

## Is there a Relationship between Volume of Activity and Quality of Care in French Hospitals?

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Concentration of certain procedures in high-volume hospitals is increasingly being presented as a means of improving the quality of care. However, until now no study has verified the link between volume of activity and quality of the care in France. This study provides new quantitative evidence on the correlation between the volume and outcomes of care exploiting French hospital data. For six out of eight conditions studied, results show that the probability of readmission and mortality is higher in low-volume hospitals. The intensity and the functional form of the link differ by condition and depend on the technical complexity of the procedure/treatment. Moreover, the relation is not linear: the impact of volume on the outcomes flattens gradually as the activity increases. In certain domains, it may be efficient to limit the number of hospitals with very low volume but there would be little additional benefit to centralize hospital activity beyond a certain point.

In France, as in other countries, volume of activity thresholds are increasingly used as criteria for assessing and regulating the quality of care. These thresholds have a considerable influence on the way hospital supply is structured. The underlying hypothesis is that a high volume of activity guarantees the quality of care supplied. This theory appears to be confirmed by international research, notably from the United States, that suggests that the higher the volume of clinical activity the better the quality of care and more particularly of highly

complex surgical procedures [Com-Ruelle, Or, Renaud, 2008].

In the current context of hospital restructuring, however, the volume-quality relationship remains a controversial issue in France. The validity of this relationship in the French healthcare system could be questioned. The organisation of care at both national health system level and hospital level are factors that can condition the quality of care. In order to assess the legitimacy of policies aimed at concen-

trating hospital activity, it is equally important to determine whether volume has a constant and identical impact for all types of care activities.

To date, however, no research is available at national level in France that allows the results presented in the literature to be validated against French hospital data. Furthermore, existing literature does not shed much light on the explanatory factors, the strength and nature of the relationship between activity volume and quality of care.

Pourtant, dans le contexte actuel de res- This study provides new quantitative evidence on volume-quality relationship by apprehending quality in terms of outcome using two common indicators: in-hospital mortality and unplanned readmissions within 30 days following discharge (Definitions insert). First, it validates the existence of a volume-outcome relationship in the French healthcare context. Then, it analyses the strenght of this relationship according to the nature of the surgery or medical treatment under consideration, its continuity and other factors relative to hospital that may have an influence on this relationship. The following questions are asked:

- Is there a significant difference in the mortality and readmission rates between hospitals, once controlled for case-severity?

- Does a hospital's volume of activity have an impact on the probability of patient readmission or mortality, all else being equal?

- Is the relationship between volume and outcome linear? Is it of the same magnitude for all types of procedure whatever the degree of complexity and whatever the frequency?

- Do other hospital characteristics have an impact on the care outcomes and alter the volume-outcome relationship?

Eight hospital procedures were analysed so as to cover a broad range of medical and surgical interventions most fre-

quently studied in the literature: complex surgery (colon cancer surgery, coronary bypass surgery and pancreatic resection), more standard surgery (total hip replacement, appendectomy and implantation of stents) and the medical treatment of outcome monitored diseases (acute myocardial infarction and cerebrovascular accident). The analysis was carried out on all acute care stays for the year 2006. The 30-day readmission and hospital mortality rates were calculated by monitoring patient trajectories in different hospitals (Sources insert).

### Significant inter-hospital variations concerning readmission and mortality rates

The frequency and distribution of admissions between hospitals vary according to the type of care delivered (table 1). For example, in 2006, only 2,268 pancreatic resections were carried out in a large number of hospitals, which corresponds to an average of five interventions of this type per hospital per year. Colon resection surgery is also scattered among a large number of hospitals since 842 hospitals carried out this operation at least once in 2006.

Admissions for the implantation of stents and coronary bypass surgery are, on the contrary, concentrated in a smaller number of hospitals: the 12,374 admissions for coronary bypass surgery were distributed among 56 distinct hospitals.

## BACKGROUND

This study falls within broader research on the quality of hospital care in France. It follows from a review of international literature published in September 2008 [Com-Ruelle, Or, Renaud, 2008]. This research was financed by the French National Authority for Health (HAS) following an invitation to tender. It was conducted with the collaboration of Laurent Tardif (Adysta Conseil), who constructed the admissions chain and contributed to the construction of outcome indicators, and Laure Com-Ruelle (Irdes) who provided her medical expertise throughout the study.

The raw readmission and mortality rates are naturally very different from one type of procedure to the next (table 1). Surgical interventions on patients with cancer (pancreatic or colon resection) present a high risk of readmission within 30 days: in one case out of three for the pancreas and one out of four for the colon. Medical treatments for infarction and cerebrovascular accident present the highest risk exposure with a 10% raw mortality rate within 30 days in both cases.

The use of a standard protocol to measure readmission and mortality rates enabled us to erase differences in patients' age and gender and also the main inter-hospital differences in patients' clinical profiles. The analysis using standard readmission and mortality indicators reveals significant disparities from one hospital to the next. Nevertheless, these inter-hospital variations are more or less significant according to the procedure studied (graph 1).

T1

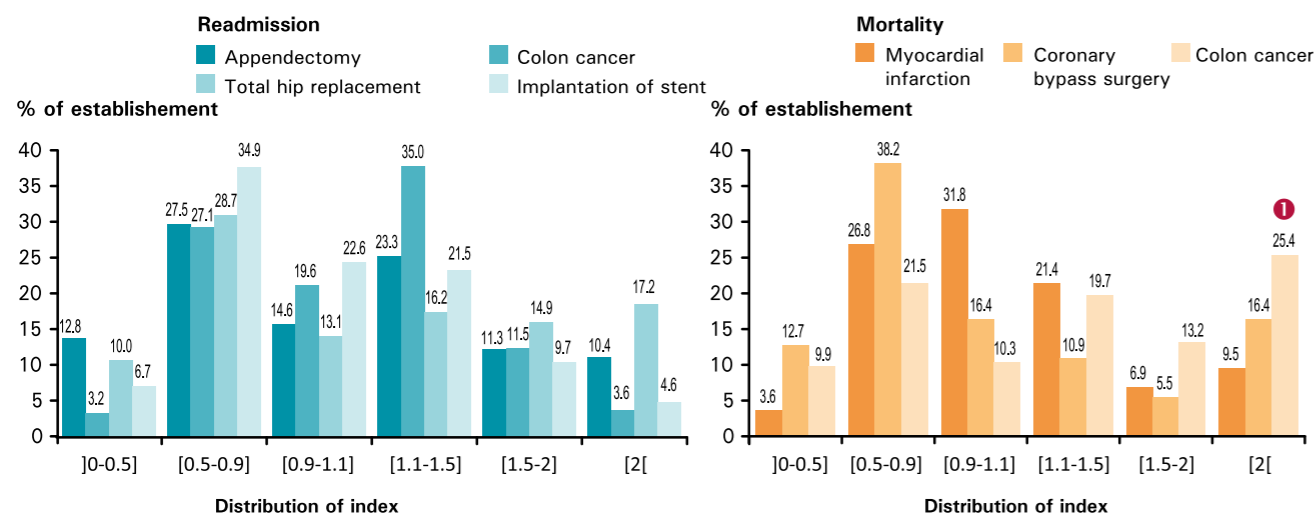
### Description of the analysis sample and raw 30-day rates of readmission and mortality

	Cerebro-vascular accident	Appendectomy	Acute myocardial infarction	Coronary bypass	Implantation of stents	Total hip replacement	Colon cancer resection	Pancreatic resection
Number of initial stays	87,382	141,068	45,447	12,374	28,912	65 174	29,499	2,268
Number of establishments involved	990	867	784	56	216	806	842	477
Average number of stays per establishments	88	163	58	221	134	81	35	5
30-day readmission (raw rate)	12.4%	4.5%	19.1%	9.4%	14.1%	4.8%	26.1%	36.8%
30-day mortality (raw rate)	10.0%	-	9.8%	3.0%	1.5%	-	3.7%	7.4%

Data: 2006 French Medical information System Program.

G1

Dispersion of standardized indexes for 30-day readmission and mortality for certain interventions



The value of the standardized index is calculated by hospital. An index of 1 means that the hospital has an average mortality/readmission rate taking into account patient profiles in terms of age, gender and DRG; an index of 1.5 means that the hospital has a 50% higher than average mortality/readmission rate.

**Reading guide:** in the case of colon cancer surgery, 25% of hospitals experience at least twice as many deaths within 30 days than the average taking into account patient profiles in terms of age, gender and DRG.

**Data:** 2006 French Medical Information System Program.

In the case of coronary infarction, hospitals present relatively homogeneous mortality indexes after controlling for the patients' clinical characteristics. On the contrary, in the case of colon cancer, variations in the mortality rate are considerable between hospitals.

For standard surgical interventions such as appendectomy or the implantation of stents, the 30-day readmission index per establishment is fairly homogeneous with a low readmission rate in most hospitals. On the contrary, for surgical interventions concerning colon cancer and total hip replacement, readmission rates are more dispersed and globally higher: at comparable age, gender and clinical profile, 35% of hospitals have 10 to 50% readmissions above the average rate for colon cancer; for total hip replacement, a third of hospitals have readmission rates at least 50% above the average.

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This approach is nevertheless inadequate as it does not fully take into account patients' clinical characteristics and the severity of cases on initial admission and cannot therefore establish a valid volume-outcome relationship. In order to evaluate the specific effect of an establishment's volume of activity on the probability of readmission or death, multilevel logistic models were used so as to simultaneously control for patients' clinical characteristics and the institutional differences that can have an influence on the distribution of patients between hospitals (Methods insert).

SOURCES

The data used were extracted from the French Medical Information System Program in medicine, surgery and obstetrics for the year 2006 that covers the short-stay activity for the totality of private and public hospitals. This database enables the description of hospital patients' morbidity using medical criteria. The Annual Health Establishment Statistics is complementary and used to describe hospital characteristics.

Eight hospital procedures are selected in this study. For the majority of surgical interventions, hospital activity is identified according to selection criteria combining medical acts specific to the procedures being studied and diagnosis-related groups (DRG), and in the case of medical treatments and cancer surgery according to principal diagnosis (PD) and surgical DRG. For further details concerning the PD and DRG codes retained, please refer to the complete study report [Or, Renaud, December 2009].

even when controlled for case-severity at admission.

effect on the probability of dying within 30 days for four out of the six procedures analysed: colon cancer surgery, pancreatic resection, acute coronary infarction and cerebrovascular accident (CVA). In the case of CVA, only the introduction of volume in quintiles gives significant results. On the contrary, there is no significant correlation between coronary bypass mortality and a hospital's volume. It should nevertheless be reminded that coronary bypass surgery is already largely centralised in France (table 1). Finally, volume of activity for appendectomies and the implantation of stents, fairly standard procedures, has no impact on either readmission or mortality rates.

Finally, a significant relationship between the volume of activity (measured by the number of admissions related to an intervention in the previous year in the same establishment) and health outcome is observed for certain surgical interventions and certain medical treatments. The 30-day probability of readmission is higher in low-volume hospitals for six procedures: colon cancer surgery, coronary bypass surgery, pancreatic resection, acute coronary infarction, cerebrovascular accident and total hip replacement (table 2). Volume of activity has a discriminating

Volume of activity has a significant influence on care outcome

The multilevel models confirm that the case-severity on initial admission, measured by the existence of major complications, the number of co-morbidities and the patient's age, considerably increases the probability of dying within 30 days. The analysis equally confirms that there are significant inter-hospital disparities in the probability of readmission or death,

DEFINITIONS

Health outcome indicators

The two indicators most widely used in available literature were retained to study care outcome: the occurrence of readmission or death. The joint use of these indicators ensures the pertinence of conclusions, notably for diseases with a low mortality risk.

Mortality

**Definition:** All deaths occurring within 30 days following the initial admission is considered as an event of mortality whether the patient dies during the initial stay or after unplanned readmission in another acute care facility.

The indicator does not take into account deaths occurring in the home or in rehabilitation and long term care settings.

The analysis of mortality is limited to six procedures, deaths following an appendectomy or total hip replacement being too rare to have a real significance in terms of quality of care.

Readmission

**Definition:** Any complete hospitalisation (of over 24h) in an acute care facility within 30 days following discharge is considered as being a readmission.

Initial admissions terminating with the patient's death being analysed separately, these are simply removed from the readmissions sample so as not to introduce bias in the measurements. Furthermore, consultations and day hospitalisations that are planned contacts are not included in the readmissions.

Ideally, the measurement of readmissions should only concern unplanned hospitalisations related to complications following the initial intervention and carried out in all types of hospitals. In practice, in the hospital database, emergency hospitalisations cannot be identified with precision.

The analysis is carried out successively on raw rates of readmission and mortality then standardized indexes. These indexes are calculated by an indirect standardization method on age, gender and Diagnosis-related Groups (DRG) for patients treated in each hospital.

T2

Synthesis of the multilevel model results for the probability of readmission/mortality for the eight procedures

	30-DAY READMISSION								30-DAY MORTALITY					
	Appendectomy	Cerebrovascular accident	Myocardial infarction	Colon cancer resection	Pancreatic resection	Coronary bypass surgery	Implantation of stent	Total hip replacement	Cerebrovascular accident	Myocardial infarction	Colon cancer resection	Pancreatic resection	Coronary bypass surgery	Implantation of stent
Age	ns	-	+	--	--	ns	ns	++	++	+++	+++	++	++	+++
Gender (ref.: Men)   Women	ns	-	-	--	--	ns	ns	--	ns	+	ns	ns	ns	ns
Major associated co-morbidity	++	+	++	+	ns	++	++	++	+	+++	++	++	+++	+++
Stay in intensive care unit	ns	ns	ns	-	ns	ns	ns	ns	++	+	+	ns	ns	+++
Number of associated diagnoses	+	++	ns	+	ns	ns	ns	++	+	+	++	++	++	ns
Length of initial stay (ref.: median length stays)	Shortest stays		--	+	ns	--	ns	ns	++	++	++	++	++	+
	Longest stays		++	-	+	ns	ns	++	++	--	--	--	--	ns
Log (volume of activity for the procedure)	ns	--	--	--	---	--	ns	---	ns	--	---	---	ns	ns
Weight of surgery in total activity	-	ns	--	--	ns	ns	ns	---	--	---	---	ns	ns	---
Degree of specialisation in the treatment	--	ns	ns	ns	ns	ns	ns	ns	--	--	ns	ns	ns	---

This table summarises the influence of the different variables tested in the model.

'ns': non-significant; '+': significant positive effect (p < 0,05); '-': significant negative effect; '++' indicates that the coefficient is greater than '+' and smaller than '+++'. For example, the presence of a major associated co-morbidity during the initial stay significantly increases the probability of readmission for all the procedures except pancreatic resection. This impact is more significant for a total hip replacement (++) than for a cerebrovascular accident. Similarly, the volume of activity relative to the intervention has a negative impact on the probability of readmission and mortality for the majority of procedures.

**Data:** 2006 French Medical Information System Program.

The strength of the volume-outcome correlation appears to vary according to the nature of care delivered (surgical *vs.* medical) and is sensitive to the complexity of the procedure. The strongest correlation is observed for complex interventions such as cancer surgery, and is more moderate for relatively standard interventions such as appendectomies and the implantation of stents. This observation corroborates the results presented in the majority of previous studies. Available literature suggests that volume of activity has a greater impact in complex procedures because of a higher learning effect: the quality of care improving with accumulated experience, and this appears more significant in the case of more complex protocols.

### The impact of activity volume on quality is not linear

Our results equally confirm that the strength of the link and the functional form of the volume-outcome relationship vary according to type of procedure. For most procedures, there is a real improvement in outcome over the whole spectrum of care activities but the impact seems to diminish as the volume of activity increases following a logarithmic curve (relationship in 'L'). In the case of readmissions, this applies to pancreatic resection, total hip replacement, infarctions and cerebrovascular accident procedures and in the case of mortality, pancreatic resection, and colon cancer surgery.

In certain cases (readmissions in colon surgery and coronary bypass, mortality in infarctions) the volume-outcome correlation is considerably weaker and reveals more of a 'threshold effect': below a certain threshold, hospital volume has a clear impact on the probability of readmission and mortality, but above this threshold, the correlation between volume and outcome virtually disappears.

In any case, the hypothesis for a linear and systematic correlation between quality of care and hospital volume seems unrealistic.

## STATISTICAL METHODS

### Multilevel model

The principle behind multilevel modelling is to model an individual phenomenon, in this case the probability of being readmitted to hospital or dying in the 30 days following a medical or surgical intervention, by simultaneously controlling for individual characteristics (relative to patients and hospital stays) and contextual variables (relative to the hospitals).

The dependent variable is thus dichotomous (0/1) and is subjected to logistic modelling.

The explanatory variables are introduced successively in a three-phase modelling strategy:

### Patient and hospital stay variables

- Patient's gender (0/1) and age (divided into quintiles);
- The number of co-morbidities (in classes), the existence of a major complication during the initial stay (0/1) or being moved to intensive care (0/1);
- The length of the initial hospitalisation, measured in quartiles, by opposing the shortest stays (quartile 1) and the longest stays (quartile 4) to average length stays (quartiles 2 and 3), as an indicator of case severity.

### Volume of activity of the procedure in the establishment

The pertinence of the different functional forms were tested:

- linear relationship: logarithmic, exponential, square root and quadratic form transformations using a probability test to determine the most adequate form (Akaike criterion);
- introduction of volume divided into homogeneous categories, quintiles or deciles.

In the end, the log-linear specifications were retained and used systematically in the analyses.

### Other 'hospital' variables

These variables are tested in different configurations but are not all introduced simultaneously given the obvious risk of multicollinearity:

- the percentage of admissions relating to a specific procedure in the total number of complete hospitalisations in a given establishment (%) so as to determine the existence of a 'procedure specialisation' effect;
- the weight of surgery/medicine in the hospital's total acute care activity (%);
- the number of beds installed in surgery/medicine according to the nature of the intervention studied (logarithm);
- the hospital's status, distinguishing teaching hospitals from the others;
- the existence of an emergency service (0/1);
- the number of paramedical personnel (excluding doctors) expressed as a full-time equivalent per bed;
- the occupancy rate (%).

Analysis of sensitivity of results dropping the few very low-volume hospitals confirms the robustness of the results

### The hospital's degree of specialisation and the weight of surgery in its activity equally have an impact on outcomes

At equivalent case profiles and activity volumes, hospitals specialised in a given procedure have significantly lower 30-day risk of mortality and readmission for cardiovascular diseases (cerebrovascular accident and infarction) and total hip replacements. This implies that hospitals with a comparatively lower total volume in these procedures can nevertheless obtain good results by specialising in that procedure if it constitutes an important part of their total activity.

The weight of surgery in a hospital's total acute care activity equally has a positive impact on health outcome. For example, in two hospitals carrying out the same number of colon cancer resections per year, unplanned readmissions and mortality rates will be lower in the hospital that has centred its activity on surgery. This result could suggest that organisational or learning effects are greater in surgical procedures due to a transfer of skills or technical capacity between surgical units within the same hospital.

The other hospital level variables tested do not have a significant effect on health outcome, possibly because of interactions between the different hospital characteristics: size, ownership status, teaching etc.



These different characteristics are highly correlated.

### Refine knowledge of the volume-quality link to better adapt responses

This study provides new results for understanding the importance and form of the relationship between volume and quality of care in the French hospital context. In order to better describe this relationship, it would be desirable to improve both outcome indicators used and control of the clinical severity of admissions in the different hospitals. It is, in fact, possible that some of the differences observed in mortality or readmission rates are due to clinical heterogeneity not captured by the model's variables.

This study nevertheless confirms the conclusions put forward by the majority of international research: for certain procedures and interventions there is a significant relationship between volume of activity and health outcome. Translating these results into recommendations remains nevertheless delicate.

Finding the right balance between costs and benefits in concentrating hospital care supply is particularly complex. In this respect, volume of activity constitutes an excellent leverage to improve outcomes in certain domains. Nevertheless, concentration of activity in large hospital structures is costly, has repercussions in terms of access to care and can generate pernicious effects related to having a monopoly position.

Moreover, as the nature and intensity of the volume-outcome relationship varies considerably from one procedure to another, it is essential to take this into account in the reforms currently being implemented. For example, if the non-linear relationship suggested in this study was to be confirmed, it would be more effective

to limit the number of very low-volume facilities but there would be little advantage gained in concentrating activity beyond a certain threshold. It is particularly important to target procedures for which a significant relationship between activity and quality of care has been proven.

Finally, a more thorough investigation of the mechanisms underlying the volume-outcome relationship is necessary in order to better adapt responses. More particularly, the direction of causality in the relationship between volume of activity and quality of care remains a subject for debate. If a high volume of activity can lead to an improvement in the care process and health outcome (learning effect), better outcomes in an establishment can also lead to an increase in volume by its reputation and patient orientation (referral effect). Several authors have suggested that both these explanations could

be valid [Luft et al., 1987; Shaihan and Normand, 2003]. It is important to understand the relative importance of each of these phenomena that certainly vary according to the procedure under consideration.

Furthermore, it should not be forgotten that the way volume is apprehended can also have repercussions on the volume-outcome relationship. At hospital level, we focused on the number of admissions for a given type of procedure; nevertheless, a surgeon's volume of activity (notably the number of interventions per surgeon) can have its own specific effect on the quality of care. Finally, it should be reminded that the volume of activity is not in itself the answer to improving the quality of care but it reflects differences in the management, the organisation and the delivery of care and for which there is insufficient information. This study thus calls for improving knowledge in this direction. ♦

## GLOSSARY

- **[DRG] Diagnosis-related group:** [GHM] Groupe homogène de malades
- **[MISP] (French) Medical Information System Program:** PMSI, Programme de médicalisation des systèmes d'information  
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- **Acute myocardial infarction:** infarctus aigu du myocarde
- **Annual Hospital Statistics:** SAE, Statistique annuelle des établissements de santé
- **Appendectomy:** appendicectomie
- **Cerebrovascular accident (CVA):** Accident vasculaire cérébral (AVC)
- **Colon cancer:** cancer du colon
- **Coronary bypass surgery:** pontage aorto-coronarien
- **Follow-up and rehabilitation care:** soins de suite et de réadaptation (SSR)

- **Implantation of stent:** pose de stent
- **Learning effect:** effet d'apprentissage
- **Organisation effect:** effet d'organisation
- **Outcome monitored disease:** pathologie traçante
- **Pancreatic resection:** resection pancréatique
- **Referral effect:** effet d'adressage
- **Short-stay:** court séjour
- **Standardized indexes:** indices standardisés
- **Teaching hospital:** Centre hospitalier (regional) universitaire
- **Total hip replacement:** prothèse totale de la hanche
- **Volume of activity:** volume d'activité
- **Volume-outcome relationship:** relation entre volume d'activité et résultats des soins.

## FURTHER INFORMATION

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