What is already known on this topic

The number of convictions for homicide has increased in the past 30 years

In that time the number of mental hospital beds has been reduced by more than half, as part of "care in the community"

What this study adds

Perpetrators of stranger homicide are less likely to have a mental illness or to have been under mental health care than perpetrators of homicides in general

Stranger homicides are most commonly committed by young men and the victims are usually men

Stranger homicides are more likely to occur as a result of physical fights or attacks

Perpetrators of stranger homicides are most often under the influence of alcohol or drugs

Funding: The National Confidential Inquiry into Suicide and Homicide by People with Mental Illness is funded by the National Institute for Clinical Excellence.

Contributors: JS, TA, and LA contributed to the design, data collection, data analysis, and drafting the paper. JS and LA are grant holders on the project. IH, SF, PT, and NK contributed to data collection and analysis and drafting the paper. JS will act as guarantor for the paper. The guarantor accepts full responsibility for the conduct of the study, had access to the data, and controlled the decision to publish.

Competing interests: LA is currently seconded part time to the Department of Health as National Director for Mental Health and in this capacity provides advice on mental health policy.

Ethical approval: This study was approved by the multi-centre research ethics committee.

1 *Criminal Statistics England and Wales; 1999.* London: Stationery Office, 2000.
2 Thornicroft G, Strathdee G. How many psychiatric beds? *BMJ* 1994;308:816-9.
3 Ritchie JH, Dick D, Lingham R. *The report of the inquiry into the care and treatment of Christopher Clunis.* London: HMSO, 1994.
4 Petch E, Bradley C. Learning the lessons from homicide inquiries: adding insult to injury? *J For Psych* 1997;8:161-84.
5 Taylor PH, Gunn J. Homicides by people with mental illness: myth and reality. *Br J Psychiatry* 1999;174:9-14.
6 Phelan JC, Link BG. The growing belief that people with mental illnesses are violent; the role of the dangerousness criterion for civil commitment. *Soc Psychiatry Psychiatr Epidemiol* 1998;33:S7-12.
7 Appleby L, Shaw J, Amos T, Robinson J, McCann K, Parsons R, et al. *Safety first. The national confidential inquiry into suicide and homicide by people with mental illness.* London: Department of Health, 2001.
8 Shaw J, Appleby L, Amos T, McDonnell R, Harris C, McCann K, et al. Mental disorder and clinical care in people convicted of homicide: national clinical survey. *BMJ* 1999;318:1240-4.

(Accepted 21 January 2004)

Does it matter what a hospital is "high volume" for? Specificity of hospital volume-outcome associations for surgical procedures: analysis of administrative data

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Abstract

Objective To determine whether the improved outcome of a surgical procedure in high volume hospitals is specific to the volume of the same procedure.
Design and setting Analysis of secondary data in Ontario, Canada.
Participants Patients having an oesophagectomy, colorectal resection for cancer, pancreaticoduodenectomy, major lung resection for cancer, or repair of an unruptured abdominal aortic aneurysm between 1994 and 1999.
Main outcome measures Odds ratio for death within 30 days of surgery in relation to the hospital volume of the same surgical procedure and the hospital volume of the other four procedures. Estimates were adjusted for age, sex, and comorbidity and accounted for hospital level clustering.
Results With the exception of colorectal resection, 30 day mortality seemed to be inversely related not only to the hospital volume of the same procedure but also to the hospital volume of most of the other procedures. In some cases the effect of the volume of a different procedure was stronger than the effect of the volume of the same procedure. For example, the association of mortality from pancreaticoduodenectomy with hospital volume of lung resection (odds ratio for death in hospitals with a high volume of lung resection compared with low volume 0.36, 95% confidence interval 0.23 to 0.57) was much stronger than the association of mortality from pancreaticoduodenectomy with hospital volume of pancreaticoduodenectomy (0.76, 0.44 to 1.32).
Conclusion The inverse association between high volume of procedure and risk of operative death is not specific to the volume of the procedure being studied.

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BMJ 2004;328:737–40

Introduction

Evidence that the short term outcomes of complex surgical procedures are better in hospitals that do high volumes of such procedures has prompted some

ELPS *This is the abridged version of an article that was posted on bmj.com on 12 March 2004: http://bmj.com/cgi/doi/10.1136/bmj.38030.642963.AE*

authors to suggest that high risk surgery should be regionalised at high volume hospitals.[1–5] Health policy measures advocating volume based regionalisation are, for the most part, predicated on the overwhelming empirical evidence of hospital volume-outcome associations.[6] In general, policy initiatives have proposed that patients needing certain high risk surgical procedures should have them done in a hospital that performs a large volume of similar procedures.

The findings of volume-outcome studies are usually interpreted in the light of the conceptual framework of quality in health care: structures, processes, and outcomes.[7] High volume hospitals are assumed to have structural characteristics associated with better quality of care, and providers in these hospitals are thought to improve their processes of care through experience in providing complex care. Central to this framework is an implied linkage between the volume of a specific surgical procedure done in a hospital and the outcome of the same surgical procedure. The finding of improved outcome after pancreaticoduodenectomy in high volume hospitals has been uniformly attributed to the high volume of pancreaticoduodenectomy,[3 8–10] not the volume of a different complex procedure, the volume of all complex procedures, or other hospital characteristics.

We sought to answer the question of whether the improved outcome observed in high volume hospitals was unique to the volume of the procedure of which the outcome is being assessed.

Methods

Sources of data

We used abstracted electronic records to identify hospital separations in Ontario, Canada, between 1 April 1994 and 31 March 1999 and linked these records to a database of vital statistics.

Surgical procedures—We examined the outcome of five surgical procedures in relation to volume: oesophagectomy, excision of a segment of the colon or rectum for colorectal cancer, pancreaticoduodenectomy, major lung resection (lobectomy or pneumonectomy) for lung cancer, and repair of an unruptured abdominal aortic aneurysm (AAA).

Measurement of hospital volume and outcome—We calculated the average hospital volume of each procedure on the basis of the number of identical procedures done at the hospital over the five year study period. We dichotomised hospitals into two volume categories (high volume hospitals and low volume hospitals) at the median average annual hospital volume. The outcome measure for all analyses was death within 30 days after the surgical procedure, regardless of place or location.

Statistical analysis—The overall strategy of the analyses was to model the association of hospital procedure volume with 30 day mortality, adjusting for the patient level characteristics of age, sex, and comorbidity. Age was represented as a continuous variable in the analyses, as was comorbidity. For each surgical procedure, we first assessed the outcome (death within 30 days of surgery) in relation to whether a patient had surgery at a hospital that did a high or a low volume of the same procedure. Next, we assessed the outcome among those patients having a procedure (for example, oesophagectomy) according to whether they had surgery at a hospital that did a high or a low volume of each of the other four procedures (for example, colorectal resection, pancreaticoduodenectomy, lung resection, and AAA repair). In total, we created five separate cohorts of patients (one for each surgical procedure) and did five volume-outcome analyses for each of the five procedure based cohorts.

Results

Patients and hospitals

During the five year study period, 31 632 patients had one of the five surgical procedures of interest (table 1). Mortality within 30 days of surgery ranged from 3.8% (excision of colon or rectum for cancer) to 13.4% (oesophagectomy).

Volume-outcome associations

In table 2, the rows indicate the procedure of which the outcome is being assessed, and the columns indicate the procedure that was used to define hospital volume. For example, the first column of data in the first row represents the outcome of oesophagectomy according to the hospital volume of oesophagectomy. The second column of data in the first row represents the outcome of oesophagectomy according to the hospital volume of colorectal resection. Comparisons of operative mortality by hospital volume for the same procedure are indicated in bold along the diagonal.

Table 1 Characteristics of patients and hospitals for people who had one of five major surgical procedures in Ontario, Canada, between 1994 and 1999

Variable	Oesophagectomy	Colorectal resection	Pancreaticoduodenectomy	Lung resection	Repair of aortic aneurysm
No of patients	613	18 898	686	5156	6279
No of hospitals	47	134	49	54	57
Average annual hospital volume:					
Median* (interquartile range)	8.8 (2.8-16.6)	52.8 (33.6-87.4)	5.4 (2.8-11.4)	45.0 (18.2-86.0)	42.0 (21.8-92.8)
Range	0.2-19.0	0.2-149.8	0.2-24.8	0.2-129.4	0.2-130.0
Mean (SD) age in years	64.2 (10.7)	68.8 (11.6)	62.7 (11.7)	65.1 (9.6)	70.7 (7.4)
Median (interquartile range) Charlson score†	4 (2-6)	0 (0-6)	1 (0-6)	1 (0-6)	0 (0-1)
No (%) male	450 (73.4)	10 197 (54.0)	386 (56.3)	3023 (58.6)	5168 (82.3)
30 day mortality (No (%))	82 (13.4)	713 (3.8)	66 (9.6)	215 (4.2)	265 (4.2)

*Used as a cut-off point to divide patients among high volume hospitals and low volume hospitals for analyses of the outcome of the same procedure. As the distribution of hospital volumes for other procedures usually differed from the distribution of hospital volumes of the procedure whose outcome was being studied, cut-off points used to separate high volume and low volume hospitals varied according to the procedure volume specified as the exposure variable.
†Weighted measure of the number of comorbid medical conditions, calculated by using secondary diagnosis codes for hospital admissions for surgical procedure.

Table 2 30 day mortality after each of five major surgical procedures according to hospital volume, by volume of same procedure and volume of other procedures

	Procedure used to categorise hospital volume				
Procedure and outcome	**Oesophagectomy**	**Colorectal resection**	**Pancreaticoduodenectomy**	**Lung resection**	**Repair of aortic aneurysm**
Oesophagectomy					
Mortality at LVH (%)	**51/328 (15.55)**	52/329 (15.81)	54/328 (16.46)	51/328 (15.55)	56/344 (16.28)
Mortality at HVH (%)	**31/285 (10.88)**	30/284 (10.56)	28/285 (9.82)	31/285 (10.88)	26/269 (9.67)
Adjusted odds ratio† (95% CI)	**0.60 (0.30 to 1.20)**	0.64 (0.33 to 1.23)	0.59 (0.32 to 1.11)	0.60 (0.30 to 1.20)	0.54 (0.29 to 1.02)
Colorectal resection					
Mortality at LVH (%)	359/9581 (3.75)	**362/9690 (3.74)**	349/9536 (3.66)	351/9502 (3.69)	343/9684 (3.54)
Mortality at HVH (%)	354/9317 (3.80)	**351/9208 (3.81)**	364/9362 (3.89)	362/9396 (3.85)	370/9214 (4.02)
Adjusted odds ratio† (95% CI)	0.97 (0.82 to 1.14)	**0.98 (0.83 to 1.16)**	1.06 (0.90 to 1.25)	1.00 (0.84 to 1.17)	1.10 (0.94 to 1.30)
Pancreaticoduodenectomy					
Mortality at LVH (%)	43/344 (12.50)	38/350 (10.86)	**38/348 (10.92)**	47/354 (13.28)	40/360 (11.11)
Mortality at HVH (%)	23/342 (6.73)	28/336 (8.33)	**28/338 (8.28)**	19/332 (5.72)	26/326 (7.98)
Adjusted odds ratio† (95% CI)	0.48 (0.30 to 0.79)**	0.86 (0.49 to 1.50)	**0.76 (0.44 to 1.32)**	0.36 (0.23 to 0.57)***	0.75 (0.45 to 1.27)
Lung resection					
Mortality at LVH (%)	126/2597 (4.85)	122/2610 (4.67)	110/2628 (4.19)	**126/2597 (4.85)**	108/2592 (4.17)
Mortality at HVH (%)	89/2559 (3.48)	93/2546 (3.65)	105/2528 (4.15)	**89/2559 (3.48)**	107/2564 (4.17)
Adjusted odds ratio† (95% CI)	0.64 (0.44 to 0.94)*	0.62 (0.42 to 0.93)*	0.88 (0.58 to 1.35)	**0.64 (0.44 to 0.94)***	0.90 (0.60 to 1.37)
Repair of aortic aneurysm					
Mortality at LVH (%)	149/3249 (4.59)	147/3185 (4.62)	153/3263 (4.69)	170/3358 (5.06)	**166/3259 (5.09)**
Mortality at HVH (%)	116/3030 (3.83)	118/3094 (3.81)	112/3016 (3.71)	95/2921 (3.25)	**99/3020 (3.28)**
Adjusted odds ratio† (95% CI)	0.89 (0.64 to 1.25)	0.92 (0.65 to 1.29)	0.82 (0.60 to 1.12)	0.64 (0.48 to 0.85)**	**0.62 (0.46 to 0.83)****

LVH=low volume hospital; HVH=high volume hospital. Odds ratios are for death in HVH compared with LVH. Values in bold along the diagonal indicate comparisons where the outcome and exposure (hospital volume) were for the same surgical procedure.
*P<0.05.
**P<0.01.
***P<0.001.
†Adjusted odds ratios estimated by binary regression models, with adjustment for age, sex, and Charlson score and accounted for the effect of hospital level clustering.

Association of outcome of procedure with volume of same procedure

Hospital volume and 30 day mortality were significantly associated for lung resection and AAA repair. Although the point estimates of the association of volume and outcome for oesophagectomy (adjusted odds ratio 0.60, 95% confidence interval 0.30 to 1.20) and pancreaticoduodenectomy (0.76, 0.44 to 1.32) were consistent with an inverse relation between volume and outcome, the number of patients who had these procedures was relatively small and the confidence intervals included values consistent with no association. We found little evidence of an association between volume and outcome for colorectal resection.

Association of outcome of procedure with volume of different procedure

We also examined the effect on operative mortality of the hospital volume of procedures other than the one for which the outcome was being measured. These comparisons are indicated by the non-bold data off the diagonal in table 2. In many instances, 30 day mortality was associated with the hospital volume of different procedures. For example, the reduction in 30 day mortality after pancreaticoduodenectomy in hospitals that were high volume hospitals for AAA repair was similar to the reduction in 30 day mortality after pancreaticoduodenectomy in hospitals that were high volume hospitals for pancreaticoduodenectomy.

The association with the volume of a different procedure was occasionally stronger than with that of the same procedure. For example, the reduction in 30 day mortality after pancreaticoduodenectomy in hospitals that were high volume hospitals for lung resection (0.36, 0.23 to 0.57) was much stronger than the reduction in 30 day mortality after pancreaticoduodenectomy in hospitals that were high volume hospitals for pancreaticoduodenectomy (0.76, 0.44 to 1.32; table 2).

Correlation of hospital procedure volumes

The correlation coefficients for hospital volume for the five procedures we studied ranged from 0.17 (oesophagectomy and colorectal resection) to 0.73 (oesophagectomy and lung resection).

Discussion

We found that the short term outcomes of some complex surgical procedures were better in hospitals with a higher volume of the same procedure. In many cases outcomes were also better in hospitals with high volumes of different procedures. Several possible explanations for this finding exist. The volumes of some surgical procedures done within a hospital are correlated. For example, it is not surprising that the outcomes of oesophagectomies and pulmonary resections are correlated with the hospital volume of the other procedure, as the hospital volume of oesophagectomy was highly correlated with the volume of pulmonary resection. General thoracic surgeons do both of these procedures and may be clustered in specific hospitals. Alternatively, the lack of specificity of volume-outcome associations may indicate a more general relation between the overall volume of complex surgery done in a hospital and outcomes. A hospital that does a high volume of any complex procedure is likely to have certain characteristics, such as location in a metropolitan area, status as a teaching hospital, and availability of specialised resources such as intensive care units staffed by full time specialists in intensive care, on-site coronary revascularisation facilities, and interventional radiology.

What is already known on this topic

For many complex surgical procedures, outcomes are better in hospitals where a high volume of similar procedures is done

Empirical evidence of these "volume-outcome associations" has been used to support regionalisation, whereby patients who need a high risk procedure travel to hospitals that do a high volume of that procedure

What this study adds

For some complex surgical procedures, operative mortality is lower not only in hospitals that do a high volume of the same procedure but also in hospitals that do a high volume of different procedures

Shared structures and processes in hospitals that do a high volume of any complex surgical procedures may account for improved surgical outcome

Strategies such as regionalising patients who need a high risk procedure at hospitals that do high volumes of the same procedure are potentially misguided and may further exacerbate inequality of resources between hospitals

Limitations of the study

Our finding that volume-outcome associations for hospital procedures are not specific to unique combinations of the volume and outcome of the same procedure cannot plausibly be explained by problems with data quality, unmeasured severity of illness, or other well described limitations of secondary data analysis.[11 12] Can our results be explained by confounding, in that if a hospital is high volume for one procedure it is likely to be high volume for another? Although we observed modest correlations between procedure volumes within hospitals, we do not believe that our results can be explained entirely by confounding.

Although limitations such as incomplete data on comorbid conditions or misclassification of hospital volume may have affected the validity of our estimates of volume-outcome associations, we have no reason to suspect that they would cause spurious associations between the volume of one procedure and the outcome of another. Most sources of error are non-differential with respect to exposure and outcome and for a binary outcome would be expected to bias estimates of association towards the null hypothesis of no association.[13]

Implications for health policy

If the improved outcome in high volume hospitals is not specifically related to the volume of the same procedure, but is related to the shared structure and process characteristics of the large hospitals that typically do a high volume of complex surgical procedures, what do our findings say about volume based regionalisation policies? Two possible approaches exist. One is to accept the lack of specificity or understanding of the mechanisms and continue to pursue volume based regionalisation in the light of the strong empirical evidence of volume-outcome associations for many complex procedures.

Another approach is to revisit the conceptual framework underlying volume based regionalisation. Volume-outcome associations for complex surgical procedures may be less a reflection of extraordinarily good care in high volume hospitals than an indication of deficient care in poorly supported small and rural hospitals. If so, regionalisation at large hospitals may benefit the relatively small segment of the population needing complex elective surgery but would accomplish little for the many patients admitted to small and rural hospitals for emergency conditions or medical diagnoses, especially if regionalisation leads to further erosion of resources for managing complex medical problems at smaller hospitals.

Conclusion

Volume-outcome associations for hospital procedures are not specific to the volume and the outcome of the same procedure. Our data do not support health policy measures predicated on referring patients having a certain surgical procedure to hospitals that do a high volume of the same procedure. A more rational strategy might be simply to regionalise all complex operations at large hospitals. Alternatively, increased allocation of resources to smaller hospitals and targeted quality improvement programmes might reduce some of the variation in short term surgical outcomes across hospitals.

We thank Minh Le Duong-Hua for cleaning and linking the data sets.

Contributors: See bmj.com

Funding: This research was supported by an internal investigator initiated grant from the Institute for Clinical Evaluative Sciences and by the physicians of Ontario through the Physicians' Services Incorporated Foundation. DRU is a career scientist of the Ontario Ministry of Health and Long-Term Care, Health Research Personnel Development Program.

Competing interests: None declared.

Ethical approval: This research was conducted with the approval of the research ethics board of Sunnybrook and Women's College Health Sciences Centre.

1 Halm EA, Lee C, Chassin MR. Is volume related to outcome in health care? A systematic review and methodologic critique of the literature. *Ann Intern Med* 2002;137:511-20.
2 Birkmeyer JD, Siewers AE, Finlayson EVA, Stukel TA, Lucas FL, Batista I, et al. Hospital volume and surgical mortality in the United States. *N Engl J Med* 2002;346:1128-37.
3 Begg CB, Cramer LD, Hoskins WJ, Brennan MF. Impact of hospital volume on operative mortality for major cancer surgery. *JAMA* 1998;280:1747-51.
4 Birkmeyer JD. High-risk surgery—follow the crowd. *JAMA* 2000;283:1191-3.
5 Epstein AM. Volume and outcome—it is time to move ahead. *N Engl J Med* 2002;346:1161-4.
6 Birkmeyer JD. Should we regionalize major surgery? Potential benefits and policy considerations. *J Am Coll Surg* 2000;190:341-9.
7 Donabedian A. *The methods and findings of quality assessment and monitoring: an illustrated analysis.* Ann Arbor, MI: Health Administration Press, 1985.
8 Glasgow RE, Mulvihill SJ. Hospital volume influences outcome in patients undergoing pancreatic resection for cancer. *West J Med* 1996;165:294-300.
9 Simunovic M, To T, Theriault M, Langer B. Relation between hospital surgical volume and outcome for pancreatic resection for neoplasm in a publicly funded health care system. *CMAJ* 1999;160:643-8.
10 Birkmeyer JD, Finlayson SR, Tosteson AN, Sharp SM, Warshaw AL, Fisher, et al. Effect of hospital volume on in-hospital mortality with pancreaticoduodenectomy. *Surgery* 1999;125:250-6.
11 Iezzoni LI. Assessing quality using administrative data. *Ann Intern Med* 1997;127:666-74.
12 Urbach DR, Bell CM. The effect of patient selection on comorbidity-adjusted operative mortality risk: implications for outcomes studies of surgical procedures. *J Clin Epidemiol* 2002;55:381-5.
13 Urbach DR. Misclassification of hospital procedure volume in surgical outcomes studies. *Surgery* 2000;127:238-9.Note: This research was presented as a poster at the 2002 Annual Conference of the Royal College of Physicians and Surgeons of Canada, Ottawa, Ontario, Canada, 28 September 2002.

(Accepted 31 December 2004)

doi 10.1136/bmj.38030.642963.AE