple OR head OR neck OR limb OR sport* OR athlet* OR thora* OR abdom* OR brain*) NEAR/2 injur*) OR (ED NEAR/2 patient*))) AND ((outcome* OR (admiss* NEAR/2 ("intensive care" OR icu OR icus OR hospital*)) OR mortalit* OR fatal* OR surviv* OR discharge* OR ((length OR duration* OR long* OR short*) NEAR/5 stay) OR recover* OR convalescen* OR hospitalization* OR hospitalisation* OR ((treat* OR management* OR therap*) NEAR/2 (fail* OR succes*))))) AND DT=(article) AND LA=(english)

Google Scholar

"highlow volume" emergency centres|centers|wards|patients|departments"|trauma|neurotrauma|multitrauma|burn|fractures|accidents|"acute care" outcome|"care|icu|hospital admission"|mortality|fatallsurvival|discharge|"length*stay"|recovery|hospitalization