Volume and Outcome in Healthcare: Implications for Health Policy

Over the past three decades, a growing body of research has shown that the outcomes of complex surgical procedures are better in hospitals that perform a large number of similar procedures (Halm et al. 2002; Luft et al. 1979). There has been increasing interest in policies that restrict certain surgical procedures to high-volume hospitals (Epstein 2002), a strategy often described as "regionalization." The intent of regionalization is to reduce the risk of poorer outcomes associated with treatment at low-volume hospitals, particularly for high-risk procedures such as coronary artery bypass graft and major pancreatic surgery.

Why Is Volume Related to Outcome?

Virtually all health researchers now accept that the relation between volume and outcome is a real phenomenon, and not an artifact of poor study design, case-mix variation, or other limitations of health services research methods. Volume-outcome associations have been identified in hundreds of studies covering a variety of surgical procedures, medical conditions, health outcomes, risk-adjustment methodologies, study populations and healthcare environments.

Two possible explanations for volume-outcome relationships have been proposed. One hypothesis ("practice makes perfect") suggests that by increasing its experience with a surgical procedure, a hospital improves its outcomes through better structures and processes of care (Flood et al. 1984). A second hypothesis ("selective referral") implies a referral system that channels more patients to hospitals and physicians that already achieve better results (Luft et al. 1987). These hypotheses are not mutually exclusive, and the extent to which either contributes to the observed relation between volume and outcome is not clear. Most studies are simple cross-sectional analyses comparing outcome among hospitals with different volumes, and cannot provide evidence of a causal association or explain the underlying mechanism. Interestingly, the few studies that have tracked outcome in relation to changes in volume at the same hospitals over time have shown that changes in volume did not result in the expected change in outcome (Hamilton and Hamilton 1997), suggesting that health policy interventions intended to improve outcome by increasing hospital volumes may not be effective.

Limitations of Volume-Based Regionalization

Several observations prompted further exploration of the relation of volume and outcome in light of recent health policy discussions. Volume-outcome associations were increasingly prevalent in the literature, and have been described not just for complex surgical procedures but also for routine procedures such as inguinal hernia repair and cataract surgery, as well as critical care, diagnostic tests, and the treatment of medical conditions such as HIV, acute myocardial infarction and community-acquired pneumonia. In fact, it is virtually impossible to find a surgical procedure or medical condition that has been evaluated in more that one study that does not have a volume-outcome association. In this context, any volume-outcome association would more likely be considered a natural feature of the healthcare landscape than an unusual phenomenon warranting specific action.

Further, high-volume hospitals in Ontario do not appear to be high-volume for only one procedure. Hospitals that provide the highest volume of complex care for one particular condition usually provide a high volume of complex care for many other conditions, which would erode the feasibility of volume-based regionalization.

Does It Matter Which Services a Hospital Delivers in High Volume?

It was hypothesized that the observed association between volume and outcome may not be a phenomenon particularly related to surgical procedures. ICES researchers proposed that there is a large degree of variation in health outcomes across hospitals, and those that perform a high volume of complex surgical procedures also tend to have better outcomes of hospital care in general.

To test this hypothesis, the outcomes of five complex surgical procedures done in Ontario between 1994 and 1999 were examined. For each of the five procedures, hospitals were categorized into two groups, high volume and low volume, and analyzed to determine if there was a relationship between the volume and outcome of each procedure. For four of the five procedures, higher volume was associated with better outcome, a result consistent with the literature (Urbach and Baxter 2004).

A different set of analyses was also performed. Once again, the outcomes of surgical procedures according to hospital volume were measured, but this time, the effect of the volume of the other surgical procedures was analyzed. Not only was high volume of an unrelated surgical procedure frequently associated with improved outcome, but occasionally the outcomes were better in a hospital that performed a high volume of a different procedure (Table 1).

Implications

These findings suggest that volume-outcome associations, traditionally regarded as a peculiarity of complex surgical procedures, may actually be a reflection of variation in the outcomes of general hospital care, a problem not addressed by conventional volume-based regionalization strategies. While a relatively small number of patients, such as those requiring elective complex procedures, might benefit from referral to a high-volume hospital, the much larger number of persons requiring local care for other emergency medical conditions, such as acute myocardial infarction or pneumonia, would not benefit from volume-based regionalization. Further, to the extent that variation in the outcomes of hospital care

Table 1: 30-day mortality after five major surgical procedures according to hospital volume, by volume of the same procedure and volume of the other procedures, in Ontario, 1994 to 1999

	Procedure Used to Categorize Hospital Volume				
Procedure and Outcome	Esophagectomy	Colorectal Resection	Pancreaticoduodenectomy	Lung Resection	AAA Repair
Esophagectomy					
Mortality at LVH (%)	**15.55**	15.81	16.46	15.55	16.28
Mortality at HVH (%)	**10.88**	10.56	9.82	10.88	9.67
Crude OR (95% CI)	**0.66 (0.41, 1.07)**	0.63 (0.39, 1.02)	0.55 (0.34, 0.90)*	0.66 (0.41, 1.07)	0.55 (0.34, 0.90)
Adjusted OR§ (95% CI)	**0.60 (0.30, 1.20)**	0.64 (0.33, 1.23)	0.59 (0.32, 1.11)	0.60 (0.30, 1.20)	0.54 (0.29, 1.02)
Colorectal Resection					
Mortality at LVH (%)	3.75	**3.74**	3.66	3.69	3.54
Mortality at HVH (%)	3.80	**3.81**	3.89	3.85	4.02
Crude OR (95% CI)	1.02 (0.87, 1.18)	**1.02 (0.88, 1.89)**	1.07 (0.92, 1.24)	1.05 (0.90, 1.21)	1.14 (0.98, 1.32)
Adjusted OR (95% CI)	0.97 (0.82, 1.14)	**0.98 (0.83, 1.16)**	1.06 (0.90, 1.25)	1.00 (0.84, 1.17)	1.10 (0.94, 1.30)
Pancreaticoduodenectomy					
Mortality at LVH (%)	12.50	10.86	**10.92**	13.28	11.11
Mortality at HVH (%)	6.73	8.33	**8.28**	5.72	7.98
Crude OR (95% CI)	0.51 (0.30, 0.86)*	0.75 (0.45, 1.25)	**0.74 (0.44, 1.23)**	0.40 (0.23, 0.69)†	0.69 (0.41, 1.16)
Adjusted OR (95% CI)	0.48 (0.30, 0.79)†	0.86 (0.49, 1.50)	**0.76 (0.44, 1.32)**	0.36 (0.23, 0.57)‡	0.75 (0.45, 1.27)
Lung Resection					
Mortality at LVH (%)	4.85	4.67	4.19	**4.85**	4.17
Mortality at HVH (%)	3.48	3.65	4.15	**3.48**	4.17
Crude OR (95% CI)	0.71 (0.54, 0.93)*	0.77 (0.59, 1.02)	0.99 (0.76, 1.30)	**0.71 (0.54, 0.93)***	1.00 (0.76, 1.32)
Adjusted OR (95% CI)	0.64 (0.44, 0.94)*	0.62 (0.42, 0.93)*	0.88 (0.58, 1.35)	**0.64 (0.44, 0.94)***	0.90 (0.60, 1.37)
Abdominal Aortic Aneurysm Repair					
Mortality at LVH (%)	4.59	4.62	4.69	5.06	**5.09**
Mortality at HVH (%)	3.83	3.81	3.71	3.25	**3.28**
Crude OR (95% CI)	0.83 (0.65, 1.06)	0.82 (0.64, 1.05)	0.78 (0.61, 1.01)	0.63 (0.49, 0.81)	**0.63 (0.49, 0.81)**
Adjusted OR (95% CI)	0.89 (0.64, 1.25)	0.92 (0.65, 1.29)	0.82 (0.60, 1.12)	0.64, (0.48, 0.85)	**0.62 (0.46, 0.83)**

LVH: low-volume hospital; HVH: high-volume hospital; OR: odds ratio; CI: confidence interval. Odds ratios are for death in HVH compared with LVH. Bolded values 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 were estimated by binary regression models, with adjustment for age, gender and Charlson score, and accounted for the effect of hospital-level clustering.

is related to existing variations in hospital resources, transferring additional resources to large hospitals is likely only to exacerbate inequality of resources across hospitals.

While the study does not refute the benefits of concentrating complex health services at certain hospitals, it does indicate that a strategy of regionalization based on functional geographic regions or health service networks has more conceptual promise than purely volume-based regionalization strategies. To the extent that volume-outcome associations reflect the larger problem of variation in the quality of hospital care, strategies aimed at improving quality at smaller hospitals are more likely to benefit public health than volume-based regionalization.

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