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Institut de recherche
et documentation en économie de la santé

Volume d'activité et qualité des soins dans les établissements de santé : enseignements de la littérature

Laure Com-Ruelle, Zeynep Or, Thomas Renaud.
Avec la collaboration de Chantal Ambroise et Anna Marek

Rapport n° 545 (biblio n° 1734) - Décembre 2008

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Sommaire

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Synthèse

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Contexte

Au cours des deux dernières décennies, les études portant sur la relation entre le volume d'activité et la qualité des soins dans le secteur de la santé ont suscité une vive controverse, notamment parce qu'elles ont souvent servi d'argument à la concentration de l'offre de soins hospitaliers, qui est présentée comme un moyen d'améliorer la qualité des soins. En France également, la question du maintien d'un juste équilibre entre la concentration de l'activité hospitalière dans de grands centres et le maintien des soins de proximité se pose de plus en plus. Il est donc important de vérifier la pertinence des seuils d'activité dans un contexte où la maîtrise des dépenses de santé et les contraintes de la démographie médicale pèsent sur les décisions d'implantation des plateaux techniques de différents niveaux.

Objectifs

Ce travail de recherche vise à fournir une analyse synthétique de l'ensemble des connaissances disponibles à ce jour sur les liens entre le volume d'activité et la qualité des soins. Il propose en premier lieu une analyse systématique et critique des études empiriques qui ont tenté d'établir un lien entre le volume d'activité et la qualité des soins dans les établissements de santé. Ainsi, une revue systématique de la littérature des dix dernières années a été réalisée afin d'identifier les interventions chirurgicales et les autres types de soins ayant fait l'objet d'analyses sur le rapport volume/qualité. Au total, 175 articles ont été évalués selon un protocole standard.

En deuxième lieu, ce travail cherche à expliquer pourquoi et comment le volume peut générer la qualité, en identifiant les mécanismes qui sous-tendent ce lien. Les concepts théoriques relatifs à l'économie industrielle ont été mobilisés pour mieux comprendre, d'une part, le sens de la causalité entre volume et amélioration de la qualité et, d'autre part, les dynamiques sous-jacentes expliquant cette causalité.

Principaux résultats

La revue de la littérature montre que pour certaines procédures et interventions, en particulier pour la chirurgie complexe, la possibilité d'améliorer la qualité des soins lorsque le volume d'activité augmente est réelle.

La grande majorité des recherches retenues porte sur des interventions chirurgicales (85 %), principalement liées au cancer. Le reste des études s'intéresse à un ensemble hétérogène de soins, regroupant à la fois des soins médicaux et l'ensemble des prestations délivrées par des services et unités de soins spécifiques (service d'obstétrique, unité de soins intensifs…). Plus l'intervention est spécifique et complexe, plus la corrélation volume-qualité est affirmée. Pour la plupart des interventions, il n'existe pas de seuil d'activité unanimement accepté. De plus, certaines études montrent que la relation volume-qualité devient marginale au-delà d'un seuil qui peut être relativement bas. Enfin, l'influence du volume sur la qualité peut diminuer, voire disparaître au cours du temps pour certaines procédures, notamment à mesure que la maîtrise de cette procédure s'étend et que celle-ci se banalise.

L'effet d'apprentissage au niveau individuel (chirurgien) mais aussi au niveau de l'hôpital (transfert de connaissances, mode d'organisation) semble expliquer une grande partie de cette corrélation. Cet effet d'apprentissage implique en effet que la qualité des soins dispensés par les médecins et les hôpitaux augmente lorsqu'ils soignent plus de patients, grâce à une expérience accrue. Cela suggère que la relation volume-qualité résulte d'économies d'échelle internes propres à l'établissement.

Toutefois, dans certains cas, l'hypothèse alternative du « renvoi sélectif », selon laquelle les patients sont orientés vers les hôpitaux ayant de meilleurs résultats, ne peut être réfutée. Cela suppose que c'est la qualité qui engendre le volume d'activité plutôt que l'inverse.

Ce lien de causalité entre volume et qualité doit par ailleurs être nuancé : les résultats sont sensibles à la nature des procédures et interventions analysées, ainsi qu'aux seuils d'activité retenus et à des évolutions temporelles.

Introduction

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Au cours des deux dernières décennies, les études portant sur la relation entre le volume et la qualité des soins dans le secteur de la santé ont suscité une vive controverse, notamment parce qu'elles ont souvent servi d'argument à la concentration de l'offre de soins hospitaliers, qui est présentée comme un moyen d'améliorer la qualité des soins.

En France, un rapport récent[1] réalisé à la demande du ministre de la Santé et des Solidarités recommande l'introduction de seuils d'activité chirurgicale et préconise la fermeture « sans délai » de 113 services de chirurgie ayant un faible volume d'activité. Le rapport suggère que ces services ne sont pas capables de garantir une qualité et une sécurité suffisantes. De son côté, l'Institut national du Cancer (INCa), face à la nécessité de réfléchir à des critères d'autorisation en cancérologie[2], vient de définir des seuils minimaux pour autoriser un certain nombre d'interventions. En ce qui concerne la chirurgie cardiaque, qui est une des cinq activités de soins pour lesquelles les Agences régionales de l'hospitalisation (ARH) doivent élaborer un schéma interrégional d'organisation sanitaire (SROS), l'arrêté du 24 janvier 2006 fixe l'activité minimale annuelle par an et par site de chirurgie à 400 interventions majeures sur des patients adultes et à 150 actes pour la chirurgie pédiatrique[3].

Ces seuils auront une influence importante sur la restructuration de l'offre hospitalière en chirurgie. Pourtant, la question du maintien d'un juste équilibre entre la concentration de l'activité hospitalière dans de grands centres et le maintien des soins de proximité se pose de plus en plus. Il est donc important de vérifier la pertinence des seuils d'activité dans un contexte où la maîtrise des dépenses de santé et les contraintes de la démographie médicale pèsent sur les décisions d'implantation des plateaux techniques de différents niveaux.

Il existe une quantité abondante de recherches, provenant pour la plupart des États-Unis, qui suggèrent qu'un volume d'activité clinique plus élevé est associé à de meilleurs résultats des soins[4]. Ces études portent sur une grande variété d'interventions chirurgicales, de diagnostics ou de programmes cliniques et analysent, dans des contextes de soins variés, différentes populations avec des méthodes et des indicateurs de qualité résultats divers. Dans les années quatre-vingt-dix, quelques revues de littérature ont été publiées sur ces questions, notamment en anglais, mais jusqu'à présent aucune revue systématique n'était disponible en français.

À la demande de la Haute Autorité de Santé (HAS) en 2007, l'IRDES a réalisé un examen complet de la littérature portant sur la relation entre le volume d'activité dans les établissements de santé et les résultats des soins. Une revue systématique de la littérature au cours des dix dernières années a été effectuée afin d'identifier les interventions chirurgicales et les autres types de soins ayant fait l'objet d'analyses sur le rapport volume/qualité. Au total, 175 articles ont été évalués selon un protocole standard. Par ailleurs, nous avons étudié les concepts théoriques nécessaires pour mieux comprendre le lien entre volume d'activité et résultats des soins, en nous référant à l'économie industrielle.

Cette revue de la littérature comporte deux parties distinctes. Une première partie propose une analyse systématique et critique des études empiriques qui ont tenté d'établir un lien entre le volume d'activité et la qualité des soins dans les établissements de santé. L'objectif spécifique de cette partie est d'identifier :

- les champs d'activité, les conditions cliniques et les interventions (chirurgicales ou médicales) pour lesquels le lien entre volume d'activité et qualité a été étudié et ceux pour lesquels cette relation est établie ;

- les indicateurs utilisés pour mesurer la qualité des soins et le volume d'activité ;

1 Rapport présenté par Guy Vallancien, L'évaluation de la sécurité, de la qualité et de la continuité des soins chirurgicaux dans des petits hôpitaux publics en France, avril 2006.

2 La mesure 36 du plan cancer prévoit des critères d'agrément pour la pratique de la cancérologie dans les établissements de soins publics et privés. Le décret du 06 mai 2005 inclut le traitement du cancer dans les activités soumises à autorisation.

3 Circulaire DHOS/O4 n° 2006-293 du 3 juillet 2006 relative à l'activité de soins de chirurgie cardiaque.

4 Voir par exemple, Ho *et al.* (2006) ; Geubbels *et al.* (2005) ; Birkmeyer *et al.* (2002); Hillner *et al.* (2000) ; Thiemann *et al.* (1999) ; Hannan et al. (1992).

– les méthodes statistiques employées dans ces études, pour établir leur pertinence avec des critères communs (échantillon utilisé, indicateur(s) de qualité employé(s), contrôle du *case-mix*, etc.).

Une seconde partie est consacrée à l'analyse théorique des mécanismes sous-jacents de l'association entre le volume et la qualité. Cette partie vise notamment :

– à identifier les hypothèses sous-jacentes d'un lien volume-qualité dans la littérature en se rapportant à l'économie industrielle ;

– à évaluer dans quelle mesure et comment ces théories/hypothèses sont adaptées (ou adaptables) pour l'analyse des liens volume-qualité dans le domaine de la santé.

Partie 1

Lien entre volume d'activité et qualité : une revue systématique de la littérature

1. Lien entre volume d'activité et qualité : une revue systématique de la littérature

1.1. Introduction

Cette première partie présente les méthodes et les résultats principaux de la revue systématique de l'IRDES sur les liens entre le volume d'activité et la qualité des soins au sein des établissements de santé. Les principales questions adressées par cette revue sont les suivantes :

– Quels sont les domaines d'activité (interventions) le plus souvent étudiés ?

– Quels sont les indicateurs utilisés pour mesurer la qualité et le volume ?

– Dans quelle mesure les résultats convergent-ils pour une même intervention/procédure ?

– Quelle est la pertinence des méthodes statistiques utilisées ?

Cette revue systématique couvre les études publiées de 1997 à 2007. Le fait de se concentrer sur les études les plus récentes est important dans un contexte où la qualité des données et les méthodes statistiques utilisées évoluent rapidement. Avant de présenter les résultats de cette revue, nous faisons un point rapide sur les enseignements des revues systématiques antérieures afin de positionner nos résultats par rapport à ces travaux. Ainsi, nous résumons dans la section suivante les résultats de quatre grandes revues réalisées dans les dix dernières années. Nous présentons ensuite la stratégie de recherche et les méthodes employées dans notre revue systématique (section 1.3), suivies par le résumé synthétique des résultats (section 1.4). La totalité des articles étudiés est présentée dans l'Annexe 2, à l'aide d'une grille d'analyse commune.

1.2. Résumé des revues systématiques antérieures

Depuis les années quatre-vingt, un grand nombre d'études ont tenté d'établir une relation significative entre les volumes de cas traités, pour diverses interventions chirurgicales, et les résultats pour les patients. Si la plupart des études semblent indiquer que les patients soignés dans des établissements à volume élevé ont un risque de mortalité plus faible, la fiabilité des études est souvent mise en cause.

En 1997, le Centre national de revues et dissémination à l'Université de York (*NHS Center for Reviews and Dissemination*) en Angleterre a publié un examen systématique des études publiées jusqu'en 1996. Cette revue de York (Sowden *et al.,* 1997), qui est devenue une référence majeure dans ce domaine, tire trois conclusions principales sur la relation volume-qualité :

– Contrôle du *case-mix* : la plupart des recherches ne contrôlent pas suffisamment les caractéristiques cliniques des patients traités dans les différents établissements ;

– Causalité : aucune étude ne montre que l'augmentation de l'activité dans le temps conduit à l'amélioration des résultats. Il est donc difficile de conclure, à partir des résultats des études transversales (montrant que les établissements à volume d'activité élevé ont de meilleurs résultats), que ce résultat est transposable à d'autres établissements et que l'expansion de l'activité y améliorera la qualité ;

– Seuil d'activité : la plupart des études montrent que si l'augmentation d'activité engendre un gain de qualité, le niveau du seuil demandé est plutôt faible. Au-delà d'un certain seuil d'activité, les augmentations de volume peuvent être réalisées au sein d'un même établissement, sans changements structurels majeurs, mais en redéfinissant le partage du travail à l'intérieur des départements/services d'un établissement donné.

Ainsi, malgré plusieurs travaux considérés comme pertinents, la revue de York conclut essentiellement que la plupart des études disponibles sont contestables du point de vue méthodologique et qu'elles ont peu de valeur pour orienter les décisions concernant la restructuration des services de soins.

Les résultats des autres revues systématiques suivant la revue de York vont dans le même sens. Slim et Chipponi (2002), en étudiant la littérature entre 1985 et 2001 sur un certain nombre d'interventions chirurgicales, notent que peu d'études s'appuient sur un bon ajustement des caractéristiques des patients pour comparer les centres de soins ou les chirurgiens. Ils concluent que les biais méthodologiques ne permettent pas une conclusion définitive, même si une relation positive est suggérée, notamment pour les centres de soins. En ce qui concerne le volume d'activité du chirurgien et ses résultats, ils estiment que la relation est moins bien établie.

En évaluant les études publiées entre 1980 et 2000, Ethan *et al.* (2002) concluent qu'un

volume d'activité élevé est associé à de meilleurs résultats pour un grand nombre d'interventions mais que l'ampleur de cette relation varie largement. Les auteurs notent toutefois qu'en raison des problèmes méthodologiques liés à la plupart de ces études, il apparaît difficile de se fonder sur ces conclusions pour orienter les politiques régionales.

Signalons enfin la revue ICIS (2005) commandée et publiée par l'Institut Canadien d'information sur la santé, qui tend plutôt à confirmer les résultats de l'étude de York : « *[…] on a peu souvent pris en compte les risques préexistants et les autres caractéristiques ayant des répercussions sur les résultats pour les patients comme l'âge, la gravité des maladies et les autres problèmes de santé.* » . Les auteurs notent également qu'il est difficile de comparer les conclusions de chaque étude en raison de différences existant sur trois principaux points : la définition des interventions, les seuils utilisés pour définir le volume, et les mesures des résultats utilisées. Ainsi, même si les établissements ayant un grand volume d'activité obtiennent souvent de meilleurs résultats, ils concluent que la relation entre le volume et les résultats n'est pas explicite.

1.3. Méthodologie de la revue IRDES

1.3.1. Identification des études

Nous avons recherché de manière systématique les études publiées entre 1997 et 2007 portant sur des procédures chirurgicales, des interventions et/ou d'autres types de soins ou services de santé dont les résultats ont été étudiés à partir d'une mesure du volume de soins.

La recherche bibliographique a été effectuée à partir des mots-clés sur les bases de données électroniques suivantes (1997-2007) :

=> Medline, Pubmed, Embase (Elsevir), Pascal (CNRS-INIST France), Bdsp (Banque de données santé publique), bases IRDES.

La stratégie de recherche est décrite en détail en Annexe 1. Une revue de la littérature préliminaire a été effectuée pour définir les mots-clés utilisés. Nous avons cherché à éviter les restrictions *a priori* concernant les interventions et les types de soins (ce qui était le cas pour la plupart des revues précédentes). Ainsi, nous avons pu identifier des études portant même sur des soins de ville.

Nous avons parcouru les titres et les résumés de près de 1 000 articles repérés par la recherche électronique et avons exclu les articles dont le sujet principal n'était pas l'évaluation des résultats en fonction du volume de soins. Notre investigation a été complétée par une recherche manuelle des bibliographies.

Après élimination des doublons, nous avons recensé au total 226 références entrant dans le cadre de notre étude. Dans cette liste, 29 articles ont été exclus de la procédure de relecture car ils ne correspondaient pas exactement à notre problématique « volume-qualité » ou ne comportaient pas de résultats empiriques. En outre, 22 articles n'ont pas été inclus dans notre revue puisque nous n'avons pas réussi à les obtenir dans les délais de notre étude[5]. Au final, nous avons examiné 175 articles en détail.

1.3.2. Critères d'inclusion et d'exclusion

Seules les études publiées ces dix dernières années, présentant des résultats empiriques et ayant un questionnement direct sur le rapport entre le volume d'activité d'un établissement (ou d'un praticien) et les résultats de soins obtenus, ont été retenues.

Nous avons inclus un large spectre d'études portant sur des données cliniques, des données administratives, des cohortes prospectives/rétrospectives et des analyses longitudinales. Les études comparant les résultats des patients traités dans des établissements avec différents niveaux de volume et les études de type « avant/après » sont incluses. Nous n'avons pas fait de restriction concernant les variables de « qualité » ou de résultats cliniques. Toutes les variables utilisées comme *outcome* (y compris la morbidité, la satisfaction, la qualité de vie, etc.) sont conservées dans le champ analysé.

Nous avons explicitement cherché les études qui se penchent sur le volume d'activité des médecins (chirurgiens), ainsi que sur celui des établissements de santé (*Cf.* annexe 1).

Les articles ne présentant pas de résultats empiriques (discussion, revues, éditoriaux, etc.) n'ont pas été retenus. Les études utilisant les mêmes données et méthodes pour une intervention donnée (duplication de publication) ne sont présentées qu'une seule fois.

5 Dans la mesure où certains articles constituent des études régionales (une seule région) ou observationnelles provenant en grande partie des Etats-Unis, ils sont publiés dans des revues médicales à faible audience et difficilement accessibles en France.

Les études qui n'interrogent pas directement le rapport volume-qualité mais s'intéressent à l'impact des différents modes d'intervention ou traitement (par exemple anticancéreux), en contrôlant par le volume de l'établissement, ont été exclues. Pour restreindre la portée de la recherche électronique, nous avons cherché les mots-clés uniquement dans les titres et les abstracts.

1.3.3. Protocole/Grille d'analyse

Les études correspondant à nos critères ont été évaluées avec un protocole standard. Pour chaque étude, nous avons décrit les éléments suivants :

– pays ou région(s) étudiée(s) ;

– période(s) étudiée(s) ;

– type de données mobilisées (administratives, cliniques, appariements, registres) ;

– taille de l'échantillon (nombre d'établissements, de chirurgiens, de patients…) ;

– intervention(s) étudiée(s) et codes médicaux (diagnostics, actes ou autres) utilisés pour définir l'intervention (si possible) ;

– indicateurs d'*outcome* employés pour mesurer « la qualité » ;

– indicateurs de volume (par établissement et/ou par chirurgien) ;

– méthodes statistiques et économétriques ;

– variables à l'échelle des patients pour contrôler le *case-mix* (morbidité, variables démographiques, socio-économiques, etc.) ;

– résultats des soins obtenus.

Tous les articles ainsi évalués sont présentés dans l'Annexe 2.

1.4. Principaux résultats

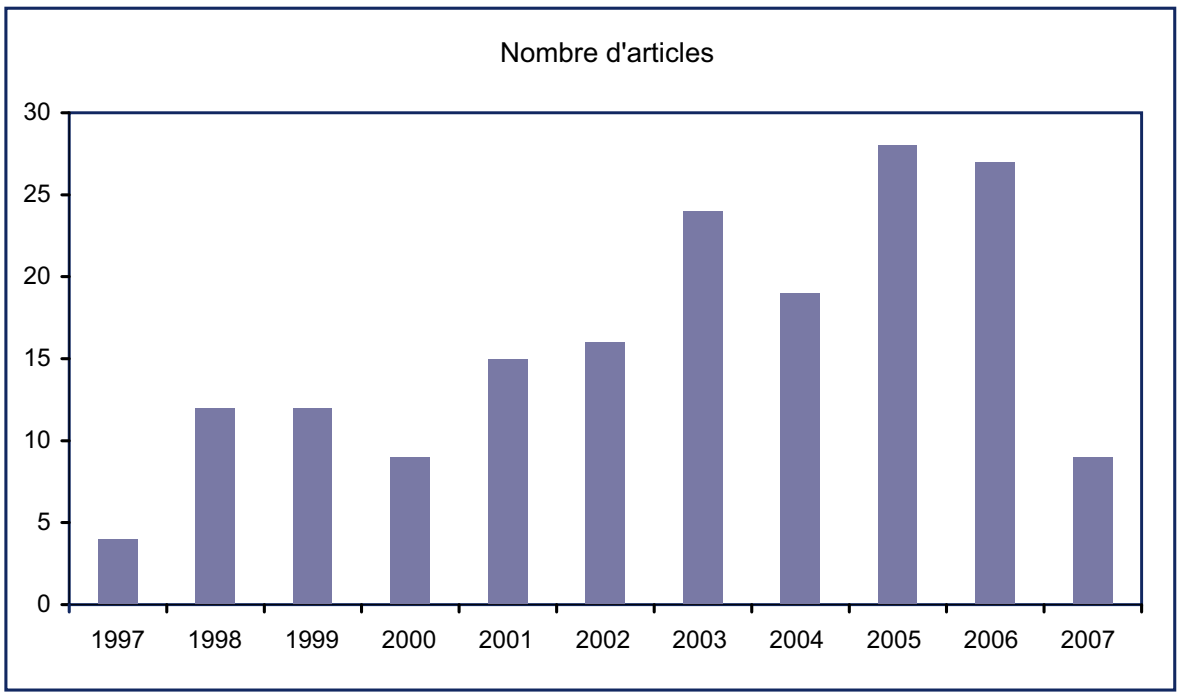
Au total, nous avons examiné **175** articles complets. Nous décrivons ci-dessous les principales caractéristiques de ces 175 articles, en distinguant les interventions étudiées, les indicateurs de qualité et de volume employés, les variables de contrôle de case-mix de et les résultats obtenus.

1.4.1. Caractéristiques des articles sélectionnés

Année de publication

Les articles étudiés ont été publiés entre 1997 et le printemps 2007. Le plus grand nombre d'articles a été publié en 2005 et 2006 (16 % et 15 % respectivement) ; relativement peu d'articles ont été publiés dans les années 1997 et 1998. Ceci reflète notre stratégie de privilégier les études les plus récentes et peut expliquer la différence entre nos conclusions et les enseignements des revues précédentes, notamment en ce qui concerne les données et méthodes utilisées (*Cf.* graphique 1).

Graphique 1
Répartition des études par année de publication



Zone géographique

La majorité des études ont été menées aux États-Unis (126 études, soit 72 %) et ensuite au Canada (16 études). Par rapport aux revues systématiques de la littérature antérieure, notre étude contient une part relativement importante d'études non-américaines. Les études réalisées en Europe représentent 12 % du total et celles réalisées dans le Pacifique occidental plus de 6 %. Une étude internationale compare la mortalité hospitalière pour les interventions coronaires percutanées à partir de 4 registres européens, 3 registres japonais, 4 registres américains et 2 registres internationaux.

Tableau 1
Répartition des études par pays

Pays de l'étude	Nombre d'articles	%
Etats-Unis	126	72,0
Canada	16	9,1
International	1	0,6
Europe	21	12,0
Allemagne	4	2,3
Angleterre	9	5,1
Espagne	1	0,6
France	2	1,1
Italie	1	0,6
Pays-Bas	3	1,7
Suède	1	0,6
Pacifique occidental	11	6,3
Australie	4	2,3
Japon	3	1,7
Corée	1	0,6
Taiwan	3	1,7
TOTAL	**175**	100,0

Sources de données et méthodes employées

Un peu plus de la moitié des études (53 %) sont basées sur des données administratives (*Cf.* Tableau 2), la plupart étant représentatives à l'échelle nationale. Presque toutes ajustent par des indicateurs de comorbidité et les caractéristiques des patients (âge, sexe). De nombreuses études sur données administratives introduisent également un contrôle du statut socio-économique des patients.

Le type de données utilisées détermine la qualité de la mesure et du contrôle du *case-mix*: celui-ci s'améliore dans les publications basées sur un appariement de données administratives et cliniques et *a fortiori* dans les données cliniques pures (comme les registres) qui sont généralement beaucoup plus détaillées au point de vue clinique.

44 études reposent sur des données administratives hospitalières, chaînées avec d'autres bases de données cliniques (ou, à défaut, fournissant des données de morbidité détaillées). On en compte 26 qui sont basées sur des registres spécifiques: elles offrent évidemment un meilleur contrôle des caractéristiques des patients avec de très nombreuses variables cliniques bien ciblées. 6 publications sont fondées sur des enquêtes ponctuelles *ad hoc* et 5 sur une base prospective avec un suivi de cohorte.

Nous avons également repéré une analyse utilisant une étude de cohorte intégrée dans un essai clinique randomisé.

La plupart des études sont menées de façon rétrospective, mais certaines proposent un suivi prospectif, notamment les études de cohorte. Certaines s'appuient sur un suivi mixte, combinant ces deux aspects rétrospectif et prospectif.

Les méthodes statistiques utilisées dans ces études sont diverses mais généralement bien adaptées, comprenant des analyses uni-variées et bi-variées (avec des tests du Khi²), des tests statistiques variés (T-test, test de Wilcoxon ou méthode rank-sum) ou des régressions simples (logistique, linéaire).

Certaines études s'appuient sur des modèles statistiques (analyse de la variance, régression logistique multiple) avec des ajustements sur des plus ou moins nombreuses variables: le profil sociodémographique et socio-économique du patient, la sévérité de la maladie (stade de gravité d'une tumeur par exemple), les comorbidités, les caractéristiques des procédures chirurgicales, les autres traitements éventuellement administrés, etc.

3 études sur 4 portaient sur plusieurs années (de 2 à 10 ans). Ceci permet l'utilisation de techniques économétriques plus élaborées et plus pertinentes dans certaines études prenant en compte la temporalité (économétrie de panel) ou certaines caractéristiques des établissements hospitaliers (méthodes multi-niveaux). De manière générale, ces études comprennent une multitude de techniques et d'approches économétriques différentes et plutôt innovantes.

Tableau 2
Nature des données utilisées dans la littérature

Type de données mobilisées	Nombre de publications
Données administratives	81
Appariement de données cliniques et administratives	44
Données cliniques	50
Suivis de cohorte/essais cliniques	12
Etude de cohorte incluse dans un essai clinique randomisé	1
Enquêtes ponctuelles	6
Registres	26
Registres avec suivi prospectif	5

1.4.2. Soins et interventions étudiés

La grande majorité des recherches publiées portaient sur des interventions chirurgicales (85 %). Le reste des études s'intéresse à un ensemble hétérogène de soins, regroupant à la fois des soins médicaux et l'ensemble des prestations délivrées par des services et unités de soins spécifiques (service obstétrique, unité de soins intensifs, etc.). Enfin, 3 études consacrées aux soins de ville ont également été conservées dans le champ de notre revue systématique.

Tableau 3
Nature des soins et des interventions étudiés dans la littérature

	Nombre	Pourcentage
Interventions chirurgicales dont :	**147**	**84,0**
Interventions liées à un cancer/tumeur	*90*	*51,4*
Interventions cardio-vasculaires	*67*	*38,3*
Interventions orthopédiques	*18*	*10,3*
Autres	*10*	*5,7*
Centres de soins médicaux dont :	**14**	**8,0**
Soins intensifs	*1*	*0,6*
Traumatologie	*10*	*5,7*
Urgences	*2*	*1,1*
Tous soins confondus	*1*	*0,6*
Soins médicaux à l'hôpital dont :	**6**	**3,4**
Cardiologie	*3*	*1,7*
Respiratoire	*2*	*1,1*
Néphrologie	*1*	*0,6*
Soins obstétriques dont :	**5**	**2,9**
Accouchement non compliqué	*1*	*0,6*
Naissance à risque (sous-poids)	*2*	*1,1*
Soins intensifs pédiatriques/ néonataux	*2*	*1,1*
Soins de ville	**3**	**1,7**
Total	**175**	**100,0**

Les interventions chirurgicales

Concernant les interventions chirurgicales, sur 147 articles examinés, près d'un quart porte sur plusieurs interventions : au total, les articles retenus analysent 185 interventions chirurgicales distinctes. Trois articles ont examiné un ensemble hétérogène d'interventions chirurgicales, l'un d'entre eux analysant jusqu'à 16 interventions différentes. Les pourcentages indiqués ci-dessous feront référence au nombre d'articles examinés alors que le Tableau 3 présente (sous le libellé « interventions chirurgicales ») le nombre total d'interventions étudiées par catégorie et les pourcentages qui s'y réfèrent.

a. Chirurgies du cancer

La chirurgie du cancer est un objet d'analyse fréquent dans la littérature : 58 études parmi celles retenues portent sur ce sujet et analysent un total de 90 interventions distinctes sur le cancer.

En termes de résultats, seule une faible minorité ne trouve pas d'association entre volume et qualité (5 études). 86 % des études analysées révèlent une relation positive entre volume et qualité. 3 études concluent à une association plus mitigée dépendant fortement de la procédure analysée et/ ou de l'indicateur de qualité retenu.

Sur le plan anatomique, les publications portent le plus souvent sur un seul organe et une seule procédure chirurgicale, essentiellement sur l'appareil digestif (55 %) et dans une moindre mesure sur l'appareil urogénital (21 %). Mais une part non négligeable d'entre elles rassemble au sein d'une même étude plusieurs localisations et, par conséquent, plusieurs procédures chirurgicales (19 %). Plus précisément, la répartition des études selon les localisations anatomiques des tumeurs est la suivante :

– *appareil digestif (55 %)* : 8 études sur les résections de l'œsophage, 2 sur les pancréatectomies, 4 sur les pancréatico-duodénomectomies, 2 sur les résections hépatiques, 8 interventions sur le côlon et/ou le rectum, 1 étude portant à la fois sur les gastrectomies et les colectomies ;

– *appareil urogénital (21 %)* : 6 analyses sur les interventions pour cancer du sein, 1 sur les ovaires, 1 sur l'utérus, 2 sur la prostate et 2 sur la vessie ;

– *poumons (2 %)* : 1 étude portant sur les poumons (thoracotomie pour cancer du poumon) ;

– *autres (3 %)* : 2 études portant sur des cancers autres, 1 sur le cancer de la thyroïde et 1 sur un cancer du cerveau (au niveau de la glande pituitaire) ;

– *mixtes : cancers différents (9 %) :* 5 études intègrent des cancers de localisation différentes cités ci-dessus ;

– *mixtes : cancers et autres tumeur (9 %) :* 5 autres études intègrent à la fois des cancers de localisation diverse et des interventions hors cancer, portant le plus souvent sur l'appareil cardiovasculaire mais aussi orthopédique.

Cette répartition n'est pas représentative des interventions chirurgicales effectuées mais elle montre cependant l'intérêt particulier qui existe pour les procédures relatives aux cancers dont l'incidence est très importante.

Sur le plan géographique, les États-Unis rassemblent à eux seuls 60 % des études sur la chirurgie du cancer, suivis du Canada (14 %), du Royaume-Uni (3 études), de la Hollande (3), de l'Allemagne (2), du Japon (2), et enfin de l'Espagne, de la Suède, de l'Australie et de la Corée (chacun 1).

La plupart des études font état d'ajustements ou de contrôles des résultats par un socle minimum de variables sociodémographiques et de comorbidité. Certaines contrôlent également par le statut de l'hôpital ou du chirurgien vis-à-vis de certaines activités, tel que le degré d'enseignement dispensé.

S'agissant des cinq études qui ne repèrent aucune relation entre volume et qualité, il s'avère qu'elles portent toutes sur des tumeurs de l'appareil digestif et que trois d'entre elles s'appuient sur des effectifs très faibles (*Cf.* Etudes n° 23, 117 et 162 dans l'Annexe 2). Par ailleurs, cette absence de résultat renvoie peut-être à la spécificité du lien volume-qualité selon la nature de la maladie et la procédure analysée, puisque deux études récentes et plus robustes sur le traitement du cancer colorectal ne mettent en évidence aucune corrélation entre le volume d'intervention d'une part, et le nombre de rechutes et la mortalité d'autre part (n° 48 et 76).

Parmi les trois études présentant des résultats plus contrastés, l'une concerne la résection pancréatique (n° 153), la seconde porte sur le cancer de l'estomac (n° 27) et la troisième (n° 30) couvre cinq types de cancer (côlon, œsophage, foie, sein, poumons).

Tableau 4
Nature des interventions liées au cancer étudiées dans la littérature

	Nombre	%
Appareil digestif, dont :	32	55,2
Oesophagectomie et/ou résection du cardia	8	13,8
Estomac	2	3,4
Pancréas	8	13,8
Foie - Résection hépatique	3	5,2
Côlon, rectum	10	17,2
Mixte (Gastrectomie, colectomie)	1	1,7
Urogénital, dont :	12	20,7
Sein	6	10,3
Ovaires	1	1,7
Utérus	1	1,7
Prostate (Prostatectomie radicale ou non)	2	3,4
Vessie (Cystectomie radicale)	2	3,4
Bronches, poumons	1	1,7
Autres	2	3,4
Etudes mixtes dont :	11	19,0
Différentes localisations de cancers	6	10,3
Cancers et autres interventions non liées au cancer	5	8,6
Total	**58**	**100,0**

Le nombre de patients inclus ou observés est très variable d'une étude à l'autre : de moins de 200 (oesophagogastrectomie) jusqu'à près de 350 000 dans le cas d'une étude mixte sur plusieurs types de cancers et d'interventions, répartis dans un plus ou moins grand nombre d'hôpitaux.

Les techniques chirurgicales employées peuvent varier d'un malade à l'autre, notamment en fonction du stade de sévérité de la tumeur, mais aussi d'un établissement à l'autre et/ou d'un chirurgien à l'autre. Le recrutement des patients opérés n'est pas non plus toujours homogène selon les zones géographiques. Dans le cas du cancer, il faut garder à l'esprit que souvent l'intervention chirurgicale n'est qu'une étape dans un processus de traitement plus global, relayée par exemple par de la chimiothérapie et/ou de la radiothérapie, ce qui n'est pas sans influence sur les indicateurs de qualité utilisés. En effet, la pratique de ces thérapies complémentaires doit se conformer aux recommandations de bonnes pratiques. Ainsi, pour certains cancers étudiés ici, il est capital que l'analyse tienne compte de l'existence de ces traitements complémentaires lorsqu'ils sont indiqués.

b. Interventions cardio-vasculaires

67 études portent sur une ou plusieurs interventions cardio-vasculaires. L'intervention chirurgicale la plus souvent étudiée est le pontage aorto-coronarien (PAC). Le PAC est une intervention

à cœur ouvert, devenue relativement commune, coûteuse, présentant un risque élevé de mortalité et qui nécessite une compétence technique importante.

18 études évaluent l'effet du volume de pontages sur les résultats obtenus. A l'exception de deux d'entre elles, toutes ces études montrent une relation positive entre le volume d'activité des établissements et des chirurgiens et de meilleurs résultats, mesurés le plus souvent par la mortalité à l'hôpital et/ou à 30 jours.

Parmi ces études, l'une d'entre elles observe les résultats en termes d'infections nosocomiales après l'opération (n° 40), une autre compare le temps d'attente avant l'opération dans différents établissements (n° 45) et une troisième intègre également les durées de séjours (n° 74). Près de la moitié des publications évalue l'activité des chirurgiens en plus de (ou au lieu de) l'activité des établissements. Elles concluent toutes que le volume d'activité des chirurgiens a un impact significatif sur la qualité. Une seule d'entre elles suggère que le volume d'activité du chirurgien n'a pas d'effet sur les résultats des PAC (réalisés à « cœur battant ») dans les établissements à haut volume d'activité (n° 13). Mais cette étude trouve une relation négative entre le volume d'activité des chirurgiens (même dans les établissements à forte activité) et la mortalité pour les pontages réalisés avec « circulation extracorporelle ».

Tableau 5
Nature des interventions cardio-vasculaires étudiées dans la littérature

	Nombre	%
Pontage aortocoronarien	18	26,9
Intervention coronaire percutanée	11	16,4
Réparation de l'anévrisme de l'aorte abdominale	10	14,9
Angioplastie et thrombolyse	7	10,4
Endartériectomie de la carotide	7	10,4
Remplacement de la valvule sigmoïde	4	6,0
Angioplastie coronaire percutanée transluminale	4	6,0
Pose de stent coronaire	2	3,0
Autres	4	6,0
Total	**67**	**100**

Une étude française exploitant les données de registre de l'Agence Régionale d'Hospitalisation d'Ile-de-France suggère qu'il n'y a pas de relation entre le volume de pontages de l'établissement et le taux de mortalité pour les patients à bas risques (cas non-urgents et non compliqués), mais que les taux de complication y sont plus élevés (n° 39). En revanche, l'étude montre que les taux de mortalité et de complication sont liés de manière significative au volume d'activité pour les interventions urgentes. Une autre publication (n° 141) compare les taux de mortalité des hôpitaux classés par groupes selon des seuils d'activité utilisés par Leapfrog[6] aux Etats-Unis : au-delà de l'existence réelle d'un lien volume-qualité, cette étude montre qu'il existe des variations intra-classes importantes (c'est-à-dire des variations à l'intérieur de ces groupes d'hôpitaux définis).

Les 9 études sur la réparation de l'anévrisme de l'aorte abdominale (AAA), qui est une intervention extrêmement délicate nécessitant une greffe dans l'aorte, trouvent toutes une relation négative entre le volume d'activité et la mortalité.

La grande majorité des études examinant différentes interventions coronaires sont unanimes dans leurs conclusions : il existe un impact du volume d'activité, non seulement des établissements, mais aussi des chirurgiens, qui permet de réduire la mortalité et d'augmenter la survie des patients. Ainsi, une étude (n° 10) démontre que, pour un chirurgien, c'est son volume annuel d'activité qui prend le pas sur son nombre d'années d'expérience. Une autre étude, (n° 29) axée sur le remplacement de la valvule sigmoïde chez les personnes âgées, suggère que les établissements à bas volume suivent moins bien les recommandations cliniques et les évolutions technologiques les plus récentes.

Une étude japonaise n'observe aucun lien entre le nombre d'angioplasties réalisées pour infarctus du myocarde aigu (IMA) dans les établissements, et les taux de mortalité (n° 127). La seule autre étude suggérant que le volume d'interventions coronaires par chirurgien n'a pas d'impact sur les résultats vient des Etats-Unis, mais elle est basée sur un échantillon très réduit de 9 chirurgiens.

Une étude internationale compare les résultats (mortalité à l'hôpital) des interventions coronaires percutanées à partir de 4 registres européens, 3 registres japonais, 4 registres américains et 2 registres internationaux (n° 126). Elle observe que, dans chaque pays, il existe une relation inverse entre le volume d'interventions réalisé et la mortalité. En parallèle, l'étude montre que, dans l'ensemble, la qualité des soins est meilleure au Japon, où même les établissements ayant une faible activité ont des résultats comparables aux meilleurs établissements des autres pays.

6 Leapfrog est un groupement d'employeurs qui achètent des soins de santé aux États-Unis. Il vise à améliorer la qualité, la sécurité et la transparence des soins achetés pour les Américains. Pour choisir les hôpitaux et juger de leur qualité, un des critères utilisés est le volume d'activité concernant les interventions chirurgicales.

c. Interventions orthopédiques

18 articles évaluent diverses procédures chirurgicales orthopédiques, notamment la prothèse totale de la hanche et du genou. La quasi-totalité confirme que les résultats en termes de mortalité, de réadmission, de complications postopératoires (telles que dislocations, embolie, infection, etc.) et de durée de séjour après opération s'améliorent avec le volume d'activité des établissements et/ou des chirurgiens (*Cf.* Tableau 6).

La plupart des études examinent à la fois le volume d'activité spécifique de l'établissement et celui des chirurgiens. L'une d'entre elles (n° 37) suggère que si le nombre (volume) de prothèses de hanche réalisées par le chirurgien est un déterminant significatif des résultats, ce n'est pas le cas du volume global d'activité orthopédique de l'établissement.

Une autre étude (n° 95) observe que la relation entre le volume des interventions et la qualité n'est pas systématique et que, dans le contexte américain, le type de HMO[7] ou d'assurance des patients peut avoir plus d'influence sur les résultats.

Tableau 6
Nature des interventions orthopédiques étudiées dans la littérature

	Nombre	%
Arthroplastie totale de la hanche	5	27,8
Arthroplastie totale du genou	4	22,2
Arthroplastie totale de l'épaule	3	16,7
Intervention majeure sur la hanche et le genou	1	5,6
Fracture de la hanche	3	16,7
Scoliose pédiatrique	1	5,6
Réparation du poignet	1	5,6
Total	**18**	**100**

d. Autres interventions chirurgicales

Nous avons également recensé 15 autres interventions chirurgicales étudiées dans la littérature qui ne se rattachent à aucune des catégories précédentes (*Cf.* Tableau 7).

Tableau 7
Nature des autres interventions chirurgicales étudiées dans la littérature

	Nombre	%
Chirurgie bariatrique	3	20,0
Cataracte	3	20,0
Incontinence urinaire	1	6,7
Interventions gastro-intestinales complexes	1	6,7
Reconstruction pelvienne	1	6,7
Chirurgie pédiatrique	3	20,0
Dérivation ventriculo-péritonéale	1	6,7
Hémorragie sous-arachnoïdienne	1	6,7
Cholecystectomie laparoscopique	1	6,7
Total	**15**	**100**

Parmi ces études, trois analysent l'impact de l'activité du chirurgien sur les résultats après une chirurgie de la cataracte :

– La première, une étude américaine (n° 175), observe qu'il existe une relation positive et significative entre le volume d'activité des chirurgiens et de meilleurs résultats (taux de complications) et que cette relation se confirme même pour des seuils d'activité très élevés (> 1 000 actes par an).

– Une deuxième étude, anglaise (n° 15), trouve des résultats similaires.

– Toutefois, une autre étude menée par les mêmes auteurs (n° 14), réfute ces résultats en introduisant un meilleur contrôle du *case-mix.* Les auteurs soulignent l'importance de bien contrôler les facteurs de risque pour attester de la fiabilité d'une étude volume-qualité sur la chirurgie de la cataracte.

La plupart des autres études sur les interventions listées dans le Tableau 7 confirment le lien significatif et positif entre volume d'activité et qualité des résultats obtenus, sauf pour la pancréatectomie pédiatrique (n° 162). Notons toutefois qu'en raison de la rareté de cette opération, les résultats de cette étude ne s'appuient que sur cinq cas.

Soins médicaux et prises en charge de services spécifiques

Certaines études ne portent pas sur des interventions bien ciblées, mais sur des soins non chirurgicaux ou sur des prises en charges globales assurées par des services et des unités de soins spécifiques. Au total, nous avons repéré 28 études qui entrent dans ce cadre.

7 Le *Health Maintenance Organization* (HMO) constitue une forme d'organisation de managed care qui contracte directement avec les producteurs de soins (sur une base tarifaire et de contenu des prestations de soins délivrées) et qui couvre les assurés à la condition que ceux-ci ne consultent que les producteurs de soins agréés par le HMO.

Cinq études portent sur des procédures obstétriques et sur la prise en charge des nouveau-nés prématurés. Les études analysant l'activité dans les centres de soins intensifs pour les prématurés concluent en général que la mortalité néonatale diminue avec l'activité du centre ; seule une étude anglaise apporte des conclusions différentes. Sur deux études observant la relation entre le volume d'accouchements des femmes enceintes à faible risque et les taux d'intervention pour complications, ainsi que la mortalité néonatale, la première (australienne) ne constate aucune corrélation, tandis que l'autre (allemande) observe des taux de mortalité plus élevés dans les cliniques à faible volume d'activité. Précisons que, contrairement à l'étude allemande, l'étude australienne ne contrôle pas les facteurs de risques.

Nous avons isolé 6 études qui s'intéressent davantage à la prise en charge globale à l'hôpital des pathologies (principalement cardiaques mais aussi respiratoires) qu'à des interventions spécifiques. Elles suggèrent toutes que les patients traités dans des établissements à haut volume ou par des médecins à forte activité (expérimentés) ont des taux de survie plus élevés. Une autre étude porte sur la prise en charge d'une maladie rare (systémique lupus erythematosus) et suggère également que l'expérience des médecins (mesurée par le volume de patients traités) est un facteur important de réduction de la mortalité.

14 études évaluent le volume d'activité de services ou d'unités spécifiques de prestation de soins, notamment les centres de traumatologie. Les résultats concernant ces centres de traumatologie ne semblent pas tranchés puisque la moitié des études mettent en évidence une relation significative entre le volume d'activité des centres et la qualité, tandis que l'autre moitié observe que le volume n'a pas d'effet sur les résultats. Cependant, même les études validant la corrélation volume-qualité tempèrent cette conclusion en indiquant que cette relation est surtout vérifiée pour les cas les plus compliqués. Enfin, une publication portant sur les unités de soins *intensifs* pour trois diagnostics principaux, montre que le volume a un effet significatif pour les patients souffrant d'affections respiratoires compliquées ou gastro-intestinales, mais pas pour ceux ayant des problèmes neurologiques.

Soins de ville

Citons également 3 études fondées sur l'analyse du volume d'activité en soins de ville. Même si ces études n'entrent pas dans notre champ d'analyse *stricto sensu*, elles ont été conservées dans la revue de la littérature dans l'objectif de replacer les résultats des études hospitalières dans un contexte plus large. La première étude porte sur la relation entre le volume d'activité (visites en ambulatoire et séjours) des centres psychiatriques et la qualité des soins fournis mesurée par les indicateurs HEDIS[8] : elle établit une relation positive (n° 8).

La deuxième étude évalue le nombre de patients traités par médecin généraliste et conclut que les patients âgés diabétiques consultant des médecins ayant une activité importante ont plus de chances de recevoir des soins de bonne qualité (n° 4). En revanche, une troisième étude américaine arrive à la conclusion inverse : elle montre que les médecins ayant une patientèle importante réalisent leurs consultations plus rapidement, ce qui a un effet néfaste sur la qualité, mesurée par la satisfaction des patients et le taux des soins préventifs fournis (n° 105).

Effet pervers d'une trop forte activité

Par ailleurs, nous avons repéré 3 études (n° 172, 173 et 174) démontrant qu'un volume d'activité trop élevé pouvait avoir des répercussions néfastes sur la qualité des soins et sur les résultats sanitaires. Une première étude relève une relation positive entre le volume des patients traités par infirmier et la survenue d'événements indésirables. Deux autres études examinent l'activité des services d'urgence et montrent que la mortalité hospitalière y est plus élevée dans les périodes de suractivité. Notons que ces études cherchent à établir l'impact d'une « surcharge » (par exemple un taux d'occupation supérieur à 100 %) sur les résultats et emploient des méthodes différentes de la plupart des études traditionnelles sur le lien volume-qualité. Nous les avons incluses ici à titre illustratif car elles permettent de remettre en perspective la relation volume-qualité, en pointant les risques potentiels d'une suractivité.

1.4.3. Définition de la qualité

Le taux de mortalité est l'indicateur de résultat le plus couramment retenu. Le plus souvent, il s'agit du taux de mortalité à l'hôpital ou bien à 30 jours. De nombreuses études s'intéressent également à la survie du patient sur des périodes plus longues, de 1 à 5 ans (voire 10 ans). Une autre mesure fréquemment utilisée, si l'intervention ou les soins étudiés s'y prêtent, est la durée du séjour d'hospitalisation. La survenue de réadmissions

8 HEDIS (*Health Employer Data and Information Set*), qui couvre 73 millions d'Américains, est la plus importante base de données aux Etats-Unis. Elle fournit de nombreux indicateurs pour mesurer la performance des soins de santé mentale, notamment en termes de suivi après hospitalisation et de pertinence des traitements médicamenteux (antidépresseurs).

non programmées, de ré-interventions ou de complications postopératoires est aussi fréquemment étudiée. Certaines études s'intéressent, enfin, aux infections ou aux autres événements indésirables survenus à l'hôpital pendant ou après les soins.

Les indicateurs de qualité utilisés concernent, par ordre de fréquence :

– la mortalité hospitalière, la mortalité à 30 jours, 60 jours et à 2 ans ;

– les complications postopératoires et les décès par complications postopératoires ;

– la durée de séjour totale ou celle en soins intensifs ;

– le taux de réadmission à l'hôpital ;

– le taux de ré-intervention ;

– le taux de rechute ;

– le taux de survie globale (à 5 ans, 6 ans, 10 ans et à plus long terme) ou le taux de survie à 5 ans sans rechute ;

– le taux d'apparitions de certaines séquelles (ex. colostomie permanente) ;

– le temps de survie avant décès par cancer ou quelle qu'en soit la cause ;

– le taux d'échec du chirurgien.

De manière générale, on constate que les indicateurs utilisés pour évaluer les résultats sont de plus en plus variés et le plus souvent adaptés aux procédures spécifiques étudiées. Par exemple, les études sur des interventions complexes présentant un risque de mortalité élevé se concentrent sur les taux de mortalité tandis que toutes les études sur les interventions orthopédiques, telles que la prothèse totale de la hanche ou du genou, examinent non seulement les taux de mortalité mais aussi plusieurs indicateurs de complications postopératoires à long terme (Tableau 8).

Tableau 8
Indicateurs de résultats utilisés selon les interventions étudiées

		Chirurgie du cancer	Chirurgie cardiaque	Chirurgie orthophédique	Centres de traumatologie	Obstétrique
		% des études mobilisant cet indicateur de résultats				
Mortalité	Mortalité hospitalière	60,3	71,6	11,1	80,0	60,0
	Mortalité à 30 à 90 jours	24,1	19,4	55,6	-	-
	Taux de survie à long terme (6 mois à 10 ans)	29,3	-	-	40,0	-
Réhospitalisation	Réadmissions/ réinterventions à 30 j	10,3	1,5	-	10,0	-
	Réadmissions/ réintervention de 60 j à 5 ans	-	-	27,8	-	-
Autre	Complications post-opératoires	29,3	25,4	50,0	-	-
	Durée moyenne de séjour (DMS)	25,9	10,4	44,4	40,0	20,0
	Coût hospitalier	10,3	6,0	16,7	-	20,0
	Résultats cliniques du patient	0,0	17,9	11,1	-	20,0
	Infections nosocomiales	0,0	3,0	27,8	-	20,0
	Autres	8,6	7,5	-	-	-

Guide de lecture : 60,3 % des études portant sur la chirurgie du cancer ont utilisé la mortalité hospitalière comme indicateur de résultat. La plupart des études utilisent plusieurs indicateurs de résultats conjointement, ce qui explique que les sommes des pourcentages en colonne soient supérieurs à 100 %.

1.4.4. Définition du volume d'activité

L'indicateur de volume utilisé préférentiellement est le nombre de séjours spécifiquement lié à l'intervention étudiée, et mesuré au niveau de l'hôpital et/ou du chirurgien. Parfois, on y adjoint le volume de consultations réalisées.

Variable continue ou variable en classes

Il existe deux façons de considérer le volume : comme une variable continue ou comme une variable en classes. Considérer le volume comme une variable continue implique que les résultats cliniques varient de manière continue (voire linéaire) selon les différentes valeurs du volume d'activité. Dans une grande majorité des études, le volume est considéré comme une variable nominale, qui regroupe les établissements/chirurgiens dans des catégories définies par des seuils de volumes. Ces seuils de volume et les catégories qui en découlent peuvent être fixés *a priori* ou *a posteriori*. La définition *a posteriori* des catégories est parfois critiquée, avec l'argument que l'analyste peut choisir des points de découpage pour définir des catégories de volume qui optimisent la corrélation volume-résultats. Définir des catégories de volume *a priori*, avant l'observation des données, est censé garantir une plus grande objectivité. Par ailleurs, notons que dans la plupart des études examinées ici, les seuils sont définis de façon à créer un nombre limité de classes de volume d'importance égale à partir de la distribution observée (de 2 à 4 le plus souvent, fondées sur la médiane ou les quartiles). Le nombre de groupes peut monter jusqu'à 10 quand le découpage se fonde sur les déciles de la distribution.

Le découpage en classes de volume d'activité, d'une part, permet une plus grande souplesse dans la forme du lien testé entre volume et qualité et, d'autre part, facilite la lecture des résultats et leur interprétation par les utilisateurs. Seulement deux études ont traité le volume uniquement comme une variable continue, tandis qu'un quart des études ont utilisé la combinaison des deux approches : par exemple en modélisant d'abord le volume en tant que variable continue pour établir le lien volume-qualité, puis en introduisant des classes de volume pour évaluer les niveaux de risque.

De manière générale, on peut donc dire que la définition de « haut » ou « bas » volume varie d'une étude à l'autre et dépend largement de l'intervention/procédure étudiée. Il est très difficile de fournir un résumé des seuils utilisés par intervention en raison de la multitude des méthodes employées. Au final, pour la plupart des interventions, il n'existe pas de seuils d'activité unanimement acceptés. Par exemple, plusieurs études américaines ont remis en question la pertinence des découpages *a priori* et la validité des seuils de volume utilisés comme indicateurs de qualité par le groupe Leapfrog aux Etats-Unis. Ces études indiquent que les variations de mortalité intra-classe demeurent importantes dans les classes créées par Leapfrog.

Volume d'activité mesuré par établissement ou par médecin ?

La plupart des études se sont concentrées sur le volume d'activité global, mesuré au niveau de l'établissement de soins. Cependant, plus d'un tiers des études (63) s'intéressait également au nombre d'interventions réalisée par les praticiens, chirurgiens notamment. Ces études démontrent majoritairement (96 %) une relation positive entre la qualité des résultats et le volume d'activité de ceux-ci.

Il est clair que l'activité d'un établissement et de ses chirurgiens sont corrélées. Il n'existe toutefois pas de conclusions définitives sur l'importance relative de chacune dans le niveau de résultats. En effet, peu d'études ont essayé de distinguer, en utilisant par exemple des modèles hiérarchiques, l'effet du volume de l'établissement de l'effet de l'activité du chirurgien. De manière générale, ces études suggèrent, d'une part, que le volume d'activité de l'établissement et du chirurgien sont tous les deux significatifs même lorsqu'ils sont contrôlés simultanément et, d'autre part, que l'impact spécifique du volume d'activité des chirurgiens persiste même dans les établissements à très forte activité. Cela étant, l'importance relative du volume d'activité de l'établissement ou du chirurgien semble varier d'une procédure à l'autre et en fonction de l'indicateur de résultat utilisé.

1.4.5. Ajustement par les caractéristiques cliniques du patient (*case-mix*)

Les caractéristiques des patients, telles que l'âge, le sexe, la gravité de la maladie, les comorbidités existantes, le statut socio-économique, etc. influent sur les résultats d'une intervention ou d'un traitement. Dans les études qui tentent d'expliquer les variations des résultats obtenus en fonction du volume d'activité, il est important de s'assurer que ces caractéristiques n'influencent pas la relation volume-qualité de manière indue. La revue de la littérature de York (Sowden *et al.*, 1997) avait notamment critiqué la qualité de l'ajustement par les caractéristiques cliniques des patients (*case-mix*) dans les études évaluées : «*... la plupart des recherches ne contrôlent pas suffisamment*

les caractéristiques cliniques des patients traités dans différents établissements ».

De ce point de vue, on constate que les études réalisées au cours des dix dernières années se sont beaucoup améliorées. Nous n'avons repéré aucune étude hospitalière qui ne contrôle pas les facteurs de risque basiques des patients. Au minimum (dans les études basées sur des données administratives), les résultats sont ajustés par l'âge, le sexe, ainsi que par un indice de comorbidité (tel que l'indice de Charlson). Mais la plupart des études introduisent d'autres types de contrôle clinique, en testant différents indices de gravité et de morbidité en plus de l'indice de Charlson.

Signalons que 40 études introduisent également des variables socio-économiques relatives aux patients, en s'appuyant généralement sur l'appariement entre différentes bases de données. Les études fondées sur des registres de pathologies spécifiques présentent dans l'ensemble un très bon contrôle de la morbidité, assis sur un large spectre d'indicateurs cliniques. Par exemple, les études sur les interventions pour cancer ajustent par le type de tumeur, le stade de gravité et l'état de santé général des patients (tension artérielle, diabète, problèmes cardiaques, etc.).

Partie 2

Causalité entre volume d'activité et qualité : éléments théoriques

2. Causalité entre volume d'activité et qualité : éléments théoriques

2.1. Introduction

Malgré l'existence d'un important corpus de recherches empiriques sur le lien entre les volumes d'activité de soins spécifiques et les résultats en termes de santé des patients (*Cf.* partie 1), peu d'études se sont concentrées sur l'explication de ce lien. Deux questions sont essentielles pour comprendre le lien volume-qualité : d'une part, le sens de la causalité entre volume et amélioration de la qualité et d'autre part, les dynamiques sous-jacentes expliquant cette causalité. Si le volume génère de la qualité, il est important de comprendre pourquoi et comment en identifiant les mécanismes qui sous-tendent ce lien.

En premier lieu, dans le contexte du marché hospitalier, le sens de la causalité dans la relation observée entre volume et qualité doit être questionné. Deux hypothèses principales ont été mises en avant :

– La théorie des effets d'apprentissage (ou «la pratique rend parfait»), selon laquelle la qualité des soins dispensés par les médecins et les hôpitaux augmente lorsqu'ils soignent plus de patients (grâce à une expérience accrue). Cela suggère notamment que la relation volume-qualité résulte d'économies d'échelle ;

– La théorie des « renvois sélectifs », selon laquelle on oriente plus volontiers les patients vers des médecins et des établissements de bonne réputation qui offrent des soins de qualité. Contrairement aux effets d'apprentissage, la théorie des renvois sélectifs suppose que c'est la qualité qui engendre le volume plutôt que l'inverse.

La plupart des travaux théoriques et empiriques consacrés au lien volume-qualité proviennent de l'économie industrielle et utilisent le concept « d'économies d'échelle » pour expliquer le lien volume-qualité. Les sources d'économies d'échelle peuvent être statiques ou dynamiques. Les effets d'apprentissage, correspondant à une production plus efficiente avec l'expérience accumulée, ont été particulièrement bien démontrés dans un grand nombre de secteurs d'activité.

Cette partie est organisée de la manière suivante : nous présentons tout d'abord (section 2.2) le concept d'économies d'échelle, nécessaire pour comprendre les questions qui se rapportent aux volumes d'activité des établissements de soins. Nous développons ensuite la littérature sur les effets d'apprentissage, qui semble être particulièrement pertinente pour appréhender la façon dont le volume influence la qualité (section 2.3). Nous introduisons d'abord les aspects théoriques de la courbe d'apprentissage, puis nous cherchons à identifier la façon dont le volume est lié aux coûts et aux résultats, en exploitant les résultats empiriques provenant d'autres secteurs d'activité. Dans une dernière section, nous proposons une synthèse des enseignements pouvant être tirés des études réalisées sur l'hôpital, en observant les études empiriques questionnant le sens de la causalité entre volume et qualité et l'importance de l'effet d'apprentissage, ainsi que les mécanismes sous-jacents (section 2.4).

2.2. Les économies d'échelle

Dans le cas d'une entreprise, on dit qu'il existe des économies d'échelle sur une gamme de produits si les coûts moyens de long terme baissent à la suite d'une augmentation dans l'échelle de production. La théorie économique néoclassique postule souvent une relation entre les coûts de long terme et la taille de l'entreprise, qui suit une courbe en U. Pour les hôpitaux, qui sont des entreprises produisant une multiplicité de biens et de services, de nouveaux concepts ont été introduits afin de distinguer les économies d'échelle d'ensemble (*ray scale*) des économies spécifiquement reliées à un produit donné. De manière générale, ce terme englobe tous les facteurs qui expliquent que les coûts unitaires de production diminuent lorsque la taille d'une entreprise ou de l'un de ses services augmente.

Enfin, le concept « d'économies de gamme » désigne les réductions dans les coûts de production réalisées lorsqu'une entreprise élargit sa gamme de produits et de services (production conjointe). Il faut pour cela qu'elle puisse utiliser des *inputs* identiques, les mêmes installations et le même personnel pour produire plusieurs produits ou services.

Globalement, deux sources d'économies d'échelle sont distinguées : les économies d'échelle internes et les économies d'échelle externes. Ces deux termes sont utilisés différemment par les divers auteurs selon le degré d'agrégation choisi pour séparer les deux niveaux. Par exemple, dans le domaine hospitalier, les économies d'échelle internes se réfèreront souvent à l'hôpital, et les économies d'échelle externes à la région (ou au secteur sanitaire).

Pour comprendre comment le volume d'activité peut améliorer les résultats sanitaires dans les établissements de soins, la littérature sur les économies d'échelle internes semble particulièrement intéressante. Cependant, il est impossible d'évoquer les économies internes sans considérer également les répercussions que pourrait avoir la taille de l'établissement sur d'éventuelles économies d'échelle externes. Nous introduisons ici brièvement les économies d'échelle externes dans la mesure où elles occupent une place importante dans la littérature en économie de la santé et qu'il est indispensable de comprendre leur influence sur la performance d'un établissement de santé donné. Par la suite, nous nous restreindrons aux aspects internes des économies d'échelle, c'est-à-dire aux économies d'échelle réalisées au niveau d'un établissement donné.

2.2.1. Les économies d'échelle externes

Les économies d'échelle externes sont constituées par les avantages qu'une entreprise tire du pouvoir qu'elle exerce sur son environnement (Vettori, 2000). De ce fait, elles découlent de l'action de plusieurs agents économiques. Une entreprise de grande taille qui aurait une situation de monopole ou une situation de leader pourrait, si la concurrence est mal organisée, jouir du pouvoir de fixer les prix sur le marché. Ceci renvoie à la question de la taille de l'entreprise, appréhendée de façon absolue ou relative (par rapport à la concurrence locale), et fait donc référence à un éventuel « pouvoir de monopole ».

Les économies d'échelle externes ont une influence sur la performance des établissements et d'un secteur car elles influencent le comportement de la concurrence et les relations de pouvoir qui prévalent. Elles touchent directement à l'analyse de la concentration sectorielle.

Le marché hospitalier a traditionnellement constitué un champ d'application important pour les politiques antitrust et la littérature sur les économies/des économies d'échelle et de gamme dans le secteur hospitalier est abondante. Il existe, par exemple, de nombreux travaux sur l'existence d'économies d'échelles et sur leur importance dans la production afin de déterminer la meilleure configuration pour l'ensemble des services hospitaliers, ainsi que le niveau d'activité optimal dans les hôpitaux. La revue de York (Sowden *et al.*, 1997) propose une évaluation synthétique de cette littérature et conclut que les économies d'échelle semblent concerner davantage les petits hôpitaux. De plus, les auteurs rappellent que des estimations fiables d'économies d'échelle ne peuvent être obtenues que si tous les autres facteurs sont contrôlés par ailleurs, bien qu'il semble extrêmement difficile d'ajuster toutes les différences de case-mix et de qualité des soins entre les différents hôpitaux.

Plus récemment, des travaux – limités mais néanmoins en plein développement – ont examiné l'impact sur la qualité des soins de la concentration ou du niveau de concurrence dans le marché hospitalier. Gaynor (2004, 2006) présente un bon résumé de la littérature théorique et empirique concernant la concurrence sur le marché de la santé, et ses impacts sur la qualité et le bien-être social. Il souligne que la théorie montre que la concurrence contribue à augmenter la qualité lorsque les prix sont fixés (régulés), comme c'est le cas de la plupart des services sur le marché hospitalier français. Toutefois, les démonstrations empiriques semblent parfois contradictoires et invitent à ne pas tirer de conclusions définitives sur l'impact de la structure du marché sur les indicateurs de qualité, notamment sur la mortalité à l'hôpital. Les limites méthodologiques de ces études sont bien soulignées par Gaynor. Retenons surtout que cette littérature restreinte provient majoritairement des États-Unis et qu'elle suggère, globalement, que la concurrence contribue à augmenter la qualité.

2.2.2. Les économies d'échelle internes

Les économies d'échelle internes résultent des avantages procurés par la taille au niveau de la gestion et de la production pour une entreprise donnée (ou un seul service). Cela fait référence à toutes les améliorations de gestion rendues possibles par l'accroissement de la taille, d'une part avec la standardisation, la mécanisation, etc. et d'autre part par l'amélioration de l'organisation et la planification (production « à temps », automatisation, mais aussi partage du temps de travail, informatisation, etc.). Ceci démontre l'importance de la technique de production lorsque le coût de production croît plus lentement que la capacité de production générée, mais aussi l'importance de l'apprentissage lorsque le nombre d'erreurs diminue avec la quantité produite et que la production est mieux répartie.

On peut alors distinguer deux sources d'économies d'échelle internes : statiques et dynamiques. Les économies d'échelle internes statiques sont directement liées au processus de production et permettent une réduction des coûts unitaires par une augmentation de la production à un moment donné (l'élasticité des coûts par rapport à la production est inférieure à 1). Les coûts unitaires diminuent au moment t à cause d'une baisse des coûts marginaux ou à cause de l'existence de coûts fixes de production.

Les économies d'échelle internes dynamiques mettent en rapport la diminution des coûts unitaires avec l'augmentation de la production cumulée, ce qu'on appelle également des *effets d'apprentissage.* Les économies d'échelle dynamiques peuvent aussi provenir d'améliorations de l'organisation du travail, de progrès technologiques et de la capacité des employés à mieux travailler (Vettori, 2000).

Bien qu'en théorie l'effet d'apprentissage ne soit que l'une des sources possibles d'économies d'échelle internes, c'est sur ce sujet spécifique que la littérature a été la plus riche et la plus essentielle pour comprendre les mécanismes du rapport de causalité entre volume et qualité.

2.3. Théorie de la courbe d'apprentissage (*learning by doing*)

Le terme général de fonction d'apprentissage, ou fonction de progrès, a été introduit dans la littérature à partir d'études plus anciennes portant sur l'industrie aéronautique, la construction navale et l'industrie lourde. Dans les années trente, Wright (1936) a observé que le coût direct généré par la production d'une cellule d'avion diminuait avec la quantité cumulée de cellules d'avions produites. Ce résultat a été largement corroboré par d'autres études réalisées dans les années quarante dans le secteur de l'industrie aéronautique - mais aussi par la suite dans une variété de secteurs industriels – et qui ont démontré que le coût marginal de production décroît avec l'expérience cumulée (Hirsch, 1952 ; Hirsmann, 1956 ; Liebermann, 1984). Cette chute du coût marginal est connue sous le nom d'effet d'apprentissage (*learning by doing*). Des études plus récentes ont également mis en évidence l'existence d'une courbe d'apprentissage dans les sociétés de services (Darr *et al.*1995).

La forme conventionnelle de la courbe d'apprentissage est :

$$Y = \alpha X^{-b} \qquad (1)$$

où Y désigne le coût direct pour produire la $X^{ème}$ unité. X désigne la production cumulée (volume), α est le coût de production de la première unité, et b « l'élasticité d'apprentissage » qui définit le taux de réduction des coûts à mesure que le volume (production cumulée) augmente. Dans cette équation, la production cumulée X est une variable *proxy* de la connaissance acquise à travers la production.

La forme fonctionnelle la plus appropriée pour la courbe d'apprentissage n'a pas véritablement été testée, mais un grand nombre d'études ont montré que la relation log-linéaire était bien adaptée. La courbe d'apprentissage a été utilisée comme fondement dans des stratégies de fabrication, des processus marketing, mais aussi pour mettre en œuvre des politiques antitrust.

Si la présence d'une courbe d'apprentissage est bien documentée dans un grand nombre d'industries, les dynamiques du lien entre volume (production cumulée) et apprentissage sont moins bien établies. L'apprentissage pourrait se développer à travers l'expérience accumulée par les travailleurs ou par l'encadrement (management), une meilleure coordination des processus de production, mais aussi à travers un investissement croissant dans des équipements plus performants.

À la fin des années soixante, les travaux du Boston Consulting Group ont démontré la grande utilité du concept de la courbe d'apprentissage (ou « courbe d'expérience » comme les auteurs l'ont qualifiée) et ont suggéré que cette courbe d'apprentissage était la résultante de l'apprentissage au travail, de l'amélioration des processus de production (organisation et coordination du travail), de la standardisation de la production et d'économies d'échelle statiques. Ils n'ont pas essayé de distinguer le rôle de chacun de ces différents éléments. Mais plusieurs études ont par la suite essayé de différencier les économies d'échelle statiques - qui postulent que le volume actuel affecte les résultats actuels - des effets dynamiques d'apprentissage qui postulent que le volume actuel affecte à la fois les résultats actuels et futurs. La plupart des études industrielles suggèrent que les économies d'échelle statiques sont significatives, mais restent beaucoup moins importantes que les économies générées par les effets d'apprentissage (Stabaugh et Townsend, 1975 ; Lieberman 1984). Lieberman (1984) a également démontré qu'il existe des différences, faibles mais néanmoins significatives, dans la pente de la courbe d'apprentissage entre différents produits. L'effet de l'apprentissage est d'autant plus important (c'est-à-dire que la pente de la courbe d'apprentissage est d'autant plus grande) que les dépenses en recherche et développement, ainsi que l'investissement en capital (humain et technique) dans une entreprise sont élevés.

Toutefois, certaines études ont démontré qu'il existe des limites aux potentialités des effets d'apprentissage ceux-ci sont notamment conditionnés à la capacité de l'encadrement (management) à tirer le meilleur parti des ressources mises à sa disposition (Kimberly, 1981 et Huber, 1991).

De plus, l'hypothèse selon laquelle l'apprentissage est associé au volume implique que les effets de l'apprentissage et l'expérience ainsi accumulée persistent au cours du temps. Or, les entreprises et les organisations peuvent perdre (partiellement) le gain de l'apprentissage et donc oublier l'expérience accumulée en raison du turnover des employés, des périodes d'inactivité ou de l'incapacité à institutionnaliser le capital de connaissances acquis (Argote *et al.*, 1990 ; Besanko *et al.*, 2007). Ainsi, la recherche académique semble maintenant avoir établi que les taux d'apprentissage peuvent différer selon les situations d'apprentissage et en fonction des biens et services produits.

2.4. L'effet d'apprentissage dans le contexte hospitalier

Par définition, la courbe d'apprentissage s'applique aux coûts de production. Or, dans la littérature médicale, l'apprentissage est mesuré en termes d'amélioration des résultats (c'est-à-dire en général une mortalité plus faible ou moins d'événements indésirables), et non en termes de coûts des soins.

La plupart des études initiales sur la relation entre le volume d'activité chirurgical et les résultats montrent une relation négative entre nombre de patients opérés et mortalité. Ces résultats sont souvent interprétés comme la confirmation de l'existence d'une courbe d'apprentissage (Luft *et al.,* 1979) et donc la justification de concentrer certains services de soins. Il est, en effet, raisonnable de considérer qu'une équipe chirurgicale qui effectue une cinquantaine d'interventions cardiaques par mois est plus compétente qu'une équipe qui n'effectue qu'une ou deux interventions par mois.

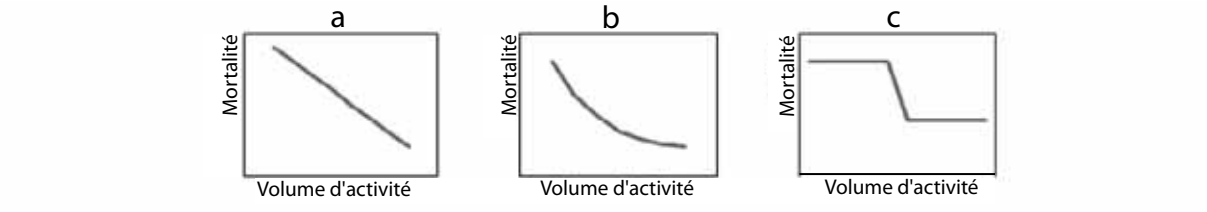
Cela étant, dans le cas du secteur hospitalier, certains auteurs ont avancé que le lien observé entre volume et qualité pouvait refléter un phénomène d'adressage spécifique dans lequel les patients sont orientés vers les hôpitaux ayant de meilleurs résultats (Dranove, 1998 ; Luft *et al.*, 1987). Il est probable que certains patients (ou leurs médecins) choisissent des hôpitaux en fonction de leurs résultats et de leur réputation plutôt que ceux qui sont situés à proximité ; cela aurait pour conséquence d'augmenter le volume des patients dans les meilleurs hôpitaux. Ce concept est baptisé « renvoi sélectif ». On s'attend à ce que ce renvoi sélectif soit plus massif pour des situations non urgentes et nécessitant l'adressage d'un médecin, mais qui présentent des risques et/ou des complications élevés.

Le sens de la causalité a des implications importantes pour la mise en œuvre des politiques de planification dans le secteur hospitalier. Si le lien existant entre volume et qualité est majoritairement dû à des effets d'apprentissage, la centralisation de certains services serait notamment susceptible de présenter un intérêt général. Si l'explication principale est plutôt le renvoi sélectif, la régionalisation pourrait entraîner une réduction de la concurrence, sans améliorer la qualité observée. En outre, la forme fonctionnelle de cette relation « volume-qualité » ainsi que les dynamiques d'apprentissage, c'est-à-dire la façon dont l'apprentissage se développe avec l'expérience et la façon dont il est transféré, constituent des questions importantes pour les établissements de santé et en termes de planification.

2.4.1. Comment le volume engendre-t-il la qualité des soins ?

Tout d'abord, nous ne savons pas avec certitude si la relation entre le volume d'activité et la qualité est linéaire, simplement continue ou définie par un (ou des) point(s) d'inflexion. Le graphique 2 ci-dessous présente quelques formes possibles. Par exemple, introduire un seuil d'activité pour orienter les patients suppose qu'il existe un seul point de coupure (graphique 2.c). Si l'idée d'introduire une seule référence de volume pour distinguer la qualité des hôpitaux est attractive, cela peut être trop simpliste. Les études provenant des autres secteurs d'activité montrent par ailleurs que la forme la plus appropriée pour la courbe d'apprentissage est la forme log-linéaire (graphique 2.b).

Graphique 2
Les formes envisageables de la relation « volume d'activité - mortalité »



Par ailleurs, la différence entre les économies d'échelle statiques et les économies d'échelle dynamiques (effets d'apprentissage) est importante pour comprendre cette relation. En ce qui concerne les économies d'échelle statiques, le lieu physique (hôpital) dans lequel volume est concentré importe peu : un volume d'activité élevé générera de bons résultats quel que soit l'hôpital concerné. Pour ce qui est de l'effet d'apprentissage, le lieu ou le mode d'organisation de l'hôpital importe davantage : transférer l'activité d'une organisation (hôpital) à une autre peut entraîner la perte de l'expérience acquise au sein du premier hôpital. De plus, les bénéfices tirés de la concentration du volume dans un seul hôpital se développeraient au fil du temps. Cela implique que les bénéfices nets d'une fusion des établissements hospitaliers seraient moins importants dans les approches de régulation régionale.

Dans l'une des rares études analysant l'importance relative des économies d'échelle statique par rapport à l'apprentissage au cours du temps, Gaynor *et al.* (2005) mettent en cause l'importance de l'effet d'apprentissage pour les procédures de pontage aorto-coronarien. En examinant la mortalité dans les hôpitaux californiens entre 1983 et 1999, les auteurs suggèrent que le lien volume-qualité est expliqué principalement par les économies d'échelles statiques. Ils font également une estimation du niveau d'oubli (érosion des connaissances acquises) en introduisant les valeurs des volumes annuels d'activité des années antérieures dans leur régression de mortalité. Leurs estimations montrent que les volumes ont uniquement un effet immédiat sur les résultats (seuls les volumes des années présentes sont influents), ce qui suggère que le phénomène d'« oubli » est significatif. Mais les auteurs reconnaissent qu'ils n'ont pas pu examiner correctement la structure de décalage dans le temps dans la fonction d'apprentissage, en raison de la multicolinéarité des données.

Vivian Ho (2002, n°161) avance par ailleurs que l'amélioration des résultats peut être liée au temps (progrès technologique) et à l'accumulation d'une connaissance collective : le présupposé est que l'on peut également apprendre en observant les pratiques des autres (*learning by watching*). L'auteur utilise des données longitudinales (de 1984 à 1996) pour examiner le lien entre le nombre d'ACPT (angiographies coronaires percutanées transluminales) réalisées dans les années précédentes et les résultats actuels en termes de coût et de mortalité hospitalière, en contrôlant par l'établissement et par des effets temporels fixes. De cette façon, elle distingue l'effet d'apprentissage propre de l'effet des progrès technologiques. Ho observe que l'amélioration substantielle des résultats d'ACPT réalisée au cours de la période était davantage due à la diffusion technologique qu'à des effets d'apprentissage. Elle suggère ainsi que la régionalisation de l'intervention ACPT peut entraîner des économies en termes de coûts par patient, mais seulement de faibles améliorations dans les résultats sanitaires.

2.4.2. Effet d'apprentissage ou renvoi sélectif ?

L'étude de Luft *et al.* (1987) est la première à avoir testé explicitement l'impact du renvoi sélectif par rapport à celui de l'effet d'apprentissage (dénommé par les auteurs « la pratique rend parfait »). En exploitant les données de mortalité liée aux 17 interventions/diagnostics en 1972 dans 900 établissements américains, ils modélisent simultanément l'impact du volume sur la mortalité et l'impact de la mortalité sur le volume d'activité des établissements. Les auteurs observent que les hôpitaux présentant de faibles taux de mortalité attirent les patients hospitalisés pour anévrisme de l'aorte abdominale (AAA), fracture du fémur, ulcère gastrique, ablation de la prostate et cardiaque by-pass (renvoi sélectif). En revanche, pour les infarctus du myocarde, les syndromes de détresse respiratoire, hystérectomie, opérations sur l'estomac et sur l'intestin et la PTH, ils trouvent que l'effet d'apprentissage est significatif. Les résultats pour les autres interventions étudiées ne sont pas concluants (cirrhose, appendicectomie, angioplastie cardiaque, cystectomie, réparation d'hernie, les hémorragies sous-arachnoïdiennes). Ils en concluent que l'importance relative des phénomènes de renvoi sélectif et d'apprentissage varie selon les diagnostics ou la procédure, en fonction des aspects cliniques, mais que les deux explications sont valides.

Farley et Ozminkowski (1992) soutiennent également que l'impact du volume sur les résultats varie d'une procédure à l'autre et que le renvoi sélectif, ainsi que l'effet d'apprentissage, peuvent être importants. À partir d'une analyse des donnés longitudinale de 500 hôpitaux américains (données de panel), ils concluent qu'une augmentation de volume d'activité réduit la mortalité hospitalière pour l'infarctus du myocarde, la réparation de hernie et le syndrome de détresse néonatal. En revanche, ils concluent que le renvoi sélectif est significatif pour le pontage aorto-coronarien et qu'il n'y a aucun effet pour la prothèse totale de hanche.

À partir d'une analyse du volume et les résultats de la réparation d'anévrisme de l'aorte abdominale,

Hannan *et al.* (1992) pointent que l'effet d'apprentissage, et en particulier la spécialisation des chirurgiens, est un facteur important pour réduire la mortalité. Ils examinent les variations dans les volumes d'activité des chirurgiens et les établissements sur trois ans (1985-1987) pour tester le sens de la causalité avec la mortalité hospitalière. Ils observent que les établissements qui avaient des volumes d'activité élevés initialement attiraient plus de patients dans les années suivantes par rapport à ceux qui avaient un taux de mortalité élevé, mais cet effet (renvoi sélectif) n'était pas significatif pour expliquer la réduction de mortalité observée. En examinant le volume par type de procédure effectué par chirurgien, les auteurs concluent que l'effet d'apprentissage au niveau de chirurgiens est déterminant dans cette relation.

Dans une étude atypique au sein de cette littérature, Tay (2003) examine l'impact de la qualité et de la distance sur le choix d'hôpital des patients Medicare (États-Unis) atteints d'un infarctus du myocarde en 1994. La qualité est mesurée par plusieurs indicateurs : les taux de mortalité et de complications, mais aussi le niveau de ressources dédiées (nombre d'infirmiers par lit), et la capacité de l'hôpital à réaliser deux interventions cardiologiques de haute technologie : la pose d'un cathéter et la revascularisation. L'auteur observe que la demande hospitalière (volume) est négativement affectée par la distance du patient, et positivement par la capacité technologique et humaine de l'hôpital. Elle calcule, par exemple, que l'adoption d'un plateau technique permettant la pose de cathéters augmenterait la demande de 65 %, alors que l'accroissement de 1 % du nombre d'infirmiers par lit augmenterait la demande de seulement 24 %. Ainsi, en utilisant une modélisation relativement sophistiquée, Tay démontre que la demande hospitalière (volume) accompagne la qualité. Elle souligne également que l'importance de la distance dans les choix hospitaliers est souvent sous-estimée. Néanmoins, il convient de noter que dans sa modélisation, Tay considère que la qualité est une variable exogène (indépendante) de la demande. Cela dit, elle ne traite pas le problème d'endogénéité potentielle entre la demande et la qualité, les hôpitaux pouvant décider de leur niveau de qualité en fonction de la demande existante.

Dans une étude récente, Gowrisankaran *et al*. (2006) tentent de déterminer, en utilisant des variables instrumentales, si le volume engendre une amélioration des résultats ou si, au contraire, les hôpitaux qui mettent le mieux en œuvre certains types d'intervention attirent plus de patients. Ils testent le rôle de l'apprentissage, de l'oubli et du renvoi sélectif dans l'analyse du lien volume-qualité pour trois procédures chirurgicales : la pancréato-duodénectomie, le pontage aorto-coronarien et la réparation d'anévrisme de l'aorte abdominale. Ils utilisent des données provenant de Floride, entre 1988 et 1999, et de Californie, entre 1993 et 1997. En premier lieu, ils observent un effet causal significatif du volume sur la qualité. De plus, leurs résultats montrent, pour le pontage et l'anévrisme abdominal, que l'effet d'apprentissage joue un rôle important dans l'explication des différences entre les résultats (ajustés sur le risque) des hôpitaux. Les auteurs notent également que le degré d'oubli dans les organisations diffère de manière significative selon les procédures, l'oubli étant plus lent pour la pancréato-duodénectomie et plus rapide pour le pontage aorto-coronarien.

Cette brève revue de littérature présente les principaux concepts nécessaires pour comprendre la littérature empirique examinant le lien entre le volume de l'activité et la qualité des soins fournis dans les hôpitaux. Le sens de la causalité entre volume et qualité fait toujours débat dans le secteur hospitalier. Toutefois, l'hypothèse selon laquelle, toutes choses égales par ailleurs, la qualité de soins s'améliore avec l'expérience accumulée, a été largement démontrée en économie industrielle. Dans le cas des soins hospitaliers, l'importance de l'effet d'apprentissage semble varier, d'une procédure à l'autre et est significatif, notamment dans le cadre de soins complexes. La littérature montre par ailleurs que le volume d'activité d'un établissement détermine également son niveau d'influence dans sa zone d'implantation et a donc des répercussions sur l'activité des hôpitaux environnants et sur le niveau de concurrence. Les dynamiques d'apprentissage (c'est-à-dire la façon dont l'apprentissage se développe avec l'expérience et la façon dont il est transféré) constituent des questions importantes pour les établissements de santé et pour le planificateur qui doit anticiper les risques d'une trop forte concentration.

Conclusion

Conclusion

Dans ce rapport, nous avons réalisé un examen complet de la littérature portant sur la relation entre le volume d'activité dans les établissements de santé et les résultats des soins au cours des dix dernières années. Nous avons identifié les principales interventions chirurgicales, ainsi que d'autres types de soins fournis à l'hôpital et dans d'autres contextes de soins, dont les résultats ont été étudiés en fonction du volume d'activité. Au total, nous avons examiné 175 articles. La grande majorité des études (84 %) portait sur des interventions chirurgicales, mais on repère, de plus en plus, des études portant sur une grande variété de soins, y compris les soins mentaux et ceux de ville.

Nous avons présenté les principaux résultats et enseignements des études retenues, en décrivant leurs principales caractéristiques méthodologiques. Rappelons ici que les méthodes statistiques utilisées se sont nettement améliorées et diversifiées ces dernières années. La littérature sur le lien entre le volume et la qualité des résultats cliniques des établissements de soins suggère clairement que, pour certaines procédures et interventions, on peut sensiblement améliorer la qualité lorsque le volume d'activité augmente. Ceci semble être particulièrement valable pour la plupart de interventions cardio-vasculaires et pour la chirurgie complexe, en particulier dans le traitement des cancers.

Bien que le sens de la causalité et les mécanismes sous-jacents de cette relation fassent toujours débat, il semble que l'effet d'apprentissage au niveau individuel (chirurgien) et au niveau de l'organisation (transfert de connaissance) explique une grande partie de cette corrélation. Toutefois, l'hypothèse du « renvoi sélectif », selon laquelle les patients sont orientés vers les établissements de qualité, n'est pas complètement réfutée pour certaines procédures hospitalières. À cet égard, il ne faut pas négliger les effets pervers possibles sur la qualité des soins d'une trop forte concentration de l'activité.

In fine, il est important de relever les critères qui tempèrent cette relation. En effet, le lien volume-qualité est sensible :

– à la nature des procédures et interventions analysées, et particulièrement à leur niveau de technicité. Plus l'intervention est spécifique et complexe, plus la corrélation entre volume et qualité est affirmée ;

– aux seuils d'activité retenus dans les études. En l'occurrence, pour la plupart des interventions, il n'existe pas de seuil d'activité unanimement accepté. De plus, certaines études montrent que la relation volume-qualité devient marginale au-delà d'un seuil relativement bas ;

– à des évolutions temporelles. L'intensité des relations entre volume et qualité peut évoluer au cours du temps : l'influence du volume sur la qualité peut diminuer, voire disparaître au cours du temps pour certaines procédures, notamment à mesure que la maîtrise de cette procédure s'étend et que celle-ci se banalise.

En tout état de cause, bien que le volume d'activité semble être un critère permettant d'évaluer la qualité des soins, notamment chirurgicaux, il n'est pas le seul à prendre en considération pour mesurer et améliorer la qualité dans les établissements de santé.

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Liste des tableaux et graphiques

Liste des tableaux

Liste des graphiques

Annexes

Annexe 1 - Stratégie de recherche bibliographique

Les filtres utilisés pour limiter la recherche sur différentes bases sont :

– Publication dans les dix dernières années

– Uniquement les articles contenant les mots-clés dans les titres et résumés

– Langues utilisées : anglais, français

– Exclusion des revues et des méta-analyses dans « type de publication »

– Inclusion des ouvrages, rapports, thèses, congrès

Research 1 :

- Volume and Outcome(s) or Quality or Mortality or Survival or Readmission or Infection or Length of stay

Research 2 :

- Physician or Surgeon and Volume and [Quality or Outcomes or Mortality or Survival or Readmission]

Research 3 :

- Centralization or Centralized or Centralisation or Centralised and Hospitals and [Quality or Outcome(s) or performance]

À partir de ces mots-clés, nous avons procédé à des combinaisons en rajoutant d'autres mots-clés dont : « relationship », « impact », ou « relation ».

Le tableau de la page suivante présente les différentes combinaisons des mots-clés, le nombre d'articles identifiés sur toutes les bases avec ces mots-clés, ainsi que ceux choisis pour la revue, après élimination des articles hors sujets.

Ainsi, nous avons parcouru les titres et/ou abstracts de près de 1 000 articles. Après élimination des doublons, nous avons recensé au total 226 références uniques entrant dans le cadre de l'étude sur l'incidence du volume sur la qualité. **29** articles ont été exclus de la revue car ils ne correspondaient pas à l'étude empirique ou qu'ils n'avaient pas la relation « volume-qualité » comme problématique principale. **22** autres ont été exclus dans la mesure ou nous n'avons pas réussi à les obtenir dans les délais de notre étude ou à un coût raisonnable.

	Étude	Mots – Clés	Result	Select
Research 1	**H1**	«**Volume** » [Title/Abstract] AND (« outcomes » [Title/Abstract OR (« quality » [Title/Abstract] OR « mortality » [Title/Abstract] OR « survival » [Title/Abstract] OR « readmission » [Title/Abstract] OR « infection » [Title/Abstract] OR « length of stay » [Title/Abstract])) AND (« hospitals » [Title/Abstract] OR « **hospital** » [Title/Abstract]) NOT Review [Publication Type] NOT Meta-Analysis [Publication Type] **AND « relationship** » [Title/Abstract] Field : **Title/Abstract,** Limits : **added to PubMed in the last 10 years, English, French, published in the last 10 years, Humans**	➜ 202	123
	H2	« **Volume** » [Title/Abstract] AND (« outcomes » [Title/Abstract] OR (« quality » [Title/Abstract] OR « mortality » [Title/Abstract] OR « survival » [Title/Abstract] OR « readmission » [Title/Abstract] OR « infection » [Title/Abstract] OR « length of stay » [Title/Abstract])) AND (« hospitals » [Title/Abstract] OR **« hospital** » [Title/Abstract]) NOT Review [Publication Type] NOT Meta-Analysis [Publication Type] NOT « relationship » [Title/Abstract] **AND « relation** » [Title/Abstract] Field : **Title/Abstract**, Limits : **added to PubMed in the last 10 years, English, French, published in the last 10 years, Humans.**	➜ 66	38
Research 1	**H3**	« **Volume** » [Title/Abstract] AND (« outcomes » [Title/Abstract] OR (« quality » [Title/Abstract] OR « mortality » [Title/Abstract] OR « survival » [Title/Abstract] OR « readmission » [Title/Abstract] OR « infection » [Title/Abstract] OR « length of stay » [Title/Abstract])) AND (« **hospitals » [Title/Abstract] OR « hospital » [Title/Abstract**]) NOT Review [Publication Type] NOT Meta-Analysis [Publication Type] **NOT « relationship** » [Title/Abstract] **AND « impact »[**Title/Abstract] Field : **Title/Abstract**, Limits : **added to PubMed in the last 10 years, English, French, published in the last 10 years, Humans.**	➜ 200	35

	Étude	Mots – Clés	Result	Select
Research 2	**D1**	« **Volume** » [Title/Abstract] AND (« outcomes » [Title/Abstract OR (« quality » [Title/Abstract] OR « mortality » [Title/Abstract] OR « survival » [Title/Abstract] OR « readmission » [Title/Abstract] OR « infection » [Title/Abstract] OR « length of stay » [Title/Abstract])) AND (« **physician » [Title/Abstract] OR « surgeon » [Title/Abstract] OR « surgical » [Title/Abstract])** NOT « review » [Publication Type] NOT « meta analysis » [Publication Type] **AND « relationship** » [Title/Abstract] Field : **Title/Abstract**, Limits : **added to PubMed in the last 10 years, English, French, published in the last 10 years, Humans.**	**➜154**	**84**
	D2	« **Volume** » [Title/Abstract] AND (« outcomes » [Title/Abstract] OR (« quality » [Title/Abstract] OR « mortality » [Title/Abstract] OR « survival » [Title/Abstract] OR « readmission » [Title/Abstract OR « infection » [Title/Abstract] OR « length of stay » [Title/Abstract])) AND **(« physician » [Title/Abstract] OR « surgeon » [Title/Abstract] OR « surgical »** [Title/Abstract]) NOT « review » [Publication Type] NOT « meta analysis » [Publication Type] **NOT « relationship** » [Title/Abstract] **AND Relation** [Title/Abstract] Field : **Title/Abstract**, Limits : **added to PubMed in the last 10 years, English, French, published in the last 10 years, Humans.**	**➜ 55**	**27**
Research 2	**D3**	« **Volume** » [Title/Abstract] AND (« outcomes » [Title/Abstract] OR (« quality » [Title/Abstract] OR « mortality » [Title/Abstract] OR « survival » [Title/Abstract] OR « readmission » [Title/Abstract] OR « infection » [Title/Abstract] OR « length of stay » [Title/Abstract])) AND (« **physician » [Title/Abstract] OR « surgeon » [Title/Abstract] OR « surgical » [Title/Abstract]**) NOT « review » [Publication Type] NOT « meta analysis » [Publication Type] **NOT « relationship** » [Title/Abstract] **AND « impact »** [Title/Abstract] Field : **Title/Abstract**, Limits : **added to PubMed in the last 10 years, English, French, published in the last 10 years, Humans.**	**➜ 160**	**23**

	Étude	Mots – Clés	Result	Select
Research 3	**C1**	(« **Centralisation** »[Title/Abstract] OR « centralization »[Title/Abstract] OR « centralised »[Title/Abstract] OR centralized[Title/Abstract]) AND ((«**hospitals »[Title/Abstract] OR « hospital** »[Title/Abstract]) AND « quality »[Title/Abstract] OR « outcomes »[Title/Abstract] OR « performance »[Title/Abstract]) NOT « Review »[Publication Type] NOT « Meta-Analysis »[Publication Type] **AND « relationship »**[Title/Abstract] Field : **Title/Abstract**, Limits : **added to PubMed in the last 10 years, English, French, published in the last 10 years, Humans.**	**➜ 10**	**2**
Research 3	**C2**	**(« Centralisation »[**Title/Abstract] OR « **centralization** »[Title/Abstract] OR « **centralised »**[Title/Abstract] OR « **centralized »[**Title/Abstract]) AND (« hospitals »[Title/Abstract] AND (« quality »[Title/Abstract] OR « outcomes »[Title/Abstract] OR « performance »[Title/Abstract])) NOT « review »[Publication Type] NOT « meta analysis »[Publication Type] **NOT** **« Relationship** »[Title/Abstract] **AND « relation »**[Title/Abstract] Field : **Title/Abstract**, Limits : **added to PubMed in the last 10 years, English, French, published in the last 10 years, Humans.**	**➜ 2**	**1**
Cindoc, Embase, Pascal	**-**	Recherché avec les mots clés précédents	**363**	**45**

Annexe 2 - Grille d'analyse

N°	Période étudiée	Pays et/ ou région d'étude	Echantillon de l'étude	Intervention étudiée	Indicateur de résultat	Indicateur volume	Seuil utilisé pour définir haut/bas volume (n)	Méthode		Variables contrôlées	Résultats
								Observation	Méthode statistique		
1	1997	France/ Rhône-Alpes	n = 5,521 PTH ; 50 Etablissement.	Mise en place d'une prothèse de la hanche (PTH).	Mortalité intra-hospitalière.	Chirurgien + Hôpital (Nombre total de PTH/An).	< 50 PTH ; =>50 PTH ; + 100 PTH.	Modèle linéaire - Calcul odds ratios.	Régression logistique.	Age, sexe, motif de l'intervention chirrugicale ; nombre de PTH par établissement.	Relation entre volume d'activité et mortalité intra-hospitalière apparaît faible si ajustement sur âge et le motif de l'intervention. L'association entre le niveau d'activité de l'établissement et la mortalité paraît vraisemblable seulement dans tranche d'âge 82 à 89.
2	1989-1992	USA	275 Surgeons 83,547 Patients 200 operations during 3 years in New-York and 30 operations per year in Pennsylvannia.	Cardio/coronary artery bypass	Physician performance, surgeon's observed predicted patient mortality.	Surgeon rates.	Surgeon with > 200 patients.	Tested using correlations weighted by the number of patients that the physicians treated.	Logistic linear regression, Chi-square tests.	Physician age, prestige and experience of surgeons, number of years pratice.	Mortality ratios decreased with increasead volume and years of experience of surgeons, age, and academic rank ; Surgical performance not associated with graduation and prestigious school, residency.
3	1990-1993	Canada, Quebec	n = 7,483	Hip fracture	Postsurgery length of stay and impatient inhospital mortalty.	Hospital rates	Quartile of surgical volume : $Hvol_h$ =<32; 33 = < $Hvol_h$ <= 49 ; 50 =< $Hvol_h$ <= 72 $Hvol_h$ >= 73.	Longitudinal data (OLS), data from the MEDECHO database contains information from hospital discharge abstract..	Determinants of postsurgery length of stay assessed using ordinary least squares regression and the explanators of inpatient mortality using logistic regression with hospital specific **fixed effects**, to control for systematic differences in outcomes that persist with time.	Number of comorbidities ; Age, Sex, Married, Income/10 000 ;	Significant negative relationship between surgical volume and both post surgery length of stay and in-hospital mortality among hip fracture, persisted with time.

N°	Période étudiée	Pays et/ ou région d'étude	Echantillon de l'étude	Intervention étudiée	Indicateur de résultat	Indicateur volume	Seuil utilisé pour définir haut/bas volume (n)	Méthode		Variables contrôlées	Résultats
4	2001	USA/ Connecticut	65 years or older ; 26,260 Medicare beneficiaries with diabetes.	Diabetic of elder patients.	Quality of care, as assessed by the claims-based processes of care hemoglobin A lc testing, lipid profile testing ; and retinal eye examinations.	Physician rates.	Patient volume refers to the numbers of Medicare diabetic patients divided into 5 groups of Quintiles : Group I = 1-4 ; Group II = 5-10 ; Group III = 11-18 ; Group IV = 19 - 31 and Group V = 32 - 166 ; Physicians in volume group IV and V care for 75 % of the patient.	Using claims-based Current Procedural Terminology (CPT).	Hierarchical Linear Models (HGLMs) ; Initial bivariate analyses.	Number of patient in a pratice ; frequency of visits, physician experience, patient comorbidity, patient demographics (age, gender, ethnicity) ; chronic illness.	Patient with highest volume physician quintile were significantly more likely to get these care than patient in the lowest physician quintile.
5	1991-1993	Canada, Quebec	68 hospitals with 53 surgeries per year ; 6% of patient admitted with a hip fracture.	Hip fracture.	Lenght of stay, post surgery in-hospital mortality.	Hospital	Number of operation by hospital *h* in the time period *prior* : $HVOL_{ht}$ = tot of number of surgeries performed in hospital *h* in the 12 months *prior* to the date (*t*) of the current surgery, Average volume in 3 groups : low volume : < 34 surgeries = > 25 % ; Average : 34-71 surgeries = > 50%; High : > 71 surgerie = > 25 %.	Longitudinal data.	Proportional hazards specification, controlling hospital - Fixed effect.	Year of admission, median male income in postal code of residence and number and type of comorbities at the time of admission. Charlson index.	Higher volume associate with an increased conditional of live discharge. Significant relationship between surgical volume ant length of stay.
6	1991-1997	USA/Ohio	21,555 Medicare patients aged 65 years and older in all non federal hospitals.	Cardio/ congestive heart failure (CHF).	30 days in-hospital mortality.	Hospital rates.	Bed size accross ; The hospitals in the sample was 276 (range 84–906), the average CHF case volume was 459 (77–1,203), and the average resident-to-bed ratio was 0.13 (0–0.69).	Compares administrative versus use of clinical data. Controls for potential endogeneity in hospital volume with instrumental variables. Checks the impact of patient distance to hospital.	A linear probability regression model (LPM) was fit to the Longitidunal data to assess the effects of hospital volume on 30-day mortality ; with instrumental variables.	Comorbid conditions, vital signs, clinical status, and ; demographic characteristics (age, Gender, race) ; laboratory test results for Medicare-insured patients aged 65 years and older.	The effect of volume on mortality was smaller in magnitude when clinical data is used. A stategy of volume based referral for CHF may not really improve outcomes for elderly patients (different from surgery).
7	1994-1998	USA/South of San Francisco - California	12,730 patients at 750 hospitals.	Cardio/ (AMI) Acute Myocardial Infarction.	in-hospital mortality	Hospital Intra-Aortic Ballon Counterpulsation.	Hospitals divided into tertiles IABP Volume : 64,4% Lowest ; 54,1% intermediate ; and 50,6 % Highest volume (P for trend < 0.001).	Cohort study.	NRMI-2, a voluntary, observational database. The method of diagnosis of AMI. Analised with a series of logistic regression.	Demographics (age, sex, race), medical history, clinical charasteristics (Diabetes, Hypertension, Angina, Stroke, Chest pain on admission, ECG findings) ; procedures, Additional analyses were performed by forcing variables such as number of AMI cases per hospital per year, cardiogenic shock cases per year, no of staffed beds, and shock patients receiving IABP).	150 fewer deaths per 1 000 patients treated at the high IABP hospitals. High hospital IABP volume for patients with acute myocardial infarction was associated with lower mortality. Among the myocardial infarction patients with cardiogenic shock who underwent IABP placement, mortality rate case significantly lower at high - IABP volume hospitals compared with low-IABP volume hospitals.

N°	Période étudiée	Pays et/ ou région d'étude	Echantillon de l'étude	Intervention étudiée	Indicateur de résultat	Indicateur volume	Seuil utilisé pour définir haut/bas volume (n)	Méthode		Variables contrôlées	Résultats
8	1999-2000	USA/Eight geographics regions, US. HMO	384 plans patients; covering 73 millions enrollees notionwide.	Mental health care.	Quartile of performance on each mental health quality measure. HEDIS mental health performance measures: 7 and 30 days outpatient follow-up after discharge; Acute (enrollees took an antidepresant continuously for at least 3 months); Continuation (enrollees took an antidepressant continuously for at least 6 months) Practitioner contacts (enrolles took an antidepressant during at least three follow-up visits).	Total annual ambulatory visits, inpatient discharges services, and inpatient days - Hospital level.	Three measures of volume of mental health services: first outpatient measure examined the total annual number of plan members using any ambulatory mental health services. Two others: inpatient volume of care (the total number of members with an inpatient mental health hospitalization and the total number of inpatient mental health days). Low volume of ambulatory mental health use (<1, 090 meantal health patient/year); Low volume of inpatient mental health discharges (<65 Inpatient hospitalization/year); Low volume of inpatient mental health days (<36 inpatient days/year).	Health employer Data and Information Set (HEDIS) 2000 Descriptive data.	Logistic regression.	Patients charateristics (age, sex), payment method (Medicare, Medicaid), region.	Plans in the lowest quartile of outpatient and inpatient mental health volume had: an 8,5 (95% CI [confidence interval]=4,97 -14,37) to 21,09 (95% CI=11,32-39,28) times increase in odds if poor 7- and 30 day follow-up after discharge from inpatient psychiatric hospitalization. Low volume plans had a 3,5 (95% CI= 2,15 - 5,67) to 5,42 (CI= 3,21 - 9,15) times increase in odds of poor performance on the acute,continuous and provider measures of antidepressant treatment. Large and consistent association between mental health volume and performance.
9	1991 - 1997	US, Northest Ohio Single metropolitan area, USA	29 hospitals Respiratory n = 16,949 neurologic n = 13,805; GI dideases n = 12,881.	Patients admitted to ICU with Respiratory diagnoses, neurologic diagnoses and GI disorders.	In-hospital mortality.	Hospital admission.	Tertiles of hospitals volume: high, medium, low based on cut-offs that yielded roughly equivalent number of patient in each volume category. In the pulmonary disease cohort, low-volume hospitals had < 500 admissions, medium-volume between 500 and 1 000 admissions, and high-volume had >1 000. In the GI and neurology cohorts, low volume hospitals admitted < 400 patients, medium-volume admitted 400 to 700, and high-volume admitted > 700 patients during the study period.	Retrospective cohort study.	The X^2 test or analysis of variance. Models which are an extension of the usual Cox regression model. Using cox proportionnal hazards models for compare in-hospitals mortality between tertiles of hospitals volume for ICU. Severity of illness was measured using the APACHE III methodology.	Age, gender, admission severity of illness (measured by APACH), admitting diagnosis and source, dates of ICU and hospital admission and discharge, vital status at discharge, discharge destination, ICU and Hospital LOS, presence of seven specific comorbid conditions.	Association between ICU volume and risk-adjusted mortality were significant for patient with GI diagnoses and for sicker patients with respiratory diagnoses. However, associations were not significant for patient with neurologic diagnoses. The lack of a consistent volume-outcome relationship may reflect unmeasured patient complexity in higher volume hospitals, relative standardization of care across ICs, or lack of efficacy of some accepted ICU process of care.

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10	1993 to 1994	USA	38 Physicians; 5 high volume centers; (1 000 procedures per year); 12,985 Patients treated.	Cardio/ Percutaneous Coronary Revascularization.	In-hospital Death; models predictive of death and the composite outcome of death, Q-wave infarction, or emergency bypass surgery.	Physician rates.	High and low volume operators; 38 phycisians with >= 30 cases per year; the average physician performed a mean +/-SD of 163 +/- 24 cases per year; physician operators were also divided into quintiles by caseload, and the relationship between caseload quintile and risk-adjusted results in low risk (ACC/AHA A or B1) and high-risk (ACC/AHA B2 or C) lesions was evaluated.	Risk-adjusted measures of both death and the composite **adverse outcome** were inversely related to the number of cases each operator performed annually. Each maintains credentialing standards for individual physicians and an interventional database characterized by prospective entry of selected clinical and angiographic data, routine postprocedure analysis of ECGs analysis and coding of complications by trained personnel, and internal audits and checks for data completeness and consistency.	The relations of physician volume and years of experiences to raw and adjusted outcome were evaluated with least-squares linear regression techniques. models used Risk adjustement, Logistic regression Models.	Baselines characteristics (Age, sex), Presentation with acute MI (onset 24 hours), Canadian Cardiovascular Society angina class, cardiogenic shock, left ventricular ejection fraction, modified ACC/AHA lesion morphology classification score, number of diseased vessels, prior bypass surgery, prior restenosis, and unstable angina were recorded.	Risk-adjusted measures of both death and the composite adverse outcome were inversely related to the number of cases each operator performed annually but bore no relation to total years of experience. Both adverse outcomes were more closely related to the logarithm of caseload (for death, r =.37, P =.01; for death, Q-wave infarction, or bypass surgery, r =.58, P<.001) than to linear caseload.
11	1994 -1996	USA -New York State and California	11,225 Medicare patients; 457 hospitals; 11 population based tumor registries covering 14% of the US pop. Medicare claims for 94% of people aged 65 years and older.	Breast cancer operations.	5-year survival rates - All causes and breast cancer specific - Two outcomes analysed: time until death by any cause and time until death by breast cancer.	Hospital rates.	Hospital volume was categorized into 3 groups (low: 0–19 cases per year; medium: 20–39 cases per year; high: 40 or more cases per year) with approximately equivalent numbers of patients in each.	For each patient with breast cancer, information obtained on demographic characteristics, extent of disease, and initial therapy. SEER information has been linked to Medicare claims for people aged 65 years and older. Used Medicare Provider Analysis and Review and outpatient Standard Analytic File data to determine the hospital at which the operation was performed.	Cox proportional hazards regression models for survival data/Cohort study.	Patient characteristics (age and race) and tumor characteristics (size, grade, nodal involvement, and hormone receptor status); comorbidity index for each patient with Charlson Index (comprises 15 noncancer conditions, each of which is weighted according to its impact on mortality); capita income and educational level; the size of metropolitan standard area.	A relationship between hospital volume and all cause a mortality, that is there were moderate reductions in both all cause mortality and breast cancer cancer-specific mortality among women treated in hospitals with annual volumes of 40 or more operations performed on Medicare breast cancer patients.

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12	1992 -1996	UK region - West Midlands region of England	1,125 patients.	Cardio-oesophageal cancer.	30-day mortality rate ; 5-year survival rate and Long term survival. In-hospital mortality.	Surgical annual worklaod.	Surgeon workload : 41 Infrequent operators < 4 resections per year n = 146 (13%); 18 Intermediate operators between 4-11 resections per year n =488 (43,4%); 5 Frequent operators 12 or more resections per year n =491 (43,6%); Low volume unit (< 20 per year) ; High volume unit (> 20 per year) .	The study was a retrospective case-note review.	Pearson and Mantel-Haenszel X^2 test for linear association to test differences in 30-mortality. Kaplan-Meier survival rates were estimated and survival curves were compared by means of log rank methods. Logistic regression was used to identify predictors of 30-day mortality and thereby to estimate adjusted odds ratios. Cox's proportional hazards model used to identify predictors of survival, and to estimate adjusted risk of death.	All resections ; Oesophagus, Cardia, Gender, Stage, American Society of Anesthesiologist (ASA) grade, smoking habit, Age, Disease site, Histological type, Emergency resection or Elective resection, (operation, palliative, curative), whether preoperative chemotherapy was administred.	In this unselected population-based series there was little evidence of a trend of improving 30-day mortality rate with increasing workload, or between workload and long term survival. The 30-day mortality rate was significantly increased in patients having emergency resection (P =0,005), in patient aged over 70 years (P =0,001). The mortality rate was higher and long-term survival worse in the 16% of patients whose full hospital notes were not available for review.
13	1998-1999	US - New York State	36,930 patients ; 181 surgeons, 33 hospitals.	CABG, Coronary Artery Bypass Graft.	In-hospital Operative mortality rates.	Hospital and Surgeon	Hospital volume based on total number of off-pump and on-pump CABG procedures performed. Surgeons were divided into volume quartiles with equal numbers of surgeons in each quartile. For on-pump surgery, surgeons with very low case performed 52 procedures over the 2-year period, with low case 52 to 155, with medium case 156 to 273, and high volumes performed > 273 procedures. For off-pump surgery, surgeon case volume : Very low (< 5 procedures) ; Low (5 -10 procedures) ; Medium (11-31 procedures) ; High >31.	A retrospective cohort study analyzing the association between surgeon volume and in-hospital mortality rate for off-pump and on-pump CABG surgery.	Using random-effects logistic regression modeling. Separate multivariate Logistic regression models were created for on-pump and off-pump CABG. These models included only patient-level data. Random-effects models were then constructed in order to model the effect of surgeon volume on outcome, after adjusting for the effect of hospital volume and patient case mix, using the macro PROC GLIMMIX (SAS).	Model performance was assessed using the c-statistic. Demographics (ie, age, gender, and body surface area [BSA]) ; measures of disease severity (ie, clinical status, ejection fraction, history of previous myocardial infarction, history of congestive heart failure, previous open heart surgery, and coronary anatomy) ; and comorbidities (ie, COPD, diabetes, renal failure, peripheral vascular disease, and hypertension).	No association between the number of CABG procedures performed **off-pump** by a surgeon and in-hospital mortality (p 0.93) after controlling for hospital CABG surgery volume and patient-level risk factors. Also, no association between the off-pump CABG surgery mortality rate and the total number of both off-pump and on-pump CABG surgery cases (p 0.78). However, in the **on-pump CABG surgery** cohort, surgeons performing a high volume of CABG procedures had significantly lower risk-adjusted mortality rates among their patients compared to those performing a low and medium volume of CABG procedures (p < 0.006). The absence of an association for off-pump surgery is surprising given the more technical nature of off-pump CABG surgery.

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14	1996 - 2001	UK	667 cases of pharmaco-emulsification ; 6 surgeons.	Pharmaco-emulsification - surgery.	Complications rates.	Surgeon rates.	Low volume surgeons defined as surgeons performing fewer than 400 cataracts per year) had a higher average complication rate than the high volume ones defined as surgeons performing more than 400 cataracts per year.	This study was designed to assess the influence of case mix on the volume-outcome relation in pharmacoemulsification surgery. The case complexity was assessed using a potential difficulty score (PDS) devised from preoperative data predictive of potential surgical difficulty. The PDS was validated by a retrospective analysis of a sample of 100 cases.	The X^2 test.	(1) General co-morbidity—for example, chest or spine diseases that could prevent optimal positioning of the patient. (2) Significant ocular history—for example, previous attack of angle closure glaucoma or vitreoretinal surgery, problems with the first eye. (3) Ocular co-morbidity—for example, corneal opacity, unstable lens. Pseudoexfoliation has previously been thought to be an independent risk factor even in the absence of obvious weak zonules or a small pupil.4 5 Similarly post-angle closure eyes were thought to be a potential risk even without short axial lengths or shallow anterior chambers. (4) Cataract density as recorded at the last preoperative visit before the operation.	This study re-emphasizes the importance of case mix adjustment in comparative assessment of healthcare quality. These results may explain in part the trend previously demonstrated of lower complication rates for higher volume surgeons.
15	1996 - 2001	UK at Sunderland Eye Infirmary	6 consultant surgeons (ophtalmologist); 16,975 cases ; over 6 years.	Cataract, surgery using in pharmaco-emulsification.	Complication rates (a) Posterior capsule rupture with or without anterior vitrectomy (b) Loss of nuclear fragments into the vitreous (c) Sulcus placed posterior chamber lens (d) Anterior chamber lens implantation.	Surgeon rates	The surgeons into "high" and "low" volume. High volume surgeons were designated as those who performed more than 400 cases per year while low volume was taken as fewer than 400 cases per year - The volume of cataract surgery for each surgeon was calculated and stratified as moderate (51–200), high (201–399) or very high (400 cases per year).	Using theatre logbooks and cross checking with the hospital database, the total number of pharmacoemulsification procedures performed per surgeon per year was calculated . Significant intraoperative complications occurred.	Correlation Analisys (Spearman's RHO).	None.	When the data were pooled for all the surgeons there was evidence that complication rate decreased over time (Spearman's RHO = 20.319, p = 0.058). If the data were pooled from all the years and all the surgeons then there was strong evidence of a decrease in complication rate with an increase in the number of cases (Spearman's RHO = 20.63, p, 0.01). There are however some caveats in that the issue of case mix was not addressed and that the results are from a single unit and may not necessarily be true for other units.

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16	1993-1997	Canada-Alberta capital Edmonton	2 hospitals - 9,250 patients (,.727 procedures) - 50% men, 66.3 years age of the post regionalization group.	CABG, aortic valve replacement, repair of abdominal aneurysm, femoropopliteal bypass, mitral valve replacement, colon resection for cancer, colon resection for diverticular disease, pancreatectomy for cancer, radical nephrectomy, radical prostatectomy, craniotomy for tumour, craniotomy for subdural hematoma, hip fracture procedures, total hip arthroplasty, total knee arthroplasty, thoracotomy for tumour.	Inhospital death and 30-day readmission rates; length of stay.	Case volume hospital - pre-/post-regionalization status.	The impact of regionalization on outcomes - (pre/post - regionalization).	A computer search of hospital discharge abstracts coded for the Canadian Institute for Health Information. The reliability and utility of administrative health care data have been established.	Univariate comparisons of patient characteristics were conducted using the χ^2, t, and Mann–Whitney U tests as appropriate. The positive skew of length of stay (LOS) data, the natural logarithm of LOS was used in all analyses. Variables significant at the $p < 0.05$ level were considered for entry into a multiple linear regression model predicting LOS. Adjusted regression coefficients relating post-regionalization status to the logarithm length of stay for each procedure. Adjusted Odds Ratios relating post-regionalization status to 30-day readmission for each procedure.	Demographic data(Age,Sex), Charlson's comorbidity index, number of urgent and emergent cases.	Post-regionalization, case volume increased by 15%, and 43.6% of patients used some form of community-based health care services. The median length of hospital stay decreased from 8.0 days pre-regionalization to 7.0 days ($p < 0.001$). Overall and for specific procedures the death rate was unchanged (3.1% pre-regionalization, 2.4% postregionalization, $p = 0.06$). The readmission rates were similar (8.0% versus 7.0%). The consolidation of 16 major surgical procedures had minimal impact on death and readmission rates even though patients in the post-regionalization group were slightly older and had greater comorbidity. The decline in the LOS occurred nationally over the same period, and a corresponding increase in the use of community-based services.

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17	1997 - 1999	New-York-US	N° of Hosp? N° of Surgeon? Number of procedures 57,150 patients.	CABG, Coronary artery bypass graft.	In-hospital mortality rates; risk-adjusted mortality rates.	Annual surgeons and hospitals volume rates.	All annual hospital volume thresholds between 200 - 800; Surgeon volume thresholds between 50 -200; To test the interaction effects of hospital and surgeon volume, annual surgeon and hospital volume were each separated into 2 groups, and the resulting 4 hospital volume/surgeon volume groups were then compared by calculating the risk-adjusted mortality rate for each group.	This study examines both hospital and surgeon volume-mortality relations for CABG surgery through the use of a population-based clinical data set. The bivariate relation between in-hospital CABG surgery mortality rates and each of the patient risk factors contained in the registry was examined by means of 2 tests after creating categories for the continuous variables of age and ejection fraction.	These multivariable analyses were conducted by using 3 methods—logistic regression analysis, generalized estimating equations (GEE), and hierarchical logistic regression analysis. The last two methods were used to account for clustering of the observations within hospitals.	Age, gender, discharge status, patients' clinical risk factors and complications; ventricular function (ejection fraction); a recent myocardial infarction, left main artery disease, compromised hemodynamic state (shock, hemodynamic instability, cardiopulmonary resuscitation), a large group of comorbidities (carotid disease, renal failure, diabetes, previous stroke, aortoiliac disease, congestive heart failure, previous PCIs, open heart operations, stents, hepatic failure).	CABG surgery performed by surgeons with annual volumes of 125 in hospitals with annual volumes of 600 was 0.84%, compared with a prevalence of 1.35% for patients undergoing CABG surgery performed by surgeons with annual volumes of <125 in hospitals with annual volumes of < 600 (P< 0.001). That both hospital and surgeon volume are still associated with lower risk-adjusted mortality rates. The differential in mortality rates between hospitals was highest for lower hospital volume thresholds.
18	1998 - 2000	US - New York	34 hospitals, 263 operators; n =107,713 patients.	Cardio/ Percutaneous Coronary Interventions (PCI).	3 outcomes: - in-hospital mortality; - same-day CABG surgery; - same-stay CABG surgery.	Hospital and Surgeon Volume.	Three hospital-volume thresholds (400, 500, and 600 procedures per year).	Administrative and clinical data.	The patient risk factors, were compared by use of X^2 tests, logistic regression analysis. The regression coefficient of this binary variable was then exponentiated to obtain the adjusted odds ratio for the adverse outcome occurring in the lower-volume group relative to adverse outcome occurring in the higher-volume group .Adjusted odds ratios.	Demographics (Age, Sex), Infection fraction, patient preprocedural risk factors, complications of care, discharge disposition, and provider (hospital and operator); cardiac function, coronary vessels diseased, vessels diseased and attempted, previous open heart surgery, and previous myocardial infarctions; type C lesion ; comorbidities (carotid disease, renal failure, diabetes, previous stroke, aortoiliac disease, congestive heart failure, previous PCIs, open heart operations, and stents).	Higher-volume operators/ hospitals experience lower risk-adjusted PCI outcome rates. The study suggest that volume-based criteria be considered for referrals to higher-volume hospitals until better data become available for assessing quality. Assessment of relative quality of care could be based on risk-adjusted outcomes, not on much cruder criteria, such as provider volume. However, population-based clinical data are rare, for risk adjusting PCI outcomes.

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19	1990-1999	Germany/ Hesse	582,655 infants born, 67 differents items.	Neonatology and perinatology.	Birthweight-specific mortality rates during labour or within the first 7 days of life (early-neonatal death).	Born units/ hopital volume.	Hospital volume was categorized according to the number of births per year into very small (500 births/ year), small (501–1,000 births/year), intermediate (1,001–1.500 births/year) and large (1,500 births/year). Low-risk births were assumed for normal weight babies (using the traditional cut-off of 2,500 g birthweight), excluding those infants with a documented congenital anomaly as a cause of death. All other births were classified as non-low risk.	Administrative Data from the perinatal birth register of Hesse.	Several logistic regression models adjusting for additional risk factors.	Type of birth clinic : closed, attending hospitals, government hospitals, perinatal centres. Size of birth clinic : (low-risk birth); Risk factors by type of birth clinic (95% CI): Death from congenital anomaly; Congenital anomaly ; Low birthweight (<2,500g) ; Preterm (< 37completed weeks); Caesarean section . All births : Size of birth clinic (births/year); Birthweight-specific subgroups.	The results indicate that early-neonatal death in low-risk births in very small delivery units (500 births) is substantially increased when compared with low-risk births in large delivery units (1,500 births). Even small (501–1,000 births) and intermediate delivery units (1,001–1,500 births) showed a significantly increased early-neonatal death rate compared to large delivery units (1,500 births). This analysis presents an urgent public policy issue of whether such elevated risk in smaller delivery units is acceptable or if further consolidation of birthing units should be considered to reduce early-neonatal mortality. Reorganization of obstetric care should be discussed to reduce early-neonatal death rates.

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20	1984-1996	US California	353,488 patients ; 3 periods.	Cardio/PTCA, percutaneous transluminal coronary angioplasty.	In-hospital bypass surgery (CABG) death rates and in-hospital mortality rate.	Hospitals volume.	The relation between volume and outcomes was analyzed over 3 time periods : 1984 to 1987, 1988 to 1992, and 1993 to 1996. Tables comparing outcomes were generated for patients treated in hospitals with low volume (200 procedures per year), intermediate volume (200 to 400 procedures per year), and high volume (400 procedures per year).	Patient data were obtained from the OSHPD discharge data, Version A, from 1984 to 1996. The OSHPD database provides standardized information from hospital discharge abstracts for all patients admitted to California hospitals.	Descriptive statistics and logistic regression model.	Patient characteristics by hospital volume and period : Age, sex ; AMI, and multivessel PTCA ; Length of stay ; comorbidity index with Charlson comorbidity index (diabetes, renal insufficiency, and peripheral vascular disease).	In a logistic regression, PTCA procedures significantly predicted in-hospital mortality and bypass surgery rates in all 3 time periods. However, coefficient estimates indicate that improvements over time in outcomes for hospitals performing, 200 procedures were comparable to the predicted benefits of increasing volume above 400 procedures within time periods. Over time, the disparity in outcomes between low- and high-volume hospitals has narrowed, and outcomes have improved significantly for all hospitals. Given these improvements, lower minimum volume standards may be advisable in less populated areas, where the alternative is no angioplasty at all. Although the volume-outcome relation persists over time, in-hospital mortality and CABG rates have decreased for all hospital sizes. Moreover, the relative performance advantage of high- versus low-volume hospitals has decreased overtime. These results have important implications for decisions regarding minimum volume standards and regionalization of innovative technologies. The relative benefit of more favorable outcomes at larger facilities must be weighted against the potential decline in access resulting from minimum volume standards or regionalization.

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21	1992	US	6,115 physicians 97,478 Medicare patients at 984 hospitals.	Cardio/Coronary Angioplasty.	In-hospital bypass surgery (CABG) death rates and in-hospital mortality rate.	Hospital and Physician Angioplasty Volume.	Outcomes were generated for low-volume (<25 annual procedures), medium-volume (25 to 50 annual procedures), and high-volume (>50 annual procedures) physicians after stratifying.	Data come from Part A (hospital) and part B (physician, outpatient) claims containing demographic and limited clinical information on all inpatient hospitalizations that were billed to Medicare, including the patient's Health Insurance Claims (HIC) number.	Logistic regression models.	Patient's age, sex, race, discharge status including death, up to 10 discharge diagnoses and 6 procedures identified by International Classification of Diseases (ICD) codes, and attending physician according to Unique Physician Identification Number. Clinical information from physician and outpatient bills to Medicare : service or procedure provided according to CPT codes, AMI, number of vessels undergoing angioplasty, and hospital characteristics including hospital volume and medical school affiliation and comorbidity according to the Charlson index.	After adjusting for patient caracteristics, low volume physicians were associated with higher rates of bypass surgery (P<.001) and low volume hospitals were associated with higher rates of bypass surgery and death rates of bypass surgery (P.001). This study suggests that adherence to minimum volume standards by physicians and hospitals will lead to better outcomes for elderly patients undergoing coronary angioplasty. Improved outcomes up to treshold of 75 Medicare cases per physician and 200 cases per hospital.
22	1988-1995	US, 19 states in US	Patients older than 65 years of age, 720 hospitals 24,926 procedures (25,000 Patients).	Pancreaticodu-odenectomy.	In-hospital mortality (procedure specific)	Hospital volume hospital status.	Hospital volumes differed significantly among the three hospital types (P .0001), both in an overall way and pairwise (P .0001).	Nationwide Inpatient Sample database from 1988 to 1995, containing 24,926 patients undergoing pancreatectomy for periampullary cancer. One of the databases of the Healthcare Cost and Utilization Project (HCUP), a standardized, multistate health data system.	Spearman rank correlation analysis with hospital as the unit of analysis. Comparisons of hospital volume for the three hospital types in an overall manner with the Kruskal-Wallis test, and pairwise comparisons among hospital types with a Wilcoxon rank sum test. To evaluate patient and hospital factors that may influence mortality, a multiple logistic regression model used, accounting for the correlation structure of patients from the same hospital having similar outcomes using methods of generalized estimating equations.	Type of hospital (rural, urban nonteaching, urban teaching), patient sex, age (50, 50 – 59, 60 – 69, 70 – 79, and 80 years), year of admission (1988 – 1989, 1990 – 1992, 1993 – 1995), and admission status (elective/missing or urgent/ emergency.	Regression results show that sex (male), age, emergency admission and hospital volume were significantly predictive of hospital mortality. In-hospital mortality in the low-volume hospital setting is prohibitive, and review of each institution's mortality rates must occur before these procedures are performed in those institutions. In addition, patients over the age of 60 years, male patients, and those with an urgent admission are at a significant risk of in-hospital death, and consideration should be given toward transfer to an experienced institution.

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23	1992-2002	US	14 surgeons, 23 operations, 46 patients.	Hepatic Resection (Liver).	Complications rates, 30-day postoperative Mortality.	Hospital and surgeons volume.	Procedures performed were hepatic lobectomies (n = 15; right, n = 11; left, n = 4), trisegmentectomies (n = 5; right, n = 3; left, n = 2), segmentectomies (n = 16; left lateral, n = 12; right posterior, n = 4), and wedge resections (n = 10). Low volume varied between <1 to <22 cases per year, with most in the range of 1 to 5 cases per year; low, medium -, and high-volume hospitals for pancreatic resection were defined as <3, 3 to 13, and >13 per year.	Very small sample. Half the patients (23) were operated by 1 sugeon, the rest by 13 different ones.	Objective of the study was to evaluate the experience of a low-volume community-based teaching hospital with a surgical residency training program. This was a retrospective review of the patients medical records. Outcomes were limited to those in the perioperative period.	Age, sex, type of hepatic resections (hepatic lobectomies (n = 15), trisegmentectomies (n = 5), segmentectomies (n = 16), and wedge resections (n = 10)); Indications for hepatic resection (liver metastases from colorectal cancer); comorbidities (coronary artery disease and hypertension, Diabetes, Chronic obstructive pulmonary disease, Congestive heart failure); Coronary artery disease was defined by the clinical signs of angina pectoris, a history of myocardial infarction, angiographic, evidence of ischemia on prior noninvasive studies,or peripheral vascular disease.	Major liver resection can be performed safely with low rates of morbidity and operative mortality with careful selection of patients at a low-volume community-based teaching hospital.

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24	1988-1992	US-11 states	3,161 patients 1,078 hospitals	Resection of Colon cancer.	Mortality: 5-years overall survival rates; Cancer recurrence: 5-year recurrence-free survival rates.	Hospital procedures, Medicare case volume	Defined tertiles of hospital procedure volume (low [46 cases per year, based on Medicare volume], medium [47 to 84 cases per year], and high [85 cases per year]) on the basis of Medicare procedure volume of the hospital where study participants had surgery.	Nested cohort study within a randomized clinical trial.	Among hospitals that were jointly represented in our cohort study and the NIS database (255 hospitals), the Spearman rank correlation coefficient for annual colorectal cancer surgery volume, as measured by the Medicare claims database and the NIS database. The distribution of baseline characteristics across hospital procedure volume tertiles was evaluated by using Chi-square tests for categorical variables and Wilcoxon rank-sum tests for continuous variables. Overall and recurrence-free survival rates were examined by using the Kaplan–Meier method and differences among tertiles were assessed by using the log-rank test. The entire cohort was analyzed by using Cox proportional hazards regression.	Baselines characteristics (Age, sex, race), performance status, stage of disease, and peritoneal implants, tumor differentiation was included in the models; number of lymph nodes; Baseline ECOG, rates of bowel obstruction or perforation at the time of surgery, tumor location within the bowel, and chemotherapy assignment.	According to prospectively recorded data from a large clinical trial, patients whose colon cancer was resected at low-volume hospitals experienced a higher risk for long-term mortality; however, this increased mortality was not attributable to differences in colon cancer recurrences. In this trial of chemotherapy patients with high-risk stage II and stage III colon cancer, overall survival after curative surgery was significantly improved among patients who underwent surgery at a hospital with a high volume of colon cancer surgeries. 16% increase in overall mortality observed among patients resected at low-volume centers, but there was no significant relation between hospital procedure volume and the risk for cancer recurrence or cancer-specific mortality.
25	Over 5 years: 1998-2003	England	6,317 patients 210 Centres, 50 operations/ year.	Radical cystectomy urological.	30-day in-hospital mortality rate (MR); Hospital Stay.	Hospital's annual case volume.	This threshold would appear to be reached at a case volume of 5 – 15 cystectomies/year. At a caseload threshold of 6 cystectomies/year. 8 – 10 cases/year as possible threshold values. High-volume hospitals (≥ 11 case/year) to those in low volume hospitals (< 11 case/year). The case volume threshold to be as high as 16 case/year includes more centres with optimum mortality outcomes.	All cystectomies for urological cancer in England over 5 years were analysed from Hospital Episode Statistics (HES) data.	This produced a scatter plot with a parabolic distribution. Using logarithmic transformation, there was a significant inverse correlation (−0.733, $P < 0.01$) between the variables of operative volume and MR.	The characteristics of patients treated: age (66.3 v 65.7 years) and gender (68.3% male *vs* 66.4% male) and the significant difference in MR above and below the threshold is confirmed (4.58% vs 8.11%, $P<0.05$). The duration of hospital stay between the groups (21.9 vs 21.7 days) not a satisfactory variable for measuring outcome.	Analysis of HES data confirms an inverse relationship between hospital caseload and mortality for radical cystectomy. Applying 95% confidence intervals, the minimum caseload required to achieve optimum outcomes was 11 procedures/ year. Increasing the caseload beyond this minimum did not produce a significant reduction in MR. This finding would appear to support guidelines suggesting that complex procedures should take place in high-volume centres.

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26	2000-2002	US	37,233 patients 463 hospitals.	Cardio/ ST-segment elevation myocardial infarction (STEMI), treated with primary percutaneous coronary intervention (PPCI) and fibrinolytic therapy.	In-hospital mortality, Treatment times In STEMI (time to reperfusion) - door to balloon times or - door to needle times.	Patient and hospital level ; PPCI cases at hospitals.	Hospitals caracterize into 4 quartiles on the basis of the relative proportion of reperfusion-treated patients treated with PPCI : 34.0%, 34.0 to 62.5%, 62.5 to 88.5%, and 88.5%. ; PPCI volume (30, 30 to 70, 70) and estimates for hospital volume based on the number of STEMI cases per year (50, 50 to 150, 150).	Data from the National Registry of Myocardial Infarction-4. The National Registry of Myocardial Infarction (NRMI) is an ongoing observational study of acute myocardial infarction patients admitted to participating hospitals in the United States. We included patients in the NRMI-4 cohort admitted between Jan. 2000 and Dec. 2002.	**Multivariable hierarchical logistic-regression** models examined the independent relation between PPCI specialization and the likelihood of in-hospital mortality and delayed reperfusion, after adjusting for patient and hospital characteristics, including PPCI volume. Multivariable hierarchical linear-regression models evaluated the independent relation between PPCI specialization and door-to-balloon times and door-to-needle times.	Patient and hospital characteristics : Demographics (age, sex, race), Medical history, comorbidities, prior myocardial infarction or revascularization, chest pain, systolic blood pressure, heart rate, Killip classification, performance of a prehospital ECG, ECG findings, time from symptom onset to hospital arrival, time and day of presentation (weekdays between 8 AM and 6 PM or other), hospital location and teaching status, and the presence of on-site cardiac surgery.	Greater PPCI specialization was associated with a lower relative risk of in-hospital mortality in patients treated with PPCI (adjusted relative risk comparing the highest and lowest quartiles, 0.64 ; P 0.006) but not in those treated with fibrinolytic therapy. Compared with patients at hospitals in the lowest quartile of PPCI specialization, adjusted door-to-balloon times in the highest quartile were significantly shorter (99.6 versus 118.3 minutes ; P 0.001), and the likelihood of door-to-balloon times exceeding 90 minutes was significantly lower (relative risk, 0.78 ; P 0.001). Adjusting for PPCI specialization diminished the association between PPCI volume and clinical outcomes. Greater **specialization** with PPCI is associated with lower in-hospital mortality and shorter door-to-balloon times in STEMI patients treated with PPCI.

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27	1975-1994	Japan-Osaka	28,608 patients aged 35-79 years old ; study divided into 4 periods.	Stomach cancer.	5-years survical rates.	Hospital surgical volume.	The study was divided into four periods ; 1975–79, 1980–84, 1985–89 and 1990–94, according to year of diagnosis. All hospitals in Osaka which reported at least one case with surgical treatment for stomach cancer were divided into 4 categories of hospital volume with almost equal sizes : high, medium, low, and very low, according to the total number of surgical procedures in each study period.	Using data in the OCR's data processing for cancer statistics, primary facilities for treatment of each cancer were determined and coded according to the following categories.	Observed 5-year survival was calculated by the Kaplan-Meier method. Survival differences were analyzed by Cox's proportional hazards model adjusting for age at diagnosis and sex. The statistical package software STATA was used for statistical analysis. Statistical significance and 95% confidence intervals (CI) of hazard rate ratio were obtained and judged by using a 2-sided test.	* The number of hospitals and number and range of stomach cancer surgical procedures per hospital, by study period and category of hospital volume; * mean age of analyzed patients at diagnosis according to the hospital volume and the study period; * the observed 5-year survival of the cases whose cancer was confined to the original organ (localized), together with their age- and sex-adjusted hazard rate ratios compared by hospital volume; * the results for the cases whose cancer had spread to the regional lymph nodes; * the 5-year survival for the cases whose cancer had spread to immediately adjacent tissue. Differences in survival rates between the high-, medium- and low-volume groups were not seen in the period 1975–79; * the results for the cases whose cancer had metastasized to distant organs.	This study suggests that the positive relationship between hospital volume and 5-year survival for stomach cancer patients observed in Osaka Prefecture during 1975–79 had **decreased** in the two decades of the study, and **disappeared** in 1990–94 **except** for the very-low-volume hospitals. Stomach cancer patients treated in these hospitals remained at significantly higher risk of death than in the high-volume hospitals. In the case of the distant group, there was no clear relationship between hospital volume and 5-year survival during the study periods.

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28	1992-1996	US-Carolina/ Texas	Medicare beneficiaries 65 years of age; Patients: 3 cohorts ranged: * 24,166 colectomies performed by 2,682 surgeons, * 10,737 prostatectomies performed by 999 surgeons, * 2,603 rectal resections performed by 1,141 surgeons.	* Colon Cancer, * Prostate Cancer, * Rectal Cancer.	For colon cancer: * 2-Year mortality rates, * Ostomy. For Prostate cancer: * Postoperative complications, * Late urinary complications. For Rectal Cancer: * 2-Year mortality. *Abdominoperineal resection.	Surgeon rates/ Hospital volume.	Volume was modeled as a continuous variable in all analyses. Odds ratios are reported per 100- unit decline in volume increments for the colon and prostate cancer analyses and per 10-unit decline for the rectal cancer analysis.	Reanalysis of 3 previously published volume–outcome studies. All 3 data sets were obtained by using the linkage of the Surveillance, Epidemiology, and End Results registries with Medicare claims from the Centers for Medicare & Medicaid Services. Evaluated the effect of surgeon volume on outcomes in 3 settings: adjustment solely for case mix; adjustment for case mix and hospital volume; and adjustment for case mix, hospital volume, and clustering.	Volume–outcome trends were analyzed by a conventional method (logistic regression) and corrected for clustering. Two widely used statistical methods for analyzing clustered data, a random-effects model (in which the impact of each surgeon is modeled explicitly) and generalized estimating equations GEE (in which the underlying patient-specific analysis is adjusted to accommodate the effect of clustering on the statistical significance of the analyses), were used and compared, and the degree of clustering was presented graphically.	Clinical and demographic variables were used to adjust for differences in patient case mix among individual surgeons. These included age; sex; ethnicity; disease stage at diagnosis; disease grade; income level; and the presence of particular features such as emergent presentation, obstruction, or perforation.	Substantial **clustering** was observed in the analyses involving morbidity and points. The 2 statistical techniques produced noticeably different results in some analyses. The presence of clustering represents variations in outcomes among providers with similar volumes. Thus, in volume–outcome studies, the degree of clustering of outcomes should be characterized because it may provide insight into variations in quality of care. Since the impact of clustering typically attenuates the strength of the statistical significance, volume-outcome trends are frequently modest. Large sample sizes are needed to establish many of these trends in a convincing way. However, volume–outcome relationships in many studies are overwhelmingly consistent in demonstrating a positive association between hospital volume and outcomes.

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29	1999-2001	US 50 States	80,470 older patients aged >= 65 years 1,045 hospitals.	Aortic Valve Replacement.	**Quality**: Valve type selection (use of bioprosthetic valves).	Hospital volume.	Volume was represented by 9 indicator variables representing patients undergoing valve replacements in hospitals in the 2nd through 10th deciles of increasing hospital volume. Annual valve surgery volume for the 10 deciles were 20, 30, 41, 51, 65, 82, 103, 135, 181, and 573.	The risk-adjusted association between volume and the use of bioprosthetic valves was determined by adding indicators for hospital volume to the multivariable risk adjustment model that included patient-specific risk factors.	Bivariate associations between valve type and demographic variables and primary and secondary diagnosis and procedure codes that represented potential patient risk factors were determined with the use of the Wilcoxon test or the X^2 statistic. Significant variables (P 0.05) in bivariate analyses were entered into a stepwise logistic regression. The bivariate association between hospital volume deciles and the use of bioprosthetic valves was determined by the 2 tests for trend. Bivariate associations between volume deciles and patient characteristics that were identified as multivariable predictors of valve type were also examined by ANOVA for continuous variables and the 2 tests for linear trend for categorical variables.	Patients' state of residence; primary and secondary diagnoses and procedures. age (in 5 groupes: 70 to 74, 75 to 79, 80 to 84, 85 to 89, 90 years, with reference of 65 to 69 years), Race : black or other nonwhite; year of AVR surgery; gender; angina pectoris; and several comorbid conditions (peripheral vascular disease, nonmetastatic cancer, coagulopathy, peptic ulcer, and primary diagnosis of AMI). Diabetes was defined by ICD-9-CM codes; Surgical priority: emergent and urgent admissions, relative to elective admissions. Admission source : transferred from another facility or admitted through emergency.	Hospital volume was a strong predictor of bioprosthetic valve use in older patients undergoing AVR. The lower use of bioprosthetic valves in low-volume hospitals is at odds with recent guidelines recommending bioprosthetic valves in patients aged 65 years. These findings further support the use of volume as a marker of hospital quality.
30	1990-2000	Canada - Ontario	Number of patients and hospital per procedures: Breast (n = 14,346; N = 152) Colon (n = 8,398; N = 151) Lung (n = 2,698; N = 67) Esophagus (n=629; N = 68) Liver (n = 362; N = 41).	Cancer surgery/ breast, colon, lung, esophagus and liver lobectomy.	In-hospital death rate; long-term survival rate.	Hospital procedure volume.	Procedure volume cut-off points/3 years Hospital volume Characteristic : Low;Low–medium; Medium–high; High **Breast** : ≤ 102; 103−158; 159−264; ≥ 265. **Colon :** ≤ 61; 62−90; 91−137; ≥138 **Lung :** ≤ 32; 33−85; 86−130; ≥131 **Esophagus :** ≤ 7; 8–19; 20–43; ≥ 44 **Liver :** ≤ 23; ≥24.	Results were robust to changing volume groups.	Logistic regression and proportional hazards models were used to consider the clustering of data at the hospital level and to assess operative death and long-term survival.	Patient demographics (age, sex, postal code or place of residence), major diagnoses and procedures, and outcomes such as discharge status (dead or alive); hospital teaching status (yes or no), various patient characteristics including age, sex, comorbidity score, place of residence (rural v. urban) and socioeconomic status (highincome, medium-income or lowincome level).	Increased hospital procedure volume correlated with improved **longterm survival** for patients who underwent resections of **breast, lung and liver**. No significant HR for operative death for patients who underwent colon, liver, lung and esophageal cancer resection. Hospital teaching status had no impact on patient outcomes.

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31	1998-2003	US	310,759 women; 2,986 hospitals.	Urogynecologic surgery (pelvic reconstruction).	In-hospital mortality; perioperative complications and nonroutine discharge.	Hospital and surgeon procedures volumes.	Three volume groups were defined by mean annual hospital volume : into 3 groups of equal size (tertiles). Low-volume hospitals (LVH) performed on average <92 cases per year, medium-volume hospitals (MVH) performed 92 to 185 cases, and high-volume hospitals (HVH) performed >185 cases per year. Surgeon volumes : low-volume (LVS) performed on average <8 cases per year, medium (MVS) performed 8 to 18 cases, and high (HVS) performed >18 cases per year.	The effect of hospital volume on outcomes using data from the Nationwide Inpatient Sample (NIS). Retrospective cohort study of women.	Univariate and bivariate analyses were performed using Chi-square and simple linear regression analysis.	Patient demographic information (age, race), and hospital characteristics : year, median area income, Payer status (Medicare, Private, Medicaid, Other), number of procedures per admission, hospital teaching status, Hospital in urban setting, location, and region; comorbidity index based on the Dartmouth-Manitoba algorithm.	Women who had procedures at low volume hospitals had almost a 3-fold higher risk of death and were more likely to have a nonroutine discharge, compared to those at high-volume hospitals. Women who had procedures by low-volume surgeons were also more likely to suffer **complications** and have non-routine discharges compared to those with high-volume surgeons.
32	1994-1999	Canada, Ontario-Canada	N° patient 31,632/ N° Hosp Oesopha : 613; 47 Col. res : 18,898; 134 Pancrea : 686; 49 Lung res : 5,156; 54 Rep of AA : 6,279; 57.	Oesophagectomy, Colorectal resection, Pancreatico-duodenectomy, Lung resection, Repair of abdominal aortic aneurysm (AAA).	30 days operative mortality.	Hospital volume procedures.	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. Divided into two equal groups of volume categories (high volume hospitals and low volume hospitals) at the median average annual hospital volume, such that patients having a surgical procedure.	Administrative data. Electronic records to identify hospital separations in Ontario between 1994 to 1999. Linked to a database of vital statistics; five separate cohorts of patients (one for each surgical procedure) and did five volume-outcome analyses for each of the five procedure based cohorts.	Odds ratio and Linear models for binary outcomes to estimate associations between hospital volume and 30 day mortality. To account for the effects of clustering at the hospital level in the adjusted analyses, we estimated the model parameters and standard errors by using generalised estimating equations.	Patient level characteristics of age, sex, and comorbidity using Charlson score with Median (interquartile range), No of patients, No of hospitals, Average annual hospital volume (Median, range), Mean (SD) age in years.	With the exception of colorectal resection, 30 day mortality is inversaly related not only to the hospital volume of the same procedure, but also to the hospital volume of most other procedures. We found little evidence of an association between volume and outcome for colorectal resection. 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.

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33	1995	US, New -York US	151 Physicians, 1,342 Primary angioplasty procedures, 32 Hospitals, procedures within 23 hours of onset of AMI, 22,000 patients.	PTCA performed as primary reperfusion therapy for acute myocardial infarction (AMI) (primary angioplasty).	In-hospital mortality rates.	Physicians and hospitals procedures volumes.	Physicians and hospitals were categorized into terciles based on the volume of primary angioplasty procedures performed in 1995. The small number of patients in the first tercile of both physicians and hospitals, the first and second terciles in each category were combined and labeled as low volume, with the highest tercile defined as high volume, resulting in the following 4 groups : low-volume physicians, high-volume physicians, low-volume hospitals, and high-volume hospitals.	Data set represents the experience across a state (New York) and includes patients treated in rural, urban, teaching, nonteaching, not-for-profit and for-profit hospitals. The responsible physician, completes a questionnaire containing information on patient/ operation caracteristics after each intervention.	Using stepwise multiple logistic regression models. Categorical variables were compared by X 2 analysis, and continuous variables were compared by Student's t test. Significance of trends for increasing hospital and physician volume categories was assessed with the Cochran-Armitage test. All probability values are 2-tailed. Unadjusted and Adjusted Relative Risk of In-Hospital Death.	Demographic (age and sex), N° of patients, medical history (smoking, the prevalence of diabetes, hypertension, peripheral vascular disease PVD, stroke) ; Cardiac history (prior MI, prior cardiac heart surgery, prior PTCA, history of congestive heart failure) ; preprocedural shock or hemodynamic instability (the requirement for pharmacological or mechanical support to maintain blood pressure or cardiac output), and time to treatment (< 6 or ≥ 6 hours).	First, an inverse relation exists between physician primary angioplasty experience and in-hospital mortality. Second, there is a strong trend toward a relation between hospital primary angioplasty volume and mortality such that 18 lives per 1,000 patients treated would be saved by treatment in a high-volume hospital. Finally, an interaction between hospital and physician primary angioplasty volume and in-hospital mortality exists such that those AMI patients treated in high-volume hospitals by high-volume physicians have a 49% lower in-hospital mortality rate than those treated by low-volume physicians in low-volume hospitals.
34	2000 - 2001 -2002	US, New-York and Pennsylvania US	15,509 patients aged 18 years or older 40,668 hospitalizations.	Systemic lupus erythematosus (SLE) **a rare and uncommon potentially fatal immune disease.	Risk of in-hospital mortality.	Physician experience and hospital volume.	Physician volume was categorized into 3 groups : 1 hospitalization of a patient with SLE per year, 1–3 hospitalizations per year, or 3 hospitalizations per year. These cut points were based on whole numbers and accommodated the positively skewed distribution of the average physician volumes, with 46%, 42%, and 12% of patients in these categories.	The unit of analysis was the patient. All adjusted models included all covariates simultaneously.	Comparisons of patient characteristics across categories of physician volume were made using analysis of variance or rank sum tests for continuous variables, and chi-square tests for categorical variables. The association of physician volume with in-hospital mortality.	Patient age, sex, ethnicity, medical insurance status (Private or Public, Medicare, no insurance, or unknown), presence or absence of nephritis, SLE Comorbidity Index, and type of admission (emergency versus urgent) ; hospital volume and bed size, rural or urban location, teaching status, and year of hospitalization.	Findings indicate that higher disease-specific physician volume is associated with lower risks of in-hospital mortality in patients with SLE. The association was most evident among patients with nephritis, the subgroup with the highest mortality risks.

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35	1997-1999	US, New-York US	57,150 patients 192 surgeons 33 hospitals.	CABG, Coronary Artery Bypass Graft .	30-day in-hospital mortality rate.	Hospital and surgeon annual volume cases.	Annual hospital volume thresholds for isolated CABG surgery (between 200 and 600 cases, in units of 100 cases). Four surgeon/hospital volume groups were created by separating each type of volume into 2 groups. The group with low surgeon volume (125 cases) and low hospital volume (600 cases). A predicted probability of death of 2% was chosen as a cutoff point to separate patients into low-risk (2%) and moderate-to-high-risk groups. hospital volume thresholds between 200 and 600, for both risk groups, patients in higher-volume hospitals consistently had a lower risk of death than those in lower-volume hospitals, as evidenced by adjusted ORs<1.	A logistic model was developed. Many risk factors in this model were also significant predictors in the EuroSCORE cardiac surgery model and the Society of Thoracic Surgeons (STS) CABG model11 for 30-day mortality. This model was used to predict each patient's probability of death, which represents surgical risk.	The interaction effects of hospital volume and surgeon volume was the reference group in the logistic regression models, and adjusted ORs were calculated for the other 3 groups. In addition to conventional logistic regression analyses, generalized estimating equations and hierarchical logistic regression were also used to account for the clustering of patients within surgeons and hospitals in the analyses that examined the joint impact of hospital and surgeon volume on outcomes.	Patients age, gender, Ventricular function ; Previous myocardial Infarction (between < 6 hours to ≥ 8 days) ; Left main coronary artery disease, hemodynamic state (unstable, shock, cardio-resuscitation), Comorbities (Stroke, Aortoiliac disease, Malignant ventricular arrhythmia, Chronic obstructive pulmonary disease, Extensively calcified ascending aorta, Diabetes, Hepatic failure, Renal failure, Renal failure requiring dialysis), Previous open heart operations, Number of categorical risk factors squared.	For both low-risk and moderate-to-high-risk patients, higher provider volume is associated with lower risk of death.
36	1989 et 1995	US, California - US	1989 : 24,883 PTCAs in 110 hospitals 1995 : 37,118 PTCAs in 146 hopsitals.	Cardio/Coronary Angioplasty.	In-hospital mortality after PTCA in 1989 and in 1995.	Annual hospital PTCA volume and stent placement.	The annual hospital PTCA volume is dichotomized at 2 levels, 200 and 400 PTCAs per year.	Used of the Office of Statewide Health Planning and Development (OSHPD) data set. Administrative database.	For statistical analysis, the continuity (Yates') correction for X^2 analysis, Fisher's exact tests, and 2-tailed t tests were performed as appropriate.	Patients age, sex, LOS, discharge status (including death), and hospital charges for each admission ; diabetics, Coronary intervention (patients undergoing single vessel PTCA with thrombolysis), principal diagnosis (AMI).	An inverse relationship between hospital PTCA and stent volume and adverse patient outcomes (less risk of dying or needing to undergo emergency CABG). Resource utilization was also significantly reduced in these high volume hospitals.
37	1995 or 1996	US, Colorado, Pennsylvania, Ohio- US	5,211 Medicare patients 167 hospitals.	Hip replacement.	Perioperative morbidity and mortality rates and predictors of postoperative complications. 90-day rate of orthopedic adverse events, defined as dislocation of the prosthetic hip and deep wound infection of the hip.	Volume of THRs performed at hospital, and surgeon volume.	6 mutually exclusive hospital–surgeon-volume groups, pairing each of the 3 hospital-volume strata (1–25, 26–100, and over 100 THRs annually) with each of the 2 surgeon-volume strata (1–10 and over 10 THRs annually).	Data were derived from several sources, including Medicare Part A and Part B claims, the American Board of Medical Specialties, a hospital survey regarding institution-specific characteristics, and the American Hospital Association 1995 Annual Survey.	Used a Chi-square test for trend to assess the relationship between the hospital-level factors, as well as patient-level and surgeon-level factors, and the rate of adverse events. All potential predictor variables associated with the rate of adverse orthopedic events were introduced to multivariate logistic models to assess whether the inverse relationship between hospital volume and adverse events was confounded by hospital-level factors and/or surgeon variables.	Patient age, sex, race, primary arthritis diagnosis (Rheumatoid, Aseptic necrosis, Degenerative arthritis, Paget's disease), comorbid medical conditions, and eligibility for Medicaid : low-income status). A comorbidity index was calculated from Medicare Part A claims based on Charlson score ; Year of THR. teaching hospital.	Hospital-level factors were not independent predictors of the association between hospital volume and orthopedic adverse events. The volume of THRs performed by **individual surgeons** is the most important determinant of orthopedic complications and should be considered in efforts to improve THR outcomes.

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38	1988-1989 and 1994-1995	Canada, Ontario - Canada	842 procedures, 68 Hospitals.	Pancreatic resection for neoplasm.	Postoperative death complication : in-hospital case fatality rate and readmission data mean length of stay in hospital.	Hospital Volume of procedures.	The distribution of surgical volumes for each hospital and defined total procedure volume as low (fewer than 22 procedures over the period or fewer than 3 procedures/year), medium (22–42 procedures over the period or 3–6 procedures/year) or high (more than 42 procedures over the period or more than 6 procedures/year).	A population-based retrospective analysis.	The X^2 test or analysis of variance was used to determine the statistical significance of the differences. Logistic regression was used to assess relations between surgical volume and mortality rate, and linear regression was used to assess relations between surgical volume and length of stay. The linear regression models considered only patients who were discharged alive.	Hospital and patient characteristics (age, sex), patient's discharge status (dead or alive), length of hospital stay from date of admission, comorbid conditions by Charlson Score, admission status (elective or urgent/ emergent), hospital affiliation (teaching or nonteaching institution) and hospital size (number of beds).	The study supports the hypothesis that there is a positive relation between surgical volume and patient outcome after pancreatic resection for neoplasm ; that is, patients treated in institutions with a higher volume of procedures have better outcomes, in terms of postoperative death and mean length of stay, than those treated in institutions with a lower volume of procedures.

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39	2001-2002	France (IdF) Paris Area	44 Hospitals 37,848 patients.	Cardio/primary percutaneous transluminal angioplasty (PTCA) after emergency procedures for AMI, cardiogenic shock, or OHCA due to acute coranary artery occlusion.	In-hospital mortality and overall in-hospital complications rates.	Hospital PTCA volume.	Volume thresholds used in the analysis were those recommended by the French Society of Cardiology: < 250 procedures/year: insufficient to ensure patient safety) 250–400 procedures/year: considered insufficient, but could work. 400–600 procedures/year: Adequate activity volume > 600 procedures per year: Sufficient activity. Level of patient safety is deemed optimal. A threshold of 400 procedures per year used to define low (<400) and high (equal to or >400) volume centres.	Clinical status at discharge (dead or alive) was also recorded in another database (PMSI). A cross check was performed using this database to validate the deaths recorded in the CARDIO-ARIF database.	Univariate analysis carried out to identify the risk factors associated with in-hospital mortality. The associations between categorical variables were assessed using the x2 test and differences between continuous variables were compared by Student's t-test. Multivariable backward logistic-regression models were used to identify determinants of in-hospital mortality. Calibration was evaluated using the Hosmer–Lemeshow test and discrimination was based on the area under the ROC curve.	Patients age, sex, pre-procedural clinical status (silent, stable or unstable angina, pre-operative assessment for cardiac valvular surgery, AMI, cardiogenic shock, OHCA, and other reasons), reasons for performing the procedure in case of silent or stable ischaemia, ST- or T-wave changes, and/or creatine kinase (CK) or troponine elevation if unstable angina, myocardial infarction, or OHCA) procedural info. (no of lesions dilated, amount of stents implanted), pre- and post-procedural complications (AMI, repeat PTCA, emergency CABG, stroke, vascular complications requiring surgery, renal failure requiring dialysis, blood transfusion, death). Status at discharge (dead or alive), emergency procedures, (AMI of less than 24 h onset, cardiogenic shock, or OHCA).	First, in the modern age of stenting, there is **no relationship** between hospital PTCA volume and in-hospital mortality **in non-emergency** procedures (in low-risk patients). In contrast, in **emergency procedures** performed in patients with AMI, cardiogenic shock, or successfully resuscitated OHCA, a clear inverse relationship exists. Second, the overall complication rate is higher in low-volume centres in both planned and emergency procedures. Tolerance of low-volume thresholds for angioplasty centres with the purpose of providing primary PTCA in AMI should not be recommended, even in underserved areas.
40	2000-2001	Taïwan	3,227 patients, 285 Ssis.	CABG, Coronary Artery Bypass Graft Surgeries.	Incidence of Surgical site infection (SSI) during hospitalisation and post discharge (within 30 days).	Surgeon volume and Hospital volume.	The surgical volume was divided into quartiles. Hospital volume: First quartile (≤ 132); Second quartile (133-182); Third quartile (183-299); Fourth quartile (≥ 300). Surgeon volume : First quartile (≤ 36); Second quartile (37-77); Third quartile (78-99); Fourth quartile (≥ 100).	Used claim data from the National Health Insurance program in Taiwan lacked clinical information on the severity of infection, such as the depth of infection (ie, superficial, deep, or organ-space SSIs) and the perioperative level of blood sugar.	Used X^2 test to analyze the relationships between the characteristics of the patients and hospitals and the incidence of SSI. Then used a random-intercept model to investigate the relationship between the incidence of SSI and the surgical volume.	Patients' sex and age, LOS in intensive care, underlying diseases (eg, diabetes, chronic obstructive pulmonary disease, heart failure, renal failure, and renal insufficiency), hospital characteristics (eg, ownership and accreditation status).	There was a negative association between surgical volume and the incidence of **surgical site infection** following coronary artery bypass graft surgery. The hospital volume has a greater effect than does surgeon volume on reducing the incidence of surgical site infection.

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41	1990-1993	US, New Hampshire, Maine, and Massachusetts US	12,988 Procedures 5 Hospitals 31 Cardiologists.	Cardio/ Percutaneous Coronary Interventions.	Rates of CABG (emergency/non emergency), new MI, angiographic success, clinical success, in-hospital mortality.	Surgeon volume.	Operators were categorized into terciles based on annualized volume of procedures. (Low, Middle, High).	Study by Northern New England Cardiovascular study group. Univariate and multivariate regression analyses were used to control for case-mix. used our prospective, multicenter, clinical data base to address the question of whether operator volume is related to angiographic success, clinical success and adverse events after PCIs. No control of hospital characteristics.	Pearson chi-square tests were used to assess the univariate association between potential predictors and the outcome variables. For each outcome, logistic regression models run (controlling case-mix) with entry and exit criteria set at $p \leq 0.05$. Rates for successful and adverse outcomes were then calculated using the beta estimates from the logistic regression model, and direct standardization was used to calculate adjusted rates.	Age, gender, presence of diabetes, history of peripheral vascular disease, history of chronic obstructive pulmonary disease, previous PCIs, previous CABG and previous myocardial infarction (MI). Indication for the procedure (Asymptomatic, Stable angina, Unstable angina, Postinfarction angina, Postinfarction anatomy, Primary therapy for MI, Cardiogenic shock); the priority of the procedure (emergency, urgent and nonurgent); Angiographic data: presence of 50% left main coronary artery stenosis (LMCA); LAD, left circumflex artery, right coronary artery or in a bypass graft; the number of lesions attempted; the interventional devices used; and the location and complexity of the treated lesion or lesions. Lesion complexity (A, B, C),	There is a significant relation between operator volume and outcomes in PCIs. High volume operators are more successful and encounter fewer adverse outcomes. Study demonstrates two relations between operator volume and outcomes for PCIs: 1) Higher operator volume is associated with a greater degree of angiographic and clinical success; and 2) lower operator volume is associated with an increased likelihood of postprocedural CABG. However, a significant difference in in-hospital mortality across terciles was not present.

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42	1994-1996	US, Northern New England and Massachussets US	15,080 PCIs performed during 14,498 hospitalizations 47 cardiologists 6 Hospitals.	Cardio/ Percutaneous Coronary Interventions.	In-hospital outcomes included death, emergency coronary artery bypass graft surgery (eCABG), non-emergency CABG (non-eCABG), myocardial infarction (MI), death and clinical success.	Surgeon volume.	Operators were categorized into terciles based on their annualized volume of procedures (Low, Middle, High).	Study by Northern New England Cardiovascular study group. Updates their previous results and finds no significant relation for this period studied. No control of hospital characteristics.	Logistic regression was used to assess whether changes in case-mix differed across terciles of operator volume, except for the ordinal variables of indication, priority and lesion type where a Mantel-Haenszel chi-square statistic was used. Multivariate models were used to adjust for differences in case-mix and severity of illness across terciles of operator volume when comparing outcomes.	1) site and primary operator; 2) demographic data: patient age, gender, height, weight; 3) medical history: previous coronary artery bypass graft surgery (CABG), PCI or myocardial infarction (MI), family history of premature coronary artery disease, the presence of congestive heart failure, hypertension, treated diabetes, current smoking, hypercholesterolemia, chronic obstructive pulmonary disease, peripheral vascular disease, cerebrovascular disease, renal failure, baseline creatinine; 4) primary indication for PCI: stable angina, unstableangina, postinfarction angina, postinfarction anatomy, primary therapy for acute MI, cardiogenic shock; 5) priority at PCI: emergent, urgent, nonurgent; 6) therapy before during and after the procedure: intravenous heparin, intravenous nitroglycerin, thrombolytic therapy, insertion of an intraaortic balloon pump; 7) cardiac anatomy and function: percent stenosis of left main coronary artery, number of other diseased native coronary vessels, dominance, number of bypass grafts, ejection fraction, left ventricular end diastolic pressure; 8) PCI procedure information.	Using current data, there is no significant relationship between operator volumes averaging ≥ 68 per year and outcomes at high volume hospitals.

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43	1999-2001	US, Durham, North Carolina; Lebanon, New Hampshire; and Portland, Maine-US	1672 Physicians ICDs, 9,854 Patients.	Cardio/ implantable cardioverter-defibrillator (ICD).	30-day mortality; 90-day mortality; 30-day mechanical complications; 90-day mechanical complications; 30-day ICD infection; 90-day ICD infection.	Physician ICD Volume.	Physician volume categories by assigning one-quarter of the patients to each quartile. Annual Medicare Volume to Outcome: Open bars = 1 to 10; ruled bars = 11 to 18; dotted bars = 19 to 28; solid bars = 29. ICD Annualized Volume: 1-6 (n = 2,487); 7-11 (n = 2,559); 12-17 (n = 2,336); 18 (n = 2,472).	Using the 20% Part B Medicare files claims, identified all claims with an appropriate current procedural terminology (CPT code) for placement of a complete ICD for any indication, a valid physician identifier, and a procedure date between 1999-2001.These claims were collapsed into a set of unique patient identifiers that became our study cohort.	Categorical variables are summarized as frequencies. Differences in patient characteristics by physician volume category were assessed using the chis-quare test. Differences in outcomes across physician volume categories were assessed using the chi-square test of trend. Multiple logistic regression models were used to assess the effect of physician volume category on outcomes while adjusting for patient characteristics.	Patient characteristics adjusted for included age, gender, race, urgency of admission (outpatient procedure, elective, urgent, emergency), admission for acute myocardial infarction, and Charlson comorbidity score (includes cancer, liver disease, renal failure, diabetes mellitus, myocardial infarction, peripheral vascular disease, dementia, chronic obstructive pulmonary disease, rheumatic heart disease, and acquired immuno-deficiency syndrome). We also controlled for the volume of pacemaker implantations.	An association between a higher volume of ICD implants and a lower rate of mechanical complications and infections. This association suggests that ICD implantation should not be performed by physicians without regard to their procedural volume. Conclude that patients who have their ICD implanted by high-volume physicians have lower rates of mechanical complications and ICD infection than patients who have their ICD implanted by low-volume physicians. This findings suggest that ICD implantation should be directed toward high-volume physicians.

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44	2002	US, Michigan - US -	165 operators; 18,504 consecutive PCIs; 14 hospitals.	Cardio/ percutaneous coronary intervention (PCI).	Clinical and point Adverse Outcome: Contrast nephropathy, Vascular complications, Transfusion, Death, MI, Stroke or TIA, Emergency CABG, All CABG, Repeat PCI, MACE.	Operator volume.	Operators were grouped by quintile (Q) according to the number of procedures performed as follows: the first quintile included operators performing 1 to 33 PCI/year, the second quintile included operators performing 34 to 89 PCI/year, the third quintile included operators performing 90 to 139 PCI/year, the fourth quintile included operators performing 140 to 206 procedures/year, and the fifth quintile included operators performing 207 to 582 procedures/ year. The ACC and AHA currently recommend a minimum of 75 PCI/year per operator. Therefore, a secondary analysis was performed with the 75 PCI/year as a cutoff to differentiate "low volume operators" from "high volume operators."	Clinical, procedural, and outcome data were prospectively collected in 14 hospitals in Michigan in the calendar year 2002. Data were collected with a standardized data collection form and standardized definitions. Data are expressed as mean standard deviation or as percentage.	Analysis of variance was used for differences between means, and Pearson chi-square test was used for differences in frequencies. Trends across quintile of procedure volume were evaluated with the Cochran-Armitage trend test for significance. Independent predictors of in-hospital mortality and MACE were determined by stepwise multivariate logistic regression analysis. Model discrimination was assessed with the c-statistic, and goodness of fit was assessed with the Hosmer-Lemeshow statistics. Three groups of models were fitted. In the first group, hospitals were considered as fixed effects; in the second group, a random effect was included, assuming normal hospital-effect distributions; and in the third group, generalized estimating equations were fitted to control for clustering and variation by hospital.	Baseline demographics (age and gender, smoking), comorbidities (historical: hypertension, diabetes mellitus, extracardiac vascular disease, congestive heart failure, renal failure requiring dialysis, gastro-intestinal bleeding, chronic, procedure obstructive pulmonary disease, atrial fibrillation, history of cardiac arrest, prior history of percutaneous intervention, prior history of coronary artery bypass surgery. Clinical presentation at time of PCI: creatinine 1.5 mg/dl, MI within 7 days, MI within 24 h, cardiac arrest, prior thrombolysis, cardiogenic shock, ventricular tachycardia or fibrillation in the setting of acute MI, emergency angioplasty, rescue angioplasty after failed thrombolysis, unstable angina (requiring intravenous nitroglycerin and heparin treatment), Procedural characteristics: number of diseased vessels (70% stenosis), left ventricular ejection fraction 50%, ACC type C stenosis, visible thrombus on the initial coronary angiogram, prior history of MI, left main stenosis (70%), anemia (hemoglobin 10g/dl), and the presence of moderate or heavy calcification.	Although the relationship between operator volume and in-hospital mortality is no longer significant, the relationship between volume and any adverse outcome is still present. Technological advancements have not yet completely offset the influence of procedural volume on proficiency of PCIs. After adjustment for comorbidities and other confounders, low procedure volume continues to be a predictor of worse outcomes (MACE), and this relationship appears to be relatively independent of the patients'risk. In addition, the volume threshold might be higher than the threshold of 75 procedures/year suggested by the ACC/AHA guidelines.

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45	1998-1999 2000-2002	Italy, Emilia-Romagna	16,512 patients aged ≥18 years 6 Centres.	CABG, Cardiac.	Mortality rates: In-Hospital, 30 Day. Patients' timely referral to hub centers, average waiting times.	Surgical center volume of cases.	Before/after study. Compares the outcomes before after 2000 (regionalisation).	Case mix adjusted before (1998–1999) - after (2000–2002) comparison. Patients were identified in the regional hospital discharge database (SDO) provides information on patient. The impact of the regionalisation policy was assessed by regression model including a dummy variables which represent the period (2000–2002) right after regularisation (2000). The policy effect is expressed in terms of odds ratios (OR) with 95% confidence intervals (95%CI).	Univariate analyses were carried out to assess differences in patients' case mix across the five study years, using the X^2 test for trend or analysis of variance for categorical and continuous variables, respectively. Yearly mortality and referral rates were adjusted through a logistic regression model including covariates. Year specific adjusted mortality and case mix adjusted referral rates were calculated by multiplying O/E by the overall mortality rate observed over the whole study period. A multivariate linear regression used in assessing changes over the study period in patients' waiting times, adjusting for the same set of covariates.	Demographic characteristics: patient age, sex; Comorbidity (measured with the Charlson comorbidity index12) conditions : Chronic obstructive lung disease, Congestive heart failure, Cerebrovascular disease, Peripheral vascular disease, Renal failure in previous admissions ; Type of surgical intervention - Admission (elective versus urgent), degree of risk (assessed on the presence of key clinical conditions : diagnosis of acute myocardial infarction, cardiac catheterisation on the same day of the intervention, percutaneous transluminal coronary angioplasty (PTCA) on the same day of intervention, Intra-aortic balloon pump), type of surgery.	Study provides additional evidence on the benefit of regionalisation of cardiac surgery interventions. Better clinical outcomes could be achieved if clinical practice was regulated in such a way as to assure that each surgical centre had a volume of cases sufficient to maintain the required clinical competence. In-hospital mortality reduced by 22%, 30 day about 18%. Timely referrals for sugery increased by 21% and mean waiting times reduced by 7.5 average days.

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46	1996-2000	US non federal Hospital	5,497 operations 538 hospitals 825 surgeons 18 - 28 States.	Transsphenoidal surgery for pituitary tumor.	Adverse outcomes : inhospital mortality, outcome at hospital discharge, complications of surgery, length of stay (LOS), and hospital charges.	Annual hospital and surgeon caseload of transsphenoidal surgery, as well as to other patient and provider characteristics.	Single cutpoint with resultant information loss (8 – 10), Low and High volume quartiles for transsphenoidal pituitary tumor surgery caseload (one to four admissions per year and 25 or more admissions per year, respectively) Hospital volume by quartile : 1-4 ; 5-9 ; 10-24 ; 25 + (admissions/year) Surgeon volume by quartile : 1 ; 2-3 ; 4-7 ; 8 + (admissions/year).	For these years, the NIS contains discharge data on 100% of discharges from a stratified random sample of non federal hospitals in 19 – 28 states.	Statistical methods included the Fisher's exact and Wilcoxon rank tests, Spearman rank correlation, and loglinear least-squares, ordinary logistic, and proportional-odds ordinal logistic regression. To correct for possible clustering of similar outcomes within hospitals, which could cause falsely inflated estimates of the statistical significance of regression coefficients, a sandwich variance-covariance matrix was estimated from the data using methods due to Huber and White, with adjustment for clustering by hospital or surgeon. LOS and hospital charges were analyzed as logarithmic transforms using least-quares regression corrected for clustering as described above.	Patients demographics : age, sex, race, median household income for ZIP code of residence, primary payer (Medicare, Medicaid, private insurance, self-pay, no charge, other), type of admission (emergency, urgent, elective or routine) and admission source (emergency room ward, transfer from another hospital acute care hospital, transfer from long-term care, and routine), Year of treatment, Procedure : Biopsy, Partial hypophysectomy, Total hypophysectomy, Cushing's disease. Hospital region (Northeast, Midwest, South, or West), location (rural or urban), teaching status, and bed size (small, medium, large).	Higher-volume hospitals and surgeons provide superior short-term outcomes after transsphenoidal pituitary tumor surgery with shorter lengths of stay and a trend toward lower charges. Complications were coded in 26.8% of patients. Patients of higher-volume hospitals and surgeons had lower mortality rates, better hospital discharge disposition, and fewer complications. Patients of high-volume providers were younger, healthier, and white, more often had private insurance, and resided in wealthier areas.

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47	1993-2003	US	**No. of patients:** Prostatectomy: 141,052 Cystectomy: 19,319 Esophagectomy: 4,020 Pancreatectomy: 9,153 Pneumonectomy: 90,088 Liver Resection: 3,630.	Cancer surgeries (prostatectomy, cystectomy, esophagectomy, pancreatectomy, pneumonectomy, and liver resection).	Operative mortality was defined as an intraoperative death or death during the course of hospitalization after cancer surgery. Prolonged LOS for each procedure defined as the group of patients whose LOS was greater than the 90th percentile within each year.	Annual hospital volume.	Within each year, hospital volume was measured and sorted into deciles separately for each procedure. These deciles were ranked from low (bottom decile) to high (top decile).	Data from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample were abstracted.	The bivariate relationship between each of the outcomes and the categoric covariates was assessed using the Rao-Scott 2 test, whereas the bivariate relationship between the outcomes and the continuous covariates was tested using a simple logistic regression model and the Wald 2 test. For each procedure, unconditional logistic regression models were used to estimate the adjusted attributable risk as a result of hospital volume, comparing low-volume with high-volume hospitals.	Covariates: Patients characteristics (number, age, race (white, African American, Hispanic, other, or missing), sex, admission acuity (elective v nonelective admission - urgent/emergent admission), type of insurance (private, Medicare, or other), and comorbidities.	For patients undergoing major cancer surgery, the benefits of volume-based referral depend on the interplay between procedure utilization, the magnitude of effect, and the outcome chosen. High volume hospitals had lower operative mortality rates. Generally, mortality declined over time for all of the cancer procedures. The regionalization of all procedures (the bottom 90th percentile) to high-volume hospitals would save many more lives and avoid many more prolonged hospitalizations than reported in this study. We chose the bottom decile of hospital volume as a threshold for volume-based referral across all procedures for consistency and practicality; although it may be feasible to regionalize all esophagectomies, it would be impractical to do the same for prostatectomy. Furthermore, the relationship between some procedures and outcomes may be primarily mediated at the level of the surgeon rather than at the level of the hospital.

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48	1990-1992	US, 11 states	1,330 patients Primary rectal cancer surgery was performed at 646 United States hospitals.	Rectal cancer (primary).	Rates of sphincter-reserving operations. Cancer Recurrence (Mortality) and Survival rates : * 5-year overall survival ; *5-year disease-free survival ; *5-year recurrence-free survival ; * 5-year local recurrence-free survival.	Hospital procedure volume.	Hospital procedural volume defined by tertiles of low [0 to 8.3 Medicare cases/yr], medium [8.4 to 16.7 Medicare cases/yr], and high [17 to 92 Medicare cases/yr]) on the basis of the Medicare procedure volume of the hospital.	Prospectively recorded data of Cohort study and the NIS database (345 hospitals), the Spearman rank correlation for annual rectal cancer surgery volume as measured by the Medicare claims database and the NIS database was 0.87. Used data from a l**arge randomized trial of patients** with stage II and III rectal cancer to examine the influence of hospital procedure volume on sphincter-reserving surgery and long-term outcome.	The distribution of baseline characteristics across hospital procedure volume tertiles was evaluated using Mantel-Haenszel X^2 tests for categoric variables and ANOVA for continuous variables. Overall survival (OS), disease-free survival (DFS), recurrence-free survival (RFS ; local or distant), and local recurrence-free survival (LRFS) rates were examined using the methods of Kaplan and Meier, and differences among tertiles were assessed by the log-rank test. The entire cohort was analyzed using Cox proportional hazards regression, with a priori inclusion in the model of Patients characteristics. Differences in rates of APR by hospital volume tertile were analyzed using logistic regression, with adjustments.	Baseline Charateristics : Number of patients and hospitals, annual case volume, age, sex, race (White, African-American and Other), bowel obstruction at presentation, performance status, number of positive lymph nodes, and extent of disease through the bowel wall, distance from anal verge (on the basis of operative, sigmoidoscopy, or colonoscopy report), Invasion to perirectal fat or adjacent organs, Performance status at study entry, Grade of differentiation (Well, grade 1 ; Moderately, grade 2 ; Poorly, grade ; Other) ; Influence of Adjuvant Therapy.	Hospital surgical volume had no significant effect on rectal cancer recurrence or survival when patients completed standard adjuvant therapy. Sphincter preserving surgery was more commonly performed at high-volume centers. Nonetheless, patients who underwent surgery at low-volume centers were significantly more likely to require a permanent colostomy by virtue of undergoing an APR.

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49	1991 - 1994	US	101,604 prostatectomies aged 65 years old.	Radical prostatectomy.	Length of a patient's hospital stay, Patients outcome : surgical complications, readmission rate, and mortality rate in a 30-day period following surgery.	Volume of hospital load of prostatectomies.	Hospitals were classified into four categories of prostatectomy volumes based on the number of prostatectomies performed : 1) Low volume (≤ 25th percentile or ≤ 38 prostatectomy surgeries in the study period ; number of hospitals in this category = 2,013); 2) medium-low-volume (26th–50th percentile or 39–74 surgeries in the study period ; number of hospitals in this category = 4,463); 3) medium-high volume (51st–75th percentile or 75–140 surgeries in the study period ; number of hospitals in this category = 4,257) ; 4) high-volume (≥76th percentile or ≥141 surgeries in the study period ; number of hospitals in this category = 116), Surgery volume : Low (≤38) Medium-low (39–74) Medium-high (75–140) High (≥141).	Cross-sectional analyses descriptive statistics regarding rates of complications, readmission, and mortality in each hospital volume category were age-adjusted by use of the entire study cohort as the standard population.	Odds ratios (as estimates of relative risks) were derived from the logistic regression and were used to assess the effects of hospital volume on short-term outcomes. To assess volume relatedness, used linear regressions to conduct trend tests.	Covariates included age (65–69 years, 70–74 years, or <75 years), race, surgeon speciality (urology or other), prostatectomy volume (low, medium-low, medium-high, or high), teaching status of the hospital, comorbidity (yes or no) of patients affected (Hypertension, Cardiac, Pulmonary, Diabetes, Renal disease); and year of surgery (1991, 1992, 1993, or 1994).	Within-hospital longitudinal analyses revealed that hospitals with a relative increase in prostatectomy volume had a 57% greater reduction in the length of a patient's stay compared with those with a relative decrease in volume (P = .005). Changes in prostatectomy volume **did not** affect the frequency of complications, mortality, and readmission. These findings suggest that an increase in a given hospital's prostatectomy volume may decrease the length of stay without an adverse impact on patient outcomes.

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50	1994-1997	US, California - US	7,257 patients 367 Hospitals.	Rectal Cancer.	Three end points were analyzed : permanent colostomy, 30-day postoperative mortality, and overall mortality rate in the 2 years after surgery.	Number of operations performed at a hospital (i.e. hospital volume).	Quartiles of hospital volume : Low to High <7; 7 – 13 ;14 – 20; >20.	This study assessed the association of hospital volume with colostomy rates and survival for patients with rectal cancer in a large representative cohort identified from the California Cancer Registry. Data Sources and Study Cohort. patients diagnosed from with stage I – III rectal cancer who underwent surgical resection. Registry data were linked to hospital discharge abstracts and ZIP-code-level data from the 1990 U.S. Census.	Associations of hospital volume with permanent colostomy and 30-day mortality were assessed with the Mantel–Haenszel trend X^2 test and multivariable logistic regression. Overall survival was examined with the Kaplan–Meier method and a multivariable Cox proportional hazards model. Multivariable analyses adjusted for demographic and clinical variables and patient clustering within hospitals. All tests of statistical significance were two-sided.	Demographic (age, sex, race) and clinical characteristics (tumor stage, socioeconomic status quartile, hospital volume, and comorbidity index, Tumor location (Rectal Rectosigmoid).	In unadjusted analyses across decreasing quartiles of hospital volume, we observed statistically significant increases in colostomy rates and in 30-day postoperative mortality and a decrease in 2-year survival. The adjusted risks of permanent colostomy, 30-day mortality, and 2-year mortality were greater for patients at hospitals in the lowest volume quartile than for patients at hospitals in the highest volume quartile. Stratification by tumor stage and comorbidity index did not appreciably affect the results. Adjusted colostomy rates varied statistically significantly (P<.001) among individual hospitals independent of volume. Rectal cancer patients who underwent surgery at high-volume hospitals were less likely to have a permanent colostomy and had better survival rates than those treated in low-volume hospitals. Identifying processes of care that contribute to these differences may improve patients' outcomes in all hospitals.
51	1990-1995	US, Maryland - US	9,918 elective CEAs 48 hospitals.	Carotid endarterectomy (CEA).	Postoperative death/strokes and neurologic complications rates (Hospital charges and LOS).	hospital surgical volume.	Low-volume (≤ 10 cases/year ; n = 12), moderate-volume (11 to 49 cases/year ; n = 24), and high-volume (≥ 50 cases/year ; n = 12) institutions.	The Maryland Health Services Cost Review Commission database was reviewed to identify all patients who underwent elective CEA as the primary procedure in all acute care hospitals in the state over the past 6 years. All perioperative deaths and strokes identified in the database.	Data were analyzed with the Kruskal-Wallis or Mann-Whitney tests Post-hoc comparisons were performed with Fisher's protected least significant difference, Bonferroni, and Scheffé's post hoc tests, using analysis of variance as an approximation of the Kruskal-Wallis test as a result of the large sample size.	Age, Complexity Score.	There was an inverse correlation between hospital caseload and operative mortality rate, and a significantly higher complication rates in low-volume compared with moderate and high volume hospitals. Furthermore hospital charges were significantly lower in high-volume hospitals reflecting shorter LOS.

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52	1997	US	3,073 patients 483 hospitals.	Aorto-bifemoral bypass (AFB).	* In-hospital mortality, * Prolonged LOS.	Hospital Volume.	Hospital volume was a dichotomous variable with low volume (25/y) and high volume (>25/y).	Data from a nationally representative hospital discharge database: Nationwide Inpatient Sample (NIS). The NIS is a 20% random sample of all hospital discharges in the United States, stratified by geographic region, urban or rural location, teaching status, ownership, and bed size.	Unadjusted and case mix–adjusted analyses were performed. Univariate comparisons of hospital volume, patient characteristics, and outcome variables with the 2 tests, Wilcoxin rank-sum test, simple logistic and linear regression, where appropriate. The Charlson comorbidity score was used with ICD- 9-CM codes from an index hospitalization to account for comorbidity. Multiple logistic regression of in-hospital mortality and prolonged LOS was used to test their association with hospital volume after adjusting for potentially confounding patient case mix variables.	Patient characteristics: Age (Without/With COPD overall, sex, race), nature of admission (Elective admission, Urgent admission, Emergent admission), comorbidity Index diseases, Insurance (Medicare, Private, Medicaid); Median income by ZIP code; COPD, chronic pulmonary disease.	AFB operative mortality was significantly lower at high-volume hospitals (more than 25/year) in this nationally representative database (40% decreased risk of hospital mortality). Without other information regarding quality of surgical care for patients in need of AFB, referral to a high-volume center can result in superior outcome.
53	1992-2001	Canada, Ontario - Canada.	2,601 patients with ruptured AAA repair; 13,701 patients with elective AAA repair.	AAA, abdominal aortic aneurysm.	Survival after repair of ruptured abdominal aortic aneurysm (AAA) and survival after elective AAA repair. And Crude and Adjusted 30-day mortality rate.	Surgeon Volume Rates and Hospital factors.	Annual surgeon volume was calculated by enumerating the number of cases a given surgeon performed each year. Cut points were selected to define high-volume and low-volume surgeons. These cut points were chosen a priori as the median.	In this population-based retrospective cohort study, surgeon billing and administrative data were used to identify all patients who had undergone AAA repair. Demographic information was collected for each patient, as well as numerous variables related to the surgeons and hospitals. Data were obtained from four sources: the CIHI data base, the OHIP data base (physician billings), census data, and the Ontario Physician Human Resources Data Center (OPHRDC) data base.	Elective aneurysm repairs and repairs of ruptured aneurysms were considered separately. Correlation between continuous variables was examined. Patient, surgeon, and hospital factors independently associated with survival were identified with a proportional hazards multivariate backward selection process. Proportional hazards survival analysis was used because it has superior power to logistic regression analysis. Hazard ratios for variables were compared with a two-tailed z test between elective AAA repair and ruptured AAA repair. All volume measures were analyzed in our multivariate survival analysis model as continuous variables.	**Patients Factors:** Age (per 5 y); Charlson Comorbidity Index; Gender; Income quintile (per increase of 1); Distance from patient's home to hospital (km); **Surgeon factors:** Annual surgeon volume of ruptured AAA repairs (per 5 cases); Annual surgeon volume of elective AAA repairs (per 10 cases); Procedures performed, by surgeon specialty:General surgeon; Cardiothoracic surgeon; Vascular surgeon. **Hospital factors:** After-hours repair (weeknight, weekend, holiday); Procedure performed in teaching hospital; Population of city where operation performed; Annual hospital volume of ruptured AAA repairs; Annual hospital volume of elective AAA repairs; Year operation performed.	For elective AAA repair, and even more so for ruptured AAA repair, high-volume surgeons with subspecialty training conferred a significant survival benefit for patients. Although this would seem to argue in favor of regionalization, decisions should await a more complete understanding of the relationship between transfer time, delay in treatment, and outcome.

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54	2002-2003	US	20,241 nonsurgical patients; 37 acute care hospitals; 122,498 patients admitted to 104 ICUs at 45 hospitals.	Mechanical ventilation.	Survival rates; mortality rates and the length of the stay at hospitals Length of mechanical ventilation; Length of stay in ICU; Length of hospital stay (days); Mortality in ICU; In-hospital mortality.	Hospital Volume.	Categorizing volume into quartiles: Quartile 1 (87 – 150 patients/yr) Quartile 2 (151 – 275 patients/yr) Quartile 3 (276 – 400 patients/yr) Quartile 4 (401 – 617 patients/yr).	Used data from the Acute Physiology and Chronic Health Evaluation (APACHE) clinical outcomes database. a cohort study with the use of the APACHE clinical database, which prospectively collects information on patients in 104 ICUs at 45 hospitals in the United States as part of its predictive capabilities. The APACHE database (Cerner) supplies data on risk-adjusted outcomes to participating hospitals for benchmarking purposes. Local, trained clinical coordinators supervise data collection.	Adjusted for the severity of illness and other differences in the case mix. Bivariate analysis comparing demographic characteristics across the quartiles of hospital volume was performed with analysis of variance for continuous variables and the chi-square test for categorical variables. Multivariate modeling was performed with logistic regression for mortality and linear regression for length of hospital stay, after adjusting for potential confounders. For the assessment of volume as a continuous variable, used the fractional polynomial method, an iterative estimation process that determines the best-fitting polynomial-regression function.	**Hospitals Characteristic :** Teaching status {Academic, Community with house staff, Community} Region {Southeast, Northeast, Midwest, West} No. of hospital beds {Median; Interquartile range} No. of APACHE ICUs/hospital {Median, Interquartile range} Non-APACHE ICU beds **Patients Characteristic :** Age, Sex, APACHE III score, Race or ethnic group Transferred from outside hospital, Discharged from ICU to outside hospital; Type of ICU {Multidisciplinary; Medical; Surgical; Coronary care; Neurologic; Cardiothoracic surgery}; **Diagnostic category** {Pneumonia; Congestive heart failure; Neurologic disease; Sepsis; Chronic obstructive pulmonary disease; Post – cardiac arrest; Drug overdose; Gastrointestinal bleeding; Oncologic disease; Acute coronary syndrome; Arrhythmia; Other respiratory disease; Other medical disease; Other gastrointestinal disease; Other cardiac disease} **Intensivist physician staffing** {Low-intensity care model; High-intensity care model}.	Mechanical ventilation of patients in a hospital with a high case volume is associated with reduced mortality. Further research is needed to determine the mechanism of the relationship between volume and outcome among patients with a critical illness. Data demonstrate an association between an increase in hospital volume and a lower risk adjusted mortality among patients requiring mechanical ventilation.

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55	1995-1996-1997	US, Massachussets-US	10,211 Patients 10,211 CEAs 60.3 hospitals 3,388 procedures in FY95, 3,568 in FY96, and 3,255 in FY97.	Carotid endarterectomy (CEA).	In-hospital stroke and mortality rates.	CEA volume.	Five high volume AMCs (HVAMCs) were compared with all other nonacademic hospitals, which were further subdivided by annual volume into high volume non-AMCs (≥50 cases), medium volume non-AMCs (24-49 cases), and low volume non-AMCs (12-23 cases).	Carotid endarterectomy has a further advantage in that the indications and outcomes for this operation have been extensively scrutinized in the United States and abroad with randomized prospective studies. Health Share Technology maintains a database. Data on individual patients, including charges, were obtained from the Massachusetts Division of Health Care Finance and Policy, and hospital cost and charge data were provided by the Health Care Financing Administration. The cost data were determined with the ratio of cost to charges (RCC) approach, which requires two steps.	Statistical analysis was performed with analysis of variance to compare the means of all the cost and LOS data, and χ 2 tests was used for comparison of incidence (significance assumed for P ≤.05).	Patient age, sex, hospital costs, demographic, and charge reports, LOS, and disposition. Procedure volume (Indication (eg, asymptomatic versus symptomatic)). The total number of CEAs by year and grouping. The number of medical centers in each of the categories. Minor or nonteaching hospitals.	Patients in HVAMCs have the best outcomes after CEA. Despite the achievement of significant efficiencies, AMCs have a small cushion to reduce further either LOS or resources to maintain a competitive cost position and to compensate for the fixed expenses of academic medicine. The Balanced Budget Act raises an equity concern for AMCs because it differentially affects the centers with the best outcomes. The financial implication of this may be a direct incentive for procedures to be done in centers with less optimal outcomes.

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56	1994-1995	US	98,898 Medicare patients 65 years of age or older ; Hospital = 95,185 ; Physician's N = 81,728.	Cardio/Acute Myocardial Infarction in Eldery Patients.	30-Day Survival rates ; mortality more than/within 30-day and 1 yr after admission; long term mortality.	Hospital volume, Physicians.	Hospital volume as an ordinal variable according to quartile, the hazard ratio for 30-day survival among patients in the lowest versus the highest hospital-volume quartile was 1.17 (95 percent confidence interval, 1.09 to 1.26 ; P<0.001); for the second quartile the ratio was 1.07 (95 percent confidence interval, 1.01 to 1.13 ; P = 0.02); and for the third quartile the ratio was 1.05 (95 percent confidence interval, 0.99 to 1.10 ; P =0.11). **Hospital volume :** * <1.4 patients/wk(n =24,829); * 1.4–2.5 patients/wk(n =24,743); * 2.6–4.4 patients/wk (n =24,648); * >4.4 patients/wk (n =24,678).	Performed a retrospective cohort study, using data from the Cooperative Cardiovascular Project (CCP), which was conducted by the Health Care Financing Administration (HCFA). This cohort was uniquely suited for the analysis of the effects of aspects of the health care delivery system : the nationwide sample comprised nearly 100 percent of elderly patients with myocardial infarction who had fee-for-service insurance coverage, and the study had extensive clinical data, blinded data abstraction, and reliable long-term follow-up.	Used proportional-hazards methods to adjust. Multivariate model, adapted from models for the assessment of 30-day mortality after myocardial infarction. The independent variables were collinear (Spearman correlations, <0.5). Used Kaplan–Meier curves to compare unadjusted survival. To determine whether there was a selection bias, we used logistic regression to calculate a predicted one-year mortality rate for each quartile of hospital volume and for each physician specialty. We used data on covariates for each patient from the proportional hazards model while neutralizing the effects of hospital-related variables by standardizing them to the lowest-mortality groups. Generalized estimating equation, and the Cox proportional-hazards survival analysis. Unadjusted Kaplan–Meier survival curves for quartiles of hospital volume.	Clinical Diabetes mellitus, Prior congestive heart failure, Prior myocardial infarction, Prior angioplasty, Prior bypass surgery, Mean heart rate, Mean arterial pressure anterior infarction, Killip class, demographic (age, sex, race), and health-system–related variables, including the availability of invasive procedures, the specialty of the attending physician, and the area of residence of the patient (rural, urban, or metropolitan).	There was a continuous inverse dose–response relation between hospital volume and the risk of death. The availability of technology for angioplasty and bypass surgery was not independently associated with overall mortality. Patients with acute myocardial infarction who are admitted directly to hospitals that have more experience treating myocardial infarction, as reflected by their case volume, are more likely to survive than are patients admitted to low-volume hospitals.

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57	1998-1999	UK	186 UK NICUs 13,515 infants 54 NICUs.	Neonatal intensive-care units (NICUs).	Primary outcomes were : hospital mortality, mortality or cerebral damage, and nosocomial bacteraemia.	Volume of patients, nursing provision, and neonatal consultant provision.	Data about unit activity and staffing provision allowed stratification into 12 types of NICU with a three (high, medium, and low volume) by two (high and low neonatal consultant provision) by two (high and low nursing provision) factorial design. Patient volume was defined as number of very low birthweight infants (<1500 g) admitted per year : high-volume NICUs admitted more than 57 per year ; medium-volume units admitted 35–57 per year ; and units with low patient volumes admitted less than 35 per year.	To identify the groups of units required for the factorial design, a national census was done. Phase I census data identified 186 UK NICUs (units intending to provide sustained neonatal intensive care). The census was done without nationally agreed and verifiable definitions of neonatal intensive care, nurse or cot establishment, or unit size. Procedures and statistical analysis Controversy still exists about the best period—in the case of neonatal intensive care from birth or up to 12 h after admission—to obtain data for use in risk-adjustment methods.	Multiple logistic regression models of the three primary outcomes were developed to adjust for risk before the study hypotheses were investigated.	**Characteristics of eligible infants :** High consultant availability; High nurse provision; Number of infants; Number of units; Birthweight; <1500 g; Gestation (weeks); Attributable mortality; Cerebral abnormality; Nosocomial bacteraemia.	Study showed that high-volume NICUs in the UK cared for sicker infants, were busier, and had higher crude mortality and morbidity than medium-volume and low-volume units. Risk adjusted mortality or cerebral damage were unrelated to patient volume or staffing provision.

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58	1992-1996	US, New - York US	11,522 patients 159 surgeons 72 hospitals.	Prostatectomy.	Outcomes after radical prostatectomy. * Postoperative death (Surgery-related death 30 and 60 days), * Postoperative complications, * Late urinary complications, and * Long-term incontinence.	Hospital volume and surgeon volume (the number of procedures performed at individual hospitals and by individual surgeons, respectively).	Hospitals and surgeons were classified into four volume categories on the basis of quartiles of the patient cohort.	**Study Cohort:** Selected all patients 65 years old or older who were listed in the SEER data base as having received a diagnosis of prostate cancer between the index period. the cohort by excluding patients who were not treated in a SEER state, were not enrolled in both Part A and Part B of Medicare, or were not listed in Medicare records as having undergone prostatectomy within six months after the diagnosis.	The following patient-related covariates were used for risk adjustment. The extent of coexisting illnesses according to the Romano modification of the Charlson index. Calculated hospital volume in two ways : with all the patients and with only those 65 years of age or older. The Spearman rank-correlation coefficient. Analyses of volume were adjusted for within-hospital (or within surgeon) correlations in outcome with use of the generalized-estimating- equations modification of logistic regression. Used a correlation-adjusted logistic-regression model to estimate the expected rate of events for each surgeon by adjusting for the surgeon's patients' ages and coexisting illnesses and by adjusting for hospital volume and surgeon volume, modeled as continuous variables. Used the standardized deviations (z scores) of the observed frequencies from the expected frequencies for each surgeon to calculate the correlation between the outcomes and to characterize the degree to which individual surgeons could be identified as being associated with exceptionally high or low risk of adverse outcomes.	Patients Charateristics (age, race No. of patients, No. of patients per hospital, Romano–Charlson comorbidity index), Stage III or IV cancer.	In men undergoing prostatectomy, the rates of postoperative and late urinary complications are significantly reduced if the procedure is performed in a high-volume hospital and by a surgeon who performs a high number of such procedures.

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59	1994-1999	US	14 types of procedures 43 percent (for nephrectomy) to 75 percent (for carotid endarterectomy).	Cardiovascular procedures and eight types of major cancer resections.	Mortality (in-hospital or within 30 days).	Hospital volume (total number of procedures performed per year).	Hospital volume, expressed as the average number of procedures per year, was first evaluated as a continuous variable. Created categorical variables, defining five categories of hospital volume : very low, low, medium, high, and very high. For each procedure, the hospitals were ranked in order of increasing total hospital volume, and then five volume groups were defined by the selection of whole-number cutoff points for annual volume that most closely sorted the patients into five groups of equal size (quintiles).	The Medicare Provider Analysis and Review (MEDPAR) files. These files contain hospital-discharge abstracts for the acute care hospitalizations of all Medicare recipients to create cohorts for the analysis of outcomes, applied several restrictions in order to increase the homogeneity of the study samples and thus minimize the potential for confounding by case mix.	Multiple logistic regression.	Patients charateristics : age, sex, race, interaction, year of procedure, the relative urgency of the index admission (elective, urgent, or emergency), the presence of coexisting conditions, and mean income from Social Security. Charlson score » 3.	In the absence of other information about the quality of surgery at the hospitals near them, Medicare patients undergoing selected cardiovascular or cancer procedures can significantly reduce their risk of operative death by selecting a high-volume hospital.

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60	1998-1999	US	474,108 patients 8 procedures.	Cardiovascular procedures and 4 cancer resections.	Operative mortality.	Surgeon volume and hospital volume (each in terms of total procedures performed per year).	Volume was evaluated as a continuous (log-transformed) variable in the assessment of statistical significance. Cutoff points into three evenly sized groups with low, medium, and high volume. In sensitivity analyses, we recategorized hospital volume as a binary variable according to the criteria established by the Leapfrog Group for four procedures : coronary-artery bypass grafting (450 or more procedures per year vs. fewer than 450), repair of abdominal aortic aneurysm (50 or more per year vs. fewer than 50), esophagectomy (13 or more per year vs. fewer than 13), and pancreatic resection (11 or more per year vs. fewer than 11).	Using information from the national Medicare claims data base. The Medicare Provider Analysis and Review (MEDPAR) and inpatient files, which contain hospital-discharge stracts for the fee-for-service, acute care hospitalizations of all Medicare recipients, were used to create our main data sets for analysis ; the Medicare denominator file was used to determine the vital status of the patients.	Used multiple logistic-regression analyses with adjustment for characteristics of the patients. adjusted for the effect of clustering of patients within surgeons and clustering of surgeons within hospitals by using binary mixed-effects models incorporating the two levels of nesting.	**Patients characteristics :** {age group (in five-year intervals), sex, race (black or nonblack), year of procedure (1998 or 1999), procedure was performed electively or not, and the mean income from Social Security in the ZIP Code of the patient's residence. Charlson scores}, **Hospitals characteristics :** the type of ownership (not-for-profit, for-profit, or government), location (urban or nonurban), and teaching status.	For many procedures, the observed associations between hospital volume and operative mortality are largely mediated by surgeon volume. Patients can often improve their chances of survival substantially, even at high-volume hospitals, by selecting surgeons who perform the operations frequently. The patients treated by high-volume surgeons had lower operative mortality rates than those treated by low-volume surgeons. Surgeon volume accounted for a relatively large proportion of the apparent effect of hospital volume, to a degree that varied according to the procedure. For some procedures, the association between hospital volume and outcome disappeared almost entirely after surgeon volume had been taken into account. The relative importance of surgeon volume and hospital volume varies according to the procedure.
61	1994-1998	US	772,586 patients 1,470 participating hospitals.	Cardio, Acute myocardial infarction Primary angioplasty or Thrombolytic therapy.	In-hospital mortality (Survical after AMI).	Volume of primary angioplasty or thrombolytic therapy.	Quartiles of Primary angioplasty or Thrombolytic therapy. The volume was calculated as the total number of patients who underwent primary angioplasty at each hospital divided by the total number of days for which the hospital reported data to the NRMI. Eligible hospitals were ranked according to volume, and the 25th, 50th, and 75th percentiles were used as cutoff points to define quartiles.	The National Registry of Myocardial Infarction (NRMI) is a voluntary registry of cross-sectional data on patients hospitalized with confirmed myocardial infarction. Entire NRMI cohort.	A linear association among the four quartiles was assessed with the use of the Mantel–Haenszel chi-square test for categorical variables, analysis of variance for continuous variables, and the nonparametric median (Brown–Mood) test for comparisons of median values. Forward multiple logistic-regression models were developed to identify predictors of mortality. The C statistic to determine the predictive value of each fully adjusted model.	The study variables included characteristics of the hospitals (urbanor rural location, the number of beds, and whether or not the hospital was a teaching center) and demographic and clinical characteristics of the patients, medical history Angina, Myocardial infarction, Heart failure, PTCA, CABG, Stroke }, Cardiac risk factors { Diabetes mellitus, Hypertension, Current smoking, Family history of coronary, artery disease High serum cholesterol}.	Among hospitals in the United States that have full interventional capabilities, a higher volume of angioplasty procedures is associated with a lower mortality rate among patients undergoing primary angioplasty, but there is no association between volume and mortality for thrombolytic therapy.

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62	1999-2001	US, California and New-York	6 physicians to the 9 member Cardiac Advisory Board, 138 hospitals in California, 39 hospitals in New-York.	Cardio, Coronary revascularization (CABG and PCI procedures).	In-hospital mortality and Risk factors rates.	Procedural volume (CABG and PCI).	High and Low volume CA - CABG (≥ 300/year ; < 300/year) CA - PCI (≥ 600/year ; < 600/year).	OSHPD PDD is an administrative database aggregated from 2-page patient discharge abstract produced from the clinical record of every patient discharged from an acute or subacute-care facility.	The continuity-adjusted X^2 test was used to determine differences in rates between California and New York.	Sex, Diabetes, Emergency, Shock CVD, COPD, PVD, Renal Failure, Dialysis, Prior CABG, CHF or Low EF.	Risk adjusted excess coronary artery bypass grafting mortality in California is related to the large number of low-volume programs. No volume effect was noted for risk adjusted PCI. Excess PCI intervention mortality might be related to case selection or timing of intervention.
63	1999-2002	US territories, and the District of Columbia	421 997 patients 268 trauma centers in 36 states.	Trauma care.	Outcomes parameters included length of hospital stay, length of ICU stay, total days on ventilatory support, and in-hospital survival.	Optimizing Physician Staffing/ Trauma Admission Volume.	The total number of admissions during a 24-hours period. The lowest number of admissions (7,504) occurred between 5:00 am and 6:00 am, The Highest number of admissions (26,373) occurred between 6:00 pm and 7:00 pm.	Voluntary database, analysis of the National Trauma Data Bank (NTDB).	The statistical Package for the Social Sciences version 12 was used for all statistical analyses. Frequencies and percentages were used to describe the pattern of admissions. Comparison of means and odds ratio were used to compare subgroups on salient variables.	Database contains information including patients demographics, facility profile, scene, emergency departement (ED) was categorized as dead on arrival, died in ED, operating room (OR), Intensive care units (ICU), telemetry, floor, ED observation, and burn unit. hospital, inter hospital transfer, procedure type, geographic location and day and hour of admission and other temporal information, type of injury severity (blunt trauma, penetrating trauma, or burns).	Trauma admissions conform to a sine-wave pattern with a 3,5-fold increase in admissions between morning and evening hours. Therefore, additional resources needed in the hours around 7:00 PM and later. Educational and administrative activities are best scheduled during low volume morning hours. Night time admissions are higher risk and thus more likely to need senior-level expertise and consume hospital resources. Trauma centers should use these findings to improve outcomes by developing optimal staffing patterns and matching resource allocation to need as a function of time.

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64	1994 - 1999	US	67 Hospitals 29 States 181,371 Patients aged 18 years of age or older.	Trauma care.	In-hospital survival.	Trauma center volume.	Total Number of Patients With Major Trauma by hospital Volume Quartiles (for blunt trauma and penetrating trauma) { < 140 ; 140 -261; 262-462 ; >462 }.	Retrospective analysis was based on data obtained from the National Trauma Cohort Databank for 1999.	Logistic regression modeling was used to analyze the relation between survival rates and hospital volume for patient sustaining either severe blunt or severe penetrating trauma. The models were evaluated by assesment of discrimination (calculated of the area under the ROC receiver operating characteristic) and calibration (assessed using the Hosmer-Lemeshow goodness-of-fit-statistic.	Patients demographics (age, sex), preexisting comorbidities, prehospital care, hospital demographics characteristics {(trauma center designation : blunt trauma, penetrating trauma) ; Hospital size, teaching status (University, Community, Nonteaching)}, severity scoring components.	The findings of this study do not support the position that higher trauma center volumes are associated with improved survival. The implication of this study is that the hospital volume criteria established by the American College of Surgeons may need to be reexamined. No association could be demonstrated between trauma volume and outcome for blunt trauma, A separate multivariate analysis of patients with penetrating trauma also could not demonstrate a significant volume mortality association.
65	1990-2000	US	172 VA Medical Centers ; 34,888 individuals with a new diagnosis of CRC during FY and 22,633 surgical resection.	Colorectal Cancer.	Long term survival.	Hospital surgical volume.	The median value (50th percentile), as the cutt-off value (25 procedures per year). Surgical volume was assessed as a categorical variable (< 25 procedures, ≥ 25 procedures per year).	Cohort study The log-log survival plots used to examine the proportionnal hazards assumption, which was met in all models.	Overall - 5 years cumulative survival was calculated from Kaplan-Meir estimates, adjusted risk of death was estimated using Cox proportional hazards models. X^2 test were conducted to compare demographic and clinical characteristic of patients who had surgical resection for CRC compared to patients who didn't have surgical resection.	Patients demographics (age, sex, year of diagnosis) ; Race/ ethnicity, Marital status, Deyo Score, Metastatic disease, CRC site (colon, Rectum), Chemotherapy, Radiotherapy.	Greater hospital surgical volume is an independant predictor of prologed long-term survival following surgery for both colon and rectal cancer in the VA health-care system. The volume-long term mortality relationship is greater for rectal than for colon cancer patients, perhaps reflecting the fact that surgery for rectal cancer is more technically demanding.

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66	1944-1995	US, Philadelphia-US	25,222 patients 43 Laboratories.	Cardio, PCI (percutaneous coronary interventions).	* Revascularization (follow-up hospitalization for PCI or CABG) * MI as a primary or secondary diagnosis code, * Death.	Annual PCI (Laboratory) volume.	Annual volume was categorized as: * < 400, * 400-599, * 600-899, * ≥ 900 procedures per year.	Study was a population-based cohort study that analyzed data from Pennsylvania Health Care Cost Containment Council (PHC4).	1-month, and 6 month events was estimated by use of multivariable analyses adjusting for patient and procedural characteristics. Robust variance estimates were computed for all survival analyses and generalized estimating equation logistic regression were used for all inhospital events. Control for confounding was provided by use of multivariate Cox and logistic regression with all covariates in the database.	Patients and procedure characteristics: age, sex, race, length of stay during index (PTCR > 7) ; Multivessel procedure by PCI code (PCI > 6), ASG, MI (None, early MI PCI, Post MI PCI), Insurance (Medical assistance, Medicare, Commercial/other), Device (Stent).	Study confirmed the Volume/ Complication relationship for inhospital CABG, it did not reveal an association between volume and postdischarge events. These results suggest that inhospital complications will remain the standard for assessing laboratory volume and that selective use of higher-volume laboratories may not improve long term outcomes. Higher-volume laboratories did not exhibit lower rates of revascularization or adverse cardiac events at 1or 6 months after hospital discharge, despite their lower risk of inhospital CABG.
67	1982-1994	US, California	100,963 LEAB; 106,493 CEA; 35,130 unruptured AAA; 7,327 ruptured AAA primary procedures.	Cardio, vascular: * LEAB (lower extremity arterial pass); * CEA (carotid endarterectomy), * AAA (Abdominal aortic aneurism repair); * Lower extremity angioplasty, * CABG.	In-Hospital mortality rates.	Hospital procedure volume.	The number of surgeries categorized into: * Low volume (under < 20 surgeries for the surgical procedure during the year) * Moderate volume (20 to 49 surgeries) * High volume (50 or more for AAA and 50 to 99 and 100 or more for LEAB and CEA).	The data in this study were analyzed for risk factors collected in the California administrative data bases, namely age, sex…	Using multiple logistic regression to control for risk factors and time trends.	Characteristics: Age category, gender, year of surgery, whether admission was througth the emergency room, and number of hospital surgeries for that procedure during the year. Selected diagnostic Comorbidities (diabetes).	In-hospital mortality rates for CEA, LEAB and unruptured AA have been significantly decreasing over time. Mortality is inversely related to hospital volume and directely related to patient age and emergency status. Mortality trends over time for ruptured AAA remains unchanged; however, mortality is less in high-volume hospitals. Coronary angioplasty (PTCA) has not an impact on rates for LEAB.

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68	1994-1999	US	446 acute care hospitals 62,299 patients with AMI.	Patient with AMI treated with Primary angioplasty VS thrombolytic therapy.	* In-hospital mortality * nonfatal stroke (both hemorrhagic and thrombo-embolic), other major bleeding following reperfusion therapy, and subsequent revascularization during the index hospitalization.	Hospital primary angioplasty procedural Volume.	Hospital classified into Primary angioplasty volume quartiles based on the annual number of procedures each had performed. * 112 classified as Low volume (≤16 procedures), * 223 as intermediate volume (17-48 procedures), * 111 as high volume (≥ 49 procedures).	Retrospective cohort study. The study population divided into 2 cohorts based on whether the patients received intravenous thrombolysis or primary agioplasty.	Developed additional regression models to test for an interaction between hospital primary angioplasty volume and reperfusion modality.	Baseline Charateristics: Demographic (age, sex, race (white, black, and other), Medical History (Diabetes, Hypertension, Hypercholesterolemia, Current smoker, Prior angina, prior CHF, prior MI, piror stroke, prior angioplasty, Prior CABG surgery), clinical presentation, medical therapy, and hospital variables.	Patients with AMI treated at hospitals with high or intermediate volumes of primary agioplasty had lower mortality with primary angioplasty than thrombolysis, whereas patients with AMI treated at hospitals with low angioplasty volumes had similar mortality outcomes with primary agioplasty or thrombolisys.
69	2000-2001-2002	US	51 Physicians, 6,510 PCIs.	Cardio, PCI (percutaneous coronary interventions).	Complication rates * death, * myocardial infarction, * coronary perforation, * emergent coronary artery bypass surgery and pericardial tamponade.	Operator volume	Operator volume according to the average number of PCI procedures performed during the 3-year period, each operator was categorized into one of three groups; * Low (< 50 cases per year), * Intermediate (50-74 per year); or high volume (≥ 75 case per year).	Study performed a post hoc analysis of prospectively gathered PCI data, in the current era of ubiquitous stent use, at two teriary cadiac care centres.	The patient was the sampling unit. Standard multiple logistic regression was implemented, where the physician volume was entered along with other factors.	Patients demographics (age, sex), coronary risk factors including diabetes, hypertension, previous history of ischemic heart disease, elevated serum cholesterol, smoking, family history of coronary artery disease, serum creatinine, as well as hospital length of stay, and cost of care. Number of physician, total volume of cases from 2000 to 2002, Mean complexity score per operator, ICVL direct cost, ALOS, Major complications.	Low and intermediate volume operators can have good outcomes in a high-volume hospital environment. The ACC/AHA guidelines do suggest that intermediate volume operators can continue to do PCI in a high volume > 600 procedures per year. Study suggest yearly operator volume, although very important, should not be the only factor used in setting standards for interventional cardiology certification or as the full measure of quality.

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70	1995 - 1996	US ?	832 Patients; 52 redo CABG operations; 2 Hosptials.	CABG.	Short-term hospitals Complication and 1 & 5-year in-hospital outcome : * mortality *Acute myocardial infarction * Cerebro vascular accident * Prolonged ventilation * Reanimation * Rethoracothomy for bleeding * Wound complication * Intra aortic ballon pump.	Surgical volume.	Fully equiped university location (FE) and The low volume limited facility location (LVLF) of departement.	Retrospective study investigates the short and mid-term outcome of non-emergent primary isolated cCABG surgery in relation to risk stratification in FE and LVLF. The applicability of the **Parsonnet score and the EuroScore** models was tested retrospectively to our study population.	Cohort data. Used Risk assessment. Cumulative survival curves were constructed using the Kaplan-Meier method. Among patient subgroups the log-rank test was used to compare survival curves. A logistic multivariable regression, stratified by the two hospitals, was used to adjust for the baseline differences to determine the impact on in-hospital mortality and hospital complications. To determine independant predictors of 1- and 5- year survival multivariate analysis was carried out using stepwise Cox regression.	Pre-selected variables : age, gender, indication {Stable angina, Unstable angina, PostMI angina}; History (of MI, Coranary angioplast, Obesity}; Risk factors {Diabetes, Hyperlipidemia therapy, Hypertension, COPD, Renal impairment}; Angiographic factors {Number of diseased vessel, 1or 2 or 3 vessels, Left main stem, Ejection fraction (normal, reduced or moderate, poor)}.	Careful decision making, selection of low-risk patients for a low volume and limited facility location resulted in excellent in-hospital survival with very low complications rates.
71	2001 - 2003	US	70,757 Patients, 92 ICUs.	Cardio, ICU type : * Cardiothoracic ICU only * Coronary care/ Medical cardiac care only * Medical ICU only * Medical ICU/ coronary care, combined * Medical ICU/ Coronary care/ specialized * Medical/surgical combined * Medical/ surgical/coronary care combined * Neurologic/ neurosurgical ICU combined * Other mixed * Surgical ICU only * Surgical/trauma ICU combined.	In-Hospital Mortality rate.	ICU patients volume.	ICU volume traeated as a categorical variables. ICUs divided into volume quartiles (based on annual volume) with equal number of ICUs in each quartiles : Low volume (<632 ICU admissions/ year) ; medium volume (632-827), High volume (828 - 1233), and very High volume (>1233). High risk volume was defined as the annual volume of patients with SAPS II score >41 corresponding to the 75th percentile of the patient risk distribution. High-risk volume groups were defined as follows : low volume (>133 ICU admission/ year), medium volume (134 - 216), high volume (217- 295), and very high volume (>295).	Retrospective cohort study.	Hierarchical logistic regression modeling was used to examine the volume-outcome association and it allows the simultaneous assessement of patient-level risk factors and ICU characteristics while controlling for the correlation of outcome among patients treated within the same ICU (clustering). The C-statistic was used to evaluate model discrimination, and the Hosmer-Lemeshow statistic was used to examine model calibration.	**Hospital characteristics** { Geography (Urban, Suburban, Rural), Affiliation with medical school, Affiliation with primary critical care fellowship, Trauma center designation}, Bed Number, Hospital organisation, trauma center, Medical school affiliation} ; **ICU characteristics** { Annual patient volume, median, Annual High-risk volume, median, In-Hospital mortality rate, median ; ICU Type, Number of ICU beds median} ICU model, Day coverage, Night coverage, CCm fellowship/rotation, bed number, Nursing policy ; Patients characteristics { number of patiens, ICU number, Age, Gender, SAPS II mean}.	High ICU patients volumes are associated with lower mortality rates in High-risk critically ill adults. Regionalisation of adult critical care may result in better outcomes for high-risk patients.

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72	1992 -1998	Canada, Ontario - Canada	98,194 patients 5,374 physicans.	Cardio, AMI (Acute Myocardial Infarction).	Mortality risk rates for 30 days and 1-year after or post-AMI (Crude mortality and risk-adjusted mortality) Length of stay.	Physician Volume and Hospital AMI Volume.	* **Hospitals** were classified as low (≤33 AMI cases per year), medium (34-99 cases per year), or high (≥ 100 cases per year) volume. * **Annual Physician volumes**: (AMI cases per year) * 1 to 5; * 6 to 13, * 14 to 24, * and more than 24 AMI cases treated per year.	Retrospective cohort study using linked administrative databases containing patient admission information.	Multivariable analyses of the physician volume effect were also conducted using random effects hierarchical logistic regression models that adjusted for patients and physicians characteristics. The multilevel models were fit using the software package MLwiN and took into account the hierarchical nature of the data, with patients clustered within physicians and physicians clustered within hospitals.	**Patients characteristics:** age, gender, predicted 30-day or 1-year mortality, social economicus status, Income, Clinical status admission; **Physician Characteristics:** Speciality (family Physician, General internist, Cardiologist), age, sex; **Hospital Characteristics:** hospital volume, teaching, availability of on-site revascularization facilities, Rural hospital.	Patients with AMI who are treated by high-volume admitting physicians are more likely to survive at 30-days and 1 year.
73	During 1997	US	167,208 patients aged 65 to 99 years 6,534 physicians 1 003 Hsopitals.	Cardio, PCI (percutaneous coronary interventions) in the Era of Coronary Stent.	Patients Outcome * Rates of CABG surgery folowing a PCI, 30-day mortality *The combined end point of CABG or 30-day mortality during the index episode of care.	Physician and Hospital Volume rates of Medicare PCIs.	Physcian PCI volume was calculated by counting all 1997 Medicare claims for angioplasty, stent, or artherectomy. Hospital PCI volume was calculated by counting all claims for coronary angioplasty, stent, or artherectomy. Physicians and Hospitals volume stratified into: low, intermediate, and high volume categories. Physician Medicare PCI volume per Year: (< 30; 30-60; > 60). Hospital Medicare PCI volume per Year: (< 80; 80-160; > 160).	Analysis of data from Medicare Claims History files used both Part A (hospital) and Part B (physician) claims.	Patients characteristics and outcomes were compared across volume strata. Logistic regression models were used to adjust for patient characteristics while assessing the relationship. Used X^2 test to assess differences across categories and analysis of variance test were used to assess differences among means. Following multivariate analysis with logistic regression, direct standardization techniques were used to generate adjusted rates of outcomes adverses.	**Patients characteristics:** age, sex, race, urgency of admission (elective, urgent, emergency), acute myocardial infarction (AMI), comorbidity, and the number of vessels revascularized (single vessel or multivessel PCI). Comorbidity using the Dartmouth-Manitoba modification of the Charlson Comorbidity index score (0; 1 or ≥ 2); Stent use.	Medicare patients treated by high-volume physicians and at high-volume centers experience better outcomes following PCIs.

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74	1996	US 19 states	100,318 angioplasties 191 hospitals 43,966 involved stent placement.	CABG by Stent and PTCA.	* Same admission hospital death * same admission CABG surgery * length of stay * Median charges.	Patient with and without AMI (codes410.xx) and hospital volume rates.	Patients were subdivided into two distinct groups : with a principal diagnosis of AMI and without such a diagnosis. Hospital were categorized as low volume if they performed ≤ 200 cases per year, medium volume as 201-400 cases per year, and high volume as >400 cases per year.	Study from both randomized trials and administrative databases. Data were derived from the Nationwide Inpatient Sample (NIS) from Health care Cost and Utilization. Project Release 5, which contains hospital discharge abstract data.	Univariate differences among low, medium, and high volume institutions were compared using the Chi-Square for trend statistic. Outcomes for stents and conventional PTCA were compared with the Chi-Square test for categorical variables and the Student's *t*-Test for continuous ones. Logistic regression was used to determine if stent associated with better outcomes.	**Baseline Characteristics** : age, sex, race, risk factors {Diabetes, Hypertension, Cerebrovascular disease, Chronic pulmonary disease, Renal disease, Mutivessel angioplasty}, Primary Payer {Medicare, Private insurance, Medicaid, Other}; State.	In general, outcomes were better in high volume centers, although in the stent group, there was no clear relationship between volume and out come. These results support earlier findings that hospital mortality and particularly same admission surgery rates are lower with stenting. Altougth the volume outcome association for stenting was less clear than in Medicare these result do not mean that the fundamental volume outcome relationship has been changed by stenting.
75	1999-2004	Germany : Berlin, Dresden, Essen, Freïburg, Göttingen, Mannheim, Münster	1,454 Pancreatic Head Resection, 944 for malignacy, 7 surgical departments.	Pancreatic Head Resections.	Mortality rates after PHT.	Hospital volume.	Annual Hospital Volume ranged from 14 to 52 (10 to 43 in Malignancy) cases/ year.	Questionnaires were completed by seven high-volume surgical departments regarding quantitative and qualitative aspects of pancreatic head resections in the period from 1999-2004 (Five prospective and two retrospective institutional database).	Treatment strategies vary frequently, partially because of the lack of evidence-based data. Performed a multi-institutional analysis evaluating current numbers indications, techniques, and complications rates of PHR.	Quantitative : Annual numbers of different types of surgery for each malignant and benign disease ; after PHR ; and morbidity including reoperation, type and technique of pancreatic anastomosis, use of abdominal drains, and median lenght of postoperative hospital. Evaluated the percentage of different tumor entities, of superior mesenteric portal vein resection, the type of lymphadenectomy. The type and frequency of neoadjuvant and adjuvant therapies after resection of pancreatic adenocarcinoma.	The results of analisys confirm that pancreatic head resection can be performed with low mortality in specialized units. Variations in indications, operative technique, and perioperative care may demonstrate the lack of evidence-based data and/ or personal and institutional experience. The low number of patients receiving adjuvant therapy after resection of pancreatic cancer suggest that more efforts must be made to establish novel adjuvant therapies under randomized study conditions.

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76	1990	Canada, Ontario	1,072 patients incident cases of rectal adenocarcinoma diagnosed (Major resections) ; 418 procedures with pathology available 124 hospitals.	Cancer Rectal cancer.	Operative mortality and long term overall survival.	Hospital procedure volume or Teaching Hospital status.	Individual hospitals were placed into low-volume (11 or less), medium-volume (12 to 17) or high volume (18 or more) groups based on the number of major resections perfomed during the study period. And into teaching (training of physicians) or nonteaching institutions. Volume cutoffs created three evenly sized groups.	Administrative database lacked details on the presence of metastic disease, use of adjuvant therapy, incidence of local tumor recurrence, and cancer-related mortality.	Volume appropriate, chi-square, Kruskal-Wallis, or Wilcoson two-sample testing measured for differences among the groups in patient and tumor variables and in treatment and outcomes measures. Logistic regression models analyzed operative mortality, whereas proportional hazards models assessed long-term survival.	For major resection : age, sex, comorbidity score For resection with pathology available : N° of cases, Node positive, Full wall invasion, Moderate differentiated, Ulcerating morphology, Vascular/lymphalic invasion.	There were no clinically significant differences in treatment measures operative mortality, and long-term survival among the hospital groups according to both univariate and multivariate analyses. In conclusion, the absence of a hospital volume or teaching status effect on treatment and outcome measures suggests that for rectal cancer surgery, centralization of procedures into high-volume or teaching centers is unlikely to improve surgical quality.
77	1994-1996	Korean	1,351 patients in 24 hospitals, 6 nurses.	Breast cancer operation.	Unplanned readmission rates within 30 days of surgery.	Breast cancer operation cases Hospital volume.	Hospital divided into three categories based on breast cancer operation cases: low-volume hospitals (≤ 50 annual procedures), medium-volume hospitals (51-99 annual procedures), and high-volume hospitals (≥ 100 annual procedures).	The category and volumes of hospitals and surgical information were collected using questionnaires designed for each category of hospital.	The effect of independant variables on the readmission of patients to hospitals were examined using multivariate analysis, especially by logistic regression analysis.	Patients ages, clinical state, histologic differentiation and co-morbidity (Absent, present).	Unplanned readmission within 30 days following discharge were significantly higher in hospitals with a lower surgical volume.
78	1994-2005	US, Maryland - US	6,181 patients ; 894 surgeons ; 49 hospitals.	Uterine Cancer.	In-hospital death rates	Surgeon and Hospital case volume.	The primary independant variables in study were individual surgeon uterine cancer case volume and individual hospital uterine cancer case volume. Surgeon case volume was categorized as low (≤ 99 cases/12 years) or High (≥ 100 cases/12 years). Hospital case volume was categorized as low (≤ 199 cases/12 years) or High (≥ 200 cases/12 years).	A statewide hospital discharge database was used to identify women undergoing primary fot Uterine cancer. The study design was a cross-sectional analisys of hospital discharge data from nonfederal acute care hospitals collected by Maryland HSCRC.	Using univariate Logistic regression models to evaluate for significant factors associated with in-hospital mortality and access to high volume care.	Patient demographics (age, etnicity), payer status Insurance, hospital type, Discordance surgeon or attending physician, ICU length of stay.	Surgery performed by high-volume surgeons was associated with a 48% reduction in the risk of hospital death. Incresead efforts to concentrate the surgical management of uterine cancer by high volume surgeons at high volume centers should be undertaken.

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79	1992 - 1998	Canada, Ontario - Canada	3,815 women.	Ovarian Cancer.	30-day postoperative mortality, reoperation rate, and overall survival.	Hospital and Physician Volume of procedures.	The volumes of ovarian cancer surgeries by hospital were classified as 15 surgeries per hospital per year (low volume centers), 16-99 (Intermediate volume centers), and greater than 100 (High-volume centers). The number of ovarian cancer operations per year by physicians showed three zones in the curves: The group of physicians who performed 10 or more operations per year (high volume), those that performed 3-9 operations per year (Intermediate volume), and those that performed 1-2 operations per year (low volume).	This Population based cohort study included all newly diagnoses ovarian cancer in all women in Ontario. Hopitalization and surgical billing databases were used.	Logistic regression was used to evaluate the importance of hospital type, hospital volume, surgical specialty, and surgeon volume of ovarain cancer operations on outcomes.	Covariates include (Patient's Age at initial surgery, Co - morbid diagnoses (exclusive of cancer), an indicator variable for metastatic disease, and an indicator variable for Emergent, Urgent versus Elective surgery. Comorbidity using Charlson Comorbidity Score.	There is a relationship between hospital volume and reoperation rate. Institution type only influenced reoperation rate. Statistically significant associations were found between surgeon specialty and all three outcome variables. Adjusted survival is improved when the operation made by gynnecologist or gynecologic oncologist. The volume of surgery performed by an individual surgeon only influenced **reoperation rate**.
80	1984-1993	US - (New York, California, Maryland, Californian), England - Scotland	5,013 patients aged 65 years or older. 32 Hospitals.	Cancer: - Pancreatectomy, - Esophagectomy, - Pneumonectomy, - Liver resection, - pelvic exenteration.	In-hospital mortality rates.	Hospital procedures volume.		**Retrospective Cohort** study using Surveillance, Epidemiology and end results (SEER) registry.	SEER- Medicare linked database.	Co-morbidity, age, cancer stage.	These data support the hypothesis that when complex surgical oncologic procedures are provided by surgical teams in hospitals with specialty expertise, mortality rates are lower. Adjustement for case-mix and other patient factors did not change this results.
81	1993-1995	US	1,389 procedures; 9 operators.	Cardio, Coronary Interventions.	* Incidence of complication; * In-hospital mortality.	Individual operator coronary interventional volume.		The clinical and coronory interventional procedures were prospectively entered into a database for all the patients who underwent operation between 1993-1995.Very detailed data on patients.	A single center, over 3 years evaluation. Chi-square and Fischer test.	Baseline demographics (age and gender), clinical indication, comorbidities (congestive heart failure, previous CABG, previous PTCA, or AMI. Baseline procedural variables (no of lesions, etc.).	Despite individual operator volumes below those currently being considered for credentialing, the overall institutional outcome was excellent in a diverse and complex patient population.
82	1997-1998	US	31 academic level 1 or 2 trauma centers PAI admission 478 patients; 541 Multisystem blunt trauma.	Trauma care.	* Inpatient mortality * Hospital length of stay.	Trauma Centers volume.	High volume (> 650 trauma admissions/ year) Low-volume (≤ 650 admissions/year).	Retrospective cohort study.	Logistic (for mortality) and linear (for LOS) regression.	Age, sex, mechanism of injury, transfered from other center, Shock, massive blood transfusion.	The result indicate that a strong association exists between trauma center volume and outcomes, with significant improvements in mortality and LOS when volume exceed 650 cases per year. The benefits are evident in patients at high risk for adverse outcomes.

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83	Jan - Aug 2000	US	80,904 patients 78,745 primary total knee replacements.	Total knee replacement.	Perioperative mortality and complications in the first 90 days postoperatively. 5 outcomes : * Death * Acute myocardial infarction * Deep infection * Pneumonia * Pulmonary embolus.	Hospital and surgeon volume.	Hospital and surgeon volume were defined as the number of primary and revision total knee replacement performed in hospital or by the surgeon in Medicare recipients. Hospital volume : 1-25 ; 26-100 ; 101-200 ; > 200; Surgeon volume : 1-12 ; 13-25 ; 26-50 ; > 50.	New York state trauma registry data.	Multivariate analyses performed to adjust the relation with logistic regression.	Age, sex, race (white), co-morbidity (0 or >1), diagnosis (Osteoarthritis, R. arthritis, other), medicaid eligible.	Patients managed at hospitals (more than 200 compared with less than 25) and by surgeons with greater volumes (more than 50) of total knee replacement have lower risk of perioperative adverse events (risk of pneumonia, death, MI, infection) following primary total knee replacement. These data should also be integrated into the policy debate about the advantages and drawbacks of regionalizing total joint replacement to high-volume centers.
84	1994-1995	US, New-York US	26,973 inpatients 43 trauma centers.	Trauma.	Risk-adjusted inpatient mortality rate.	Hospital volume rates.	Three volume measures used : * Total annual volume of trauma cases ≥ 1,200 and total annual volume ≥ 240 for patients with Injury Severity Score (ISS) ≥ 15 * Total annual volume of patients with ISS ≥ 15, and * total annual volume of cases in the Registry (inpatient with ISS ≥ 9).		Used Logistic regresion to identify significant independant predictors of mortality, their weight, and the probability of in-hospital mortality for each patient.	Age, age squared, sex, motor responses of patient, blood pressure, ICISS.	Unable to document an inverse relationship between hospital volume and inpatient mortality rate for trauma centers in New York state. Low volume centers (not meeting ACS criteria) had lower, although not significant, risk adjusted mortality rates.
85	1990-1995	US, New-York US	31 hopitals 97,137 operations.	Cardiovascular procedures : * CABG * elective repair of AAA; * repair of congenital cardiac defects.	In-hospital deaths.	Hospital volume.		Discharge abstract data from Statewide research system.3 cohort patients.	Used standard logistic regression techniques.	Age, sex, surgical complexity categories.	In AAA operation, a significant inverse relationship between hospital volume and in-hospital deaths was determined. For congenital cardiac defects, a significant inverse relationship (which was most pronouced for neonates) was found between volume and death. However, lack of such a relationship for CABG. This observation may be largely explained by the qualtity improvement program in New-York state for bypass operations since 1989. If so, these results have important implications for expanding the scope of quality improvement efforts.

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86	1998-2000	US	12,594 patients total shoulder arthroplasty; 17,999 patients hemiarthroplasty.	Total Shoulder Arthroplasty (TSA), Hemiarthroplasty (HA).	* Inhospital mortality rate, * Length of stay in the hospital, * Disposition of the patient on discharge, and * In-hospital postoperative complications.	Surgeon and hospital caseload volume.	TSA and HA Hospital volume: < 5 ; ≥ 5 - < 10 ; ≥ 10 Surgeon Volume: < 2 ; ≥2 - < 5 ; ≥ 5.	Retrospective cohort study level III-2.	Logistic regression with generalized estimating equations and multiple linear regression models were used to estimate the adjusted association between surgeon and hospital volume and outcomes fot TSA and HAS.	Adjusting for comorbidity for charlson index, age, race, household income, and sex.	Patients who have a TSA or HA performed by high-volume surgeon (more than 4 a year) or in a high-volume hospital (more than 10) are more likely to have a better outcome.
87	1990 - 1993	England	14 English emergency department; 2,190 patients.	Trauma care.	Mortality 6 months after the incident.	Annual case volume of hospital .	Annual case volume of hospital varied between hospitals from 5 to 96 a year.	Prospective follow-up study of all major trauma patients (with injury score > 15) arriving alive, with no invariably fatal injury.	Using the stratified W statistic, an age and severity adjusted measure of outcome, the relationship between volume of cases and outcome was initially examined using the Spearman correlation coefficient. Multiple regression analisys was used to explore further the relationship, after adjustement for hospital-level characteristics.	Hospital characteristics { Neuro surgeon, CT scanner, Trauma team, N senior doctors}, Patient characteristics {Age, ISS mean, % died, % with blunt injuries, with multiple injuries, % with multiple injuries, % head injuries, % of case out of hours}.	Little evidence that all patients with major trauma do better in higher volume departements, there was evidence that patients with complex needs, such as the multiple injured or those with head injuries, had better outcomes.
88	1998-1999	US, California-US	98,245 patients admitted after injury, 38 Lever I (n = 12) or II (n = 26) trauma center.	Trauma care.	Mortality and length of hospital stay.	Patient hospital volume.	Hospital volume was derived from the annual number of admissions per center: < OR ≥ 1,200/year. ISS < 15, ISS > 15.	Data of this study were obtained from the patient discharge data of the State of California.	The covariates were entered into a multiple logistic regression model to assess inpatient mortality and a multiple linear regression model to assess hospital length of stay.	Covariates including age , sex, mechanism of injury, Injurity Severity Score and Trauma center designation.	Hospital volume was not a good proxy for outcome. Low-volume centers appeared to have outcomes that were comparable to centers with higher volumes. Perhaps institutional outcomes rather than volumes shoul be used as a criterion for trauma center verification.

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89	1995-1996	US	58,521 procedures for elective primary total hip replacement or 12,956 procedures revision total hip replacement.	Total Hip replacement Primary (PTH) and Revision (PR).	Outcome (≤ 90 days postoperative) * Mortality, * Dislocation, * Deep infection, * Pulmonary embolus.	Hospital and Surgeon Volume.	Analyses of Hospital volume were adjusted for surgeon volume, and inversly. Divided hospital and surgeon volume into clinically sensible categories. For PTH: Surgeon volume : 1-5 ; 6-10; 11-25; 26-50; >50; Hospital volume : 1-10 ; 11-25; 26-50; 51-100; >100.	Analized claims data of Medicare recipients to identify cases of primary and revision total hip replacement.	For each outcome, constructed 2 sets of multivariate models, one examining the association between outcomes and hospital-volume strata and the other examining the association between outcomes and surgeon-volume strata. The stregth of the association between volume and outcome expressed with an adjusted odds ratio, and the test for linear trend was performed with an ordinal variable representing the volume stratum. Used additional logistic regression models of the surgeon effect within each hospital volume stratum.	Age, gender, comorbidity index, specific arthritis diagnosis, Income, and Medicaid eligibility indicator.	Patients treated at hospitals and by surgeons with higher annual caseloads of primary and revision total hip replacement had lower rates of mortality and of selected complicaitons. These analyses of Medicare claims are limited by a lack of key clinical information such as operative details and perioperative functional status.
90	1997-2000	US, New-York US	9,973 patients, 4,146 surgeons less 15 procedures.	Rotator Cuff repair.	* Length of hospital stay, * Disposition of patient discharge * Operating room time.	Hospital and Surgeon Volume.	Surgeon and Hospital volume were divided into Low, Intermediate, and High volume categories. Surgeon volume : < 15 ; 15- 29 ; ≥30 procedures. Hospital volume : < 75; 75-199; ≥ 200 procedures.		Multivariate regression models were used to estimate the risk-adjusted association between provider volume and outcomes.	Covariates : Patients characteristics (age, sex), Mean Deyo score, and patient comorbidity Charlson index. Mean number of diagnosis on this discharge.	Patients operated by low volume surgeons had significantly higher probability of an extended stay, longer times in operating room, compared with those operated by high volume surgeons.
91	1997 & 2002	UK	281,360 Hip replacement ; 211,099 knee replacement.	Total joint Replacement : Hip (THR) and Knee (TKR).	Adverse outcomes * 30-day Inhospital mortality, * length of stay, * Readmission within a year, * Rate of surgical revision within 5 years.	Surgical volumes of Hip/Knee replacement.	Annual Volume of Hospital trust into clinically sensible categories for each intervention : 1-50 ; 51-100 ; 101-250 ; 251-500 and >500.	Used HES database for England in NHStrust between financial years.	Used Logistic regression analisys to investigate odds of in-hospital death within 30-days of the operation. Univariate logistic regression looked at the association of the outcome with each exposure, and a multivariate regression analysis was carried out controlling for confounders. Likelihood ratio tests examined interactions. Poisson regression modelling was used to calculate the rate of readmission within a year.	Age, sex were controlled for as potential confounders. Type of admission (Elective, Emergency, Unknown), Charlson Co-morbidity Index, trainig centre status.	In England, there are fewer adverse events following TJR in High volume centres and in orthopaedic training centres. Adverse events are rare, but significant relation between adverse outcomes and low volume units.

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92	1997	US	277,550 patients (50,874 inpatients Primary total knee Arthroplasty ; 4,636 inpatients Revision total knee Arthroplasty).	Total Knee Arthroplasty-Primary and Revision.	* In-hospital mortality rates * In-hospital postoperative complications * length of stay in the hospital.	Hospital and Surgeon volume procedures.	The Hospital volume, was the total number of primary and revision total knee arthroplasties performed in each hospital or hospital system, divided into four groups: < 85 ; 85-149 ; 150-249 ; ≥ 250 procedures. Surgeon volume : < 15 ; 15-29 ; 30-59 ; ≥ 60 procedures.	Prognostic study, Level II-1 retrospective study Performed a secondary analisys of a analysis of a national administrative database.	Logistic and multiple regression models were used to estimated the adjusted association of surgeon or hospital volume with rates of in-hospital mortality, pulmonary thrombosis, deep venous thrombosis in the lower extremity, and postoperative wound infection as well as length of hospital stay.	Models were adjusted for comorbidity, age, gender, race, household income, and procedure, Discharge disposition.	Patients treated by providers with lower caseload volumes had higher rates of mortality following total knee arthroplasty. Proposing volume standards could decrease patient mortality following this procedure.
93	2003	New-York US	7,868 Bariatric procedures patients ; 597 Bariatric procedure patients readmitted.	Bariatric operation.	Readmission at 30 days of discharge.	Surgeon and Hospital volume.	Surgeon volume divided in low, intermediate, and high volume procedure/year : ≤ 25; 26- 150; >150. Hospital volume, number of procedures/ year : ≤ 100 ; 101-200 ; 201-300 ; >300.	Cross-sectional study based on data from inpatient discharge database.	Chi-square and Fischer's exact test were used to examine the bivariate relationship between nonordered categorical factors and readmission rate. The Cochran-Armitage test for trend was used to determine if there were any linear trends in readmission rates for ordered categorical variables. A multiple logistic regression model was constructed to examine the association between provider volume and readmission within 30 days after adjusting for patient and postoperative characteristics. C-Statistic was used to assess the predictive ability of the models.	Controlling for demographics (Age, gender, race) ; comorbidity and length of index hospitalization.	There is an important relationship between surgeon and hospital volume and short-term readmission after bariatric operation.

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94	2003	New-York US	147 Surgeon, 7,868 Bariatric procedures patients, 78 Hospitals.	Bariatric operation.	Postoperative complications rates.	Surgeon and Hospital volume.	Surgeon volume cutpoints of 25 ; 50 ; 100 ; 150 procedures. Hospital volume cutpoints of 100 ; 125 ; 150 ; 200 procedures.	Using New-York State's inpatient discharge database. Using a Cross-sectional study based on data from New-York State's 2003 inpatient discahrege database.	Chi-Square analyses were used to examine the bivariate relationship between patient risk factors and postoperative complications and to improve the parsimony of the multivariable models. After separate multiple logistic regression, equations were constructed for each of the surgeon and hospital volume threshold. C-Statistic was used to assess the predictive ability of the models.	Controlling for demographics (Age, gender, race or ethnicity) ; and comorbidities.	The likelihood of postoperative complications from bariatric procedures is greater for patients with low-volume surgeons or in low-volume hospitals.
95	1990-1996	Maryland - US	606 liver resections performed ; 52 nonfederal acure care hospitals.	Hepatic Resection (Liver).	* Average length of stay, * Average total hospital charges, * In-Hospital mortality.	Surgeon or provider Volume.	Discharges were stratified into high and low volume provider groups : High volume : >15 / year ; Low volume : ≤ 15/year. An alternative stratification performed for relative risk analysis of mortality High volume : >15 / year ; Medium volume : 7-15/year ; Low volume : < 7/ year.	Maryland discharge database were used to study.	The statistical analysis of dichotomous and categorical variables using the Chi-square statistic. Continuous. variables were compared using Student's test. One assumption of linear regression models is that continous variables must be normally distributed. Multiple linear regression models were performed to assess the relationship between hospital volume and average length of stay and average total charges, adjusted for age, race, sex and the number of comorbidities. Poisson regression used to examine the relationship.	Adjusted age, sex, race, the number o f comorbidities.	This study suggest that hepatic resections performed at high-volume center are associated with improved safety and similar total charges compared to low volume hospitals. Conclude that Hepatic resection can be performed more safely and at comparable cost at high-volume referral centers.

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96	1991-1992	Minnesota - US	1,810 patients admissions 27 hospitals.	Total Hip Arthroplasty.	* Inhospital complications * Posthospital outcomes at the time of the follow up.	Hospital and surgical Volume.		Prospective study.	Univariate comparisons used Chi-square test for nonparametric variables and t-tests for parametric variables. Multivariate analyses used logistic regression for dichotomous variables specific complications and ordinary least-squares regression for continuous variables.		These results of this study suggest that the expected effects of seeing better outcomes among teaching hospitals and among institutions and surgeon who did higher volumes of THAs did not occur systematically. For cementless prothesis group, significantly more operative complications were associated with being in HMO or with insurance other than Medicare. General complications were assiociated positively with a higher caseload per surgeon for patients receiving cemented protheses. Hospital volume had no significant relationship to the general complication rate.
97	1991-1999	Germany	4,379 infants ages 24 to 30 week and <1,500gr in 107 delivery units.	Very low birth weight.	Neonatal mortality.	Hospital volume.	Hospital : <1,000 births versus >1,000 births ; NICU : < 36 VLBW versus > 36 VLBW admissions.		1) Kaplan-Meyer survival estimates for infants from small versus large NICU, and compares them with log-rank test. Controls for confounders (case-mix). 2) Multivariate Generalised logistic regression for controlling the effect of clustring.	Large number of confounders including data on pregnancy, perinatal conditions, maternal risk factors.	Inverse relationship between 28-day mortality and the volume of perinatal unit. The relationship was more significant with perinatal unit (NICU) volume rather than total hospital birth volume.
98	1994-1998	US	2,255 patients, 16 Surgeons.	Breast Cancer Sentinel Lymph Node Mapping.	Failure rates for each surgeon.	Surgeon monthly volume.	Low average SVI : 1 - 3 cases per month ; Med Average SVI : 3 - 6 cases ; High Average SVI : > 6 cases.		Modeled as a logistic regression curve.		This experience defines a learning curve for lymphatic mapping in breast cancer patients. Data suggest that increasing volumes lead to decreased failure rates. These data provide surgeon performing SLN biopsy with a new paradigm for assesing their skill and adequacy of training and describes the relationship between volume of cases performed and success rate of SLN detection.

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99	2000	California-US	Nonacademic hospitals : 705 ; Academic hospitals : 60 ; CABG (32,210), AAA (3,389), CEA (11,432) ; ECR (335) 4 procedures.	AAA, CABG, CEA, ECR.	Procedure volume as a proxy for quality.	Hospital volume.	Examines the impact of Leapfrog's volume criteria for metropolitan areas: 500 for CABG; 30 for AAA; 100 for CEA; 7 for ECR.	Hospital volumes (compared to Leapfrog criteria) are analysed to examine the impact of regionalisation in California.			California's hospital system is far from being regionalized. Although academic hospitals appear better positioned than nonacademic hospital. The vast majority of all hospitals do not meet Leapfrog's volume criteria. As efforts to use volume as proxy measure of quality gain momentum, hospitals and physicians will be forced to measure and report quality. As such, surgeon need to decide between accepting volume as an adequate measure of quality and devoloping other possibly more direct and reliable methods.
100	1990-1994	US	30,930 patients records, 37 hospitals.	Trauma care.	Mortality rates.	Volume of centers.	Classified as : Low volume (LV, 100-500 cases) ; Mid volume (MV, 501-1000 cases) ; high volume (HV, > 1000 cases).		Using X^2 test to compare proportion of patients with severe injury and mortality.	Injury severity.	Regardless of overall volume of patients encountered, there is a consistent proportion of severe injury. The increasing mortality with the most severe injuries seen in the high volume centers may reflect overdemand on resources.
101	1995 and 1996	Louisville-US	* 2,230 trauma admissions ; 14 surgeons ; * 2,207 trauma admissions ; 13 surgeons.	Trauma care.	Overall mortality ; overall complication rate Length of stay per attending surgeon.	Surgeon annual trauma volume.				Years of experience.	Outcome after trauma seemed to be related to severity of injury rather than annual volume of cases per surgeon.

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102	2001-2003	Canada	Retrospective cohort. 284,797 cataract surgeries for > 20 years old. In 70 hospitals or eye centers.	Cataract surgery.	Postoperative adverse events until 14 days after surgery. Ex: vitrectomy, lens extraction, fluid exchange…	Surgeon volume.	Volume modelled first as a continuous variable. Then in 4 category: 1) 50-250 2) 251-500 3) 501-1,000 4) more than 1,000.	Retrospective Cohort study.	Generalised models taking into account clustering of patients.	Age and gender.	There is a volume outcome relationship for cataract surgery and this relationship persist even for very high volume surgeons.
103	1994 - 2000	Maryland - US	377 surgeons; 1,868 patients.	Shoulder Arthroplasty.	Outcomes: * Risk of complications rates; * Length of stay; * Average Total Hospital Charges.	Surgeon and Hospital volume.	Low - Medium - High.	Administrative data - Cohort Study Characteristics.		Adjusted patient demographics: age, gender, race, marital status, insurance Type (Medicaid, Medicare), income; comorbidity score by Charlson index, Diagnosis.	Study indicates that the patients of surgeons with higher average caseloads of total shoulder arthroplasties and hemiarthroplasties have decreased complications rates and hospital length of stay compared with the patients of surgeon who perform fewer of these procedures.
104	4 years Period-1997	Niagara Falls- US	486 thoracic surgical procedures; 10 esophagectomy.	Thoracic: pneumonectomy, esophagectomy.	Operative mortality * In-hospital death, * 30-day mortality.	Hospital volume.		Retrospective review of thoracic surgical operations.		Age, length of stay; stage of disease, benign disease (elective, emergency).	Despite having a very low volume of thoracic surgical cases the community hospital had crude outcomes comparable to those reported from high volume tertiary hospitals. This suggests that the surgeon may be a more important factor in the hospital volume-outcome relationship than previously throught. Nevertheless, complex thoracic surgical operations are ideally performed by an experienced surgeon, and in a high volume hospital.

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105	2 days	Ohio - US	3,893 patients, 138 Physicians.	Primary care practice : Nursing.	Clinical outcomes : The rates of preventive services delivery, patients satisfaction, and time use during patients visits.	Physician volume Patients volume.	Physician with High, Medium, and Low volume pratices. Patient volume.	Data on the contents of outpatients visits were collected using direct observation, patient and physician questionnaires and medical record review.	Time use during patient visits as measured with the Davis Observation Code (DOC). A one-way analisys of variance was used for continous outcome measures and Chi-square statistics were used to compare categorical measures.	Physician, Practice, Patient and Visit Characteristics, By patient Volume.	Physicians with high-volume practices are more efficient than those with low-volume practices in providing similar services in a shorter amount of time. This greater apparent efficiency may come at a cost of lower rates of preventive services delivery, lower patient satisfaction, and less positive doctor-patient relationship. Health care plans and physicians setting productivity goals should consider the trade-off inherent in high-volume practice.
106	1998-1999 - 2000	18 States of US	16,399 patients Hospitalizations for SAH ; 9,290 admitted through emergency departments 1,546 hospitals.	After SAH (Subarachnoid Hemorrhage).	In-hospital mortality rate.	Hospital volume of SAH cases.	Hospital case volume Quartiles.	Retrospective analysis, administrative database.	Both univariate and multivariate analyses were used to assess the case volume-mortality rate relationship. Proportions across the quartiles of hospital SAH case volume using one-way analisys of variance or Chi-square test appropriate. Used GEEs to adjust in-hospital mortality.	Controlling for : Patient age, sex, Medicaid status, hospital region, Data source year, comorbidity conditions index.	Patients with a diagnosis of SAH on their discharge records who initially presented through the emergency department of a hospital with a high volume of SAH cases had significantly lower mortality rate. Concentrating care for this disease in high-volume SAH treatment centers may improve overall survival.
107	1998-2002	Kaohsiun - Taiwan	916 patients 4 surgeons.	Laparoscopic Cholecystectomy.	**Clinical outcomes :** * complications rates, **Economic outcomes :** * length of stay, * hospital charges.	Surgeon-specific volume.	Each surgeon's volume was measured by the total number of procedures. A = 502 ; B = 192 ; C = 147 ; D = 75 cases.	A retrospective secondary data analisys. Clinical and economic information for each patient was abstracted from medical charts and the financial division.	Multiple Logistic and linear regression models were used to examine the relationship.	Selected covariates (Comorbidity with Charlson index) ; Patient demographics used : age, gender, disease diagnosis, coexixting conditions, route of admission, and pre-operative hospital days.	The operative volume of individual surgeons not only had a positive impact on clinical outcomes, but also greater effect on conservation of health care resources. The findings validate the theory of Practice makes perfect.

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108	1995-1999	California - US	39 Nonfederal hospitals 84,211 trauma patients.	Trauma acute care.	Two measures of hospital quality care: * In-Hospital mortality * Hospital readmission.	Hospital volume.	Hospital volume for nonelderdy and elderly adults was defined as the average annual number of trauma admissions. Three measures of within-hospital volume were defined for each hospital as the monthly, quartely and yearly deviations from mean monthly, quartely, and yearly volume.	Cohort study of a population based nonconcurrent.	Mutlivariable, hierarchical, mixed effects, logistic regression analyses.		The findings of this study in the context of previous research suggest that relationships between trauma volume and outcomes exist but depend on which patient populations are studied and how the data are analyzed. Furthermore, trauma centers may be subject to the detrimental effects of high temporal volume overextending existing services and capacity. Since this study found that both between-hospital volume and within-hospital volume measures are associated with outcomes.
109	1991-2001	California - US	222,684 primary total knee arthroplasty.	Primary total knee Arthroplasty.	* Mortality, * Infection, * Thrombophlebitis, * Pulmonary embolism.	Hospital surgical volume.	Surgical volume was determined as the average number of primary total knee arthroplasties performed yearly during the study period. Hospital divided into 3 tiers as High, Intermediate, Low Volume. Hospital size divided into 4 categories based on the number of beds (< 100, 100-199, 200-299, and >299).	Data for all hospitalizations obtained from discharge California's Office of Statewide Health Planning and Development (OSHPD).	Multivariate logistic regression models were performed to examine the association between hospital volume and complications.	The models were adjusted for patient age, sex, race/ethnicity, insurance type, Charlson comorbidity index, Hospital type and size and teaching status, year of surgery, and wether patients underwent bilateral procedures.	This study confirm the relationship of lower hospital volumes to a higher OR for complications after total knee arthroplasty.

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110	1989 - 1997	Maryland - US	4,561 patients; 51 hospitals, 6 procedures codes.	Complex Gastrointestinal Surgery.	Clinical and Economic Primary outcomes: * In-hospital mortality, *Average length of hospital stay, * Average total hospital charges.	Hospital volume.	Hospital stratified into 4 volume groups: High-volume provider: 201 or more procedures/year; Medium-volume group: 21 to 50 procedures/year, Low-volume group: 11 to 20 procedures/year; Minimal-volume group: 10 procedures or less/year.	Using plubicly available discharge data.	Poisson regression was used to assess the relationship between in-hospital mortality and hospital volume after casemix adjustment. Multiple linear regression models were used to assess differences in average length-of-stay and average total hospital charges among hospital volume groups.	Independant variables examined in the analisys included patient age, gender, race, admission status (elective, urgent or emergent ..), diagnosis (benign, malignant), 6 procedures, time period (fiscal years), payment source, and place of residence, Charlson comorbidity score.	This study demonstrates that increased hospital experience is associated with a marked decrease in hospital mortality. The decreased mortality at the high-volume provider was also associated with shorter lengths-of-stay and lower hospital charges. These findings were more pronounced for malignant diagnoses than for benign conditions. Characteristics of the high-volume provider thought to contribute to improved outcomes include overall experience level of the physicians and staff; specialized staff; facilities, and equipment in the operating rooms and intensive care units.
111	1993 - 1997	Las palmas de Gran Canaria - Spain	19 hospitals departments, 2,994 patients.	Cancer: Bronchogenic carcinoma (BC) Thoracotomy for lung cancer.	Operative mortality, Long term survival, Mortality ≤ 30-days.	The number of hospitals intervention volume.	Number of cases/year: 3 group: * 1 - 43; * 44 - 54; * ≥ 55.	Prospective, multicenter Spanish study.	The comparison of patient characteristics among the different groups was carried out using on-way analisys of variance (ANOVA). The survival analisys was performed employing the Kaplan-Meier test. Comparisons of survival curves were examined using the log-rank test. Mortality was analyzes by means of a binomial logistic regression model.	Adjustement following risk factors: age, sex, previous tumor, peripheral vascular disease, weight loss, systemic arterial hypertension, diabetes, level of dyspnoea, symptoms, to be bedridder, COPD, ischemic cardiopathy, and type of surgery (exploratory, thoracotomy, and incomplete surgery).	No significant differences that do not favor the hypothesis that there is increased surgical risk and worse survival in centers having a lower volume were found in this Spanish multicenter study.
112	1998-2000	Province of Ontario - Canada	13,846 medical patients; 6,373 surgical patients; 126 hospitals.	Mechanical ventilation.	All cause of mortality (death) within 30 days of initiation of mechanical ventilation.	Hospital volume ventilation.	Hospital volume was calculated as the mean annual number of ventilation episodes performed at each hospital during the study period. It as grouped in 5 volume categories: (<100; 100-199; 200-299; 300-699; ≥700).	Population-based retrospective cohort study using administrative databases.	Multivariable logistic regression analisys was used to examine the relationship.	Estimated were adjusted for patient demographics (age, sex), mean number of Charlson comorbidities, diagnoses, and admissions status, Hospital region and rural location; and accounted for clustering within hospitals.	For surgical patients requiring mechanical ventilation for >2days, hospital volume had no effect on mortality. For medical patients, higher mortality may occur in a subgroup of low-volume hospitals that do not routinely transfer their patients to larger-volume facilities. this findings needs further investigation in a larger-sized study.

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113	1998-2003	New-York US	55,016 inpatients 68 surgeons in Oncology; 61 surgeons in colorectal.	Gastrectomy and Colectomy.	In-hospital mortality.	Hospital and Surgeon Volume.	The combined Hospital/Surgeon volume measure had the following 4 categories: *Low hospital volume/Low surgeon volume; * Low hospital volume/High surgeon volume; * High hospital volume/Low surgeon volume; * High Hospital volume/High surgeon volume. Hospital volume Quartile: 1-27; 28-54; 55-140; > 141; Surgeon volume Quartile: 1-4; 5-9; 10-20; >21.		The association of in-hospital mortality and subspecialty training/interest was examined using a logistic regression model. The X^2 test was used to assess the bivariate association between each risk factor and in-hospital mortality. The correlation assessed by Spearman-rank correlation coefficient. A multivariate generalized linear model for binary outcomes was used to examine the risk-adjusted relationship.	Adjusting for patients demographics (age, gender, race), Insurance status (Medicaid), Surgical subspecialty training. Comorbidities, ischemic heart disease, airway obstruction, congestive heart failure, organ metastasis, peripheral vascular disease, chronic obstructive pulmonary disease, diabetes, and dysrhythmia.	For Gastrectomies and colectomies, risk -adjusted mortality is substancially lower when performed by subspecialty interested and trained surgeons, even after accounting for hospital and surgeon volume and patient characteristics. These findings may have implications for surgical training programs and for regionalization of complex surgical procedures.
114	1988-1998	California - Florida - US	6,652 patients 500 hospitals.	Pancreatico-duodenectomy.	Inpatient mortality rates.	Hospital annual procedures volume.	Patients were divided into approximatively quartiles according to each hospital's annual procedure volume: * very low = 1; low = 2 or 3; medium = 4 -9 ; high = 10.	Admistrative discharge data.	Logistic regression analysis was used to examine differences in inpatient mortality among hospitals with different procedure volume and years of experience.	Adjusting for patients characteristics (age, gender) and comorbidities index with Charlson Index.	Hospitals with more years of experience with pancreaticoduodenectomy had lower rates of inpatient mortality. However, higher procedure volume has played a larger role than increased experience in reducing in patient death rates.
115	1999-2002	US	24,166 patients; 93 academic centers.	Bariatric.	In-Hopital Mortality; Perioperative outcomes and cost: Length of Hospital stay; Overall complications; 30-day readmission; Mean cost; Disposition.	Annual hospital volume.	Hospital divided into 3 groups: based on the average number of bariatric operations performed within the 4-year period: High volume: > 100 cases/year; Medium-volume: 50-100 cases/year, Low volume: < 50 cases/year.	Clinical database.	Additionnal analyses were performed to determine differences between high and low volume hospital with Pearson X^2 tests. Bivariate analyses with one-way analisys of variance were performed to determine differences in length of stay and costs between the 3 groups.	Patients characteristics (age; gender; race) adjusted morbidity, Laparoscopic cases, Severity class.	Bariatric surgery performed at hospitals with more than 100 cases annually is associated with a shorter length of stay, lower morbidity and mortality, and decreased costs. This volume-outcome relationship is even more pronounced for a subset of patients older than 55 years, for whom in-hospital mortality was 3-fold higher at low- volume compared with high-volume hospitals. High-volume hospitals also have a lower rate of overall postoperative and medical care complications, which may be related in part to formalization of the structures and process of care.

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116	1991 - 1996	Maryland - US	5,860 patients ; 52 nonfederal acute care hosptials ; 658 surgeons.	Thyroidectomy.	Short-term clinical and Economic outcomes : * In-hospital complications, * length of stay, * Total hospital charges.	Surgeon volume.	Surgeon volume groups per year : * A : 1-9 cases * B : 10-29 cases ; * C : 30-100 cases * D : > 100 cases .	Using administrative data. A cross sectional analisys was conducted using a computerized statewide hospital discharge.	The distribution of patient characteristics amoung provider groups were compared using analysis of variance for the continous variables and the X^2 statistic for categorical variables. Bivariate analyses were used to determine which variables were associated with our outcomes. Multiple Linear regression was used to assess how length of stay and mean total hospital charges differed between surgeon volume groups after adjusting.	Patient age, race, gender, comorbidity score, thyroid diagnosis and procedure, insurance status, time period, place of residence.	Individual surgeon experience is significantly associated with complication rates and length of stay for thyroidectomy. Length of stay and complications were more determined by surgeon experience than hospital volume, which had no consistent association with outcomes.
117	1991 - 1997	Northern Alberta - Canada.	577 Diagnosis ;	Cancer : Gastric Cancer.	Overall survival rates (operative 30 days mortality and hospital mortality).	Surgeon Volume.		A population-based study of Tumor -node relationship.	Descriptive statistics were calculated, variable distributions tabulated and survival curves estimated using the Kaplan-Meier technique. The survival distributions between the prognostic groups were compared and the significance levels determined by use of the logrank test.	Tumor size and nodal status.	From these population data we conclude that few patients presents with «curable» gastric cancer, Node negative or small gastric cancer survival is not influenced by nodal stage, Positive margin resection survival is better than bypass or no surgery in stage IV but not stage III disease,and surgeon volume does not appear to influence patient survival.
118	1996 & 1997	US	13,887 patients 507 hospital in 1996 ; 536 hospitals in 1997.	Cardio : After Abdominal Aortic Aneurysmectomy.	In-hospital death rate and length of stay.	Hospital volume.	For AAAs, high volume was found to be greater than 30 procedures per hospital each year. Hospital assigned either high or low volume status for each year, and volume was encoded as a dichotomous variable.	NIS Administrative Database.	Univariate comparison using Chi-square test, Wilcoxon rank-sum test, Student *t*test, simple logistic regression, and simple linear regression. Mutliple logistic regression of the hospital death rate was used to test its association with hospital volume after adjusting patient case mix variables.	Unadjusted and Case-mix risk-adjusted analyses were performed. Risk adjustment included demographics (age, gender, race) comorbid disease, nature of admission (elective, urgent, or emergent), and ruptured versus intact AAAs.	This study from a representative national database documents that HVHs have a significantly lower death rate than LVHs for repair of both and ruptured AAA. These data support the regionalization of patients to HVHs for AAA repair.

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119	3 time Period 1988-1991; 1992-1996; 1997-2000	Florida; New-Jersey New-York	34,4617 patients 6 cancer operations.	Six Cancer : colon, rectum, pumonary lobectomy, pneumonectomy, esophagectomy, Wipple procedure.	Operative In-hospital mortality.	Annual hospital and Surgeon volume.	None, continious volume. For each hospital, the number of times each specific operation was performed was calculated for each year.	Looks if the link between volume and mortality has remained stable over time.	Administrative discharge data. Logistic regression.	Adjusted for patient and hospital characteristics: age, gender, race, nature of admission, health insurance, state of residence, cancer stage, and Charlson comorbidity index.	Persistence of the volume-outcome relation and increasing hospital and surgeon volumes explain much of the decline over time in inpatient mortality for five of the six cancer operations studied. Concentrating cancer resections among high-volume providers should lead to further reduced inpatient mortaltiy.
120	1992-1996	Ontario-Canada	5,878 cases; 63 vascular surgeons; 53 general surgeons; 14 cardiac surgeons.	Cardio : Elective abdominal aortic aneurysm.	30-days risk adjusted mortality rate.	Annual surgeon AAA volume and Hospital annual volume.	The Annual surgeon AAA volume divided into 3 terciles: * < 5 Cases/year; * 5-13 cases/year; * > 13 cases/year. Annual Hospital volume of elective AA surgeries performed into : Large, > 15 cases/year; Medium, 7-15 cases/year; Small, 1-6 case/year.	Retrospective cohort study with linked administrative databases.	Univariate analyses of patients and surgeon characteristics were conducted initially. A multivariate logistic regression model was created to determine the independent impact of each of these factors on 30-days mortality rates after AAA surgery.	Adjusted patients characteristics (Age, gender, Charlson comorbidity index); type of hospital; teaching status; transfer status; Median annual volume of index procedures.	Patients who undergo elective AAA repair that is performed by vascular or cardiac surgeons have significantly lower mortality rates than patients who have their aneurysms repaired by general surgeons. These results provide evidence that surgical specialty training in vascular procedures leads to better patients outcomes.
121	1996 to 1999	California-US	28,644 patients; 397 hospitals; 2,993 surgeons.	Cancer: Colorectal Cancer.	30-days Postoperative mortality and 6-year overall survival (overall mortality).	Surgeon and Hospital volume.	Individual surgeons performed 1 to 163 operations over 4-years (median, interquartile range, 1-13). The number of operations at individual hospitals ranged from 1 to 425 over 4 years (median, 41; interquartiles range 11-112). Entire Cohort: Surgeon volume : 1-12; 13-24; 25-40; >40; Hospital volume: ≤ 83; 84-151; 152-219; >219.	Cohort study from the California Cancer Registry.	X^2 test was used for categorical variables and ANOVAs were used for age. Survival by quartiles of hospital and surgeon volume was estimated with the Kaplan-Meier method and compared with the log-rank test. Multivariable analyses. Cox proportional hazards models analyze overall survival. Used Logistic regression, adjusting standard errors to control for clustering patient by hospitals.	Adjusting patients characteristics (age, gender, race/ethnicity; median household income, and Charlson-Deyo comorbidity index. Tumor site/stage.	Greater surgeon and Hospital volumes were associated with improved outcomes for patients undergoing surgery for colorectal cancer.

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122	1999-1999	US	16,988 patients ; 72 hospitals.	Cardio : Off-Pump Coronary artery Bypass.	Clinical outcomes : Mortality, 11 Complications risk.	Volume of OPCAB.	Cutt-off of 100 OPCAB operations: divided into High and Low volume off-pump facilities. (> or < 100 case per year).	Adminsitrative database containing patient, clinical, procedural, and outcome data. Case-mix data.	The p-values were calculated for each population patient and hospital using Student's *t* test. Used Logistic regression techniques and reported the odds ratio and the p values for the High volume OPCAB coefficient. 12 logistic regressions with dependent variables being patient mortality and each of the 11 complications.	Age, sex, smoker, history of tobacco use, chronic obstructive pulmonary disease, insulin-dependent and noninsulin-dependent diabetes melitus, acute renal failure, chronic renal failure, unspecified renal failure, cardiogenic chock, hypertension, AMI, old MI, cardiomyopathy, congestive heart failure, peripheral vascular disease, endocarditis., procedural characteristics, Hospital characteristics (LOS, hospital surgery volume) ; discharge disposition.	Patients at the High-volume OPCAB facilities had significantly lower rates of major complications than those at the low-volume OPCAB facilities. High volume OPCAB sites were significantly more likely to discharge their patients directly home than were low-volume OPCAB sites. The results suggested that surgical team experience and choice of approaches to performing CABG had impact on patient outcomes.
123	1985-1991	Osaka-Japan	4,333 female patients 30-64 years old ; 200 hospitals.	Cancer : Breast Cancer.	10-years survival rates.	Hospital volume.	Each Hospital divided into four categories : High, medium, low, very low.	Data from the OSAKA cancer registry (OCR).	The cumulative observed survival rate was estimated using the Kaplan-Meier method relative to the Hospital surgical volume. The relative 5-year and 10-year survival rates were calculated by the ratio of observed to expected survival. The Elderer II method was used. Survival differences were analyzed by Cox's proportional hazards models adjusting.	Adjusting for age at diagnosis and clue for detection, Cancer stage (localized, regional, distant, unknown), Range of surgeries per hospital/per year. screnning detected.	The surgical volume of the hospitals did not affect the 10-year survival rate significantly, except for the very low volume hospitals in Osaka, Japan. However, the study of these relationships should be continued and expansed in future to include quality of life.

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124	1992-2000	Massachussets - US	1,193 patients ; 64 hospitals.	Oesophagectomy.	Primary outcomes : mean and median length of stay, length of intensive care unit (ICU), In-hospital mortality ; and discharge destination.	Hospital Volume.	Hospitals were stratified to low volume hospitals (<6 cases per year) and High volume hospitals (>6 cases per year).	Data obtained from the Massachusetts Health Data Consortium on discharge information for all acute care Hospitals.	Using two sample *t*-test for the continuous variables and *x*-Square tests for categorical variables. Multiple linear and logistic regression models were used to assess the independent effect of hospital volumes.	Adjustment for volume, age, race, comorbidity score, urgency of admission, source of admission, year of admission, payer type, and place of residence were performed for the final regression models.	Hospitals that perform a high volume of esophagectomies have better results with early clinical outcomes and marked reductions in mortality compared with low volume hospitals.
125	1994-1998	Maryland - US	366 patients ; 10 complications, 52 nonfederal acute care hospitals.	Esophageal resection.	* In-hospital mortality ; * 10 postoperative complications.	Hospital volume.	Hospital volume was converted into dichotomous variables using a threshold for » low » and « high » volume.		Risk-adjusted analyses were performed using multiple logistic regression. Test of univariate association were performed using the X^2 test, simple logistic regression, t-test, Wilcoxon rank-sum, and simple linear regression.	Adjusted : age, gender, race, nature of admission, operating physician, vital status at discharge, comorbid disease adjusted for using Romano's modification of the Charlson comorbidity index.	Patients undergoing esophageal resection at LVHs were at a markedly increased risk of postoperative complicaitons and death. Pulmonary complications are particularly prevalent at LVHs and contribute to the death of patients having surgery at those centers.
126	1998-2000	Japan, Europe, America, World-Wide.	3 japaneses patients ; 4 European, 4 American, 2 World-Wide.	Cardio: primary percutaneous Coronary intervention.	In-Hospital ; 30-day mortality.	PCI volume hospitals.	The PCI volume was divided into 3 categories : * small low -volume hospital (< 200 cases/year), * Intermediate volume hospital (200-400 case/year), * Large high volume hospitals (> 400 cases/year) ; In the JSIC hospitals divided into : * < 17 cases/year : small ; * 17-48 cases/year : intermediate ; * > 48 case/year : High.	Japanese, European, American AMI databases and world wide databases of acute coronary syndrome.	Chi-square analysis used to compare dependence of categorical variables.		Comparison of the AMI databases suggest there is a relationship between the primary PCI rate and annual PCI caseload in each country. It is interesting that in Japan even low-volume PCI hospitals have comparable numbers of primary PCI cases.

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127	1997	Japan	129 hospitals, 2,491 patients.	Cardio : Angioplasty for acute Myocardial Infarction.	In-hospital mortality, In-hospital bypass surgery following PCI (CABG), the combines endpoint of In-hospital mortality or CABG.	Hospital volume.	Hospitals divided into terciles according to the annual PCI volume : * low = 10 {1-16}, medium = 33{17-55}, and high = 89{56-370}.	Data from the Japanese Coronary intervention Study (JCIS). Using the contempory database.	Differences in demographic, medical, angiographic, and procedural varaibles were statistically assessed by Chi-square test and Student's t-test. The relationship examined in terms of odds ratio using multiple Logistic regression analysis.	Adjustment : patients characteristics (age, gender, previous myocardial infarction, Hypercholesterolemia, smoking, hypertension, diabetes mellitus, renal failure, cerebrovascular disease, prior PCI, prior CABG, number of diseased vessels, attempted lesion, LVEF, types of devices, and backup cardiac surgery. baseline demographics, medical, angiographic.	There was no significant relationship between hospital volume and in-hospital outcome among AMI patients undergoings PCIs.
128	2000 - 2001	Taiwan	4,724 patients; 34 hospitals, 203 surgeons.	Cardio: After Coronary Artery Bypass Grafting.	The rates of : * In-hospital (IH), * 30-day after discharge (AD30), * In-Hospital plus 30-day after discharge.	Hospital and Surgeon Volume.	Hospital and surgeon volume divided into quartiles : * The highest quartiles : 4 ; * The lowest quartiles : 1&2; * Median quartile : 3.	Prospective cohort study.	Chi-square test for trend and trend analysis were used to test for bivariate relationship between volumes levels and patients characteristics, In-hospital characteristics and mortality rate. After adjustment by stepwise logistic regression was used to analyze the association of Model 1 & 2 &3.	Adjusted : age ; sex ; cardiac function (acute myocardial infarction (AMI), angina, congestive heart failure (CHF), ventricular fibrillation and flutter), co-morbidity (peripheral vascular disease (PVD), cerebrovascular disease, renal failure, and shock) and in-hospital complications.	The relationship of higher-volume hospitals or surgeons with lower mortality rate for patients undergoing CABG is a general phenomenon in Western and Chinese societies. However, the combination of the AD30 and IH mortality rates has to be considered when investigating procedural mortality rates in Chinese society.
129	1996-1999	New-York US	1,307 patients.	Cardio : Total Shoulder Arthroplasty (TSA).	* Death within 60-days, * Readmission within 60-days, * Length of Stay * Revision surgery within 24 months, * Hospital cost.	Hospital volume.	Hospital volume per quarter year divided in tertiles included : *Low volume : centers in which fewer than one total Shoulder arthroplasty 1 - 15 cases. * Middle volume hospitals : 16-47 cases ; * High volume hospitals : 48 or more cases.	Prognostic study, Level II-1 retrospective study.	Using Fisher's exact test, Kruskal-Wallis test data with a post hoc Mann-Withney U test for pair-wise comparison. Using Cochran Mantel-Haenszel Non zero Correlation Coefficient to test liear trend. Multivariate analysis. Collinearity measured and used linear regression plots.	Age, gender, race/ethnicity, and comorbidities by Charlson Index.	No other outcomes were significantly associated with hospital volume. The findings that greater hospital volume decreases risk of readmission may have important public health implications, but additional research is needed before implementing policy changes.

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130	1992-2003	UK	296 procedures carried out on 291 patients; 296 surgeons; 37 hospitals.	Cardio : Thoracic aorta/aortic.	Outcomes after Surgery : * Intraaortic balloon pump ; * Re-operation for bleeding; Rewiting ; * Neurological complication, *Renal complication ; * In-hospital death ; * Post-operative hospital stay; * Patient survival	Surgeon Volume.	High and Low volume Surgeon.	Demographics data and perioperative data for the period were collected by retrospective case note review. Cohort study.	The propensity scores were estimated using multiple logistic regression. Baseline characteristics were compared using the chi-squared of Fisher's exact test or Wilcoxon rank sum test. Using Cox proportional hazards regression.	After adjustment for baseline differences, era surgical risk/ complexity procedure.	Elective surgery of the ascending aorta/arch was associated with low mortality. Outcomes after emergency surgery conformed to contemporary. Only limited differences were identified both with respect to the case profile and early clinical outcomes. Better outcomes in the mid-term in the higher volume group persisted despite adjustment for differences in caseload and are worthy of further study.
131	1999 - 2001	US	12,293 PCIs performed; 28 surgeons.	Cardio : Percutaneous Coronary Intervention (PCI) Angioplasty.	*In-hospital death rate ; * In-hospital composite of death, MI, CABG, or Cerebrovascular of ≥ 2of 3 criteria.	Surgeon volume and Experience.	Operators were classified as by terciles of annual PCI : * Low ≤ 92, * Medium : 93 to 140, * High : > 140. ExperienceTerciles of years in practice : ≤8, 9 to 14, or >14 years.	Prospective database on all patient undergoing PCI at this institution.	Comparisons between groups were made with the Kruskal-Wallis test or Wilcoxon rank sum test for continuous variables, and the Chi-square or Fisher's test. To determine the independant effect of operator characteristics and BRS, performed multiple logistic regression.	Patients characteristics (age, sex, diabetes metillus, Hypertension, heart failure, MI, Prior Coronary bypass, Prior PCI, smokers, Chronic obstructive pulmonary disease, Prior stroke, Serum creatine, Multivessel Coronary disease) and Operator characteristics (years of practice and volume of PCI, and Board certification status).	In contemporary PCI practice at a large center with high-volume operators, in-hospital outcomes are not affected by operator volume, experience, or board certification. Rather, patients' clinical risk score is the overriding determinant of clinical outcomes. This findings emphasize the power of a well-organized high-volume system to minimize the impact of operator factors on outcomes of PCI.
132	1995	New-York US	151 physicians; 32 hospitals; 1,342 patients.	Cardio: primary Coronary Angioplasty with acute myocardial infarction.	In-Hospital mortality following Outcomes of Primary Angioplasty for acute Myocardial infarction.	Total annual Coronary Agioplasty Volume of Physicians and Hospitals.	Hospital Procedure volume : * High volume (≥ 400 PTCA procedures in 1995) ; * Low-volume (< 400 PTCA procedures/1995) ; Physician procedure volume : * High volume (≥ 75 PTCA procedures) ; * Low-volume (< 75 PTCA procedures).		Using stepwise multiple logistic regression models to control for potential confounding factors. Using chi-square analysis and Student's t-test.	Patients demographics and medical and cardiac characteristics. Adjusted for age, medical and cardiac history time to treatment, ejection fraction and stent use.	Outcomes of patients who underwent primary angioplasty for AMI were improved when these procedures were performed in hospitals that performed >400 PTCA cases annually. The total annual PTCA volume category for Physicians does not appear to predict outcome of primary angioplasty for AMI.

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133	1997-1999	California - US	119 nonfederal hospitals ; 120 cardiac programs ; + 200 CABG.	Cardio : Cardiac (CABG).	In-hospital death, Discharge ; transfer to another health care facility.	Hospital annual procedural volume.	Hospital grouped into quartiles using cut-point : Low (200) and high (≥500) annual volume of procedures per year CABG only ; CABG plus & Valve only : annual volume : ≥100 high ; <25.	Data of two voluntary databases using the STS natioanl database.	Chi-square and t-test ; using of scatter plots with logarithmic trendlines.		There was wider variation in outcome among lower-volume hospitals. However, many low-volume providers had excellent results. Concluded that although volume is clearly related to outcome patient-related factors and process variables may be more important. Performance improvement programs should be developed to improve communication between providers with differing outcomes.
134	1993 - 1994	San Francisco, California -US	4,010 patients ; 82 centers.	Cardio :Coronary Intervention.	The primary end-point : * composite of death ; Myocardial infarction, Nonelective repeat coronary intervention, or nonelective CABG at 30 days, or Placement of an intracoronary stent for abrupt closure during the initial procedure.	Annual institutional Volume of coronary interventional procedures.	Quartiles groups of annual interventional volume : * 90 - 554 ; * 555 - 1,200 ; * 1,201-1,492 * 1,493 -3,300.	Study assessed both procedural volume and academic status.	Logistic regression used to examine the effect of academic status and annual interventional volume on the primary composite end point. Stepwise and Barward regression methods were used to develop the final model of predictors.	Assessment of risk after enrollment, sex age, current smoking status, reason for revascularization ; types of unstable angina present ; treatment groups.	Conclude that among hospitals participating in this trial, there is nonlinear relation between annual interventionnal volume and outcomes. This relation is complex, involving variations in periprocedural infarction rates and additional, undefined institutional differences (other than academic status) that result in differences in procedural outcome.
135	1992 ; 1993 ; 1994 ; 1995 ; 1996	Florida -US	31172 LEABs, 45,744 CEAs, 13,415 AAs.	Cardio : Vascular : CEA, LEAB, AAA.	In-hospital death rates Outcome after CEA, LEAB, AAA ; length of stay.	Hospital or Surgeon volume.	General vascular surgery, hospital size, patient age and gender, type of surgery with or without certification.	Adminstrative database.	Mutliple logistic regression was used to test the significance on outcome of surgeon volume.		Surgeon volume and certification are significantly related to better patient outcomes for patients who undergo CEA and AAA. In addition, surgeons with high volumes demonstrated consistently lower mortality and morbidity rates than the surgeons with low volumes. Hospital volume for a given procedure also is correlated with better outcomes.

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136	1990 & 1995	Maryland - US	3,820 patients ; 527 recent rAAA cases.	Cardio : Repair of abdominal aortic aneurysm.	Outcomes after rAAA * Operative mortaltiy rates ; * hospital length of stay ; * Total Hospital charges.	Annual Hospital volume ; and total AAA operative surgeons volumes.	Hospital and surgeons were stratified regarding AAA and rAAA into Low, Medium, and High annual volume.	In the community-based, cross sectionnal study.	Categorical variables were analyzed by Pearson's X^2 test or Fisher's Exact Test. Continuous variables were analized by analysis of variance for parametric variables and the Mann-Whithney U test or Kruskal-Wallis test for nonparametric variables. Multiple logisitic regression was used for multivariate analysis.	Patient age, gender, race, associated comorbidity rates, operative surgeon experience with rAAA.	The incidence or rAAA does not appear to be declining. Although operative rAAA repair continues to be associated with substantial risk and remains an especially lethal condition among the elderly, the operative mortality rate has declined in recent years in Maryland. Lower operative mortality rates and hospital charges are associated with operations performed by high-volume surgeons.
137	1988-1998	Florida and California - US	292,832 admissions in florida ; 393,754 admissions in California.	Cardio : Percutaneous transluminal coronary angioplasty (PTCA).	In-hospital CABG surgery or death.	Annual PTCA procedure volume for each hospital.	The average hospital volume, the percent of hospital performing < 200 procedures, and the percent performing ≥ 400 procedures in each state and year.	Florida AHCA and California OSHPD dicharge databases.	Logistic regression pooling the data from california and Florida. Two time period dummy variables were included in the regression to compare outcomes for admisssion that occurred during 1991 to 1994 and 1995 to 1998 versus 1988 to 1990.	Age, sex, acute myocardial infarction (AMI), multivesel PTCA, and Stent placement, Charlson comorbidity index, Diabetes, Renal insufficiency, Peripheral vascular disease, length of stay.	Florida CON (Certificate of need) laws were associated with higher average PTCA volumes relative to California hospitals, where no such laws exist. Because a higher PTCA volume was associated with moderately better outcomes, CON may be marginally effective in improving outcomes for PTCA.
138	1997-1998	California - US	27,355 patients adults 68 hospitals.	Cardio : Coronary Artery Bypass Grafting.	In-hospital mortality rates after CABG.	Hospital Volume.	Hospitals were divided into terciles of annual CABG volume : * Low-volume n = 44; * Medium-volume n=19 ; * High-volume n = 5 stratified across 4 risk percentiles : 20th ; 40 th; 60 th; 80 th.	Clinical database.	Using hierarchical logistic regression and log-binomial regression models.	Adjusting for expected surgical risk. Age, sex, race, surgical priority (elective, emergent, or salvage) previous heart surgery, left ventricular ejection fraction, extent of left main coronary artery disease, extent of overall coronary artery disease, history of angina and severity...	High risk patients are more likely to undergo CABG at Low-volume facilities where their risk of dying is higher.
139	1994 - 1997	9 Provinces of Quebec Canada	14,268 patients .	Cardio: carotid endarterectomy (CEA).	Outcome after CEA: In-hospital stroke and/or death.	Hospital case volume.	Hospital CEA volume in the 4 fiscal years into 2 categories: * Low (< 150) and high (≥ 150).	Canadian administrative hospital discharge database.	Analysis of a large administrative database using logistic regression to correlate adverse outcome using logistic regression to correlate adverse outcomes after CEA with surgeon and hospital characterisics.	Patients characterisitics : age, sex, admisssion through the emergency department, comorbidities, and Hospital and Physician related variables (surgical specialty), hospital teaching status, clinical trial participation.	Several Physician and Hospital characteristics are determinants of outcome after CEA, but the negative effects of low hospital and surgeon cases volumes, in particular, suggest that regionalization should be considered for CEA and that surgeons with low case volume should not be performing CEA.

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140	1996-2001	Florida and New-York-US	452,404 patients.	Cardio: percutaneous transluminal coronary angioplasty (PTCA).	Outcomes for PTCA.	Hospital and Operator volume.	Divided hospital/operator pairs into 4 classes based on volume classifications in the the ACC/AHA. Annual operator and hospital volume: Class 1: min annual operator volume of 75 and min annual hospital volume > 400. Class 2 pairs: min operator volume of 75 and a hospital volume of 200 to 400, or an operator operator < 75 but a hospital volume > 400. Class 3: < 75 and a hospital volume from 200 to 400.	Retrospective cohort study of discharge records of patients who underwent PTCA at nonfederal hospitals.	We tested for trends over time using the Cochrane-Amritage test for trend. Used Logistic regression to calculate mean annual increases in procedure volume.	The risk adjusted end point difference between classes narrowed over time. Patients characteristics (age, gender, state, race/ethnicity, co-morbidities, admission source, type of admission.	Outcomes were best for patients receiving care from class1 hospital/operator pairs, and an increasing proportion of patients received care from class 1 pairs. There were outcomes differences within subpopulations of operators in classes 2 and 4, which suggest possibilities for alternative volume classification guidelines.
141	1996 - 2001	US	948,093 Medicare patients; 870 US hospitals.	Cardio: Coronary Artery Bypass Graft Surgery.	In-hospital or Mortality within 30 days after CABG.	Hospital volume; Leapfrog volume category.	Hospital was categorized into quintiles CABG volume: very low: fewer than 125/year; low: 125 to 204/year; Medium: 205 to 299/year; High : 300 to 499/year; Very High (more than 449/year).	A retrospective cohort study database derived from Medicare Provider and Analysis Review (MEDPAR) part. A public use data files. Clinical and Administrative database. Hospital were classified by volume criterion proposed by the Leapfrog Group.	Logistic regression was used to adjust hospital mortality rates for patient characteristics; discrimination of the volume categories was assessed by the *c* statistic.	Patients demographics; Patient comorbidiites, admission type, surgical priority.	Volume alone, as a discriminator of mortality, is only slighty better than a coin flip.
142	1998-2003	US	5,076 OPCABG surgical procedures; 44 centers.	Cardio: Off-Pump Coronary artery Bypass Graft.	* 30- day operative mortality; * Perioperative morbidity; * 180-day all cause mortality.	OPCABG procedural volume.	Procedural volume defined in two ways: * Average hospital OPCABG procedural volume in 6-month period; the most recent 6 - month hospital OPCABG volume preceding the surgical procedural. * <10,2; 10,2 - 16,6 -30,2; >30,2.	Based onVA continuous Improvment in Cardiac Surgery Program data.	Hierarchical logistic regression models evaluated the relationship between OPCABG procedure volume with risk-adjusted.	Demographics/noncardiac; Cardiac, surgical priority, current use of diuretics, of digoxin, preoperative intravenous nitroglycerin.	Did not find an association between OPCABG volume with short-term mortality, perioperative morbidity, or intermediate-term (180 day) mortality.
143	1991-2002	Connecticut-US	14, 288 CEA 26 hospitals.	Cardio: Carotid Endarterectomy CEA.	Outcome afer CEA Perioperative mortality * in-hospital death *perioperative **stroke**, * perioperative cardiac complications, * length of stay(LOS) * intensive care unit (ICU) LOS, *Unadjusted hospital charges.	Hospial Volume.	Hospital were stratified as low, medium, or high volume institution, defined as performing ≤10; 10 to 49, or ≥ 50 procedures annually. Hospitals were also stratified as low, medium or high size institutions: ≤ 131 , 132 to 279, or ≥ 280 staffed patients beds.	Hospital factors were established by telephone survey and validated by repeated survey.	Multivariable logistic regression was used to analyze data. Categorical variables were analyzed by Pearson's X^2 or Fischer exact test. Continuous variables analyzed by the Mann-Whitney *t-test* or Kruskal-Wallistest.	Race, gender; Comorbidties Population of the hospital location, setting, residents, hospital capacity bed; academic status, cardiac angioplasty capability, cardiac surgery capability, presence of surgical residents, presence of surgical ICU, number of ICU beds, size of intensive care unit; presence of an intensivist, presence of recovery beds; dedicated to vascular patients; Postop SICU admission, Hospital CEA volume, Critical pathway, Routine D/C.	Hospital-based factors, such as greater bed capacity, use of critical pathways, ability to perform cardiac angiography, or presence of a dedicated vascular recovery unit predict reduced preoperative mortality, stroke and cardiac complications from CEA. These results suggest that hospital-associated factors do impact surgical outcome and that surgeons need to optimize these factors, extrinsic to the patient and surgeon, to provide maximal quality of care.

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144	1996	New-York - US	20,078 patients ; 32 hospitals.	Cardio : Coronary Artery Bypass Surgery.	In-Hospital mortality after CABG.	Procedure volume after ajusting for severity of disease.	Low and High volume Hospital Mortality rate ; Risk group (very low, low, moderate, high, very high) 75% patients underwent surgery at high-volume centers (> 500 cases/year) and low volume (≤ 500 cases/year).	Retrospective cross - sectional: Cohort analysis conducted on clinical databases.	Logisitic regression modeling was used to explore the interaction between patient risk and procedure volume.	Demographics patients (sex, age,) and risk factors patients (hemodynamic state, ejection fraction, previous MI, previous open heart surgery, chronic obstructive pulmonary disease, Diabets, Hepatic failure, Stroke.	For the vast majority of patients, low risk patients benefits significantly more than high-risk patients from undergoing CABG surgery at high-volume centers instead of at low-volume centers. Low-risk patients benefits significantly more than high-risk patients from undergoing CABG surgery at high-volume centers instead of at low volume centers. However, before generalizing these findings to other states, this study should be repeated using other regional population based clinical databases.
145	1992-1996	Pennsylvania-US	24 accredited centers ; 88,723 patients ; 9 serious injuries.	Trauma care.	Survival outcomes Risk of mortality.	Volume of trauma admission centers.	Patients volume Per year - Injuries volume trauma centers : Low volume : < 1,200 trauma admissions/year; High volume : ≥ 1,200 trauma admission/year.	A retrospective analysis of prospectively collected data.	A logistic regression model was the created to evaluate the most seriously injured patients.	Level of accreditation, presence of in-house trauma surgeons, presence of a surgical residency program, and presence of an-site medical school. Injury type.	In this analysis, only volume of patients treated had a direct impact on survival outcome. Accreditation, regardless of level, appears to be beneficial.
146	2000	5 States (Florida, Maine, New-York, Pennsylvania, South Carolina) US	1,277 infants.	Pyloromyotomy.	* Major operative complications ; * Length of stay ; * Hospital charges.	Surgeon & Hospital Volumes.	Surgeon and Hospital volume were stratified into quintiles. Surgeon Volume in procedure/year : 1-3 ; 4-6 ; 7-10 ; 11-14 ; >14. Hospital volume in procedure/year : 1-5 ; 6-13 ; 14-27 ; 28-34 ; >34.	Data for a nationally representative sample of in infants from the Kid's Inpatients Database.	Multivariate analyses were performed to analyse the impact, and using models that accounted for the hierachical structure of patient, surgeon and hospital level covariates.	Patient-, surgeon-, hospital-level variables.	Higher surgeon and hospital volumes are associated with better outcome among infants who are treated for pyloric stenosis. Identification of aspects of medical and surgical treatment that account for this finding may lead to improvement in the outcome of infants undergoing pyloromyotomy.

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147	1987-1996	Sweden	1,429 patients; 74 hospitals.	Carcinoma of the Oesophagus and Gastric Cardia.	Hospital mortality, 5-year survival rates.	Hospital operation volume.	The patients operated were grouped into hospitals assording to yearly hospital operative volume into three groups: Low volume < 5; Intermediate-volume : 5 - 15; High-volume : > 15 resections.		Differences in hospital mortality for the groups with different hospital operative volume were tested by Fisher's exact test. The effect of hospital volume analysed by Kaplan-Meier survival curves. Using Cox model - Relative survival model can be fifted by Poisson regression, evaluation of covariates and model goodness-of-fit; using the methods for generalized linear models.	Age, hospital stay; type of operative procedure.	This study supports an inverse relationship between hospital volume and hospital mortality after surgical tumour resection of the oesophagus mortality after surgical tumor resection of the oesophagus or gastric cardia. Overall 5-year survival was significantly higher at high-volume hospitals compared to low-volume centres. We believe that national authorities must move to centralize the surgical treatment to tumours of the oesophagus and gastric cardia to high volume-hospitals. This is a prerequisite to achieving high quality surgical care and to facilitate research aimed at improving prognosis for these patients.
148	1992-1999	Netherlands	300 patients.	Pancreatico-duodenectomy.	**Part A:** *Rates of overall complications; * Death after procedure; Hospital Length old stay; * risk factors. **Part B:** ***** Postoperative death.	Hospital volume.	Hospital divided into four categorie based on the number of resections performed per year: fewer than 5; 5 to 9; 10 to 24; 25 or more.	Part A: (single institution database divided into 2 periods) & B: (Netherlands medical registry data on age and postoperative death of patients.	Groups were compared using the Chi-square statistic, the two tailed Fischer exact test, and the Mann-Withney test. Correlation between factors was calculated with Pearson correlation test. Using Chi-square analyze the impact of patient characteristics and surgical factors. Using a multiple Logistic regression model to assess their independant prognostic value for complications.	Patients characteristics: (age, gender; weight loss) Jaundice, Cardiopulmonary comorbidity, Preoperative biliary drainage, Perioperative laboratory values. Surgical details; Risk factors of complications.	During the 5-year period, 40% of the procedures were performed in hospitals performing fewer than five resections per year, and death rate was greater than in hospitals performing more than 25 resections per year. The overall death rate after pancreaticoduodenectomy did not decrease significantly during the period, and it was greater in low-volume hospitals and older patients. The lower death and complication rates in high-volume hospitals, including the single center outcomes, were similar to those reported in other countries and may be due to better prevention and management of complications. Pancreaticoduodenectomy should be performed in centers with sufficient experience and resources for support.

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149	1999	Germany	75 hospitals; 1,463 patients.	Rectal Cancer.	Short-term postoperative outcome.	Hospital annual caseload volume.	Hospital divided into three groups by annual caseload: * group 1: less than 20; group 2: 20-40; group 3: more than 40.	Prospective multicentre observational study. Hospital participated on a purely voluntary basis. The questionnaires were completed by the senior registrer of each hospital/ department. An observational study.	Using X^2 test to evaluate the number of cases, and two dimensional frequency distributions were compared using X^2 test. Additional Tukey multiple comparisons test.	Age, gender, height, weight, tumour stage, risk factor and american society of Anesthesiologist classification.	A large caseload in rectal surgery results in a significant reduction in permanent stoma formation and postoperative morbidity.
150	1993-1998	Netherlands	310 esophagec-tomies performed.	Esophagectomy.	Hospital mortality.	Hospital volume.	Centers divided into 3 categories: * (43-55)Low volume centers (1-10 esophagectomies a year), * (1-3)Medium volume centers (11-20 esophagectomies a year), * 2 High volume centers (> 20 esophagectomies a year).	DNMR database anonymous. The result of the current study based on a retrospective analysis of data from two nationwide databases.	For categorical variables, using the Chi-Square statistic for linear trend. The Mann-Withney U test used with the pTNM stages as categories.	Compare case mix with demographic data (age and gender), indication for surgery (malignant, non malignant), and pathology results.	There is a significant (inverse) relation between hospital mortality and hospital volume for esophageal resection in the Netherlands. Although hospital mortality is not the only measure for quality of care, these data suggest a potential benefical effect to centralization of esophagectomy in the Netherlands.
151	1990-1994	California - US	138 hospitals; 507 patients.	Hepatic Resection for Hepatocellular Carcinoma.	Operative mortality; Length of stay.	Hospital volume.	Hospital classified into quartiles groups. number of operations/5 years: 1-2 ; 3-6; 7-16; ≥ 17.	Retrospective cohort study.	Multiple Regression analyses were used to adjust for differences in patient mix.	Age group, sex, year of surgery, source of admission, type of resection, presence of chronic liver disease and presence of other preoperative comorbid illness.	Low operative mortality and length of stay were associated with high volume centers. These data support regionalization of high-risk procedures in general surgery, such a hepatectomy for HCC.

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152	1998-1999	US	1 946 patients, 1 118 surgeons (Thoracic & general).	Esophageal Cancer Resection.	In-hospital or 30-day mortality before discharge.	Hospital and Surgeon Volume.	The number of cases performed by each hospital and each surgeon during the 2-year study period. For both hospital and surgeon volume, we created three approximatively equal size groups on the basis of terciles of volume: low, medium, high volume.		Used multiple logisitic regression to compare the risk of operative mortality with thoracic and general surgeons, adjusting for providing volume.	Adjusted for patient demographics (age, sex, race), coexisting diseases, and admission acuity to account for case-mix differences among surgeons. Comorbidity with Charlson Index, income group.	Speciality training in thoracic surgery has an independant association with lower mortality after esophageal resection. But specialty training appears to be less important than hospital and surgeon volume.
153	1994-2004	Netherlands	19,688 patients.	Pancreatic Resection.	Mortality rates.	Hospital volume.	5 volume groups: <2 . 2 to 5. 5 to 10. 10 to 20 . and > 20 resections per year.	Medical database.	Used X^2 test an I^2 test.	Adjustment patient characteristics, pathology.	The data on hospital volume and mortality after PR are too heterogeneous to perform a meta-analysis, but a systematic review shows convincing evidence of an inverse relation between hospital volume and mortality and enforces the plea for centralization. The 10-year lasting plea for centralization among the surgical community dis not result in a reduction of the mortality rate after PR or change in a referral pattern in The Netherlands.
154	1984-1999 3 time period: 1984-1989; 1990-1994 1995-1999	Maryland - US	1,136 patients; 52 nonfederal acute- care hospitals.	Esophageal Resection.	In-hospital mortality, length of stay; Hospital charges.	Hospital volume.	Hospitals divided into three groups based on annual procedural volume: ≤ 3 procedures/year (low volume); 4 to 15 per year (medium volume); ≥ 15 per year (high volume).		Using X^2 test, simple logistic regression, t-test, Wilcosin rank sum rtest, analysis of variance, and simple linear regresion. Multiple Linear regression of Log-transformed length of stay (LOS) and hospital charges was used to estimate the association of hospital volume after adjusting,	Adjusting independent predictor variables. Adjusted for demographics (age, sex, race), comorbid disease, and severity of illness.	Hospitals that perform high volumes of easophageal resection have superior clinical and economic outcomes. By referring these patients to high volume centers, we may improve quality and reduce costs.

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155	1995-1999	California - US	3,606 patients 25 years or younger.	Scoliosis.	In-hospital mortality, surgical complications, reoperations, Length of stay.	Hospital volume.	Annual hospital volume: 5 or fewer ; 5.1 -25 ; 25.1-50 ; > 50.	The Office of Statewide Planning and Development (OSHPD) California inpatient discharge database used a retrospective review of all patients 25 years.	Multivariate logistic regression models were constructed to calculate adjusted odds ratio for outcomes.	Adjusted factors of age, sex, illness severity, neuromuscular disease, surgical approach, Medicaid status, and annual hospital volume on outcomes.	After control factors adjusted, patient insured by Medicaid were found to have a significantly greater odds for complications, increased LOS. After multivariate logistic regression revelated an inverse relationship between annual hospital volume and likelihood of reoperation, as patient treated at hospitals. The current data suggest that being insured with Medicaid in the state of California is associated with poorer outcomes after scoliosis surgery. Additionaly, this study documents a volume/ outcomes relationship in scoliosis surgery.
156	1988-2002	US	12,948 patients.	Percutaneaous Nephrolithotomy.	Prolonged LOAS and In-hospital mortality.	* Hospital PCNL volume ; * Annual hospital discharge volume.	Hospital PCNL volume were : * Very low : 1 to 4 cases/year ; *Low : 5 to 8 ; * Medium : 9 to 15 ; *High : 16 to 27 ; * and Very high : 28 or more ; And Hospital discharge volume : Very low : 1 to 8,284 discharge/year ; *low : 8,285 to 12,280 ; * medium : 12,281 to 17,647 ; *high :17,648 to 23,730 ; * and very high : 23,731 or more .	Data from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample were abstracted.	Bivariate analyses were performed using the Chi-square and t-tests. For modeling purposes potential covariates with at least a marginal association were included in the multivariate models. Logistic regression was performed using a backward model building process.	Adjusted models of independent association of patient characteristics and hospital qualities with prolonged LOS after PCNL. age, sex, race, insurance, admission type, region, Charlson Comorbidity inde Hospital characteristics.	Despite the advent of less invasive techniques PCNL remains a popular means of managing stone disease. Although mortality was rare, it was significantly lower at high than at low volume hospitals. Low short-term mortality rates coupled with shorter LOS and high succes rates may make PCNL increasingly palatable from a patient perspective and provide a potential basis for its increasing use.
157	1992-1995	US	7,229 Medicare patients.	Major HPB Procedures Pancreatico-duodenectomy.	Mortality rates.	Hospital volume.	Average Hospital annual volume divided into quartiles : * Very low : <1/year ; * Low : 1-2/year ; * Medium : 2-5/year ; * High : (5 + year).	Using Information from the Medicare claims database, performed a national Cohort study.	Using mutlivariate logistic regression to account potentially confounding patients characteristics.		Although volume-outcome relationships have been reported for many complex surgical procedures, hospital experience is particularly important with pancreaticoduodenectomy. Patients considering this procedure should be given the option of care at high-volume referral center.

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158	1998-2000	US	5,955 patients admissions; 253 hospitals; 411 surgeons.	Ventriculo-peritoneal shunt.	In-hospital mortality rates; Length of stay (LOS), total hospital charges.	Hospital and surgeon volume.	Divided hospital/surgeon into quartiles: * Low volume centers: < 28 admissions/year, *High volume centers: > 121 admissions/year. * Low volume surgeon: < 9 admissions/year, * High volume surgeon: > 65 admission/year.	Used population based national hospital discharge database-study cohort.	Using Logistic regression.	After multivariate adjustment for demographics variables, median household income for ZIP code residence, primary care, type of emergency admission, and presence of infection, source of admission.	Pediatric shunt procedures performed at high-volume hospitals or by high-volume surgeons were associated with lower in-hospital mortality rates, with no significant difference in LOS or hospital charges.
159	1992-1996	Maryland - US		Esophageal variceal bleeding.	Mortality rates.	Hospital volume.	Hospitals classified by terciles of admissions as: * High (>17 cases of variceal bleeding per year), * Medium: (12-17 cases per year); * or Low (< 12 cases per year) volume.	Cross-sectional retrospective study of hospital discharge data.	Performed multiple logistic and linear regression with the robust generalized linear model with the gamma family and log link to determine whether the outcomes were related to hospital volume.	Adjusted for age, sex, Caucasian ethnicity, Medicaid status as a proxy for lower socioeconomic status, transfer from another hospital, and year of admission.	The volume-outcome relationship may not pertain to some medical diseases such as esophageal variceal bleeding. Alternatively, the biases inherant in research using administrative data may make this relationship appear weaker for some medical than surgical diagnoses in this type of study.
160	1992-1996	US	22,672 patients aged 66 years and older; 2,677 surgeons; 660 hospitals.	Colon Cancer.	30-day postoperative mortality; 30-day PPIs (postoperative procedural intervention).	Hospital and surgeon volume.	Volume Divided into quartiles (operation per year): * Low: 1-9 surgeons; 1-58/hospitals; * Medium: 10-16 surgeons; 59-107 hospitals * High: 17-26 surgeons; 108 -150 hospitals * Very High: 27- 85 surgeons; 151-341 hospitals.	Retrospective cohort study.	X^2test were used to determine the association. A series of logistic regression models examined.	Adjusted odds ratio with patients characteristics, surgeon and hospital characteristics.	Very high surgeon volume is associated with a reduction in surgical complications. However the association between increasing hospital volume and post-operative mortality appears to derive mainly from a full spectrum of clinical services that may facilitate the prompt recognition and treatment of complications.
161	1984-1996	US, California		PTCA.	In-hospital mortality, emergency by-pass.	Hospital volume.	< 200; 200-399; 400+.	Looks at the impact of «learning » versus improvements linked to time.	Longitudinal study.	Age, sex, Charlson index, stent, LOS, AMI, multi-vessel PTCA, PTCA volume et squared volume.	Annual hospital procedure volume is associated to improved outcomes, although effect is small. No evidence of learning by doing, rather time technology effect.

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162	1993-2003	Toronto, Ontario Canada	5 patients identified as operated between 1993-2003.	Pancreatico-duodenectomy.	Mortality, morbidity ; Postoperative complications ; LOS.	Surgical volume.	High and low volume centers.	A retrospective analysis. Wilcoxon's rank sum test used to calculate significance.	Comparisons were made with adult population who went through the same operation.	Age, operative time.	Although 5 cases represent very low volume compared with high-volume adult centers, minimal difference in operative time, length of stay, and mortality (none) were observed in this series. Pediatric patients (low volume) do as well as adult patients operated in high volume institutions.
163	1988-1999	US	13,964 patients; 1,159 hospitals.	Radical Cystectomy.	In-hospital mortality ; length of stay (LOS) and Inflation adjusted charge per admission.	Hospital and surgeon volume.	Hospital and individual surgeon volume of discharges per year were separated into terciles : low, moderate, high.	All inpatient discharges after radical cystectomy for bladder cancer from the Health Care Utilization Project-Nationwide Inpatient Sample were included in the analysis.	Mortality was compared among hospital volume levels using Mantel-Haenszel Chi-square test, while the LOS and charges were compared using ANOVA. Multivariate linear and logistic regression analyses were used to adjust for confounding factors.	Independant factors : age, race, sex ; number of procedures ; primary expected payer, Medicaid/Medicare, no charge, self pay, bed size, location and teaching status of the hospital, region, Comorbidities.	Hospital and surgeon volume have a significant impact on in-hospital mortality and LOS after radical cystectomy performed at a higher volume center may result in lower charges and shorter hospital stay while decreasing the likelihood of in-hospital mortality.
164	1999-2000	US	1,356 sling procedures (5% of national random sample), 988 providers.	Sling surgery for Urinary Incontinence.	Postoperative complications, concomitant or delayed prolapse repair, outlet obstruction and repeat incontinence surgery.	Surgeon and Hospital volume.	Hospital and physicians were classified as high or low volume providers based on their cumulative operative experience during the previous 2-year. For surgeons : low volume 1 to 3 slings per 2 years period ; mid volume 4 to 6 ; high volume >7. For hospitals : 1 to 4 slings per 2 years period ; mid volume 4 to 11 ; high volume >12.	Data across the multiple data sets representing care in hospital inpatient, hospital outpatient and physician office settings.	Multivariate analysis, and individual re-indentified subjects were longitudinally tracked for 6-months before the sling procedure to asses comorbidities. Patients tracked 12 months after operation for complications.	Patients characteristics and clinical factors: age group, ethnicity and comorbidity by Charlson Index, diabetes mellitus ; chronic obstructive pulmonary disease.	Low volume providers and surgeons had higher reoperation rates to correct prolapse during the first postoperative year. This suggests that high volume providers are more likely to diagnose and manage prolapse at the time of the sling, obviating the need for a second operation.
165	1999-2001	Australia	750,491 women ; 331,147 medically low risk ; 132,696 primiparae ; 198,451 multipare.	Maternity.	Rates of intervention at birth and neonatal mortality for low risk women.	Hospital volume of birth.	Hospital volume birth : < 100; 100-500; 501-1000; 1001-2000 and >2001 births per year.	Population-based study the National Perinatal Data Collection (NPDC).	Investigated wheter unit size was an independant risk factor for each outcome factor by conducting multivariable logistic regression and multinomial logistic regression adjusting for demographic characteristics.	Adjusting for demographics characteristics such as maternal age, patient insurance classification, Aboriginal and Torres Straits Islander status and geographic residential status.	In Australia, lower hospital volume is not associated with adverse outcomes for low risk women.

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166	1995-1996	US	224 tumors diagnosed by EBNL, 604 diagnoses; 397 tumors. 2,796 patients; 66 surgeons.	Cancer: Mammogram-Detected Breast Carcinoma.	Outcome for diagnosis and treatment of breast carcinoma: Rates for EBNL and SCNB.	Volume of physicians and centers and radiologist volume.	Hospital and provider volumes were grouped by the number of biopsy procedures (1; 2-10; ≥11 procedures).	Data drom a single insurer representing 25% of the regional population. Cohort study databases.	The Chi-square test for independance was used to assess differences in positive biopsy rates by provider volume. Factors that affected the use of BCS were evaluated in a multivariate model.	Type of initial biopsy, patient age, TNM stage, Hospital volume, surgeon volume, and radiologist volume as predictors variables.	There is wide variation in diagnosis and treatment outcomes for patients with mammogram-detected breast carcinoma. Overall, practice volume was correlated with the use of BCS but not with the rate of positive biopsy rate among high-volume of practice is not a surrogate for quality in the diagnosis of breast carcinoma.
167	2000-2003	London - UK	187 patients.	Oesophagogastric cancer.	Surgical outcomes: * 30-day mortality; *In-Hospital mortality; *length of hospital stay; * postoperative complications.	* The number of attempted oesophageal resections; * The number of consultants.		Prospective consultant database.	Statistical analysis was performed using an unpaired t-test.	Patients characteristics: pre-operative diagnosis; Histology of invasive tumours; Location of invasive tumours, Pre-operative TNM staging, Neoadjuvant therapy (Chemotherapy, Chemoradiotherapy).	Despite recent increases in workload, high volume specialist units can deliver an efficient and timely service with both good treatment outcomes and minimal impact upon elective surgical waiting lists and ICU provision.
168	2000	Australia	2,383 questionnaires and 2,015 were returned; * 550 surgeons.	Colorectal Cancer.	Postoperative death within 30-days. Outcomes including Duke's stage, adjuvant treatment.	Surgeon and Hospital volume.	Surgeon and Hospital were categorized into two groups according to the number of patients with colorectal cancer seen by each surgeon over the survey period.	All new case of colorectal cancer registred at each Australian State Cancer Registry were entered into the survey. Generated a questionnaire that was sent to the treating surgeon.	Multivariate analysis, Chi-squared tests and Logisitc regression analyses were used to determine levels of statistical significance.	Patients characteristics: Age, Sex, location of residence, type of Hospital, presentation, Cancer site, preoperative diagnosis and preparation for surgery.	This nationwide population-based survey of the treatment of colorectal cancer patients suggests that the delivery of care by surgeons (the majority) who treat patients with rectal cancer infrequently should be evaluated.
169	1980-1995	US	2,409 Breast cancer cases; 9 hospitals; 5-year period.	Breast Cancer.	5-year relative Survival rates.	Hospital annual Breast case volume.	Average hospital annual case volume: 1 to 10; 11 to 20; 21 to 30; 31 to 40; above 40.	The present study is a review of cases from the Blue Mountain Regional Tumor Registry and Test that hypothesis.	Correlations and probabilities are presented.	State at diagnosis, age, treatment.	If, as in this study, survival correlates with stage at diagnosis and not with case volume, then improving survival requires identifying cases earlier. To do that requires improving saturation of the population at risk with effective screening and improving access to healthcare. That implies dispersing services instead of concentrating them in high-volume centers.

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170	1992-1996	5 States ; and 6 US metropolitan	2,810 rectal cancer patients ; 420 hospitals ; surgeon volume identified for 2,603 patients ; 1,121 surgeons.	Rectal Cancer.	Mortality at 30-days and 2 years, Overall survival, The rate of abdominoperineal resections.	Hospital and Surgeon specific procedure volume.	Hospital and Surgeon volume quartiles : * 5-year case volume : * Very-Low : 1-5 ; * Low : 6-11 ; * Medium : 12-20 ; * High : 21 - 57.	A retrospective population-based cohort study utilizing the Surveillance, epidemiology and End Result (SEER)-Medicare linked database.	All statistical test of association were corrected for «clustering». To examine overall survival we constructed a Cox proportional hazards model corrected for either within-surgeon, or within-hospital correlation.	Age, sex, comorbid illness, cancer stage, and socioeconomic status were used to adjust for differences in case mix.	Surgeon-specific experience as measured by procedure volume can have a significant impact on survival for patients with rectal cancer.
171	1995-2000	US	332 hospital/ NICU (40% of Nicu in US), 94,110 low weight infants born between 1995 and 2000.	Low birth weight.	Mortality prior to discharge at home.	Annual number of NICU admissions of VLBW infants.		Retrospective study of of Vermont Oxford Network database.	Random effects logistic regressions with mortality as a dependent variable, controlling first for patient level and then hospital level caracteristics.	Infant caracteristics at birth ; mode of delivery ; sex ; race ; prenatal care (yes/no) ; median income and education by ZIP code. Hospital ownership; teaching status.	Number of low birth infants that a hospital treats each year does not reliably predict futur mortality rates. Direct measures are better. Increase in volume was associated with a large decrease in mortality. But patient volume of NICUs were significantly associated with mortality rates.
172	2000-2001	US	4 hospitals in 2 states. Random sample of 24,676 adults discharged from Oct 2000 to Sept 2001. 6,842 cases with adverse events.	Adverse events (AE).	Likelihood of an AE in a given day. Used 19 indicators of AE including: wound infections, urinary infections, postoperative stroke, falls, adverse drug events.	Occupancy rates, admission per day, discharge per day, admisssion/ discharge turnover. Plus intensity (complexity of cases).	Looks at the variation in daily work load (patient volume per nurse) and AE. Compares w/respect to average.	Estimates two models of probability of AE. One controlling for volume.	Poisson regressions. Separate regression for each hospital.	In model1. Individual patient risk : age, sex, DRG categories, intensive care. In Model 2. adds days of the week, emergent admission, workload.	Hospitals operating at full (100%) or over capacity may experience higher rates of adverse events.
173	48 weeks in 2002-2004	Australia	1 hospital (Canberra) ; about 66,500 patients.	Emergency.	10-day mortality.	Shifts are divided into 2 overcrowded or not, following mean occupancy.		Does not control for case-mix.	Retrospective analysis/ Comparisons of two cohort of patients.	Age, season, day of the week, time of the day.	Emergency occupancy is associated with increased in-hospital mortality at 10 days after controlling for seasonal, shift, day of the week effects.

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174	July 2000-June 2003	Australia	3 hospitals, 62,495 admissions.	Emergency.	Deaths on day 2, 7 and 30.		Hospital occupancy was scored 1, 2, 3 corresponding occupancy levels (<90%; 90-99%; >100%). Access block occupancy scored: 1) <10%; 2) 10%-19% 3) >20%.	Retrospective analysis.	Hazard scale based on hospital and ED occupancy.	Age, diagnosis, referral source, urgency and mode of transport to hospital.	Hospital and ED overcrowding is associated with increased mortality.
175	1992-1995	US- New York	7,169 cases (children) in 16 acute care hospitals.	Pediatric cardiac surgery.	Risk adjusted mortality.	Sugeon and hospital volume.	Hospital volume (<100 versus >100). Surgeon volume (<75 versus >75).	Very good case-mix control.	Logistic regression.	Demographic (age, sex, race) and diagnostic risk factors (previous operations, renal dysfunction, pulmonary hypertension, …) and 4 complexity categories (very detailed).	Both hospital volume and surgeon volume are significantly linked to in-hospital mortality, and these differences persist both for high-complexity and low-complexity procedures.

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Volume d'activité et qualité des soins dans les établissements de santé : enseignements de la littérature

Si la concentration de l'offre de soins hospitaliers dans de grandes unités est souvent présentée comme un moyen d'améliorer la qualité des soins, le sens et l'ampleur de la relation entre volume d'activité et qualité des soins font toujours l'objet de débats. Ce rapport dresse un examen complet et systématique de la littérature portant sur la relation entre le volume d'activité dans les établissements de santé et les résultats des soins. Au total, 175 articles ont été évalués selon un protocole standard. Par ailleurs, nous avons étudié les concepts d'économie industrielle pour en comprendre les mécanismes sous-jacents du lien entre volume d'activité et résultats.

Cette revue montre que pour certaines procédures et interventions, en particulier pour la chirurgie complexe, la possibilité d'améliorer la qualité des soins lorsque le volume d'activité augmente est réelle. Il semble que l'effet d'apprentissage au niveau individuel (chirurgien) mais aussi au niveau de l'hôpital (transfert de connaissances, mode d'organisation) explique une grande partie de cette corrélation.

Ce lien de causalité entre volume et qualité doit par ailleurs être nuancé : les résultats sont sensibles à la nature des procédures et interventions analysées ainsi qu'aux seuils d'activité retenus. Plus l'intervention est spécifique et complexe, plus la corrélation volume-qualité est affirmée. Pour la plupart des interventions, il n'existe pas de seuil d'activité unanimement accepté. De plus, certaines études montrent que la relation volume-qualité devient marginale au-delà d'un seuil qui peut être relativement bas.

Mots-clefs : *hôpital, chirurgie, volume d'activité, qualité des soins, centralisation, théorie de la courbe d'apprentissage, économie d'échelle, revue de la littérature.*

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The volume and quality of health care in hospitals: lessons from the literature

The concentration of hospital activity in larger hospital units is often presented as a means to improve the quality of care. Nevertheless, the extent of the relationship and the direction of causality between hospital volume and health outcomes are still being debated. This report provides a comprehensive and systematic review of the literature on the relationship between hospital volume and quality of care. In total, 175 articles were analysed using a standard procedure. Furthermore, the concepts and theory from industrial economics were reviewed to understand the direction of causality, and the underlying dynamics which explain this causality.

The results of this review show that for certain procedures and interventions, in particular for complex surgery, there seems to be a real margin for improving outcomes by increasing activity volumes. The presence of a learning curve both at the individual (learning by doing) and hospital (knowledge transfer, organisation of work) levels seems to be particularly relevant for understanding this relationship.

However, the link between volume and quality should be interpreted with caution: the results are sensitive to the type of procedure or intervention studied as well as the activity thresholds. The more complex the intervention, the better confirmed the correlation "volume-quality". For most procedures there is no single minimum volume threshold which emerges from the literature. Furthermore, some studies show that the relationship between volume and outcome might become marginal after a relatively low level of activity.

Keywords: *hospital/surgeon volume, outcomes, centralization, regionalization, quality of care, theory of learning curve, scale economies, methodology, literature review.*

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