

The volume-outcome relationship in hospitals

Lessons from the literature

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Concentrating the supply of hospital activity in larger hospital units is often presented as a means to improve the quality of care, but the extent of the relationship and the direction of causality between hospital volume and health outcomes is still a matter for debate. The literature review carried out by the IRDES shows that for certain procedures and interventions, particularly complex surgery, there is a real possibility of improving outcomes by increasing activity volumes. The presence of a learning curve at both the individual and hospital level (transfer of knowledge, organisation of work) appear to explain a large part of this correlation. In certain cases, however, the alternative hypothesis of selective referral, according to which patients are directed towards the hospitals with the best outcomes, cannot be disproved.

Moreover, this causal link between volume and outcome should be interpreted with caution: the results are sensitive to the nature of the procedures analysed and to the activity thresholds used. The more complex and specific the procedure, the stronger the correlation between volume and outcome. For most procedures, there is no single minimum volume threshold which emerges from the literature. In addition, some studies show that the volume-outcome relationship becomes marginal above what may be a relatively low threshold.

Over the last twenty years, studies of the relationship between volume of activity and quality of care in the health sector have provoked heated controversy, particularly as they have often been used to argue in favour of the concentration of hospital care supply, as a means of improving outcomes.

In France, a recent report¹ commissioned by the Ministry of Health and Solidarity recommended the introduction of thresholds of surgical activity and the closing “without delay” of 113 surgical departments with a low volume of activity. The report suggested that these departments could not guarantee sufficient quality or safety. For its part, the French National Cancer Institute (INCa), faced with the need to reflect on criteria of authorisation in cancerology², has recently defined minimum thresholds for the authorisation of certain interventions. For heart surgery, one of the five care activities for which the Regional Hospital Authorities (ARH) must draw up an inter-regional health plan (*schéma régional d'organisation sanitaire - SROS*), the decree of 24 January 2006 set a minimum activity per year and per site of

Volume of activity and outcome:
care and procedures studied in the literature (1996-2007)

	Number	Percentage
Surgical procedures	178	86.4%
Cancer/tumour-related procedures	83	40.3%
Cardiovascular procedures	67	32.5%
Orthopaedic procedures	18	8.7%
Others	10	4.9%
In-patient medical care	20	9.7%
Traumatology	10	4.9%
Cardiology	3	1.5%
Emergencies	2	1.0%
Pneumology	2	1.0%
Intensive care	1	0.5%
Nephrology	1	0.5%
Mixed (all types of care)	1	0.5%
Obstetrics	5	2.4%
Safe deliveries	1	0.5%
High-risk births (underweight)	2	1.0%
Paediatric/neonatal intensive care	2	1.0%
Outpatients	3	1.5%
Total	206	100.0%

175 articles, which correspond to 206 different care and procedures, were evaluated using a standard protocol.

1 Report presented by Guy Vallancien, *L'évaluation de la sécurité, de la qualité et de la continuité des soins chirurgicaux dans des petits hôpitaux publics en France*, April 2006.

2 Measure 36 of the *Plan Cancer* makes provision for criteria of approval for the practice of cancerology in public and private health care establishments. The decree of May 6 2005 includes the treatment of cancer among the activities subject to authorisation. The approval criteria including activity thresholds for certain activities were published by the INCa in June 2008.

400 major operations on adult patients and 150 paediatric operations³.

These thresholds will have an important influence on the reorganisation of the supply of surgery. The question of finding the right balance between concentrating hospital activity in large centres and maintaining the provision of local care facilities is attracting increasing attention. It is therefore important to verify the relevance of activity thresholds in a context where the control of health spending and the constraints of medical demographics weigh on decisions about the installation of health care facilities at different technical levels.

A systematic review of the literature of the last ten years has been conducted, to identify the surgical operations and other types of care that have been analysed in terms of the volume-outcome relationship. In all, 175 articles were evaluated using a standard protocol. In addition, theoretical concepts drawn from industrial economics have been used to shed more light on the link between volume of activity and outcome.

Main results of the systematic literature review

How outcomes are measured?

Mortality rates are the most widely-used indicators of health outcomes: 92 % of the studies use at least one indicator of mortality. In most cases, this is in-hospital mortality or 30 / 60-day mortality. Many studies also investigate patient survival over longer periods, from 1 year to 5 or at most 10 years. Two thirds of the studies analyse other indicators of quality in addition to mortality. The length of the stay in hospital and the number of unplanned readmissions, re-operations or postoperative complications are frequently used as outcome indicators. Some studies also survey nosocomial infections or other undesirable events occurring at hospital and related to treatment.

Broadly speaking, the indicators used to evaluate outcomes are ever more varied, as they are chosen according to the specific procedures studied. For example, surveys of complex procedures with a high risk of death concentrate on mortality rates, while all the studies of lower-risk orthopaedic operations, such as total hip or knee replacement, examine rates of readmission or other indicators of postoperative complications.

How is the volume of activity defined?

There are two ways to approach the volume of activity: either as a continuous variable or as a variable grouped into classes. Considering volume as a continuous variable implies that the clinical results also vary in a continuous or even linear way, according to the level of activity. In the great majority of studies, the volume of activity is considered as a nominal variable, grouping hospitals or surgeons together into classes or categories defined by thresholds of volume. Thresholds and the categories that result from them can be defined *a priori* or *a posteriori*. The *a posteriori* definition of thresholds is sometimes criticised on the grounds that analysts can choose them in such a way as to optimise the volume-outcome correlation artificially. Conversely, defining the categories of volume *a priori*, before observation of the data, is considered to achieve greater objectivity. Dividing volume into discrete classes enables a non-linear link to be established between volume and outcome, making it easier to interpret the results.

The definition of “high” or “low” volume therefore varies considerably from one study to another, and is highly dependent on the type of procedure studied. In particular, it is very difficult to provide a summary of the thresholds used by type of procedure, because of the many different methods used: few procedures have unanimously-accepted thresholds. In some studies, the volume-outcome relationship is established on relatively low thresholds.

Is the volume of activity measured by hospital or by doctor ?

Most of the studies focus on the volume of activity at the level of hospitals, but more

In 2007, at the request of the Haute Autorité de Santé (French National Authority for Health-HAS), the IRDES carried out a complete review of the international literature on the relationship between volume of activity and quality of care in healthcare facilities. This literature review covers 175 studies conducted over the last ten years and examines their results (context and relevance of the studies, suitability of the methods and indicators used) using a standard analysis grid. A number of literature reviews on this question were published during the 1990s, mainly in English, but until now no systematic review had been published in French.

than a third of them (63 studies) also look at the volume of activity of individual doctors, especially surgeons. Almost all the studies (96%) demonstrate a positive relationship between outcome and volume of activity.

The activity of a hospital and its surgeons are clearly correlated. However, there are no definitive conclusions about the relative importance of each group's impact on the results obtained. Few studies attempt to distinguish, by means of hierarchical models for example, between the effect of the hospital's volume of activity and the surgeon's volume of activity. On the whole, the studies suggest that they are both significant, even when they are controlled simultaneously. In particular, they suggest that the specific impact of the surgeon's volume of activity persists, even in hospitals with very strong activity. That being so, the relative importance of the hospital's activity and the surgeon's activity appear to vary from one procedure to another and according to the outcome indicator used.

How are patient characteristics controlled for?

The control of patient characteristics (case-mix), such as age, gender, seriousness of the illness, pre-existing co-morbidities, socio-economic status, etc. is essential,

3 Circular DHOS/O4 no 2006-293 of July 3 2006 relating to the activity of heart surgery and care.



Methodology of the systematic review

Identification of studies

We systematically searched for studies published between 1996 and 2007 investigating the outcomes of surgical operations, procedures and/or other types of health care or services in relation to a measurement of the volume of activity. The majority of studies has been published quite recently, in 2005 and 2006. This review completes earlier literature reviews, in particular the one published by York University in 1997 (Sowden *et al.*, 1997).

Criteria of inclusion

Only studies published in the last ten years directly investigating the relationship between the volume of activity of hospitals or surgeons and health outcomes have been included.

Criteria of exclusion

Articles with no empirical results (*i.e.* discussions, reviews, editorials, etc.) have not been included.

Criteria of evaluation of the studies

The studies meeting our criteria have been evaluated systematically. For each study, we record:

- countries or regions studied,
- period(s) studied,
- sample (number of hospitals, surgeons, patients, etc),
- procedures studied and medical codes (diagnoses, acts or other) used to define the procedures (if possible),
- outcome indicators used to measure "quality",
- volume indicators (by hospital and/or by surgeon),
- statistical and econometric methods,
- variables concerning patients to control for case-mix (morbidity, demographic variables, socio-economic variables, etc.),
- results obtained

because they influence the outcome of operations or treatments. And yet previous literature reviews have observed shortcomings in the adjustment for case-mix in the studies examined, and a consequent risk of biased results (Sowden *et al.*, 1997).

From this point of view, the studies carried out over the last ten years show great improvement over previous studies. We identified no hospital study that did not control for the main characteristics of patients. At the very least (in studies based on administrative data), the results are adjusted for age, gender and a global index of co-morbidity/seriousness (such as the Charlson index). But most studies introduce other, more precise clinical indicators to control for the state of health of patients and the seriousness of the operation, using patient register data.

Finally, nearly one quarter of the studies also control the socio-economic profile of patients, usually by linking different databases.

Which surgical operations are the most studied?

The large majority of studies included in the review concern surgical procedures (85%),

mainly cancer-related (see Table p. 1). The others look into a heterogeneous set of care, including both medical treatments and all the services provided by specific departments and care units (obstetrics departments, intensive care units, etc.). Most of the studies report a significant link between volume of activity and quality of care

Cancer surgery

Cancer surgery is a frequent subject of analysis in the literature: 58 of the studies reviewed concern this subject, analysing a total of 90 different procedures for cancer. Only a small minority (5 studies) found no link between volume and quality. Three studies concluded that there was a weaker link, highly dependent on the procedure analysed and/or the indicator used. Most of the studies mentioned adjustments or controls of the results by a minimum base of sociodemographic and comorbidity variables (case-mix). Some also controlled by status of the hospital or of the surgeon *vis-à-vis* certain activities, such as teaching.

The five studies that observed no relationship between volume and outcome all concerned tumours of the digestive system, and three

of them were based on very small samples. Furthermore, the absence of results may derive from the specificity of the volume-outcome link according to the nature of the illness and procedure analysed; two recent and more robust studies of the treatment of colorectal cancer find no correlation between the volume of procedures and the number of relapses and/or deaths.

Cardiovascular procedures

There are 67 studies looking at one or more cardiovascular procedures. The coronary artery bypass (CAB) is the surgical operation most often studied. Eighteen studies evaluate the effect of the volume of bypasses on outcome. With the exception of two, they all find a positive relation between the volume of activity of hospitals and surgeons and outcome, most often measured by in-hospital and 30-day mortality rates.

The great majority of studies on different coronary procedures are unanimous in their conclusions: the volume of activity of both hospitals and surgeons does have an impact, reducing in-hospital mortality and increasing the long-term survival of patients (by 1 year, 2 years or more).

Orthopaedic procedures

Eighteen articles study different orthopaedic surgical procedures, particularly total hip and knee replacements. They nearly all confirm that outcome, measured in terms of mortality, re-admission, post-operative complications (such as dislocation, embolism, or infection) and length of stay after operation, improves with the volume of activity of hospitals and/or surgeons.

Medical care units

The volume-quality relation is less well-established in the 28 studies on non-surgical care in specific units and departments: obstetric procedures (delivery and post-delivery), in-hospital medical treatment of pathologies, and activity in traumatology units or ambulatory care.

Generally speaking, even the studies that confirm the volume-quantity relation qualify this result by highlighting that the relation

is verified above all for the more complex cases.

Causality of the volume-quality relation: what can we learn from the theory?

Learning effects appear to be significant

If the correlation between volume and quality of care in healthcare facilities is well-established, the direction of the causality is still being debated. Two main hypotheses have been proposed:

- the theory of “learning curve” (or “practice makes perfect”), according to which the quality of care dispensed by doctors and hospitals increases with the number of patients they treat (thanks to greater experience). This suggests that the volume-quality relation results from internal economies of scale (specific to the establishment);
- the theory of “selective referral”, according to which patients are more likely to be referred to doctors or hospitals with good reputations. This implies that it is quality that generates the volume of activity, rather than the opposite.

The hypothesis according to which, *ceteris paribus*, outcomes improve with the accumulation of experience (learning effects) has been widely recognised and documented in industrial economics. In the specific case of hospital care, learning effects appear to be very significant, particularly in the context of complex procedures.

In addition, the volume of activity of a hospital also determines the level of influence it has in its locality. It therefore has repercussions on the activity of neighbouring hospitals and on the level of competition. This generates external economies of scale that affect the performance of the hospital itself and of the wider hospital market.

Implications for policy

For the hospital sector, the direction of the causality between volume of activity and outcome has important consequences for the planning policies. If the existing link between volume and outcome is mainly due to learning effects (strong activity generates quality), then the centralisation of some procedures would be likely to offer collective benefits. Furthermore, the dynamics of learning (in other words how the organisation allows learning to develop and how it is transferred) is an important issue for healthcare facilities, in terms of recruitment, planning of activity, risk anticipation and everything that goes to improve quality.

If, on the other hand, the main explanation is the selective referral of patients (high-quality establishments attract more patients), then the concentration of activity could lead to a reduction in competition without any improvement in quality.



This literature review shows that, for certain procedures, there is a real possibility of improving outcome when the volume of activity of both hospitals and surgeons increases. This relationship is particularly well demonstrated in the case of cardiovascular procedures and major surgery. However, it is important to underline the criteria that modulate this result:

- *the nature of the procedures analysed, especially the level of*

technique involved: the more complex the procedure, the stronger the correlation between volume and quality;

- *the thresholds of activity used: for most procedures, there is no unanimously accepted threshold; moreover, the studies show that the volume-quality relation is not linear and can become marginal beyond a sometimes relatively low threshold;*
- *evolution over time: the influence of volume on outcome can weaken or even disappear over time for certain procedures, particularly as the procedure becomes more widely adopted and mastered.*

Although the direction of the causality and the mechanisms underlying this relationship are still being debated, it appears that learning effects at the individual level (surgeons) and at the level of collective organisation (transfer of knowledge) explain a large part of the correlation. Nevertheless, the hypothesis of selective referral cannot be refuted for certain hospital procedures. In this respect, the possibility that an over-concentration of activity may have pernicious effects on outcome should not be overlooked.

In any case, although the volume of activity appears to be a criterion by which outcome can be evaluated, particularly in surgery, it should not be the only one taken into account for measuring and improving quality in healthcare facilities.



FURTHER INFORMATION

- Com-Ruelle L., Or Z., Renaud T. (2008), *Volume d'activité et qualité dans les hôpitaux: enseignements de la littérature*, Rapport IRDES à paraître.
- Sowden A, Grilli R, Rice N. (1997), *The relationship between hospital volume and quality of health outcomes, CRD Report 8 (Part 1)*, University of York.



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