Study of relationships between hospital efficiency and quality of care : methods and applications to acute care hospitals in France

Angel Eugenio Benitez Collante

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Présentée par
Angel Eugenio BENITEZ COLLANTE

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Devant le jury composé de :

Patrice DEGOULET	Professeur, MD, PhD, HDR	Directeur de thèse	Université Paris Cité
Catherine QUANTIN	Professeur, MD, PhD, HDR	Rapporteur	Université Paris-Saclay
Emmanuel CHAZARD	Professeur, MD, PhD, HDR	Rapporteur	Université de Lille
Anita BURGUN	Professeur, MD, PhD, HDR	Examinatrice	Université Paris Cité
Régis BEUSCART	Professeur, MD, PhD, HDR	Examinateur	Université de Lille
Brigitte SEROUSSI	Professeur, MD, PhD, HDR	Invitée	Sorbonne Université

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Presented by

Angel Eugenio BENITEZ COLLANTE

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Before the jury composed of:

Patrice DEGOULET	Professor, MD, PhD, HDR	Thesis supervisor	Université Paris Cité
Catherine QUANTIN	Professor, MD, PhD, HDR	External examiner	Université Paris-Saclay
Emmanuel CHAZARD	Professor, MD, PhD, HDR	External examiner	Université de Lille
Anita BURGUN	Professor, MD, PhD, HDR	Examiner	Université Paris Cité
Régis BEUSCART	Professor, MD, PhD, HDR	Examiner	Université de Lille
Brigitte SEROUSSI	Professor, MD, PhD, HDR	Invited	Sorbonne Université

Knowing is not enough; we must apply.

Willing is not enough; we must do.

Johann Wolfgang Von Goethe

Scientist, Statesman, Poet, Playwright, Novelist, Art Theorist, Theatre Director, and Critic.

I dedicate this thesis,

To the most beautiful persons in the world, for the sacrifices you made for my education and to provide the light and optimism that lined my paths …
my loving parents, Carmen, and Edmundo ;
To my siblings, the best partners that supported me during my whole life …
my sisters Cristina, Laura, Silvia, Mariana, and my brother Martin.

~ ~ ~

Je dédie cette thèse,

Aux plus belles personnes du monde, pour les sacrifices que vous avez consentis pour mon éducation et pour apporter la lumière et l'optimisme qui ont jalonné mes chemins …
mes parents bien-aimés, Carmen et Edmundo ;
A mes frères et sœurs, les meilleurs partenaires qui m'ont soutenu durant toute ma vie …
mes sœurs Cristina, Laura, Silvia, Mariana, et mon frère Martin.

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Biographical sketch

Angel Eugenio Benitez Collante was raised in Corrientes, Argentina, where he obtained his Medical Doctor diploma from the *Universidad Nacional del Nordeste*. He pursued medical residency programs at *Hospital Escuela General JF de San Martin* Hospital in Corrientes, and at the Pediatric Hospital *Prof. Dr. Juan P Garrahan* in Buenos Aires.

He volunteered in the government program *Cirugía Patria Solidaria* by participating as a practitioner in missions delivering health care in underserved areas of Argentine, which has fostered his interest in pursuing a career in Public Health. Thereupon, he completed the Master of Public Health in Biomedical Informatics at *Université Paris Descartes* in 2015, the Master of Public Administration at Cornell University in 2021, and a Doctorate in Public Health at *Université Paris Cité* in 2022.

Abstract

Study of relationships between hospital efficiency and quality of care: methods and applications to acute care hospitals in France

Introduction

Hospitals are faced with increasing financial constraints, which lead them to optimize their resources and increase their activity at the risk of lowering the quality of care. France, with an activity-based financing system imposed in 2004 to not-for-profit (NFP) and for-profit (FP) hospitals, has focused its efforts in improving financial efficiency.

Objectives

The main objective of this thesis was to evaluate, on a longitudinal basis, trends in hospital resources, activity, and outcome indicators. Contributing objectives relate to the search of relevant indicators derived from systematic reviews of literature. The assessment of diverging trends between NFP and FP hospitals was considered as a secondary objective. The driving research hypothesis was that an uncontrolled search of better efficiency is associated with a decline in quality of outcomes.

Material and methods

Following the PRISMA approach, three systematic reviews were conducted to facilitate the choice of major indicators. The first review focused on hospital efficiency assessment, including indicators of resources and activity on 47 selected papers. The second review, based on 27 papers, was dedicated to health care quality assessment. The third review was based on 29 papers examining relationships between efficiency and quality indicators.

The core of the thesis was then centered on the analysis of the respective trends in associations between selected indicators of resources, activity, and clinical outcomes in France during the period 2013-2017. The estimates were obtained from INSERM, DREES, ATIH databases, and OCDE for international comparisons. Statistical methods included Armitage Chi^2 trend test for rates, variance analyses for quantitative variables, and structural equation modelling to test various hypothesis on the relationships between resource, activity, and outcome indicators.

All NFP and FP acute care hospitals were considered. Private NFP hospitals were combined with public NFP hospitals. The number of beds, health staff, stays, and the mean weight of treated cases (MWTC) were compared in partial-admission (<48 hours) and full-admission (≥48 hours). Eight comorbidity indicators were combined into a severity index. Outcome indicators included in-hospital mortality, in-patient mortality from six selected conditions, and six morbidity indicators combined into medical and surgical composite morbidity indexes. Mortality and morbidity trends were adjusted for age and sex, clinical severity, and hospital type.

Results

The total number of acute care beds decreased in NFP and FP hospitals (–4.2% and –7.5%, respectively, p<.001), in association with an increase in day-care beds' share (5.8% vs. 5.7%, p<.001). Densities of physicians, nurses and nursing assistants per bed were respectively .9, 1.8 and 2.2 times higher in NFP than in FP hospitals. The total number of stays significantly increased in NFP and FP hospitals (7.0% and 2.9%). The MWTC decreased in NFP and FP hospitals (–.8% and –4.1%, p<.001). Age-sex adjusted mortality rates in regular stays (≥24-hour) decreased in NFP hospitals and increased in FP hospitals (–1.0% vs. 3.2%). Differences in trends between NFP and FP hospitals were particularly significant in ≥48-hour stay inpatient mortality (8.0% vs .8%, p<.001). Composite morbidity indexes increased in NFP and FP hospitals in ≥48-hour stays (32.6% and 30.3%, p<.001), particularly in ≥48-hour surgical stays (49.8% and 8.4%, p<.001).

Discussion and conclusion

The increased activity in NFP and FP hospitals under restrained nursing resources is a marker of the constant search of better financial efficiency. The adverse events' increase, associated with a reduced nursing staff per stays' ratio, suggests the need for an in-depth revision of current strategies in terms of optimal hospital staffing as well as studies to evaluate what results from changes in case-mix and plausible upcoding practices aimed to optimize MWCT and DRG related incomes.

Keywords

Health policy; Healthcare quality improvement; Continuous healthcare quality improvement; Quality measurement; Patient safety; Risk adjustment

Résumé

Étude des relations entre efficience hospitalière et qualité des soins : méthodes et applications aux hôpitaux de court séjour en France

Introduction

Les hôpitaux sont confrontés à des contraintes financières croissantes, qui les conduisent à optimiser leurs ressources et à augmenter leur activité au risque de baisser la qualité des soins. La France, avec un système de financement basé sur l'activité imposé en 2004 aux hôpitaux à but non lucratif (HNL) et à but lucratif (HL), concentre ses efforts sur l'amélioration de l'efficience financière.

Objectifs

L'objectif principal de cette thèse est d'évaluer, sur une base longitudinale, l'évolution des indicateurs de ressources, d'activité, et de résultats. Les objectifs contributifs comprennent la recherche d'indicateurs pertinents dans des revues systématiques de la littérature. L'objectif secondaire est d'évaluer l'évolution différenciée des indicateurs dans les HNL et HL. L'hypothèse de recherche est qu'une recherche non maîtrisée de l'efficience est associée à une baisse de la qualité.

Matériel et méthodes

Suivant l'approche PRISMA, trois revues systématiques ont facilité la sélection des indicateurs. La première revue s'est centrée sur l'évaluation de l'efficience comprenant des indicateurs de ressources et d'activité sur 47 articles. La deuxième est consacrée aux indicateurs de qualité sur

27 articles. La troisième examine les relations entre des indicateurs d'efficience et de qualité sur 29 articles.

La partie principale de la thèse analyse l'évolution des associations entre les indicateurs de ressources, d'activité, et des résultats en France pour la période 2013–2017. Les estimations proviennent des bases de données INSERM, DREES, ATIH, et OCDE. Les méthodes statistiques comprenaient le Chi2 de tendance d'Armitage pour les taux, l'analyses de variance pour les variables quantitatives, et des équations structurelles pour évaluer les relations entre les indicateurs des ressources, activité et résultats.

Tous les hôpitaux de court séjour HNL et HL en France métropolitaine sont considérés. Le nombre de lits, le personnel, les séjours et le poids moyen du cas traité (PMCT) ont été comparés pour les secteurs d'hospitalisation partiale (<48 heures) et complète (≥48 heures). Huit indicateurs de comorbidité sont combinés dans un index de sévérité. Les indicateurs de résultats comprennent la mortalité hospitalière et associée à six diagnostics principaux, et six indicateurs de morbidité médicale ou chirurgicale pour des séjours ≥48 heures combinés en index de morbidité médical et chirurgical. Les taux de mortalité et de morbidité sont ajustés pour l'âge, le sexe, de la sévérité clinique, et le type d'hôpital.

Résultats

Le nombre total de lits de court séjour diminue dans les HNL et HL (–4,2% et –7,5% respectivement, p<0,001), en association avec l'augmentation de la part des lits d'hospitalisation de jour (5,8% et 5,7% respectivement, p<0,001). Les densités de médecins, d'infirmiers et d'aides–soignants par lit sont respectivement 0,9, 1,8 et 2,2 fois plus élevées dans les HNL que les HL. Le nombre total de séjours augmente significativement dans les HNL et HL (7,0% et 2,9%). Le PMCT diminue dans les HNL et HL (–0,8% et –4,1%, p<0,001). Les taux de mortalité pour les séjours ≥24 heures diminuent dans les HL et augmentent dans les HNL (–1,0% vs. 3,2%, p<0,001). Les différences entre HNL et HL sont significatives en mortalité hospitalière pour les séjours ≥48 heures (8,0%, vs. 0,8%). Les index de morbidité augmentent pour les HNL et HL pour les séjours ≥48 heures (32,6% vs. 30,3%, p<0,001), en particulier pour les séjours chirurgicaux (49,8% et 8,4%, p<.001).

Discussion et conclusion

L'augmentation de l'activité sous ressources restreintes est un marqueur de la recherche d'une meilleure efficience. L'augmentation des indicateurs de morbidité, associée à la réduction du ratio des infirmiers par séjour suggère la nécessité d'une révision des stratégies de dotation de personnel, et d'études pour évaluer des variations en case-mix et pratiques de codage orientés à l'optimisation des revenus liés au PMCT et DRG.

Mots clés

Politique de santé; Amélioration de la qualité des soins; Amélioration continue de la qualité des soins; Mesure de la qualité; Sécurité des patients; Ajustement sur risque

Résumé Substantiel

Étude des relations entre efficience hospitalière et qualité des soins : méthodes et applications aux hôpitaux de court séjour en France

Introduction

Les hôpitaux sont confrontés à des contraintes financières croissantes, qui les conduisent à optimiser leurs ressources et à augmenter leur activité au risque de faire baisser la qualité des soins. Différentes stratégies ont été mises en place pour évaluer et améliorer l'efficacité hospitalière, notamment l'augmentation de l'offre de services médicaux, ou la réduction des dépenses de fonctionnement. Une des plus anciennes stratégies de recherche de l'efficience financière est la réduction du nombre de lits, associée si possible à une réduction des charges en personnels et de la durée des séjours. Cependant, la diminution du personnel médical par lit pourrait être associée à une augmentation du taux de mortalité hospitalière. Une réduction des ratios infirmiers par heure par patient pourrait se traduire par une augmentation de la charge de travail par infirmier associée à une augmentation de la mortalité hospitalière, une augmentation du taux des infections nosocomiales, des chutes et des ulcères de pression et plus généralement à une augmentation du taux de complications et d'erreurs médicamenteuses. L'évaluation continue des indicateurs de résultats cliniques est essentielle dans le cadre d'un effort continu d'amélioration de l'efficacité financière.

La France, avec un système de financement principalement basé sur l'activité, et imposé depuis 2004 aux hôpitaux à but non lucratif (HNL) comme aux hôpitaux à but lucratif (HL), a principalement concentré ses efforts sur l'amélioration de l'efficience financière.

Objectifs

L'objectif principal de cette thèse est d'évaluer, sur une base longitudinale, l'évolution simultanée d'indicateurs de ressources, d'efficience et de qualité des résultats. Les objectifs contributifs se rapportent à la recherche d'indicateurs pertinents au travers de revues systématiques de la littérature. L'objectif secondaire est d'évaluer l'évolution différenciée des indicateurs sélectionnés dans les secteurs à but non lucratif et lucratif. L'hypothèse de recherche principale est qu'une recherche non maîtrisée de l'efficience pourrait être associée à une baisse de la qualité.

Matériel et méthodes

Suivant l'approche PRISMA, trois revues systématiques ont été réalisées pour faciliter le choix des indicateurs pertinents. La première revue s'est concentrée sur les indicateurs d'efficience comprenant des indicateurs de ressources et d'activité et s'est appuyée sur une sélection de 47 articles. La deuxième revue, basée sur 27 articles, est consacrée aux indicateurs de qualité des résultats médicaux. La troisième revue, basée sur 29 articles, examine les relations entre les indicateurs d'efficience et de qualité des résultats.

Les estimations des indicateurs utilisées pour la modélisation statistique de la performance hospitalière proviennent principalement de l'INSERM, la DREES, la base du PMSI de l'ATIH, et l'OCDE pour les comparaisons internationales.

La partie introductoire de la thèse est centre sur l'étude de la performance des hôpitaux de court séjour en de Paris pour la période 2009-2013 à travers de l'analyse des tendances longitudinales d'efficience technique mesuré par la méthode SFA.

Ensuite, une analyse préliminaire du système de santé français dans une perspective internationale a observé les tendances en activité hospitalière et des événements indésirables pour la période 2013-2017.

Ensuite, Une évaluation d'impact de la mise en place d'un système de santé unifié au Brésil, et sa consolidation en 2001, comparé avec l'Argentine possédant un système de santé mixte, en appliquant la méthode différences de différences s'est concentré sur les indicateurs de soins

préventifs, d'accès à la santé et de protection financière, ainsi que les résultats cliniques pour la période 2000-2016, permettant l'évaluation des performances des systèmes de santé des deux pays.

La partie principale de la thèse est centrée sur l'analyse longitudinale de l'évolution respective des associations entre les indicateurs sélectionnés de ressources, d'activité et de résultats cliniques en France pour la période 2013 – 2017. Les méthodes statistiques incluent le test du Chi2 de tendance d'Armitage pour l'évolution des taux, des analyses de variance pour les variables quantitatives, et des modélisations par équations structurelles pour tester différentes hypothèses sur les relations entre les indicateurs de ressources, activité et résultats cliniques.

Tous les hôpitaux de soins de court séjour à but non lucratif et lucratif en France métropolitaine sont considérés. Les hôpitaux privés à but non lucratif ont été combinés avec les hôpitaux publics pour constituer le secteur HNL. Le nombre de lits, le personnel de santé, les séjours de soins aigus et le poids moyen des cas traités (PMCT) ont été comparés pour les secteurs d'hospitalisation partiale (<48 heures) et hospitalisation complète (≥48 heures). Le PMCT a été analysé séparément dans les secteurs HNL et HL. Huit indicateurs de comorbidité sont retenus et combinés pour fournir un indicateur composite de sévérité clinique. L'évaluation des indicateurs de résultats cliniques comprennent l'analyse de l'évolution de la mortalité hospitalière et associée à six diagnostics principaux sélectionnés, et six indicateurs de morbidité médicale ou chirurgicale. Les huit indicateurs de comorbidité sont combinés pour constituer un index de sévérité composite. Les six indicateurs de morbidité sont combinés pour constituer un index de morbidité composite. L'analyse des indicateurs de morbidité retenus est effectuée dans le seul sous-groupe des séjours de 48 heures et plus. Dans les modelés d'équations structurelles, les taux de mortalité et de morbidité sont ajustés en fonction de l'âge, du sexe, d'un indice de sévérité et du type d'hôpital.

Résultats

Les scores d'efficience globale diminuent de .5% par an au cours de la période 2009-2013 dans les des hôpitaux parisiens de court séjour.

Dans un contexte d'augmentation de l'activité et réduction des lits hospitalières dans les pays considérés for l'analyse international des systèmes de santé ayant un financement basé sur l'activité, l'augmentation des taux de septicémie, pneumonie bactérienne, facteurs nosocomiaux, infection de prothèse ostéoarticulaire, complication d'antibiotiques, ulcères de pression et complications chirurgicales est observé en France.

L'évolution différenciée de quatre taux de mortalité agrégée, obtenue par la méthode Difference-in-differences, est observée entre Brésil et Argentine, entre les années 2000 et 2016. Par rapport à l'Argentine, Brazil a reporté une réduction de 38,8% du taux de mortalité par des conditions maternelles, périnatales et nutritionnelles transmissibles, une réduction de 49,3% du taux de mortalité par des maladies communicables, une réduction de 22,1% du taux de mortalité par des maladies non-communicables, et une réduction de 2,2% du taux de mortalité par cancer, possiblement associé à la consolidation du système unifié au Brésil. Le Sistema Unico de Saúde (SUS).

En France, le nombre total de lits de court séjour diminue dans les HNL et HL (–4,2% et –7,5% respectivement, $p<0,001$), en association avec l'augmentation de la part des lits d'hospitalisation de jour (5,8% et 5,7% respectivement, $p<0,001$). Les densités de médecins, d'infirmiers et d'aides–soignants par lit sont respectivement 0,9, 1,8 et 2,2 fois plus élevées dans les HNL que les HL. Le nombre total de séjours augmente significativement dans les HNL et HL (7,0% et 2,9%). Le PMCT diminue dans les HNL et HL (–0,8% et –4,1%, $p<0,001$).

Les taux de mortalité ajustés selon l'âge et le sexe pour les séjours classiques (≥ 24 heures) diminuent dans les hôpitaux HL et augmentent dans les hôpitaux HNL (–1,0 % contre 3,2 %, $p<0,001$). Les différences entre HNL et HL sont particulièrement significatives en mortalité hospitalière pour les séjours ≥48 heures (8,0 %, vs. 0,8 %). Les index de sévérité sont significativement plus élevés dans les hôpitaux HNL que dans les hôpitaux HL. Les index de morbidité augmentent pour les HNL et HL pour les séjours ≥48 heures (32,6% vs. 30,3%, $p<0,001$), et en particulier pour les séjours chirurgicaux (49,8% et 8,4%, $p<.001$). Dans les modèles EQS, le taux de mortalité intra-séjour est significativement corrélé à la structure d'âge et à l'index de sévérité mais non au type HNL d'établissement. L'index de morbidité composite est significativement associé à la structure d'âge, à l'indice de sévérité composite et au type HNL d'hôpital.

Discussion et conclusion

La diminution constante d'efficience globale observée dans des hôpitaux de court-séjour de Paris en pour la période 2009-2013, couplés à l'augmentation des dépenses en technologies de l'information suggère une justification des efforts des hôpitaux pour améliorer leur efficience.

L'augmentation significatives de l'activité hospitalière observé en France, couplée à une réduction des lits et du personnel soignant cohérent avec un contexte international de financement basé sur l'activité, associé a à l'augmentation des taux d'événements indésirables pour la période 2013-2017 a suggère la nécessité d'une évaluation des associations entre efficience hospitalière et qualité des soins.

La diminution des taux de mortalité par maladies communicables et non-communicables depuis la mise en place d'un système de santé unifié en Brésil, par rapport à l'Argentine, fournis des preuves empiriques en faveur du choix d'un système de santé unifié pour les pays d'Amérique du Sud. Cependant, l'Argentine pourrait souffrir le syndrome des systèmes de santé mixtes décrit par Nishtar en 2009, une situation dans laquelle le système ne parvienne pas à affecter la qualité en raison de déficits de financement. Cette étude atteste de l'utilité des résultats cliniques agrégés dans l'analyse de l'impact des politiques.

L'augmentation de l'activité dans les hôpitaux HNL et HL en France avec des ressources infirmières restreintes est un marqueur de la recherche constante d'une meilleure efficience financière, en particulier pour la chirurgie de jour dans le secteur HL.

L'augmentation de la mortalité hospitalière en secteur HNL peut s'explique par la nécessité d'une prise en charge croissante des patients les plus graves, pendant que le secteur HL s'oriente vers augmentation croissante de l'activité de jour en particulier chirurgicale.

L'augmentation des indicateurs de morbidité hospitalière, associée à une réduction du ratio personnel infirmier par séjour, suggère la nécessité d'une révision en profondeur des stratégies actuelles en matière de dotation hospitalière, ainsi que d'études pour évaluer ce qui résulte des changements de l'offre, des ressources en personnels, du case–mix, comme de pratiques

d'optimisation du codage. Les discordances dans les modèles d'équations structurelles entre les hôpitaux NL et HL évoquent un possible surcodage de la morbidité dans les hôpitaux HNL, qui seraient plus marquée que dans les hôpitaux HL.

Cependant, la réduction du personnel infirmier associée à une augmentation des événements indésirables à l'échelle de l'hôpital et peropératoires, à savoir la septicémie et l'embolie pulmonaire, est conforme à la littérature dans le domaine d'étude. L'augmentation des taux de thrombose veineuse profonde et de déhiscence de plaie dans les hôpitaux NFP, pour lesquels la réduction du personnel infirmier est un facteur essentiel, contraste avec leur diminution dans les hôpitaux FP, qui sélectionnent des patients moins sévères.

Les limites du travail sont liées à la durée de l'étude longitudinale dans ce travail, limitée à 5 ans, aux limites du codage PMSI optimisé progressivement vers la recherche d'une meilleure efficience financière, en particulier par le codage systématisé d'indicateurs de morbidité comme les ulcères de pression, les sepsis et les infections nosocomiales. À partir des données analysées dans cette thèse, il n'est pas possible de différencier ce qui pourrait être la résultante d'une réduction de la densité infirmière par séjour mais également d'un surcodage possible participant directement à l'augmentation du PMCT et donc aux revenus de court séjour de l'hôpital.

L'évolution différentié entre els taux de mortalité hospitalière et la diminution de la mortalité composite pour certaines conditions suggèrent que l'indicateur de mortalité composite de l'AHRQ devrait être complété par des indicateurs plus représentatifs adaptés à chaque group de population spécifique considéré.

Le travail, actuellement limité à l'activité de court séjour en France, pourrait être étendu à l'activité de moyen et long séjour, mais également à d'autres pays utilisant ou non des mécanismes de financement basés sur l'activité. Il pourrait surtout être complété par l'interrogation directe des dossiers medicaux informatisés dans les hôpitaux concernés. Cette interrogation faciliterait un ajustement plus précis de la morbidité par des index de sévérité étendus comme les index de Charlson ou Elixhauser non utilisés dans ce travail limité aux seules données exploitables à partir des bases nationales et du PMSI.

Mots clés

Politique de santé; Amélioration de la qualité des soins; Amélioration continue de la qualité des soins; Mesure de la qualité; Sécurité des patients; Ajustement sur risque

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Introduction

Hospitals are faced with the challenge of improving their financial efficiency at the risk of lowering the quality of care they provide [Valdmanis 2008]. France, with a financing system mainly based on activity and imposed in 2004 to not-for-profit (NFP), as well as for-profit (FP) hospitals, has mainly focused its efforts in improving financial efficiency. Continuous evaluation of clinical outcome indicators is essential in the context of a continuous effort to improve financial efficiency [Degoulet 2017].

The main objective of this thesis was to evaluate, on a longitudinal basis, the simultaneous evolution of resources, efficiency, and outcome indicators. Contributing objectives include the systematic search of relevant indicators that could be derived from systematic reviews of literature. The secondary objective is to assess the differentiated evolution of selected indicators in not-profit and for-profit sectors. The main research hypothesis is that an uncontrolled increase in efficiency could be associated with a decline in quality of care. The driving research hypothesis is that a non-controlled search of better efficiency associated with a decrease quality of outcomes.

The work of this thesis has been structured around four chapters organized as follows:

Chapter I is devoted to the assessment of hospital performance from a hospital efficiency point of view. Through a first systematic review of literature, a set of hospital inputs around structures and resources, and outputs around hospital activity.

Chapter II is devoted to the assessment of health care quality. Through a second systematic review of literature, a set of indicators of clinical outcomes and statistical methods for outcome quality assessment are analyzed. A preliminary observation of the hospital care quality in France from an international perspective was conducted through statistical trend analysis of hospital activity, and age-adjusted rates of clinical conditions and adverse events. In addition, an impact evaluation of Brazil's unified health system achieved at the end of a two-year training period at Cornell University.

Chapter III is devoted to the study of the relationships between hospital efficiency indicators

and clinical outcome indicators in France. Through a third systematic review of literature, various indicators are analyzed and compared. The core of the thesis is centered on a longitudinal analysis of trends in several efficiency and clinical outcome indicators in France during the period 2013-2019.

Chapter IV consisted of the discussion of results, their limitations, and the perspectives for further research.

Chapter I

Determinants of hospital performance in an efficiency improvement framework

1.1 State-of-the art

Hospitals face the challenge of improving their financial efficiency at the risk of reducing the quality of care [Valdmanis 2008]. Hospitals try to minimize expenditures by optimizing resource utilization at the same time they try to improve their income for services. In order to achieve these objectives, the optimization of the inputs and outputs involved in the process of delivering care is required [Hadji 2014]. In hospital settings, the share of fixed costs tends to be high, which represents a challenge to administrators who must approach accurate predictions for every prospective period. Different strategies have been implemented to assess and improve hospital efficiency, namely increasing the offer of medical services, or reducing operating expenditures [Dormont 2012, Cylus 2016]. One of the first worldwide implemented strategic measures is the reduction of the number of beds [Kroneman 2004, Saltman 1998]. In 1987 Hancock *et col* estimated that labor spending represented more than 60% of total hospital costs, stressing on the need for evaluation or proper staffing strategies in the context of the implementation of DRG-based payment in the US [Hancock 1987]. In recent studies, hospital labor costs were estimated to represent about 41% of total operating costs, while capital costs 4% and non-capital-non-labor costs 55% [Bai 2020].

However, the decline in medical staff per bed could be associated with an increase in in-hospital mortality rate [Jarman 1999]. On the other hand, an optimal nursing staff allocation could be associated with job satisfaction, cost-effectiveness of health services and safety and the quality of care [Aiken 2014; Kane 2007; Lankshear 2005; Needleman 2011; Twigg 2012, Hadji 2014]. A reduction in ratios of nurses per hour per patient could translate into an increase in the workload per nurse associated with an increase in in-hospital mortality [Aiken 2002, Mark 2007, Driscoll 2018], an increase in the rate of nosocomial infections [Needleman 2002,

2011], falls and pressure ulcers [He 2016] and more generally to an increase in the rate of complications [Aiken 2003, Needleman 2002] and medication errors [Driscoll 2018]. Additionally, clinical outcomes could reflect all aspects of care in the final product of the health care process [Mant 2001].

However, one of the most important reasons for the increase in health expenditure could be the inefficient use of health care resources [Chang 2011]. From a hospital efficiency scope leading to decision-making, the hospital performance assessment requires the mandatory analysis of the association of hospital productivity inputs, namely resources, with the hospital productivity outputs, namely activity or financial outcomes [Hadji 2014]. However, the health care quality aspect shares a main role in conjunction with hospital efficiency in the assessment of hospital performance.

1.2 Activity-based financing in France

The *Tarification à l'activité* (T2A) is a DRG-based payment system, introduced in France in 2004, aimed to finance the acute care delivered [Or 2014]. The T2A is based on the French Diagnosis Related Group (DRG) coding system. For each hospital discharge, the T2A system associates lump payments to medical services grouped by DRG-codes, which are listed in the *Programme de médicalisation des systèmes d'information* (PMSI), which current version includes 2600 DRGs and 670 root groups, is maintained by the central governmental agency *Agence Technique de l'Information sur* l'Hospitalisation (ATIH) [ATIH 2019]. The T2A replaced a precedent system, the global endowment, with consisted of hospital payments to a projected amount of costs based on historical costs. Major objectives of the T2A implementation were improving efficiency and fairness in payments to all hospitals [Or 2014]. The T2A accounted for about 67% of hospital financing in 2017 [Gonzalez 2018]. Acute care hospitals receive complementary payments for education, research and innovation related activities, emergency and other activities, expensive drugs, and preventive care *–Missions d'enseignement, de recherche, de référence et d'innovation, MERRI, and Missions d'intérêt général d'aide à la contractualisation, MIGAC*. However, the T2A implementation in 2004 led many hospital efforts in search of improving financial efficiency [Or 2014, Chevreul 2015].

In France, publicly funded hospitals deliver services for most of the acute care activity in France, except for the surgery sector, in which the volume is shared in equal shares with the private sector [Barroy 2013]. Health policy reforms in France since 2005 could have led to reductions in hospital capacity and nursing staffing, and to hospital mergers, radically transforming the governance of health care in France [Nay 2016]. The introduction of DRG activity-based reimbursement as payment mechanism could also have led to cross-subsidization, between higher and lower cost activities delivered by medical units and at hospital level, in order to maintain the financial efficiency [Barroy 2013]. Another effect of T2A implementation was resource-pooling across medical units, namely in terms of nursing staff. The optimization of staff hours as a costly resource for hospitals has become one of the key tools for reducing costs [Barroy 2013]. Hospital mergers increased in the last decade, reducing even more the number of acute care beds in France. In the private sector, hospitals have been bought out by big private groups was of 8 in 2010, and 84 in 2017 [Herrera-Araujo 2021]. However, the motivations leading to mergers differ between for-profit and not-for-profit hospitals. While private hospitals can decide the kind of health care services they deliver, public hospitals are not as free in choosing the services they must offer. Similarly, private not-for-profit hospitals abide to the principle of delivering care to the population, facing public service obligations, under the public insurance, but have more freedom in the offer of services, in search of revenue. The implications of mergers are also different in public from private hospitals. In the French public sector, the closure of services and relocation of personnel is problematic, and besides bureaucratic negotiations, measures are received with resistance from the part of hospital personnel [Herrera-Araujo 2021]. Recent analyses suggest that hospital mergers transformed the French hospital sector through repositioning and strategic changes in the offer of health care services [Herrera-Araujo 2021].

1.3 Hospital performance in terms of efficiency

The analysis of hospital financial efficiency could depart from economic theories commonly used to explain productivity and efficiency of organizations, as follows: 1) Economies of scale, a concept by which companies can achieve efficiency by increasing production and lowering costs, which are spread over a larger number of goods or services; 2) Diminishing marginal returns, which states that after reaching the optimal production level, adding an additional

production factor will result in an increase in outputs in a smaller proportion; 3) Diminishing marginal utility, which states that per unit input improvements will advance production only marginally and decrease after a certain level of production. Modern hospitals are considered as complex decision-making units delivering multiple products, with a tendency to over-invest in capital in search of short-run equilibrium [Smet 2002]. Therefore, hospital efficiency analyses should be performed considering short periods of time, relating to the standard fiscal year duration in the accounting systems of organizations. The concept of economies of scale could have a limited application in hospital settings, due to the nature of operating costs, which can be both fixed and variable. Additionally, the concept of economies of scales states that cost savings depend on higher production levels, or bigger hospital care delivery, which is contradictory to the public health market's goals of achieving high health standards for populations, mainly by preventing avoidable hospitalizations. However, hospitals seek additional benefits from their activity while they try to reduce additional costs incurred by that same activity. A decreasing return to scale is likely to be observed in hospital settings, in which the increase by a certain percentage of production factors results in a less-than-proportional increase in hospital services. Therefore, in productivity management terms, hospital efficiency assessment would fit in the marginal analysis frame, by measuring cost efficiency. Cost efficiency can be decomposed into technical efficiency, when inputs are optimized to certain production level, and allocative efficiency, when the proportion of input resources is optimized by comparing the differing marginal costs [Farrell, 1957].

The measure of the technical and scale efficiencies of hospitals aim to assess productivity, by assessing the relationship between inputs and outputs of hospitals implementing the minimum possible quantity of resources to increase their activity [Hadji 2014]. Historically, the methods used in the assessment of hospital efficiency were of three types: ratio analyses, parametric methods, namely ordinary least squares regression (OLS), stochastic frontier analysis (SFA) and other regression analyses, and non-parametric methods, namely data envelopment analysis (DEA) and Malmquist total factor productivity (MTFP) [Sherman 1984]. The most practiced methods are Malmquist, DEA and SFA. In all three methods, the estimation of productivity can be modelled from two approaches, input-orientated or output-oriented. The input-orientated approach focuses on cost functions, while the output-oriented approach focuses on production functions. The Malmquist productivity index was one of the first methods used to measure hospital financial efficiency, by assessing a score based on the relationships between productivity inputs and outputs [Caves 1982, Kim 2021]. Methods for the assessment of

economies of scale are widely used to assess hospital efficiency, namely DEA and SFA. DEA is a purely deterministic methodology to empirically measure productive efficiency of decision-making units, which are hospitals in this case [Charnes 1978]. SFA methods depart, as a first step, from the stochastic production frontier models using trans-log or Cobb-Douglas functions to estimate production or cost functions assuming the existence of inefficiency in the production activity of the hospital [Aigner 1977, Meeusen 1977]. Once the frontier is estimated, it is used to compute scores of hospital inefficiency, by comparing hospital inefficiency scores with the production frontier. The main assumption is that hospitals make suboptimal decisions to maximize or minimize some objective function (e.g., maximize revenue or minimize costs) leading to a suboptimal production. Therefore, SFA would be arguably the preferred method to assess and compare hospitals' efficiency in activity-based financing systems, in which hospitals are permanently adapting to cost constraints by increasing their activity and reducing fixed costs mainly in terms of hospital bed capacity and personnel. The marginal utility and marginal production concepts, based on underlying laws of diminishing utility and diminishing returns, respectively, provide the basis to select an output-oriented approach to measure hospital performance. The application of SFA based on the relationship of inputs with outputs of the health care delivery process, provides with a score of technical efficiency per fiscal year, allowing benchmark comparison among hospitals.

1.4 Hospital efficiency in France

The necessary data for the assessment of hospital efficiency in France can be obtained from public records. The study A in this chapter selected a set of indicators to guide the search of hospital efficiency indicators, based on their acute care relevance and availability in databases. The French Ministry of Health provides through the *Direction de la Recherche, des Études, de l' Évaluation et des Statistiques* (DREES) or Directorate of Research, Studies, Evaluation and Statistics, the *Statistique Annuelle des Établissements de Santé* (SAE) or annual statistics of resources and activity [DREES 2022]. Hospital resource data were extracted by the SAE-Diffusion tool for not-for-profit hospitals, which included public facilities and private health establishment of collective interest or *Établissement de santé privé d'intérêt collectif* (ESPIC) as well as for for-profit hospitals. Hospitalization data were extracted from PMSI available records by sector of hospitalization, namely acute care in the case of medicine-surgery-

obstetrics (MCO), emergency as well as psychiatry, long term care, rehabilitation care, and home-based care. Three lengths of stay were considered, day care, one-night care and full-admission care for medicine-surgery-obstetrics (MCO) considered as acute care. However, the distribution of personnel by length of stay was not possible because the same personnel oversee patients hospitalized for all length of stay. Hospital financial inputs and outputs were obtained through the OPALE management tool, and from the *Comptes d'exploitation* (CEX) or Operating Accounts.

The preferred econometric method for technical efficiency assessment in article 1 included in this chapter was the Stochastic Frontier Analysis (SFA). The SFA parametric method assumes that the error in the model is a combination of a random error term υ and an inefficiency term u. The frontier production function can be empirically estimated in its basic form, and applying Cobb-Douglas or Translog functions, and written as follows:

SFA frontier $y_i = x'\,\beta + \ v_i - \ u_i$

Notation: υ=random error term; u=inefficiency term; *y*=outputs; *x*=inputs

SFA Cobb-Douglas $\ln y_i = \beta_0 + \sum_{j=1}^{k} \beta_j \ln x_i + v_i - u_i$

SFA Translog $\ln y_i = \beta_0 + \sum_{j=1}^{k} \beta_j \ln x_i + \frac{1}{2} \sum_{j=1}^{k} \ \sum_{h=1}^{k} \beta_{jh} \ln x_{ji} \ \ln x_{hi} + v_i - u_i$

The article 1 proposed an econometric model for the assessment of hospital efficiency of 20 not-for-profit acute care hospitals under *Assistance Publique–Hôpitaux de Paris* (AP-HP) administration, located in the Parisian region, during the period 2009-2013 [Degoulet 2017]. The hypothesis was that hospital technical efficiency could be decreasing overtime since the introduction of the T2A. The overarching hypothesis of the research article was clinical information systems (CIS) are not related to an actual efficiency improvement. The input and output indicators most frequently used in hospital efficiency [Hadji 2014] were integrated in SFA models implementing Cobb-Douglas functions to obtain cost-efficiency scores in software Frontier® 4.0. In tested models, four input variables were integrated into the model, namely the number of beds, and non-medical staff expenditures, and non-staff expenditure. In this study, the bed capacity represented the supply of care, while staff expenditures represented the main component of operating cost. A single variable of hospital output was considered, the

total hospital revenue, which consisted of income from medical activity, namely hospitalizations and consultations, and non-medical activity, namely research and training.

Significant differences in trends of hospital cost-efficiency scores were observed between the group of general acute care hospitals (n=17) and the group hospitals with more advanced clinical information system (n=3), namely European Hospital Georges Pompidou (HEGP), Robert Debré, and Ambroise Paré hospitals, which obtained higher technical efficiency scores. Additionally, significant differences in scores were observed between general hospitals and pediatric, which performed a higher SFA cost-efficiency score. However, during the period of study, 2009-2013, global hospital efficiency declined by .5% per year, while overall spending on information technology was on the rise. Thus, even if investments in clinical information systems contribute to increase revenue, this is not enough evidence to infer that an increase in information systems adoption could be associated with an increased financial efficiency in a budgetary contraction context [Degoulet 2016].

Study A – Systematic review on the relationships of hospital resources with activity in hospital efficiency assessment

A.1 Methods

A systematic review of literature, following the PRISMA protocol [Moher 2009], allowed to select scientific publications focused on hospital resource and activity indicators in hospital performance assessment in acute care and general hospitals. This review extends the systematic review of Hadji *et al.* [Hadji 2014]. The online search was looked for original research articles published between January 1990 and May 2022 assessing the relationships of acute care hospital inputs with outputs integrated into models for the assessment of hospital efficiency (Figure A1). The Medline and Cochrane databases were searched by MeSH terms, namely "Hospitals", "Organizational efficiency", "Cost-Benefit Analysis", "Hospital financial management", "Hospital resources", and related terms (Table 2A). Similarly, the Web of knowledge database was searched, since not benefiting from a MeSH system, by applying same MeSH terms considered as keywords in the search and including other terms such as "Production" (Figure A1). The criteria for the selection of articles in the retrieval process considered the quality of the observational study design, sample size, diversity and validity of the quantified indicators, and the statistical methods applied in hospital performance assessment (Table A2 and Figure A2).

Medline and Cochrane
Hospitals (MeSH) AND Efficiency, Organizational (MeSH) OR Hospital Financial Management (MeSH) OR Costs and Cost Analysis (MeSH) OR Cost-Benefit Analysis (MeSH) OR Benchmarking (MeSH) AND (Health Resources (MeSH) OR Hospital Bed Capacity (MeSH) OR Personnel, Hospital (MeSH) OR Income (MeSH))

Web of Knowledge
Hospitals AND (Efficiency OR Hospital Financial Management OR Cost Analysis OR Cost-Benefit Analysis OR Benchmarking) AND (Activity* OR Production OR Productivity OR Budget OR Diagnosis-Related Groups OR DRG OR Efficiency) AND (Health Resources OR Hospital Bed Capacity OR Personnel, Hospital OR Income)

Figure A1 Search strategy for a systematic review on the relationships of hospital resources with activity for hospital efficiency assessment.

Table A1 Validity criteria for the selection of articles

Design
Observational study (cross-sectional).
The study period was defined.
Sample
The sample size was justified.
The study includes acute-care and/or general hospitals.
Indicators
Reliable and valid input and output indicators were used.
Several inputs and several outputs were selected.
Varied indicators of resources and activity were considered.
Different categories of hospital staff members were considered.
The indicators were quantified.
The impact of indicators on hospital financial efficiency was assessed.
Statistical analysis
The focus was on the relationships of resources with activity and/or the hospital efficiency assessment.
Statistical methods were used to assess the relationships of inputs and outputs and/or hospital efficiency.

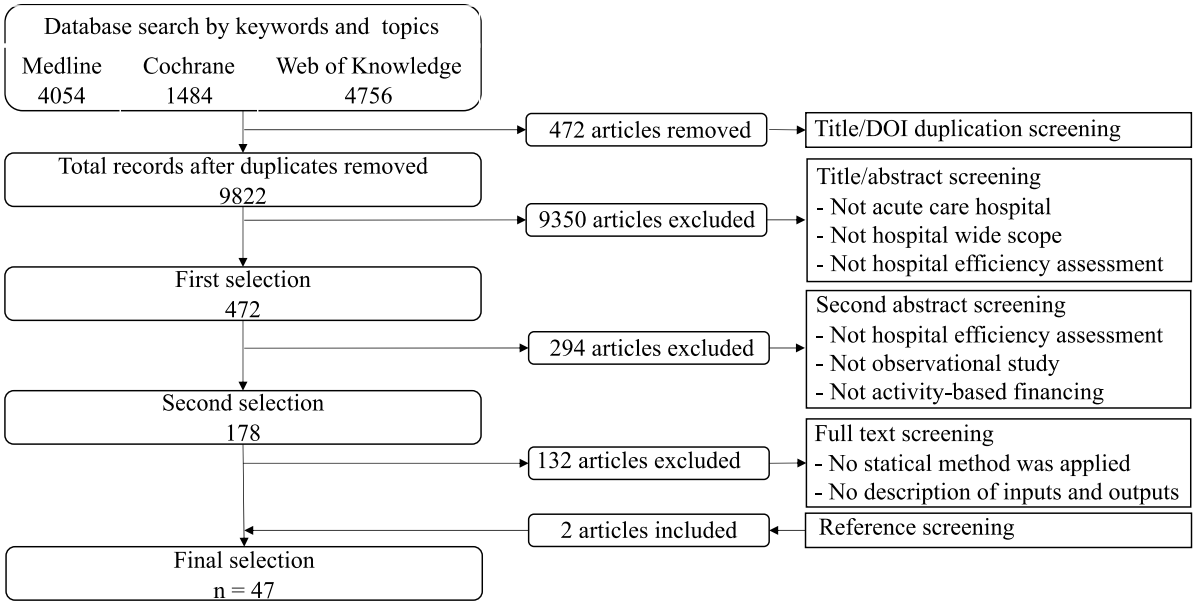

Figure A2 Flowchart of the selection of articles on the relationships of resources with activity for hospital efficiency assessment.

A.2 Results

A set of 47 original research papers was selected and listed in a summary table by several aspects, namely indicators, methods implemented, adjustment variables, indicators, and methods, implemented in hospital efficiency assessment (Table A2). The analysis of the selected articles allowed to quantify, after resolving for ambiguities and duplication is the definition of measures, the indicators and methods used in hospital efficiency assessment in the papers. The methods most used in the assessment of hospital efficiency were Data Envelopment Analysis (DEA), applied in 33 articles, and Stochastic Frontier Analysis (SFA), applied in 8 articles, as well as Malmquist index in 4 articles, Tobit method in 2 articles, and multilevel regression models in 2 articles (Table A2). The indicators most frequently assessed were extracted and listed for their analysis (Table A3). The relationships among hospital inputs and outputs integrated into the different hospital efficiency models were identified, listed, and assessed (Table A4). The frequency of the relationships between output and output most considered in the articles was assessed. For instance, the number of inpatient stays was associated with the number of beds (76.6%), number of medical staff (36.2%), nursing staff (27.7%), non-medical, and non-nursing staff (23.4%), as well as with hospital costs (40.4%) (Table A5).

Finally, a set of indicators and preferred methods for assessing hospital efficiency were selected for a model of hospital efficiency on acute care hospital in France included in this chapter (Table A6). A set of 16 hospital input indicators considered as inputs of the process of hospital activity was selected, consisting of 2 hospital capacity measures, 7 staff resources, and 7 financial input measures. A set of 16 hospital output indicators, namely 17 hospital activity outputs and 3 financial outputs consisting of hospital revenue measures.

Additionally, 7 articles presented hospital efficiency models integrating clinical outcomes as outputs, i.e., SFA models integrated length of stays [Farsi 2008, Herr 2008, Herr 2011], infections due to medical care, postoperative hemorrhage or hematoma, accidental puncture or laceration [Carey 2008]; DEA models integrated length of stays [Fuentes 2019, Kalhor 2016], mortality rate [Bagci 2021], potential years of life lost from treatable causes, mortality from treatable causes, and survival rate from treatable causes [Allin 2016]. However, these clinical outcomes were not considered for the exclusive hospital efficiency assessment in this study.

Table A2 Description of selected articles on the relationships of resources with activity for hospital efficiency assessment

Author Year	Journal References	Country	Financing mode	Start Date	Duration (months)	No Hospitals	Analysis Methods	Teaching Status	Input Indicators	Output Indicators
Allin 2016	Health Econ Policy Law. 2016;11(1):39-65	Canada	DRG	2007	36	ND	DEA	M	Hospitals spending per capita Prescription drugs spending per capita Physicians spending per capita Residential care facilities spending per capita Community nurses spending per capita	Potential years of life lost from treatable causes Mortality from treatable causes Survival rate from treatable causes
Athanassopoulos 1999	Health Care Manag Sci 1999;2:97–106	Greece	ND	1992	12	98	DEA	ND	Number of Beds Number of medical Staff in general Medicine Number of medical Staff in Surgery Number of medical Staff in Laboratory Number of Non-medical Staff Total labor costs Non labor costs Pharmaceutical supplies	Number of Patients in General medicine Number of Patients in Surgery Number of Clinical Examination Number of Laboratory Test
Bağci 2021	Hosp Top. 2021;99(2):49-63	Turkey	DRG	2012	48	92	DEA Malmquist Tobit	M	Number of beds Number of specialist physicians Number of assistant physicians Number of nurses and midwives Number of other medical staff	Number of polyclinic examinations Number of inpatient stays Number of hospitalizations Mortality rate
Ballestero 2004	Comput Oper Res. 2004;31(4):515–532	Spain	DRG	1996	12	27	DEA	ND	Number of Beds Medical Staff Cost	Number of Outpatient Visits Number of emergency visits Number of inpatient stays Number of Surgical Inpatient Stays
Barnum 2011	J Med Syst 2011;35:1393–401	USA	ND	–	–	87	DEA	ND	Number of Beds Number of total Staff	Number of Inpatient Stays Number of Outpatient Visits

Table A2 (continued)

Author Year	Journal References	Country	Financing mode	Start Date	Duration (months)	No Hospitals	Analysis Methods	Teaching Status	Input Indicators	Output Indicators
Biorn 2003	Health Care Manag Sci 2003;6:271–83	Norway	ABF	1992	108	48	DEA	ND	Number of Beds Number of Medical Staff	Number of Inpatient Stays Number of Outpatient Visits
Carey 2008	Health Serv Res 2008;43:1869–87	USA	DRG	1998	72	975	SFA	ND	Number of Non-medical Staff Medical Expenditures Operating expenses Hospital Costs	Number of Outpatient Visits Number of Outpatient Surgeries Infections due to Medical Care Postoperative Hemorrhage or Hematoma Accidental Puncture or Laceration
Chang 1998	Omega. 1998;26(2):307 317	Taiwan	Not-DRG	1990	60	5	DEA	M	Number of Medical Staff Number of Nursing Staff Number of Non-medical Non-nursing Staff	Number of inpatient days Number of Outpatient and Emergency Visits
Chern 2000	J Med Syst. 2000;24(3):159 72	USA	DRG	1984	120	80	DEA	ND	Number of Beds Service complexity (Total diagnostics) Number of Non-medical Staff Operating Expenses	Number of Outpatient and Emergency Visits Number of Inpatient Stays
Ersoy 1997	JMed Syst. 1997;21(2):67 74	Turkey	Not-DRG	1994	12	573	DEA	NT	Number of Beds Number of Medical Staff Number of Residents Number of Nursing Staff Number of Non-medical Non-nursing Staff	Number of Inpatient Stays Number of Outpatient and Emergency Visits Number of Inpatient and Outpatient Surgeries
Farsi 2008	Health Econ 2008;17:335–50	Switzerland	DRG	1998	72	148	SFA	T	Number of Beds Number of Resident Hospital costs Medical Staff Salary Non-medical Staff Salary Capital	Number of Inpatient Stays Length of Stay Outpatient Revenue

Table A2 (continued)

Author Year	Journal References	Country	Financing mode	Start Date	Duration (months)	No Hospitals	Analysis Methods	Teaching Status	Input Indicators	Output Indicators
Gai 2010	Biosci Trends 2010;4:218–24	China	ND	1993	156	ND	DEA	ND	Number of Beds Number of Medical Staff Capital Hospital expenditures	Number of Inpatient stays Number of Outpatient Visits Hospital Revenue
Grosskopf 2001a	Socio Econ Plann Sci. 2001; 35(3): 189-204	USA	ND	1994	12	213	DEA	T	Number of Beds Total Staff Number of Medical Staff Number of Resident Number of Nursing Staff Number of Non-medical Non-nursing Staff	Number of Inpatient Stays Number of Outpatient Visits Number Emergency Visits Number of Outpatient Surgery Number of Inpatient Surgery
Grosskopf 2001b	Health Care Manag Sci. 2001; 4(2): 83–90	USA	ND	1995	12	792	DEA	M	Number of Beds Number of total Staff Number of Medical Staff Number of Resident Number of Nursing Staff Number of Non-medical Non-nursing Staff	Number of Inpatient Stays Number of Outpatient Visits Number Emergency Visits Number of Outpatient Surgery Number of Inpatient Surgery
Grosskopf 2004	Eur J Oper Res. 2004;154(2):515-525	USA	DRG	1995	12	254	DEA	T	Number of Beds Number of Medical Staff Number of Resident Number of Nursing Staff	Number of Inpatients Stays Number of Outpatient and Emergency Visits
Fuentes 2019	J Comp Eff Res. 2019;8(11):929-946	Spain	DRG	2012	48	27	DEA	M	Number of Beds Number of Operating rooms Personnel costs Operating costs	Length of stay Rate of return Number of discharges Number of emergency visits Number of Surgical interventions
Gruca 2001	Health Care Manag Sci.2001;4(2):91 101	Canada	DRG	1986	12	168	DEA	NT	Number of Beds Number of Nursing Staff Number of Ancillary Staff Number of Administrative Staff Operating Expenses	Number of Inpatient Stays Number of Outpatient Visits Long-term Care Inpatient Day
Hajialiafzali 2007	J Med Syst 2007;31:166–72	Iran	Not DRG	2002	12	56	DEA	NT	Number of Beds Number of Medical Staff Number of Nursing Staff Number of Non-medical Non-nursing Staff	Number of Inpatient Surgery Number of Outpatient Visits Number of emergency visits

Table A2 (continued)

Author Year	Journal References	Country	Financing mode	Start Date	Duration (months)	No Hospitals	Analysis Methods	Teaching Status	Input Indicators	Output Indicators
Harris 2000	J Oper Res Soc.2000; 51(7):801.	USA	DRG	1991	36	20	DEA	ND	Number of Beds Service Complexity (Total diagnostics) Number of Non-Medical Staff Operating Expenses	Number of Inpatient Stays Number of Outpatient and Emergency Visits
Harrison 2004	J Med Syst 2004;28:411–22	USA	ND	1998	24	280	DEA	ND	Number of Beds Number of total Staff Operating expenses Service Complexity (Total diagnostics)	Number of Inpatient Stays Number of Outpatient Visits
Harrison 2014	Health Care Manag. 2014;33(2):117-27	USA	DRG	2007	48	165	DEA	M	Number of beds Number of employees (FTEs) Operating expenses	Number of inpatient days Number of outpatient visits Number of Surgical interventions
Herr 2008	Health Econ. 2008; 17:1057–71	Germany	DRG	2001	36	1594	SFA	ND	Number of Beds Number of total Staff Number of Medical Staff Number of Nursing Staff Medical Staff Salary Nursing staff Salary Non-Medical Non-Nursing Staff Salary Hospital cost	Length of Stay
Herr 2011	Health Econ 2011;20:660–74	Germany	DRG	2002	60	1579	SFA	NT	Number of Beds Number of total Staff Number of Medical Staff Number of Nursing Staff Number of Non-Medical Non-Nursing Staff Medical staff cost Nursing staff cost	Length of Stay Hospital Revenue
Huang 1990	J Med Syst. 1990;14(4):191-6	USA	DRG	1987	12	213	DEA	ND	Number of Beds Number of Total Staff	Number of inpatient days Number of Outpatient Visits

Table A2 (continued)

Author Year	Journal References	Country	Financing mode	Start Date	Duration (months)	No Hospitals	Analysis Methods	Teaching Status	Input Indicators	Output Indicators
Kirigia 2002	J Med Syst 2002;26:39–45	Kenya	Not DRG	ND	ND	54	DEA	ND	Number of Beds Number of Medical Staff Number of Nursing Staff Number of Non-Medical Non-Nursing Staff Hospital expenditures	Number of Inpatient Stays Number of Outpatient Visits
Krigia 2004	J Med Syst 2004;28:155–66	Kenya	Not DRG	ND	ND	32	DEA	ND	Number of Beds Number of Medical and Nursing Staff Number of Administrative Staff Number of Other allied Professionals Hospital expenditures	Number of Outpatient Visits
Kirigia 2008	J Med Syst 2008;32:509–19	Angola	Not DRG	2000	36	ND	DEA Malmquist	ND	Number of Beds Number of Medical and Nursing Staff Medical expenditures	Number of Inpatient Stays Number of Outpatient Visits
Kristensen 2010	Health Care Manag Sci2010;13:34–45	Denmark	DRG	2004	12	36	DEA	M	Hospital expenditures	Outpatient Revenue Inpatient Revenue
Lee 2008	J Med Syst 2008;33:307–15	USA	DRG	2001	48	ND	DEA	M	Number of Beds Number of Non-Medical Staff Medical Expenditures Service complexity (Number of Diagnostics)	Number of Patient stays Number of Outpatient Visits Number of Residents
Li 2001	Health Care Manag Sci 2001;4:73–81	USA	DRG	1998	60	90	SFA	M	Number of Beds Labor Capital Hospital Costs	Number of inpatient days Number of Outpatient Visits
Li 2020	BMJ Open. 2020;10(6):e035703	China	Not DRG	2017	12	68	DEA Kruskal-Wallis H test	M	Number of open beds Number of physicians Number of nurses Total expenditure	Number of discharges Number of annual visits Total income

Table A2 (continued)

Author Year	Journal References	Country	Financing mode	Start Date	Duration (months)	No Hospitals	Analysis Methods	Teaching Status	Input Indicators	Output Indicators
Linna 1998a	Health Econ1998;7:291–305	Finland	DRG	1998	12	48	SFA	M	Number of Beds Operating expenses Medical Staff Salary Non-Medical Staff Salary	Number of Inpatient Stays Number of emergency visits Number of Outpatient Visits Number of Bed Days Number of Residents Number of Medical Students Number of Nurse Students Number of Scientific Publications
Linna 1998b	Health Econ 1998; 7:415–27	Finland	DRG	1998	84	43	DEA SFA	M	Number of Beds Operating Costs Labor	Number of Inpatient Stays Number of emergency visits Number of Outpatient Visits Number of Bed Days Number of Residents Number of Nurse Students Number of Scientific Publications
Liu 2019	BMC Health Serv Res. 2019;19(1):858	China	Not DRG	2012	48	38	DEA	M	Hospital area Number of open beds Number of fixed assets Number of healthcare technicians	Income Number of discharges Number of hospital bed rotations Number of outpatient and emergency visits
Magnusse n 1996	Health Serv Res.1996; 31 (1):21–37	Norway	DRG	1989	36	46	DEA	NT	Number of Beds Number of Medical and Nursing Staff Number of Non-Medical Non-Nursing Staff	Number of outpatient Visits Number of inpatient days Number of Patient
Masiye 2006	J Med Syst2006;30:473–81	Zambia	ND	ND	ND	40	DEA	ND	Number of Beds Number of Medical and Nursing Staff Number of Non-Medical Non-Nursing Staff	Number of outpatient Visits
Mateus 2015	Eur J Public Health. 2015;25 Suppl 1:52-8	England Portugal Spain Slovenia	DRG	2002	60	571	SFA	M	Number of beds Number of employees Number of physicians Number of nurses	Number of discharges
McCallion 2000	Appl Econ.2000;32(2): 161 74	Ireland	DRG	1986	72	23	DEA Malmqui st	ND	Number of Beds Number of Nursing Staff Number of Administrative Staff Number of Ancillary Staff Specialists Staff Cost	Number of inpatient stays Number of Outpatient Visits Number of emergency visits

Table A2 (continued)

Author Year	Journal References	Country	Financing mode	Start Date	Duration (months)	No Hospitals	Analysis Methods	Teaching Status	Input Indicators	Output Indicators
Medarević 2021	Int J Environ Res Public Health 2021;18(23):12475	Serbia	DRG	2015	48	39	DEA Malmquist Tobit	ND	Number of Beds Number of physicians Number of health professionals not physicians	Number of inpatient stays Number of outpatient visits
Mehrtak 2014	Glob J Health Sci. 2014;6(4):107-16	Iran	Not DRG	2014	4	18	DEA Pabon Lasso	M	Number of active beds Number of physicians Number of nurses	Number of discharges Number of Surgical interventions Bed occupancy rate
Meyer 2008	Yearb Med Informatics.2008;1	France	DRG	1998	96	17	Cobb-Douglas	T	Labor Capital	Hospital Revenue
Oliveira 2008	Eur J Oper Res2008;185:933–47	Portugal	DRG	1998	12	88	Multilevel regression model	ND	Number of Beds Number of Medical Staff Number of Nursing Staff	Number of Inpatient Stays Number of Outpatient Visits Number Emergency Visits
Ozcan 1992	Med Care 1992;30:781–92	USA	Case Mix	1987	12	3000	DEA	ND	Number of Beds Service Complexity (Total diagnostics) Operating Expenses Labor	Number of Inpatient Stays Number of Outpatient Visits Number of Students in Training (Medical and Nurse)
Ozcan 1995	Socio Econ Plann Sci. 1995;29(2):139-50	USA	DRG	1990	12	319	DEA	M	Number of Beds Number of Non-Medical Staff Service Complexity (Total diagnostics) Operational Expenses	Number of Inpatient Stays Number of Outpatient & Emergency Visits
Yildiz 2018	BMC Health Serv Res. 2018;18(1):401	Turkey	DRG	2012	12	1079	SFA (translog)	M	Number of beds Number of ICU Beds Number of physicians not residents Number of health professionals not physicians Number of administrative staff Number of X-Ray, MR, CT, ECG, Doppler	Hospital composite output (Number of annual surgical operations, Number of inpatient days utilization, Average daily ICU occupancy rate, Number of annual child deliveries, Number of annual visits)

ND=Not Described in the paper; T=Teaching Hospitals; M=Mix Hospitals (Teaching and Non-Teaching); NT=Non-Teaching Hospitals; DRG=Diagnostic related Group; ABF=Activity-based Financing; OOP=out-of-pocket expenditure; FTE=full-time employees (FTEs).

Table A3 Hospital input and output indicators in selected articles

Indicators	No papers	References
Input		
Hospital capacity		
No beds	43	Athanassopoulos 1999, Ballestero 2004, Bağci 2021, Barnum 2011, Biorn 2003, Chern 2000, Ersoy 1997, Farsi 2008, Fuentes 2019, Gai 2010, Grosskopf 2001a, Grosskopf 2001b, Grosskopf 2004, Gruca 2001, Hajialiafzali 2007, Harris 2000, Harrison 2004, Harrison 2014, Herr 2011, Herr 2008, Huang 1990, Kalhor 2016, Kim 2002, Kirigia 2002, Kirigia 2004, Kirigia 2008, Lee 2008, Li 2001, Li 2020, Linna 1998a, Linna 1998b, Liu 2019, Magnussen 1996, Mateus 2015, Mehrtak 2014, McCallion 2000, Medarević 2021, Oliveira 2008, Ozcan 1992, Ozcan 1995, Ozcan 1995, Sahin 2000, Scott 1995, Yildiz 2018
Service complexity	6	Chern 2000, Harris 2000, Harrison 2004, Ozcan 1995, Lee 2008, Ozcan 1992
Staff resources		
No total staff	9	Barnum 2011, Grosskopf 2001a, Grosskopf 2001b, Harrison 2004, Harrison 2014, Herr 2011, Herr 2008, Huang 1990, Mateus 2015
No medical staff	23	Allin 2016, Athanassopoulos 1999, Bağci 2021, Biorn 2003, Chang 1998, Ersoy 1997, Gai 2010, Grosskopf 2001a, Grosskopf 2001b, Grosskopf 2004, Hajialiafzali 2007, Herr 2011, Herr 2008, Kalhor 2016, Kirigia 2002, Li 2020, Masiye 2006, Mateus 2015, Medarević 2021, Mehrtak 2014, Oliveira 2008, Sahin 2000, Yildiz 2018
No nursing staff	22	Allin 2016, Bağci 2021, Chang 1998, Fuentes 2019, Grosskopf 2001a, Grosskopf 2001b, Grosskopf 2004, Gruca 2001, Hajialiafzali 2007, Herr 2011, Herr 2008, Kalhor 2016, Kirigia 2002, Li 2020, Liu 2019, Masiye 2006, Mateus 2015, McCallion 2000, Mehrtak 2014, Oliveira 2008, Sahin 2000, Yildiz 2018
No non-medical non-nursing staff	11	Chang 1998, Grosskopf 2001a, Grosskopf 2001b, Grosskopf 2004, Gruca 2001, Hajialiafzali 2007, Kalhor 2016, Kirigia 2002, Magnussen 1996, Masiye 2006, McCallion 2000
No non-medical staff	6	Athanassopoulos 1999, Biorn 2003, Harris 2000, Lee 2008, Ozcan 1995, Yildiz 2018
No residents	4	Farsi 2008, Grosskopf 2001a, Grosskopf 2001b, Grosskopf 2004
No medical and nursing staff	3	Kirigia 2004, Kirigia 2008, Magnussen 1996
No administrative staff	3	Kirigia 2004, McCallion 2000, Yildiz 2018
No other allied professionals	6	Kalhor 2016, Kirigia 2004, Liu 2019, Sahin 2000, Yildiz 2018 Bağci 2021
Hospital expenses		
Hospital Cost: ‘Hospital expenditures’/‘hospital cost’/‘hospital spending’ / ‘operating expenses’ / ‘medical expenditures, medical/pharmaceutical supplies’	25	Allin 2016, Athanassopoulos 1999, Biorn 2003, Carey 2008, Chern 2000, Fuentes 2019, Gai 2010, Gruca 2001, Harris 2000, Harrison 2004, Harrison 2014, Herr 2008, Kim 2002, Kirigia 2004, Kirigia 2008, Kristensen 2010, Lee 2008, Li 2001, , Li 2020, Linna 1998a, Linna 1998b, Ozcan 1992, Ozcan 1995, Sahin 2000, Scott 1995
Medical staff cost: ‘Medical staff salary expenditures’/ ‘Medical staff cost’	7	Allin 2016, Ballestero 2004, Farsi 2008, Herr 2011, Herr 2008, Linna 1998a, McCallion 2000
Labor	7	Allin 2016, Athanassopoulos 1999, Fuentes 2019, Li 2001, Linna 1998b, Meyer 2008, Ozcan 1992
Capital	6	Gai 2010, Farsi 2008, Huang 1990, Li 2001, Liu 2019, Meyer 2008
Non-medical staff cost: ‘non-medical staff salary expenditures’	4	Allin 2016, Farsi 2008, Herr 2008, Linna 1998a
Nursing staff cost: ‘nursing staff salary expenditures’ / ‘nursing staff cost’	3	Herr 2011, Herr 2008
Non-medical non-nursing staff costs	1	Herr 2011

Table A3 (continued)

Indicators	No papers	References
Outputs		
Activity indicators		
No inpatient stays (stays, admissions, discharges, patient days, inpatient-day)	38	Bağci 2021, Ballestero 2004, Barnum 2011, Biorn 2003, Chang 1998, Chern 2000, Ersoy 1997, Farsi 2008, Fuentes 2019, Gai 2010, Grosskopf 2001a, Grosskopf 2001b, Grosskopf 2004, Gruca 2001, Harris 2000, Harrison 2004, Harrison 2014, Huang 1990, Kalhor 2016, Kirigia 2002, Kirigia 2008, Lee 2008, Li 2001, Li 2020, Linna 1998a, Linna 1998b, Liu 2019, Magnussen 1996, Mateus 2015, McCallion 2000, Medarević 2021, Mehrtak 2014, Oliveira 2008, Ozcan 1992, Ozcan 1995,Sahin 2000, Scott 1995, Yildiz 2018
No outpatient visits	25	Ballestero 2004, Barnum 2011, Biorn 2003, Carey 2008, Grosskopf 2001a, Grosskopf 2001b, Gruca 2001, Hajialiafzali 2007, Harrison 2004, Harrison 2014, Huang 1990, Kirigia 2002, Kirigia 2004, Kirigia 2008, Lee 2008, Li 2001, Li 2020, Linna 1998a, Linna 1998b, Magnussen 1996, Masiye 2006, McCallion 2000, Medarević 2021, Oliveira 2008, Sahin 2000
No emergency visits	9	Ballestero 2004, Fuentes 2019, Grosskopf 2001a, Grosskopf 2001b, Hajialiafzali 2007, Linna 1998a, Linna 1998b, McCallion 2000, Oliveira 2008
No outpatient and emergency visits	11	Chang 1998, Chern 2000, Ersoy 1997, Gai 2010, Harris 2000, Kalhor 2016, Liu 2019, Grosskopf 2004, Ozcan 1992, Ozcan 1995, Scott 1995
No residents	4	Lee 2008, Linna 1998a, Linna 1998b, Ozcan 1992
Length of stay	6	Farsi 2008, Fuentes 2019, Herr 2011, Herr 2008, Kalhor 2016, Scott 1995
No inpatient surgeries	3	Grosskopf 2001a, Grosskopf 2001b, Hajialiafzali 2007
No outpatient surgeries	3	Carey 2008, Grosskopf 2001a, Grosskopf 2001b
No inpatient and outpatient surgeries	5	Ersoy 1997, Grosskopf 2004, Harrison 2014, Kalhor 2016, Mehrtak 2014
No bed days	2	Linna 1998a, Linna 1998b
No scientific publications	2	Linna 1998a, Linna 1998b
No nursing students	2	Linna 1998a, Linna 1998b
No patients	2	Athanassopoulos 1999, Magnussen 1996
No laboratory tests	1	Athanassopoulos 1999
No clinical examinations	2	Athanassopoulos 1999, Bağci 2021
Long-term care inpatient day	1	Gruca 2001
Financial outcome indicators		
Hospital revenue	4	Gai 2010, Herr 2011, Kim 2002, Meyer 2008
Outpatient revenue	1	Farsi 2008
Patient revenue	1	Kim 2002

Table A4 Associations of hospital inputs with outputs in hospital efficiency assessment

Output variable	Input variable	No papers	References
No inpatient stays	No beds	36	Bağci 2021, Ballestero 2004, Barnum 2011, Biorn 2003, Chern 2000, Ersoy 1997, Farsi 2008, Fuentes 2019, Gai 2010, Gruca 2001, Grosskopf 2001a, Grosskopf 2001b, Grosskopf 2004, Harris 2000, Harrison 2004, Harrison 2014, Huang 1990, Kalhor 2016, Kirigia 2002, Kirigia 2008, Lee 2008, Li 2001, Li 2020, Liu 2019, Linna 1998a, Linna 1998b, Magnussen 1996, Mateus 2015, Mehrtak 2014, McCallion 2000, Medarević 2021, Oliveira 2008, Ozcan 1992, Ozcan 1995, Sahin 2000, Scott 1995, Yildiz 2018
	Service complexity	5	Chern 2000, Harris 2000, Lee 2008, Ozcan 1992, Ozcan 1995
	No medical staff	17	Bağci 2021, Biorn 2003, Chang 1998, Ersoy 1997, Gai 2010, Grosskopf 2001a, Grosskopf 2001b, Grosskopf 2004, Harrison 2014, Kalhor 2016, Kirigia 2002, Li 2020, Mateus 2015, Mehrtak 2014, Medarević 2021, Sahin 2000, Yildiz 2018
	No nursing staff	13	Bağci 2021, Chang 1998, Grosskopf 2001a, Grosskopf 2001b, Grosskopf 2004, Gruca 2001, Kalhor 2016, Kirigia 2002, Li 2020, Mateus 2015, Mehrtak 2014, McCallion 2000, Sahin 2000
	No non-medical non-nursing staff	11	Chang 1998, Grosskopf 2001a,Grosskopf 2001b, Grosskopf 2004, Gruca 2001, Kalhor 2016, Kirigia 2002, Magnussen 1996, McCallion 2000, Medarević 2021, Yildiz 2018
	No total staff	7	Barnum 2011, Grosskopf 2001a, Grosskopf 2001b, Harrison 2004, Huang 1990, Harrison 2014, Mateus 2015
	No residents	4	Farsi 2008, Grosskopf 2001a, Grosskopf 2001b, Grosskopf 2004,
	No non-medical staff	8	Bağci 2021, Biorn 2003,Chern 2000, Harris 2000, Kalhor 2016, Lee 2008, Ozcan 1995, Yildiz 2018
	No medical and nursing staff	2	Kirigia 2008, Magnussen 1996
	No other allied professionals	5	Bağci 2021, Liu 2019, Kalhor 2016, Sahin 2000, Yildiz 2018
	Hospital Costs	19	Biorn 2003, Chern 2000, Gai 2010, Gruca 2001, Harris 2000, Harrison 2004, Kirigia 2002, Kirigia 2008, Lee 2008, Li 2001, Linna 1998a, Linna 1998b, Ozcan 1992, Sahin 2000, Scott 1995, Ozcan 1995, Li 2020, Fuentes 2019, Harrison 2014
	Labor	6	Li 2001, Linna 1998a, Linna 1998b, Ozcan 1992, Li 2001, Fuentes 2019
	Capital	4	Gai 2010, Farsi 2008, Huang 1990, Li 2001
	Medical staff costs	4	Ballestero 2004, Farsi 2008, Linna 1998a, McCallion 2000
	Non-medical staff costs	2	Farsi 2008, Linna 1998a

Table A4 (continued)

Output variable	Input variable	No papers	References
No outpatient visits	No beds	22	Ballestero 2004, Barnum 2011, Biorn 2003, Grosskopf 2001a, Grosskopf 2001b, Gruca 2001, Hajialiafzali 2007, Harrison 2004, Huang 1990, Kirigia 2002, Kirigia 2004, Kirigia 2008, Lee 2008, Li 2001,Linna 1998a, Linna 1998b, McCallion 2000, Oliveira 2008, Sahin 2000, Medarević 2021, Li 2020, Harrison 2014
	Service complexity	2	Harrison 2004, Lee 2008
	No medical staff	9	Biorn 2003, Grosskopf 2001a, Grosskopf 2001b, Hajialiafzali 2007, Kirigia 2002, Masiye 2006, Medarević 2021, Li 2020, Sahin 2000
	No nursing staff	9	Grosskopf 2001a, Grosskopf 2001b, Gruca 2001, Hajialiafzali 2007, Kirigia 2002, Li 2020, Masiye 2006, McCallion 2000, Sahin 2000
	No non-medical non-nursing staff	7	Grosskopf 2001a, Grosskopf 2001b, Gruca 2001, Hajialiafzali 2007,Kirigia 2002, Masiye 2006, McCallion 2000
	No total staff	6	Barnum 2011,Grosskopf 2001a, Grosskopf 2001b, Harrison 2004, Harrison 2014, Huang 1990
	No residents	2	Grosskopf 2001a, Grosskopf 2001b, Medarević 2021
	No non-medical staff	3	Biorn 2003, Lee 2008
	No medical and nursing staff	2	Kirigia 2008, Kirigia 2004
	No other allied professionals	3	Sahin 2000, Kirigia 2004, Medarević 2021
	Hospital Costs	13	Biorn 2003, Carey 2008, Gruca 2001, Harrison 2004, Kirigia 2002, Kirigia 2008, Lee 2008, Li 2001, Li 2020,m Linna 1998a, Linna 1998b, Kirigia 2004, Sahin 2000
	Labor	2	Li 2001,Linna 1998b
	Capital	2	Huang 1990, Li 2001
	Medical staff costs	3	Ballestero 2004, Linna 1998a, McCallion 2000,
	Non-medical staff costs	1	Linna 1998a
No emergency visits	No beds	9	Ballestero 2004, Fuentes 2019, Grosskopf 2001a, Grosskopf 2001b, Hajialiafzali 2007, Linna 1998a, Linna 1998b, McCallion 2000, Oliveira 2008
	No medical staff	4	Grosskopf 2001a, Grosskopf 2001b, Hajialiafzali 2007, Oliveira 2008
	No nursing staff	5	Grosskopf 2001a, Grosskopf 2001b, Hajialiafzali 2007, McCallion 2000, Oliveira 2008
	No non-medical non-nursing staff	4	Grosskopf 2001a, Grosskopf 2001b, Hajialiafzali 2007, McCallion 2000
	No total staff	2	Grosskopf 2001a, Grosskopf 2001b
	Hospital cost	3	Fuentes 2019, Linna 1998a, Linna 1998b
	Medical staff costs	5	Ballestero 2004, Fuentes 2019, Linna 1998a,Linna 1998b, McCallion 00
No outpatient and emergency visits	No beds	10	Chern 2000, Ersoy 1997, Gai 2010, Grosskopf 2004, Harris 2000, Ozcan 1992, Ozcan 1995, Scott 1995, Liu 2019, Kalhor 2016
	Service complexity	3	Chern 2000, Harris 2000, Ozcan 1995
	No medical staff	6	Chang 1998, Chern 20000, Ersoy 1997,Gai 2010, Grosskopf 2004, Kalhor 2016
	No nursing staff	3	Chang 1998, Grosskopf 2004, Kalhor 2016
	No non-medical non-nursing staff	4	Chang 1998, Grosskopf 2004, Kalhor 2016
	No residents	1	Grosskopf 2004
	No non-medical staff	3	Harris 2000, Ozcan 1995, Liu 2019, Kalhor 2016
	Hospital Costs	6	Chern 2000, Gai 2010, Harris 2000, Ozcan 1992, Ozcan 1995,Scott 1995
	Labor	1	Ozcan 1992
	Capital	2	Gai 2010, Liu 2019

Table A4 (continued)

Output variable	Input variable	No papers	References
No residents	No beds	5	Lee 2008,Linna 1998a,Linna 1998b,Ozcan 1992,Scott 1995
	Services Complexity	2	Lee 2008, Ozcan 1992
	No non-medical staff	1	Lee 2008
	Hospital Cost	5	Lee 2008, Linna 1998a, Linna 1998b, Ozcan 1992, Scott 1995
	Labor	2	Linna 1998b, Ozcan 1992
	Medical staff cost/Non-medical staff cost	1	Linna 1998a
Length of stay	No beds	6	Farsi 2008, Herr 2011, Herr 2008, Scott 1995, Fuentes 2019, Kalhor 2016
	No medical staff/No nursing staff	2	Farsi 2008, Kalhor 2016
	No total staff	2	Herr 2011, Herr 2008
	No residents	1	Farsi 2008
	No other personnel	1	Kalhor 2016
	Hospital costs	5	Farsi 2008, Herr 2011, Herr 2008, Scott 1995, Fuentes 2019
	Labor costs	1	Fuentes 2019
	Medical staff costs	1	Herr 2011
	Non-medical staff costs	3	Farsi 2008, Herr 2008, Kalhor 2016
	Nursing staff costs	2	Herr 2011,Herr 2008
	Non-medical non-nursing staff cost/ Capital	1	Farsi 2008
No inpatient surgery	No beds No medical staff No nursing staff No non-medical non-nursing staff	3	Grosskopf 2001a, Grosskopf 2001b, Hajialiafzali 2007
	Number Total staff No residents	2	Grosskopf 2001a, Grosskopf 2001b
No outpatient surgery	No beds	3	Carey 2008, Grosskopf 2001a, Grosskopf 2001b
	No medical staff No nursing staff No non-medical non-nursing staff No residents	2	Grosskopf 2001a, Grosskopf 2001b
	Hospital Costs	3	Carey 2008, Grosskopf 2001a, Grosskopf 2001b
No inpatient and outpatient surgery	No beds	7	Ersoy 1997, Grosskopf 2004, Fuentes 2019, Kalhor 2016, Mehrtak 2014, Harrison 2014
	No medical staff	5	Ersoy 1997, Grosskopf 2004, Kalhor 2016, Mehrtak 2014, Yildiz 2018
	No nursing staff	3	Grosskopf 2004, Kalhor 2016, Mehrtak 2014
	No non-medical non-nursing staff	3	Grosskopf 2004, Kalhor 2016, Yildiz 2018
	No residents	1	Grosskopf 2004, Kalhor 2016, Mehrtak 2014, Harrison 2014
No patients	No beds	2	Athanassopoulos 1999, Magnussen 1996
	No medical and nursing staff No non-medical non-nursing staff	1	Magnussen 1996
	No medical staff No non-medical staff	1	Athanassopoulos 1999
No scientific publications	No beds Hospital Cost	2	Linna 1998a,Linna 1998b
	Hospital Cost Medical staff costs Non-medical staff cost Labor	1	Linna 1998a

Table A4 (continued)

Output variable	Input variable	No papers	References
No nurse students	No beds Hospital Cost	2	Linna 1998a, Linna 1998b
	Medical staff costs Non-medical staff cost	1	Linna 1998a
	Labor	1	Linna 1998b
No laboratory test	No beds Hospital Cost Labor	1	Linna 1998b
No clinical examination	No beds	2	Bağci 2021, Linna 1998b
	Hospital Cost	1	Linna 1998b
	Labor	1	Linna 1998b
	No specialist physicians / assistant physicians / nurses and midwives / other Medical staff	1	Bağci 2021
Long-term care inpatient day	No beds No nursing staff No non-medical non-nursing staff Hospital Cost	1	Gruca 2001
Hospital revenue	No beds	5	Gai 2010, Herr 2011, Kim 2002, Li 2020, Liu 2019
	No medical staff	3	Gai 2010, Herr 2011, Li 2020
	No nursing staff	2	Herr 2011, Li 2020
	No total staff	1	Herr 2011
	Hospital costs	3	Gai 2010, Kim 2002, Li 2020
	Medical staff cost Nursing staff cost Non-medical non-nursing staff cost	1	Herr 2011
	Capital Labor	1	Meyer 2008
Outpatient revenue	No beds No residents	1	Farsi 2008
	Hospital costs	2	Farsi 2008, Kristensen 2010
	Medical staff cost Non-medical non-nursing Total staff cost Capital	1	Farsi 2008
Patient revenue	No beds Hospital Cost	1	Kim 2002

Table A5 Frequencies of associations of hospital inputs with outputs in hospital efficiency models

Output Indicators / Input Indicators	No inpatient Stays	No outpatient visits	No emergency visits	No outpatient and emergency visits	No Residents	Length of stay	No inpatient surgeries	No outpatient surgeries	No inpatient and outpatient surgeries	Hospital revenue	Outpatient revenue
Hospital capacity											
No beds	36 (76.6%)	22 (46.8%)	9 (19.1%)	10 (21.3%)	5 (10.6%)	6 (12.8%)	3 (6.4%)	3 (6.4%)	7 (14.9%)	5 (10.6%)	1 (2.1%)
Service complexity	5 (10.6%)	2 (4.3%)	--	3 (6.4%)	2 (4.3%)	--	--	--	--	--	--
Staff resources											
No medical staff	17 (36.2%)	9 (19.1%)	4 (8.5%)	6 (12.8%)	--	2 (4.3%)	3 (6.4%)	2 (4.3%)	5 (10.6%)	3 (6.4%)	--
No nursing staff	13 (27.7%)	9 (19.1%)	5 (10.6%)	3 (6.4%)	--	2 (4.3%)	3 (6.4%)	2 (4.3%)	3 (6.4%)	2 (4.3%)	--
No non-medical and non-nursing staff	11 (23.4%)	7 (14.9%)	4 (8.5%)	4 (8.5%)	--	--	3 (6.4%)	2 (4.3%)	3 (6.4%)	--	--
No total staff	7 (14.9%)	6 (12.8%)	2 (4.3%)	--	--	2 (4.3%)	2 (4.3%)	--	--	1 (2.1%)	--
No Residents	4 (8.5%)	2 (4.3%)	--	1 (2.1%)	--	1 (2.1%)	2 (4.3%)	2 (4.3%)	1 (2.1%)	--	1 (2.1%)
No non-medical staff	8 (17%)	3 (6.4%)	--	3 (6.4%)	1 (2.1%)	--	--	--	--	--	--
No medical and nursing staff	2 (4.3%)	2 (4.3%)	--	--	--	--	--	--	--	--	--
Hospital expenses											
Hospital costs	19 (40.4%)	13 (27.7%)	3 (6.4%)	6 (12.8%)	5 (10.6%)	5 (10.6%)	--	3 (6.4%)	--	3 (6.4%)	2 (4.3%)
Labor costs	6 (12.8%)	2 (4.3%)	--	1 (2.1%)	2 (4.3%)	1 (2.1%)	--	--	--	1 (2.1%)	1 (2.1%)
Capital investments	4 (8.5%)	2 (4.3%)	--	2 (4.3%)	--	--	--	--	--	1 (2.1%)	1 (2.1%)
Medical staff costs	4 (8.5%)	3 (6.4%)	5 (10.6%)	--	1 (2.1%)	1 (2.1%)	--	--	--	1 (2.1%)	1 (2.1%)
Non-medical staff costs	2 (4.3%)	1 (2.1%)	--	--	1 (2.1%)	3 (6.4%)	--	--	--	--	--
Nursing staff costs	--	--	--	--	--	2 (4.3%)	--	--	--	1 (2.1%)	--
Non-medical and non-nursing staff costs	--	--	--	--	--	1 (2.1%)	--	--	--	1 (2.1%)	1 (2.1%)

Table A6 Selected hospital input and output indicators

Type of Indicator	Inputs	Outputs
Hospital capacity	No beds	--
	Service complexity	--
Staff resources	No medical staff	--
	No nursing staff	--
	No non-medical and non-nursing staff	--
	No total staff	--
	No residents	--
	No non-medical staff	--
	No medical & nursing staff	--
Activity indicators	--	Length of stay
	--	No beds days
	--	No inpatient stays
	--	No surgical inpatient stays
	--	No surgical interventions
	--	Long-term care inpatient day
	--	No outpatient visits
	--	No emergency visits
	--	No outpatient and emergency visits
	--	No inpatient surgeries
	--	No outpatient surgeries
	--	No inpatient and outpatient surgeries
	--	No clinical examinations
	--	No laboratory tests
	--	No scientific publications
	--	No residents
	--	No training (medical and nurse)
Financial indicators	Hospital costs	Hospital revenue
	Labor costs	Outpatient revenue
	Capital, investments	Patient revenue
	Medical staff costs	--
	Non-medical staff costs	--
	Nursing staff costs	--
	Non-medical non-nursing staff costs	--

Article 1 – *Les cercles vertueux de l'e-santé: une utopie nécessaire mais insuffisante*

[The virtuous circles of e-health: a necessary but insufficient utopia]

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Les cercles vertueux de l'e-santé : une utopie nécessaire mais insuffisante

Patrice Degoulet[1,2], Samir Mellikeche[1,2], Angel Benitez-Collante[1,2], Brahim Hadji[2], Abdelali Boussadi[2,3], Jean-Marc-Palm[4], Rodolphe Meyer[5]

[1]Faculté de Médecine Paris Descartes, France
[2]INSERM UMR 1138 Eq. 22: Sciences de l'information et médecine personnalisée
[3]Hôpital Européen Georges Pompidou, AP-HP, Paris
[4]Palmitech Group : North York, Ontario, Canada & Ouagadougou, Burkina Faso
[5]Direction des Systèmes d'Information, Hôpitaux Universitaires de Genève, Suisse

Abstract

Context: Clinical information systems (CIS) are developed with the aims of improving the quality and efficiency of care, and fostering clinical research.

Objective: This paper is based on the hypothesis that such vision is partly a utopian view of the emerging eSociety.

Methods: Examples are drawn from 15 years of experience with the fully integrated Hôpital Européen Georges Pompidou (HEGP) CIS, and from temporal data series extracted from different data warehouses of Assistance Publique - Hôpitaux de Paris (AP-HP) acute care hospitals. Four main virtuous circles are considered: user satisfaction vs. information system (IS) use, IS use vs. financial efficiency, IS use vs. quality of care, and IS use vs. clinical research support.

Results: In structural equation models (SEM), the positive bidirectional relationship between user satisfaction and IS use was only observed in the early HEGP CIS deployment phase (first four years) but disappeared in late post-adoption (≥ 8 years). From 2009 to 2015, financial efficiency of 20 AP-HP hospitals evaluated with stochastic frontier analysis (SFA) models diminished by 1% per year. A lower decrease of efficiency was observed between the two hospitals equipped with the most mature CIS than with the 18 other hospitals. Outcome quality benefits that would bring evidence to the IS use vs. quality loop are unlikely to be obtained in a near future since they require integration with general population-based outcome indicators including mortality, morbidity, and quality of life. Effective clinical research support was found from the deployment of the HEGP clinical data warehouse that was strongly coupled with the HEGP CIS.

Conclusion: Barriers to making the transformation of the utopian part of the CIS virtuous circles happen should be overcome to actually benefit the emerging eSociety.

Keywords

Information systems acceptance; Financial efficiency; Information systems outcome

1 Introduction

Les systèmes d'informations (SI) cliniques/hospitaliers/de santé (SIC/SIH/SIS) sont très largement répandus à travers le monde au bénéfice des institutions qui les déploient et des patients dont la qualité des soins est largement conditionnée par la qualité des dossiers patients électroniques (DPE), des systèmes de prescription connectée (SPC) et des systèmes d'aide à la décision (SAD) qui leur sont intégrés [1,2]. Les modèles de maturité des DPE comme le modèle EMRAM (*Electronic Medical Record Adoption Model*) de l'organisation *HIMMS Analytics* sont devenus des standards pour les stratégies de déploiement des technologies de traitement de l'information (TI) puis de benchmarking au sein et entre les institutions informatisées [3]. Aux Etats-Unis la législation sur l'utilisation significative (*Meaningful Use*) des DPE, qui assure un support financier pour les hôpitaux ou les cabinets médicaux pouvant faire la preuve d'un taux d'utilisation significatif, a eu un effet considérable sur leur diffusion rapide [4]. Ainsi au cours du dernier trimestre 2016, 35,3% des 5478 hôpitaux étudiés avaient atteint le niveau 6 ou 7 (sur une échelle de 0 à 7) du modèle de maturité HIMSS-EMRAM et 80,4% le niveau 4 ou supérieur (défini par l'intégration d'un DPE et d'un SPC multimodale à base de protocoles) [3]. En 2016, moins de 10 hôpitaux en France sont certifiés HIMSS niveau 6 et aucun au niveau 7.

Même s'ils partagent les mêmes objectifs généraux, les différentes catégories de décideurs de la santé et a fortiori les patients ont des visions contrastées lorsqu'il s'agit de déterminer des critères de succès ou d'échec d'un SI comme le montre le tableau 1.

Tableau 1 - Point de vue des différentes catégories d'acteur sur les critères de succès ou d'échec d'un SI (Adapté de [8]

Point de vue	Succès	Echec
Professionnels de santé	Satisfaction Utilisation	Mécontentement Rejet
Gestionnaires	Amélioration de la gouvernance Retour sur investissement (RSI) (financier)	Détérioration de la gouvernance Pertes financières
Personnels académiques	Taux de publications accru Financement de la recherche	Taux de publications inchangé Opportunité de financement perdues
Patients	Amélioration des résultats Réduction de la iatrogénie Protection des données individuelles	Détérioration des résultats Augmentation de la iatrogénie

Les professionnels de santé veulent percevoir les bénéfices cliniques des systèmes dans leur pratique quotidienne. Les gestionnaires s'accordent pour investir ou continuer à investir si la preuve d'un retour (financier) sur investissement (RSI) peut être apportée. Un tel RSI peut être espéré d'une meilleure prise en charge des processus métiers, d'une amélioration des communications entre professionnels, de la suppression progressive des transmissions d'information (e.g., prescriptions connectées, intégration automatique des résultats dans les dossiers patients), d'une réduction des prescriptions redondantes, et d'une amélioration des circuits de

facturation et de recouvrement des créances [2,5-10]. Les personnels académiques et les chercheurs voient dans la réutilisation des données la possibilité d'accroître le nombre et la qualité de leurs publications, mais également un facteur favorisant la mise en œuvre de protocoles de recherche clinique et leur soutien financier.

Les patients se sentent directement concernés par les résultats positifs de la prise en charge de leur problèmes médicaux (e.g., maladies chroniques), la réduction de leurs effets négatifs (iatrogénie), la sécurité des DPE et le respect de leur vie privée. Comme tous les citoyens, ils deviennent conscients de la croissance exponentielle des actes de "*ransomware*" et du risque associé à la constitution de grandes banques de dossiers nominatifs (e.g., gestion par un seul organisme, la CNAM, des dossiers personnels, regroupement dans les bases de données des grands CHU des dossiers de leurs hôpitaux, constitution des territoires de santé numériques).

Tous ces facteurs sont clairement intriqués et l'on peut proposer que leur interactions et interdépendances s'effectuent autour d'au moins 6 cercles vertueux à l'image de ceux représentés dans la figure 1. Les cercles vertueux se réfèrent à des chaînes complexes d'événements se renforçant dans une boucle de rétroaction positive ou au contraire pouvant s'annihiler lorsqu'ils ne sont pas ou plus vérifiés. Ainsi, par exemple, des utilisateurs satisfaits de leur SI seront enclins à mieux les utiliser et entrer dans une stratégie de type gagnant-gagnant avec les fournisseurs, par exemple en participant activement à des groupes de travail ou en proposant régulièrement des améliorations des logiciels. Un SI utilisé de façon adéquate améliore la qualité des soins, l'efficience économique de l'hôpital, et sert de support à la recherche clinique ou translationnelle. Les bénéfices financiers attendus peuvent se traduire par une réduction des coûts des soins mais également être réinvestis dans des programme d'amélioration de la qualité des soins et/ou de recherche. Au travers de ces boucles de rétroaction, les professionnels de santé, les chercheurs et les gestionnaires trouvent les bons arguments pour investir dans les SI et les industriels pour les promouvoir.

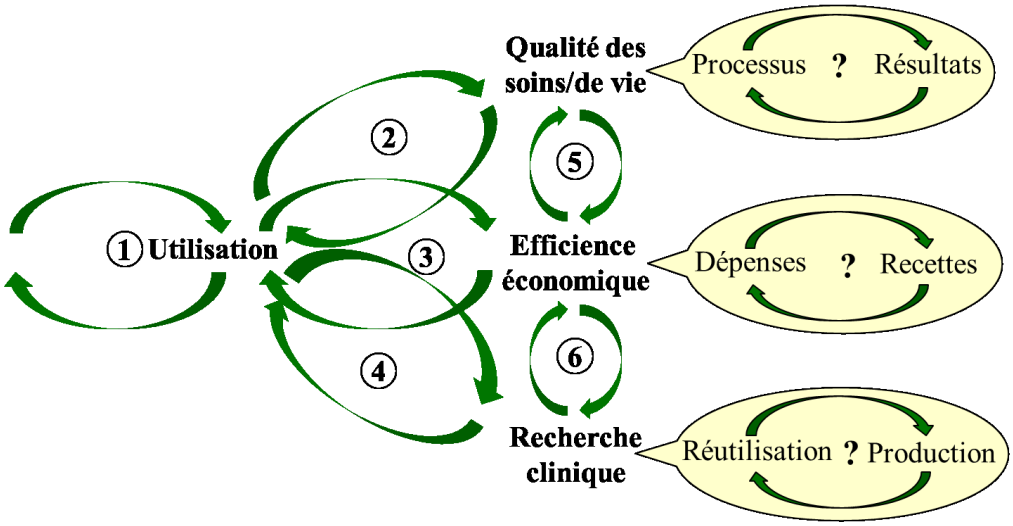

Figure 1 - Les cercles vertueux associés au déploiement des systèmes d'informations cliniques/hospitaliers/de santé. Adapté de [1]

Dans quelle mesure ces cercles vertueux sont-ils supportés par la réalité des chiffres ? Les bénéfices espérés de l'introduction d'une nouvelle technologie doivent être contrebalancés par les effets inattendus négatifs. Ainsi, par exemple, le temps de saisie d'une prescription électronique est plus lent que le temps de saisie sur papier.

La prescription informatique peut être dangereuse en l'absence d'outils d'aide à la décision (iatrogénie informatique). L'excès d'alarmes fournies par les SAD diminue leur impact sur les comportements des professionnels.

Les conclusions ou les ébauches de conclusions proposées dans cet article sont tirées de l'expérience d'utilisation du SI de l'hôpital européen Georges Pompidou à Paris (HEGP), ouvert en juillet 2000 et certifié HIMSS niveau 6 en mai 2013 et de l'interrogation des différents entrepôts de données de l'Assistance Publique Hôpitaux de Paris (AP-HP) [12]. L'hypothèse de travail est que les cercles vertueux promus par les décideurs ou les vendeurs pourraient faire partie d'une vision utopique mais productive associée au développement de la e-société [6]. Il ne s'agit nullement de tirer des conclusions à partir de l'expérience d'un seul hôpital, l'HEGP, ou d'une seule institution, l'AP-HP, mais de promouvoir le développement d'évaluations plus internationales et/ou plus globales des SI qui pourraient permettre de tester la réalité de hypothèses proposées.

2 Le cercle vertueux satisfaction-utilisation

L'évaluation continue de la satisfaction des utilisateurs est un élément essentiel de tout projet de mise en place d'un système d'information [13,14]. Elle doit être réalisée à toutes les phases d'un tel projet, i.e. durant la période de déploiement, de consolidation et d'utilisation significative (*meaningful use*) lorsque tous les utilisateurs sont supposés utiliser de façon adéquate les logiciels et que la plupart défauts majeurs ont pu être corrigés [15,16].

Les évaluations doivent s'appuyer sur des modèles validés de la littérature, basés sur des critères standardisés regroupés sous la forme de dimensions ou construits. Deux catégories principales peuvent être considérées, les modèles d'acceptation (satisfaction) et les modèle de succès. Les modèles TAM (*Technology Acceptance Model*) de Davis et coll. et ses extensions (TAM2, UTAUT) [19-21] et le modèle ECM (*Expectation Confirmation Model of information system continuance*) de Bhattacherjee [22] s'inscrivent dans la première catégorie. Le modèle ISSM (*Information Success Model*) de DeLone and McLean fait intervenir des critères de succès attendu d'un SI [17,18]. Le recueil de données peut être effectué dans le cadre d'interviews de groupe, d'enquêtes par questionnaires standardisés, d'études ethnographiques avec enregistrements vidéo ou de combinaison de ces techniques.

La sélection des dimensions et de leur importance dépend du stade de déploiement du SI [15]. Dans les phases de déploiement précoces, il est important d'observer les professionnels au plus près de leur environnement professionnel de façon à apprécier la facilité d'utilisation des SI et les processus d'interaction (utilisabilité), de même que les performances du système, la qualité de la formation initiale et du support (e.g., réparation des matériels, correction des bogues, et d'une façon générale la réponse du SI aux attentes des utilisateurs. Dans une phase d'utilisation significative, la satisfaction peut dépendre des caractéristiques des utilisateurs de la qualité du système et de capacité à s'adapter aux changements demandés par des utilisateurs bien formés [16].

La figure 2 illustre les dimensions retenues pour évaluer le SIC de l'HEGP depuis l'ouverture de cet hôpital en Juillet 2000 [14-16] et les hypothèses de recherche associées au modèle d'évaluation UMISC (*Unified Model of Information System Continuance*) [16]. Les hypothèses H_{13} et H_{14} correspondent à la boucle satisfaction-utilisation décrite précédemment. Les caractéristiques individuelles des patients sont

considérées comme des modérateurs et incluent l'âge, le sexe, et la profession médicale (H_a à H_d). 5 évaluations successives ont été réalisées en 2004, 2008, 2011, et chaque année de 2013 à 2015.

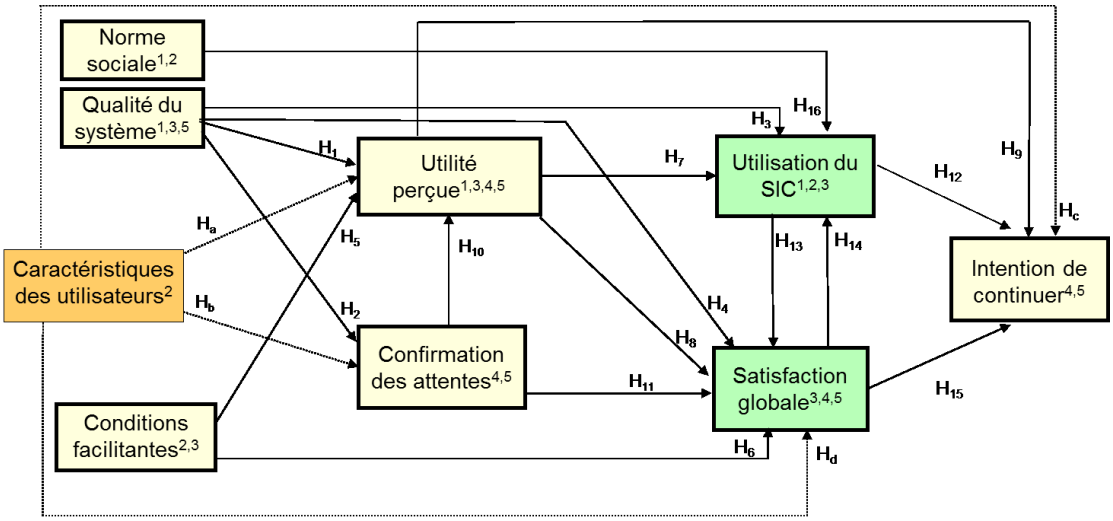

Figure 2- Le modèle unifié de l'intention de continuer à utiliser une SIC (UMISC) développé à l'HEGP (Source : [16]).

Les dimensions de l'évaluation sont sélectionnées à partir de modèles validés de la littérature : 1= Technology Acceptance Model 2 (TAM2) [19,20], 2 = Unified Theory of Acceptance and Use of Technology (UTAUT) [19-21], 3= Information System Success Model (ISSM) [17], 4= Expectation Confirmation Model (ECM) [22], 5= Information Technology Post Adoption Model (ITPAM) [14]

Les enquêtes sont basées sur des questionnaires auto-administrés et comportent de 51 à 58 questions. L'utilisation déclarée est évaluée sur une échelle de 1 à 7 pour chacune des 18 fonctions considérées (1 = non disponible, non utilisé ou non adapté à ma fonction, 2 = très rarement, 3 = rarement 4 = occasionnellement, 5 = assez fréquemment, 6 = fréquemment, 7 = très fréquemment).

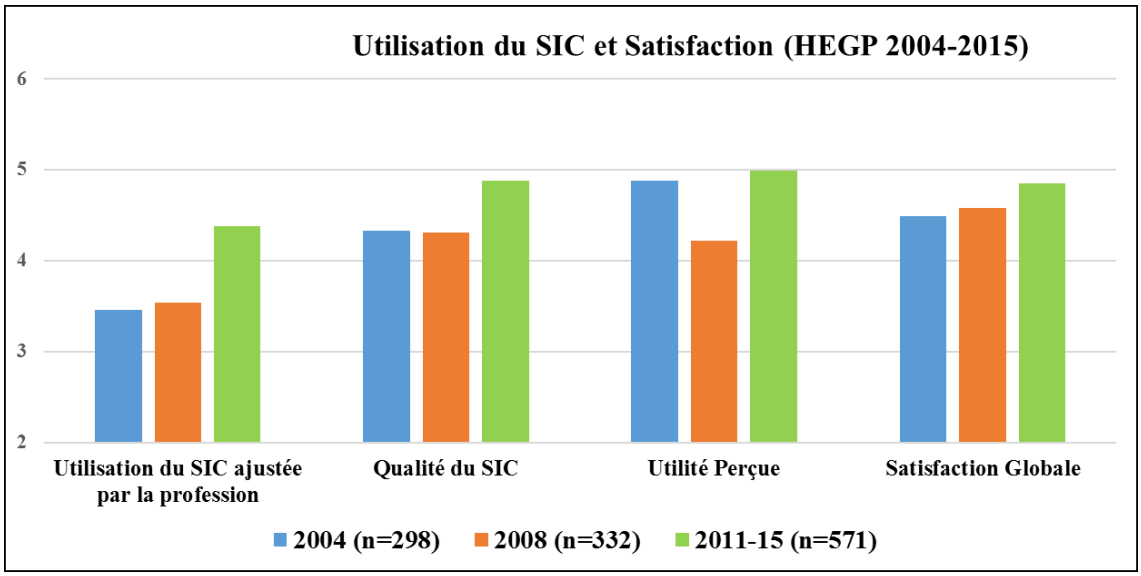

Figure 3- Evaluation de l'acceptabilité du SIC de l'HEGP lors de trois périodes successives d'évaluation (Adapté de [1]

Les réponses aux questions relatives aux dimensions de l'évaluation sont évaluées sur des échelles de Likert allant de 1 à 7. L'utilisation du SIC augmente significativement de 2004 à 2015, parallèlement à l'augmentation de la satisfaction et de ses déterminants, et ce ceci même en période de post-adoption tardive comme le montre la figure 3.

Dans les modèles de régression multiples et d'équations structurelles, la relation bilatérale entre utilisation et satisfaction, présente au début du déploiement (4 ans) disparait en phase de déploiement tardif (8 ans et plus) [15,23]. En période d'utilisation significative, tous les utilisateurs accèdent au système d'information, quel que soit leur niveau de satisfaction, la disparition de la relation bilatérale pouvant alors être considérée comme un signe de maturité du SI.

3 Le cercle vertueux utilisation - efficience économique

La plupart des appels d'offres l'acquisition d'un système d'information clinique comportent un chapitre sur le retour sur investissement (RSI) et les vendeurs font tous les efforts possibles pour trouver, au sein de leurs clients, des éléments financiers pour la promotion de leurs produits. Comme d'autres, nous pensons que les chiffres de RSI sont souvent surestimés et/ou biaisés [24,25]. Les principales limites de ces études sont résumées dans les paragraphes suivants.

Le contexte du système d'information de santé sous-jacent (e.g., couverture universelle ou non, assurances complémentaires, politique de remboursement) est un élément déterminant dans le choix des modèles financier d'évaluation. Des études réalisées avec des systèmes différents ont peu de chances de donner des résultats comparables. Par exemple, une réduction de l'utilisation inappropriée du système de santé est un résultat espéré à l'échelon national de la mise en œuvre des SI. Dans un système de financement basé sur l'activité, la réduction de l'activité va rentrer dans la colonne négative d'hôpitaux (T2A en France) ou de praticiens extrahospitaliers (paiement à l'acte) facturant leurs services. Un système informatisé efficace de récupération des impayés ou d'optimisation du codage est positif pour le budget d'un hôpital mais augmente les dépenses de santé globales. La réduction des durées de séjour est associée à une efficience hospitalière accrue et de fait à une augmentation des dépenses globales par augmentation du nombre de séjours et, éventuellement, à des coûts induits (e.g., soins de suite, soins à domicile, réhospitalisations secondaires). Les bénéfices potentiels des 79-81 milliards de dollars espérés de la mise en place de dossiers électroniques interopérables [5] se sont fondus dans l'augmentation rapide des dépenses liées à l'augmentation de la couverture sociale dans le cadre de l'*Affordable Care Act* [26].

La plupart des études économiques (e.g., avant 2005) concernent un nombre limité d'institutions ayant développé leurs SI en interne sur de longues périodes de temps. Les déploiements les plus récents font référence à un petit nombre de solutions industrielles avec des stratégies agressives de déploiement (e.g., 1-3 ans) [27]. L'adaptation aux situations locales peut d'être d'autant plus problématique que le nombre de clients augmente de par le monde peut générer des coûts d'adaptation prohibitifs.

Les bénéfices financiers sont souvent décalés (e.g., 3 à 5 ans) une fois un niveau suffisant de maturité atteint, les premières phases étant financièrement contre-productives [8,28]. Les études financières centrées sur de courtes périodes ont ainsi peu de chance de donner des résultats significatifs. Les coûts de migration d'une

solution interne vers une solution commerciale ou d'un niveau EMRAM de maturité *x* vers un niveau *y* sont insuffisamment documentés.

Des évaluations réalisées sur des unités de soin sélectionnées ou des sous-ensembles du SI (e.g., DPE, SPC, PACS) sont sujettes à des biais de sélection. Un SI est plus que la somme de ses constituants. Les bénéfices, lorsqu'ils existent, se trouvent dans des niveaux élevés de maturité (niveaux 6 et 7 du modèle EMRAM) [8,28]. Ils sont également liés à l'amélioration des communications de l'institution avec l'extérieur (e.g., généraliste, soins de rééducation, soins à domicile). Dans la revue de la littérature de Bassi et coll. sur 33 études économiques, seulement 4 articles concernaient une institution dans son ensemble [10] dont l'un était jugé négatif [27].

La monétisation de données non monétaires (e.g., la transformation en unités monétaires de la réduction de la iatrogénie thérapeutique) telle qu'elle est réalisée dans certaines études coûts-bénéfices ou coûts-conséquences est la stratégie la plus risquée [8,10]. L'accumulation de variables financières n'est pas un gage de qualité mais conduit à des modèles de plus en plus complexes au risque de ne pas prendre en compte les corrélations fortes entre les variables. Par exemple, les bénéfices associés à la réduction de la iatrogénie médicamenteuse avec un système d'aide à la prescription ne se cumulent pas mais doivent être combinés avec les erreurs générées par les systèmes de prescription (e-iatrogénèse) ou l'augmentation de la charge de travail des professionnels qui les utilisent [30,33].

Les limitations des études traditionnelles de retour sur investissement ont été une incitation forte à l'utilisation de méthodes économétriques sur des séries de données chronologiques recueillies au niveau global de plusieurs hôpitaux. Il s'agit alors de déterminer les relations entre le degré d'informatisation et l'efficience financière de ces hôpitaux. D'une façon générale, les études économétriques cherchent à relier un nombre limité de ressources (e.g., nombre de lits, dépenses en personnels et hors personnels, investissements) considérées comme des entrées avec des variables d'activité et/ou de recettes considérées comme autant de sorties du système [34,35]. Les outils de modélisation les plus utilisés concernent les fonctions de production de type Cobb-Douglas ou Translog, les outils d'analyse d'enveloppement de données (DEA) et de frontières stochastiques (SFA) [37,38]. Les dépenses et investissements IT peuvent être intégrés dans les variables d'entrées ou utilisés comme modérateurs des équations reliant entrées et sorties [39].

Dans une étude préliminaire utilisant des fonctions de Cobb-Douglas réalisée sur 17 hôpitaux de court séjour de l'AP-HP incluant l'HEGP, nous avons observé une relation positive et significative entre les investissements IT (incluant capital et travail) et la productivité hospitalière évaluée sur une période de 8 ans (1998–2005) **[**34**].** Les bénéfices espérés des investissements effectués étaient directement liés au niveau d'intégration du SI, d'autant plus élevés que l'intégration était forte.

Sur un ensemble plus large de données (21 hôpitaux de court séjour de l'APHP, 1998-2006), les entrées IT et non IT ont un effet significatif sur la productivité hospitalière. Les données de 2006 étaient prédites à partir des données de la période 1998-2005 avec une précision de 99,4% **[**39**].**

Mais faire la preuve que les dépenses associées au SI contribuent significativement au recettes ne suffit pas à démontrer qu'une augmentation de l'utilisation des SI sera associée à une efficience financière accrue. Sur un ensemble de données plus récentes (20 hôpitaux, période 2009-2013), les scores d'efficience financière dans un modèle SFA à 4 entrées (nombre de lits, dépenses en personnel médical, dépenses en

personnel non médical, dépenses hors personnel) et une sortie (recettes d'activité et hors activité), ont globalement diminué de 0,5% par an alors que les dépenses informatiques étaient clairement en augmentation (figure 4). La diminution d'efficience était par contre inférieure dans les 3 hôpitaux disposant du SI le plus avance (HEGP, Robert Debré, Ambroise Paré) que dans les 17 autres hôpitaux, une différence du même ordre de grandeur que celle observée entre les 3 hôpitaux pédiatriques et les 17 autres hôpitaux**.** Les ordres de grandeur des différences observées sont comparables à ceux observés entre hôpitaux pédiatriques et non pédiatriques.

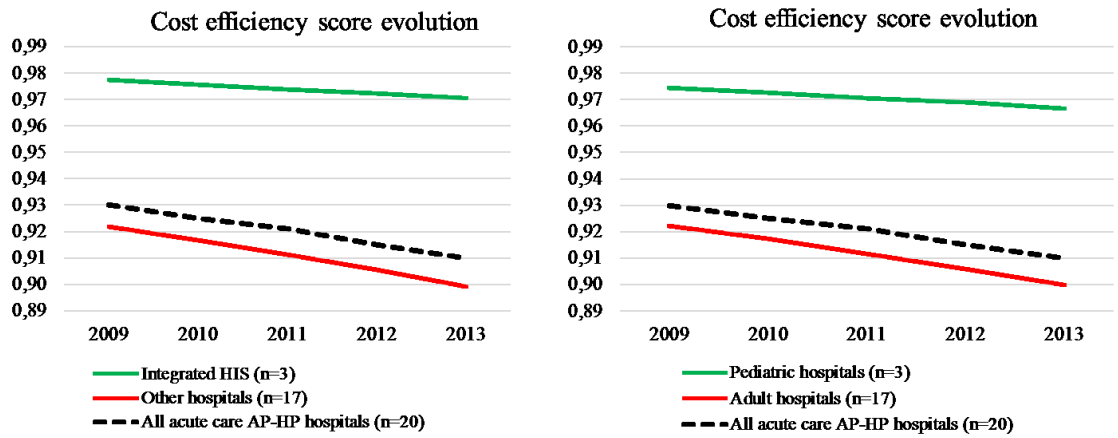

Figure 4. Evolution du score d'efficience financière des 3 hôpitaux disposant d'un SI avancé par rapport aux 17 autres hôpitaux de l'AP-HP (adapté de [1]

4 Le cercle vertueux utilisation - qualité des soins

Les bénéfices principaux en terme de qualité des soins proviennent de l'amélioration des processus. Les SI améliorent l'adhérence aux guides de bonne pratique, en particulier dans le domaine de la prévention (e.g., vaccinations) et/ou réduisent la iatrogénèse grâce à la mise en place de protocoles adaptés (e.g., prévention des infections post-opératoires et des embolies pulmonaires, ulcères de pression, chutes) [7]. L'utilisation généralisée des prescriptions connectées dans un SIC facilite l'adhérence aux règles de bonne pratique (alignement clinique) et a été associée avec une réduction de la iatrogénie médicamenteuse ou associée aux investigations complémentaires [40,41].

La mortalité hospitalière est l'indicateur de résultat utilisé le plus fréquemment et une corrélation négative avec le niveau d'informatisation des SI a été observée par Beard dans une étude de plus de 2000 hôpitaux aux USA [28].

Malgré quelques résultats encourageants, la preuve d'une relation entre maturité IT et indicateurs de résultats a peu de chance d'être obtenue à court terme dans un contexte hospitalier strict. Plusieurs arguments peuvent être avancés.

Comme le souligne Riskin et coll., alors que l'importance de la qualité des soins fait consensus, les discussions sur ce qui est réellement mesuré et ce qui peut en être conclu sont largement insuffisantes [25]. Les efforts se concentrent sur l'évaluation des processus (par exemple le contrôle de l'hémoglobine A1 chez les malades diabétiques) et non sur la qualité des résultats (par exemple la réduction des complications du diabète) qui devraient constituer l'objectif principal des études sur la qualité des soins. Les métriques de qualité utilisées par Welch et coll, Zhou et coll. ou

Acker et coll. sont essentiellement des métriques de processus et l'amélioration des processus n'est en rien une garantie d'amélioration des résultats [42-44].

Une stratégie appropriée doit être trouvée pour valider la boucle vertueuse utilisation-qualité des soins et quantifier la liaison bidirectionnelle espérée entre processus et résultats. Le degré d'utilisation du SI peut alors être réintroduit comme un facteur de modération de cette relation dans un modèle global comme celui de la figure 1. De nombreuses études d'évaluation de la qualité concernent des environnements extra et non intra-hospitaliers et ne peuvent être utilisés directement [42-44]. Dans le cadre des études effectuée à l'hôpital, les résultats peuvent être biaisés par une surreprésentation des hôpitaux universitaires au détriment des hôpitaux conventionnels [7], la sélection d'unités de soins particulières et non de la totalité de l'hôpital ou encore de sous-ensembles du système d'information et non de sa totalité (par exemple un système d'aide à la décision, un système de prescription connectée) [45,46].

La réduction de la iatrogénie médicale est un objectif majeur de qualité. Mais de nombreuse complications (par exemple la mortalité per- et surtout post-opératoire peuvent avoir un déterminant iatrogénique mais aussi correspondre à l'évolution naturelle de la maladie (sévérité du cas traité) pour une qualité des soins données. Des séries temporelles, ajustée par rapport à la sévérité des cas et réalisées dans des environnements multicentriques seront plus informatives que des études de type avant/après. Des complications observées après la sortie des patients (mortalité à 30 jours, morbidité) sont en partie liée aux conditions des patients à l'entrée et à d'éventuels défauts de qualité. D'une façon plus générale et dans le contexte de la prise en charge des pathologies chroniques, les réponses aux questions concernant la qualité ont de fortes chances de se trouver en dehors du champ restreint des périodes d'hospitalisation. Des exemples en sont le contrôle de l'hypertension ou du diabète, la prévention des complications secondaires des maladies, l'évolution à long terme des cancers ou les déterminants de la qualité de vie [47]. Apprécier l'effet des SI revient à intégrer les données hospitalières avec les données d'autres systèmes d'information (médecine libérale, caisses d'assurance maladie, etc.) qui ne constituent pas, aujourd'hui, un tout homogène.

5 Le cercle vertueux utilisation - recherche

Le développement d'entrepôts de données cliniques (EDC), alimentés à partir des systèmes d'information cliniques existants, facilite la réutilisation des données et donc la recherche clinique sous différentes formes. Les EDC apparaissent dans le niveau 7 du modèle de maturité EMRAM [3]. L'interrogation directe des bases de production d'un SIC peut ralentir son fonctionnement harmonieux. L'interrogation d'une base miroir pose peu de risque de dysfonctionnement mais nécessite une connaissance approfondie des modèles de données et un apprentissage prolongé. L'utilisation de modèles simplifiés comme le modèle en étoile i2b2 utilisé à l'HEGP [48-50] et d'interfaces conviviaux permet d'ouvrir les possibilités d'interrogation à un nombre élevé de professionnels de santé.

Les EDC peuvent servir à la réalisation d'études épidémiologiques, d'évaluation de la qualité et des pratiques et/ou de recherche translationnelle lorsque les données phénotypiques sont couplées à des données omiques, par exemple dans le contexte d'une médecine plus personnalisée [51,52].

Dans le domaine de la thérapeutique à l'HEGP, l'EDC a été considéré comme un outil essentiel pour l'évaluation de la fréquence des erreurs de prescription ou de dispensation des médicaments [53,54], l'impact des alertes sur l'ajustement des doses [55,56], mais également pour la détection des interactions médicamenteuses [57] ou pour l'évaluation "in silico" de règles de décision thérapeutique avant leur intégration dans le système de production [58].

Le tableau 1 illustre, à titre d'exemple, l'activité de recherche représentée par le nombre de projets de recherche validés par la commission éthique et recherche de l'HEGP pendant la période 2011-2015. 74 ont été retenus [50]. Ils concernent 17 services différents, soit plus de 70% de la totalité des services de l'HEGP.

Tableau 1 – Nombre et nature des projets de recherché réalisés avec l'entrepôt de données cliniques de l'HEGP de 2011 à 2015 (adapté de [50])

Année	**Nb. projets**	**Nb. services**	**Epidémio-logie clinique**	**Evaluation des pratiques**	**Recherche clinique**
2011	13	5	8	5	0
2012	4	4	1	3	0
2013	13	10	8	4	1
2014	22	11	14	5	3
2015	22	10	9	13	0
Total (%)	74 (100%)	17 (71%)	40 (54%)	30 (41%)	4 (5%)

6 Discussion et conclusion

Les incitations nationales et internationales ont eu un effet significatif sur l'utilisation des systèmes d'informations cliniques hospitaliers comme des systèmes de gestion des cabinets médicaux extrahospitaliers [3,59]. Les SI génèrent automatiquement des informations qui ne pouvaient être obtenus, dans l'ère pré-SI, que par l'analyse et le dépouillement manuel de dossiers papiers volumineux et le plus souvent incomplets [59-61]. Le temps est venu où les cercles vertueux suggérés par le développement et le marketing des SI peuvent être testés dans la vraie vie.

Les exemples donnés dans cet article, à partir de l'utilisation des entrepôts de l'HEGP et de l'AP-HP et d'une littérature nécessairement biaisée, peuvent suggérer que ces cercles vertueux font partie d'une vision en grande partie utopique des SI. Le premier exemple, à propos du cercle vertueux satisfaction-utilisation des SI, n'a été confirmé à l'HEGP que dans les phases initiales de déploiement de son SIC intégré. La disparition de la relation bilatérale entre satisfaction et utilisation pourrait au contraire devenir un critère de maturité d'un SI. Dans un hôpital sans papier, tous les utilisateurs se servent du SI, indépendamment de leur degré de satisfaction. Le second cercle vertueux (utilisation - efficience financière), même s'il est retrouvé dans plusieurs études économétriques, peut disparaître statistiquement dans le contexte d'efforts de réduction drastique des dépenses touchant à la fois les hôpitaux informatisés et non informatisés. Les dépenses informatiques ne représentant qu'une faible partie des dépenses hospitalières (1 à 3%), il est raisonnable de penser que les différences, si elles sont observées, ont peu de chances de dépasser des augmentations en pourcentages à deux chiffres.

L'analyse du troisième cercle (utilisation - qualité) est importante compte tenu d'un contexte où la recherche d'efficience peut être associée à une réduction des effectifs et donc du temps passé par les soignants au contact des patients avec le risque d'une détérioration des indicateurs de qualité. Les soins hospitaliers dans les hôpitaux de court séjour comme l'HEGP n'intéressent qu'une très faible partie de la trajectoire des patients. Les résultats intéressants en termes de résultats médicaux (*outcome*) ont toutes les chances de s'observer en dehors de ces périodes d'hospitalisation et donc des systèmes d'information clinique hospitaliers. Dans le contexte hospitalier, ce sont essentiellement les taux d'incidents, la iatrogénie (infections nosocomiales, embolies pulmonaires, chutes par exemple) et la mortalité globale ou spécifique (mortalité par infarctus par exemple) qui pourront être quantifiés.

Des considérations générales et des directions pour valider/infirmer la réalité des cercles vertueux peuvent cependant être proposées. Les évaluations doivent concerner les systèmes d'information hospitaliers dans leur ensemble, considérés comme des boites noires et non leurs sous-ensembles (par exemple un réseau d'images, la prescription connectée ou un outil de télémédecine). Elles doivent être multicentriques, répétées dans le temps et croisées avec l'évolution parallèle des systèmes de santé.

Les méthodes de mesure de l'utilisation des systèmes d'information sont cruciales et standardisées pour permettre des comparaisons intra- et inter-établissements (granularité des fonctions utilisées, échelles de mesure, etc.). L'utilisation déclarée doit être comparée à l'utilisation réelle tracée dans les SI. Les mesure de l'utilisation, de la satisfaction et de ses déterminants doivent être combinées dans des indicateurs de maturité plus globaux.

Les indicateurs associés à chacun des cercles vertueux de la figure 1 doivent être clairement séparés de façons à pouvoir analyser leurs déterminants respectifs comme leur intrication dans des modèles explicatifs plus globaux.

Dans le domaine de la qualité des soins, les indicateurs de qualité, comme c'est trop souvent le cas, doivent quitter de domaine des processus et de leur conformité aux guides de bonne pratique pour englober des indicateurs de résultats plus globaux associés au trajectoires intra et extra-hospitalières (mortalité, qualité de vie, etc.). L'alimentation dans ce contexte des entrepôts cliniques hospitaliers avec les données des registres et/ou des grandes banques de données nationales (causes de décès, bases de données de l'Assurance Maladie pour ne donner que deux exemples) représente la piste de progrès la plus prometteuse pour les deux décennies à venir. Restera à valider dans ce contexte la réalité des cercles vertueux à l'échelon de systèmes d'information régionaux ou nationaux.

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Adresse de correspondance

Patrice Degoulet
Laboratoire de Santé Publique et Informatique Médicale
Faculté de Médecine René Descartes et INSERM
15, rue de l'Ecole de Médecine, 75006 Paris

eMail: patrice.degoulet@aphp.fr

Chapter II

Determinants of hospital performance in a health care quality framework

2.1 Hospital performance in terms of quality of care

In 1966, Donabedian *et al.* proposed the study of health care quality in three aspects of care provision, structure, process, and outcome [Donabedian 1966], and defined health care outcomes in terms of recovery, restoration of function and survival [Donabedian 1966]. The Institute of Medicine proposed six dimensions of quality, namely safety, effectivity, timeliness, efficiency, equitability and patient-centeredness [IOM 2001], where safety relates to minimization of risks and harm from receiving care or adverse events of health care [AHRQ 2007]. Even if health care assessment historically focused on processes and structures, clinical outcome measures could be more relevant to assess the quality of care patients receive [Lloyd 2014]. Even if process indicators are more sensitive for directly assessing quality, clinical outcomes reflect all aspects of care in the final product of the health care process [Mant 2001]. Therefore, clinical outcome assessment could help improve the quality and efficiency of care, mainly by allowing comparisons among health institutions and assisting consumers to choose health care providers [Mainz 2003]. Additionally, regardless of the kind of organization hospitals in terms of ownership, profit seek nature or tax status, hospitals are run in such a way that resources must be optimized, and outcomes must be improved for the sake of a better health care for the population. Therefore, despite the various aspects and domains of health care quality indicators, safety and effectiveness are the most frequently represented dimensions, within the outcome aspect of Donabedian framework [Copnell 2009].

Healthcare Quality indicators were developed with the aims of improving the quality and efficiency of care. The development of indicators, which include a set of norms, criteria, standards, and other measures used in determining the quality of health care, its planning, and

delivery did not occur in a systematic fashion and some aspects received more attention than others [Copnell 2009]. However, health care quality indicators were developed driven by data availability without considering the purpose, feasibility, or health care context, can lead to measurement incoherence [Evans 2009]. Therefore, technical issues, such availability and reliability of data, as well as coding validity, robustness, sensitivity, and specificity, should condition the preferred use of some measures over others [Freeman 2002]. Even if the continuous monitoring of measures of health care quality and patient safety is a key element of strategies aimed to improve quality, standardized actionable indicators need to be implemented [Carinci 2015]. Health care services have major effects on outcomes, and therefore, the use of clinical outcomes as performance indicator is encouraged. Clinical outcome indicators are increasingly being used, not only for influencing clinical practice, but also to allow strategic decisions by hospitals to improve the quality of health care. Additionally, considering clinical outcomes, and in particular safety indicators, as measures of hospital quality of care could have several implications. Significant financial savings can derive from investments to reduce patient safety incidents [Degoulet 2017]. However, in order to allow reliable interpretation of clinical outcomes and comparisons among hospitals, the standardization of practices implemented in the assessment of quality of care is required, namely the collection of data and the adjustment by case-mix and clinical risk [Mant 2001]. The literature review provided with evidence that the field of the hospital care quality assessment has been considerably developed in the past decades. Clinical outcome indicators can be assessed for the domain to which they apply, mainly to hospital-wide, surgical, and non-surgical domains, as well as for clinical specialties and hospital departments [Copnell 2009].

2.2 Application of health care quality indicators

In general quality measures are based on clinical outcomes are frequently expressed on diagnosis codes of WHO International Classification of Diseases, which have different adaptation in each different country, found on hospital discharge records [OECD 2021]. Departing from medico-economic data codes for diagnoses and treatments, the health care quality can be assessed in terms of clinical outcome indicators classified in two main categories: morbidity and mortality. The review of literature and databases in Study B, included in this chapter, allowed to select a set of health care quality indicators by relevance and the frequency of use for hospital performance assessment. Consistent with the literature review,

hospital-wide domain and the surgical patient domain are considered separately in this research, albeit surgical patients are part of the bigger hospital-wide population. The set of selected indicators served as a guide to build hospital care quality indicators from data available in international and French databases, with the purpose of being integrated into models for acute care quality assessment. However, in order to allow accurate comparisons, the selection of clinical outcome indicators should prioritize a consensus in definitions of indicators, wide availability in countries, and standardized methods to measure them. For instance, definitions of some clinical outcome indicators are not congruent for pressure ulcers, stroke and hip fracture, differing in the number of ICD-10 codes considered in their definitions by the OECD and the AHRQ [McLoughlin 2006; AHRQ 2022].

In the research articles included in this chapter, article 2 and 3, aggregated rates of clinical outcomes were extracted from the OECD Statistics and from WHO Health Information Platform for the Americas (PLISA) tools for all countries involved, and from PMSI by with Maincare-DimBench® tool for France [PAHO 2021; OECD 2022]. In France, hospital mortality rates were built from the number of deceased in-hospital patients coded with PMSI exit code 9, over the number of hospital discharges of all in-mortality and by DRG principal diagnosis code. Hospital morbidity rates were built from the number of adverse events over the number of hospital discharges for stays of 48 hours and more. The rates of incidence were computed, for the six conditions coded as a secondary diagnosis and not as primary diagnosis. Similarly, perioperative mortality and morbidity data were obtained from hospital discharges coded in the category of care activity C of the French classification of stays– *Catégories d'activités de soins*, *CAS*–.

2.3 Health care systems' performance

The assessment of health care quality indicators attracted a growing interest among policymakers and citizens [Papanicolas 2013; OECD 2019]. Even if the assessment of health care systems performance observes more than one domain of health care quality, the analysis of hospital clinical outcomes, namely patient safety, is widely preferred to assess the final performance of the system. The interest for the assessment of health care quality in international comparisons increased with the objective to evaluate policy, guide policymaking,

and adapt health systems to new challenges in terms of health care access, coverage and quality of care for their populations. Moreover, the OECD, EU and USA lead open-participation programs for permanent updating of health care quality indicators.

However, international comparisons must account for macroeconomic and multiple local factors, namely population structure and geopolitical, economic, sociocultural, and healthcare-system-based factors [OECD 2019]; i.e., big differences in the structuration of health systems can be found in countries sharing geopolitical, sociocultural or many other similarities [OECD 2019a; Papanicolas 2018; WHO 2000]. The demographic factors include statistical measures influencing population growth or decline, as well as parameters particularly important in the assessment of health systems performance, and they can be grouped as follows: 1) Population statistics, including indicators of the population size, density, age structure, sex ratio, and dependency rates [World Bank 2019]; 2) Vital statistics, including birth rate, death rate, natural growth rate, life expectancy at birth, and fertility, and fecundity [OECD 2019b]; 3) Risk factors, including risk behaviors, namely smoking and alcohol consumption rates, and comorbidities, namely diabetes, hypertension and obesity rates [WHO 2018b, 2018a]; 4) Healthcare-system-based factors such as health insurance coverage, access to healthcare, and health financial risk protection [WHO 2021a]. The financial risk protection importance relates to World bank and WHO findings that, every year, at least 100 million people fall into extreme poverty due to health care expenses [WHO and World Bank 2017]. For international comparisons, The World Bank permanently updates a set of socio-economic indicators, which is publicly available in its World Development Indicators program [World Bank 2019b]. Furthermore, the socio-economic status, including education level, social class level and income level, is a determinant of health inequalities among older adults [Darin-Mattsson 2017]. For instance, the risk for readmission from heart failure in patients 65 years and older has a positive cumulative effect by race and marital status, albeit the educational level of a patient showed no effect [Damiani 2015]. Similarly, mortality and healthcare performance status in stroke patients vary according to socio-economic factors [Kim 2021a]. The socio-economic indicators having an influence on the health of populations could be grouped as follows: 1) Income distribution, which includes income level and GDP per capita; 2) Population dynamics, which includes education level, unemployment rates [ILO 2019; World Bank 2019]; and 3) Economic structure, which includes parity purchasing power and global health expenditure [World Bank 2019]. The systematic report of quality indicators in an increasing number of international projects and programmes, reveals the growing interest in

quality improvement as well as international efforts in achieving consensus by standardizing measures. Several countries in the world are following lessons from unified health systems, like the French health systems, in health policy, but in any case, the permanent assessment of health care quality indicators could be best practice to accurately measure the success of policies and to guide further decisions. Regardless of the country, the adoption of activity-based financing systems is associated with a tendency to increase the cost of care, mainly driven by an increase in hospital activity. Thereupon, the special interest in the assessment of trends of clinical outcomes to assess the health system performance.

This chapter includes two articles, article 2 and 3, provided with a global assessment of health care systems by observing macroeconomic health indicators, activity, and clinical outcomes. The article 2, included in this chapter, provides with an analysis of a set selected factors related to the health of populations integrated in comparisons of the performance of health systems, and a preliminary analysis of clinical outcome indicators in France. The preliminary results of this observational study on international comparisons of health systems shed light on the implications of activity-based financing on hospital activity and health care quality. The first hypothesis in this study was that a significant increase in hospital activity indicators can be observed in countries having implemented an activity-based financing system. The second hypothesis states that significant increase can be observed in the rates of incidence of hospital adverse events. This study is based on queries obtained from data available in the OECD 2019 statistics database, and from French public databases [OECD 2019, ATIH 2019] during the period of study 2013-2107.

Trends in clinical outcome rates were assessed by applying the Cochran-Armitage test for trend in the analysis of binomial proportions, in this case rates, across the levels of a single factor or covariate, in this case the year [Armitage 2008]. For each indicator, a contingency table was prepared where the indicator is the response variable of two levels (event/non-event) and the explanatory variable year is ordinal. The *Cochran-Armitage* test is based on the weighted linear regression of a binomial proportion, i.e., in-hospital mortality rate (death/survived), on the levels of an explanatory variable, i.e., the year as an ordinal variable. The null hypothesis is that there is not a significant trend in the proportion across time.

The Cochran-Armitage test for trend test statistic is written as follows:

$$T = \frac{\sum_{i=1}^{R} n_{i=1}\ (R_i - \bar{R})}{\sqrt{p1(1-p1)s^2}}$$

Notation:

R=rows, in this case, year; s^2=variance computed as: $s^2 = \sum_{i=1}^{R} n_i\ (R_i - \bar{R})^2$

In this study the two-sided *p*-value, referred as P_2, is computed as follows:

$$P_2 = Prob\ (|Trend\ Statistic| > |T|)$$

At a national level, the existence of a unified health system in France acted in favor of the obtention of homogeneous data from centralized records, allowing comparisons among hospitals from not-for-profit and for-profit sectors. This preliminary study of French health care system from an international perspective, observed significant trends in activity indicators suggest that the increase in hospital activity in France, paired with measures aimed to optimize resources, namely reductions in beds and nursing staff, could be associated with the increase in rates of adverse events in full-admission, namely sepsis, bacterial pneumonia, nosocomial factors, osteoarticular prosthesis infection, complication of antibiotics, pressure ulcer and surgical complications.

2.4 Policy impact evaluation in health care systems

The article 3, included in this chapter, conducted an impact evaluation of the implementation of the unified health system in care systems of Brazil, controlling for Argentina having a mixed health system and never implemented a unified system. The analyses focused on indicators of preventative care, health access and financial protection, and clinical outcomes for comparison of health systems performance of the two countries with data available from the period 2000-2016.

The Difference-in-differences method, applied in this analysis, also known as the controlled before-and-after study, is the gold standard statistical method in policy impact evaluation [Fredriksson 2019]. The Difference-in-differences method application in this cross-sectional treatment-control allowed to obtain an estimation of the effects of the implementation of a non-randomly implemented policy, considered as treatment. It allowed to infer strong associations

of a policy treatment implemented in one country, and not in the control country, with the outcomes. By eliminating the common trend as well as constant differences between the two countries, the difference-in-differences regression method assess the treatment effect on the sign and magnitude of the estimate of the to β_3.

The mathematical formalization can be written as follows:

$$\beta_3 = [E(Y \mid T_{post\text{-}policy}) - E(Y \mid T_{pre\text{-}policy})] - [E(Y \mid C_{post\text{-}policy}) - E(Y \mid C_{pre\text{-}policy})]$$

Notation:

β_3=difference-in-differences estimate; E=expected value; Y=Values in the group having implemented the policy; C=Value in the control group not having implemented the policy; T=Theoretical value without treatment ;

The application to the case of policy impact evaluation was formalized as follows :

$$y = \beta_0 + \beta_1\, treatment + \beta_2\, end\ point + \beta_3\, treatment{*}end\ point + \varepsilon$$

Notation:

y=observed value at the end state point; β_3=difference-in-differences estimate

end point=dummy variable for period : *end state*=0 at starting point, *end state*=1 at end point;

treatment=treatment being evaluated : *treatment*=0 if no treatment, *treatment*=1 if treatment;

The results of the comparative analysis showed that Brazil have performed better than Argentina in terms of the decline in communicable and non-communicable disease mortality since the implementation of a unified health system. The assessment of aggregated clinical outcomes in this study provided with evidence for the utility of clinical outcomes on policy impact analysis, by allowing a comparison of the outcomes of different health policy paths followed by each country and providing with empirical evidence in favor of the choice of a unified health system for South American countries [Benitez Collante 2021]. The difference in percentage between 2000 and 2016, obtained through difference-in-differences method, outweighed the difference between observed results after the implementation of the policy and the case this was not implemented, in terms of communicable maternal, perinatal, nutritional conditions (–38.8%), communicable diseases (–49.3%), noncommunicable diseases (–22.1%) and Cancer (–2.2%). However, since further research would determine if the control case in this study, Argentina may be entering the syndrome of mixed health systems, failing to effect quality because of financing deficits [Nishtar, 2009].

Study B – Systematic review on indicators and methods in health care quality assessment

B.1 Methods

A systematic review of literature on methods for the assessment of health care quality was conducted following the PRISMA protocol [Moher 2009]. The objective was to select a set of set of indicators implemented in the assessment of health care quality in acute care hospital settings. The search and retrieval process of articles, published between year 2000 to 2022, considered MeSH terms for acute care quality assessment by using clinical outcome and patient safety indicators (Figures B1 and 2B), meeting the validity criteria considered in Table B1.

Medline and Cochrane
Hospitals (MeSH) AND Quality of Health Care (MeSH) AND (Outcome Assessment, Health Care (MeSH) OR Quality Assurance, Health Care (MeSH)) AND Quality Indicators, Health Care (MeSH) AND Patient Safety (MeSH)
Web of Knowledge
(Hospitals) AND (Quality of Health Care) AND ((Outcome Assessment, Health Care) OR (Quality Assurance, Health Care)) AND (Quality Indicators, Health Care) AND (Patient Safety)

Figure B1 Search of databases strategy for a systematic review on indicators and methods for health care quality assessment.

Table B1 Validity criteria for the selection of articles

Design
Observational study, or literature/databases review
Defined study period
Sample
The sample size was justified.
The study included acute-care and/or general hospitals.
Indicators
Justification for reliable and valid indicators was provided
In observational studies, the indicators were quantified, namely in raw or risk-adjusted rates
Several adverse event indicators were selected, in hospital-wide and/or surgical domain of care
Statistical analysis
The focus was on health care quality assessment.
Statistical methods were used to assess the quality of care in observational studies

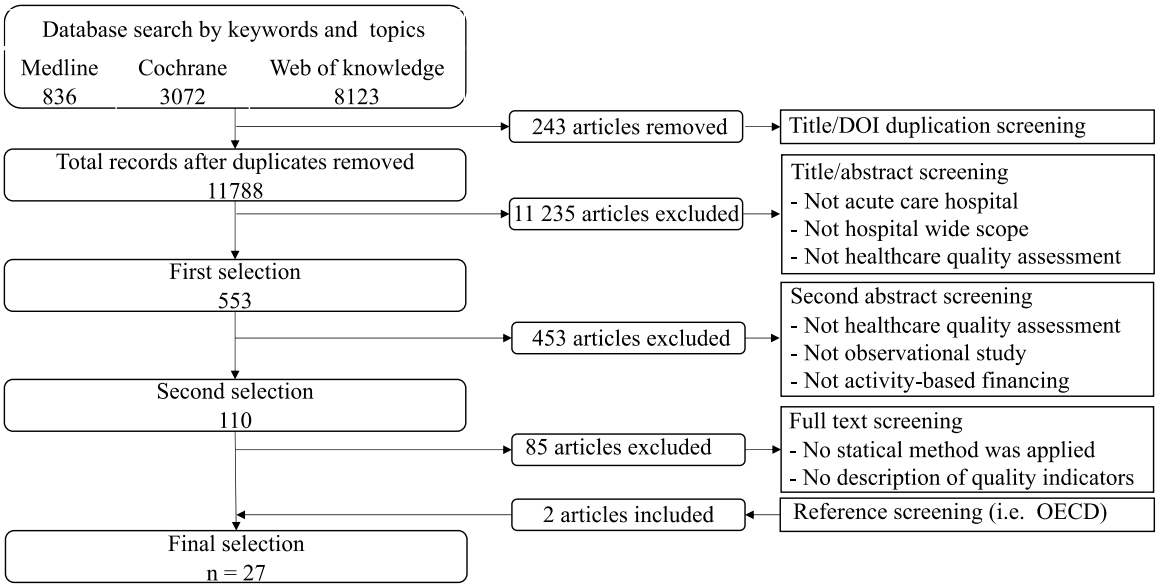

Figure B2 Flowchart of the selection of articles on indicators and methods for health care quality assessment.

B.2 Results

The final selection included a set of 27 articles consisting of 22 observational studies, 3 literature reviews [Al-ghraiybah 2021, Copnell 2009, O'Hanlon 2017] and 2 database reviews [McLoughlin 2006, Slawomirski (OECD) 2018]. In the case of literature and database reviews, only the indicators relevant to acute care and statical significance were included. All selected articles were listed and summarized by the main general aspects of the study, clinical outcome indicators, independent/control variables, clinical risk adjustment, and method implemented in the assessment of the quality of care (Table B2).

The analysis of articles allowed to select the most frequently considered measures for the assessment of quality of care (Table B3). The frequency of the use of indicators was assessed for all selected indicators. The predictive positive value of indicators to code clinical conditions was considered whenever present in literature. Therefore, a set of 7 hospital-wide mortality indicators consisting of in-hospital mortality and six rates of mortality from selected clinical conditions coded as a principal diagnosis was selected. A set of 5 hospital-wide adverse events, coded as a secondary diagnosis and not present in the moment of hospital admission, was related to hospital morbidity. Besides the in-hospital mortality in surgical patients, a list of 7 perioperative adverse events, related to surgical morbidity, was selected.

In the 22 observational studies, clinical outcomes were presented in models of exclusive health care quality assessment or integrated into more complex models also considering hospital resources and/or activity. The selected conditional mortality indicators, in particular acute myocardial infarction and pneumonia were presented as reliable measures in health care quality assessment. Whether implemented as single measures or incorporated into composite indicators for hospital care quality assessment, they were and incorporated into statistical models for comparisons among hospitals. The measure of hospital morbidity could be the most accurate method to assess the quality of care as it focuses on the incidence of inpatient adverse events.

The methods most used for health care quality assessment were regression models in 12 articles (2 multivariate, 5 logistic, 2 generalized estimating equation regression (GEE), 1 fixed effects), odds ratio in 4 articles, rate trend analysis in 2 articles, positive predictive value in 2 articles, ANOVA in 1 article, and Stochastic Frontier Analysis (SFA) in 1 article (Table B2).

The adjustment of morbidity and mortality rates by case-mix, hospital activity volume, and by clinical risk, namely comorbidities, was considered in most of the consulted literature, 16 out of 27 selected articles. This literature review provides a census of the most frequently used factors in the adjustment of results, following in most cases, the list of comorbidities listed in Charlson and Elixhauser's indexes (Table B2).

The recommendations by organizations about clinical outcome indicators for health care quality assessment were also reviewed, which helped to obtain and unify definitions of indicators. A total of 22 organizations leads ongoing projects or programs aimed to assess and improve hospitals' quality of care (Table B4). Even if the databases review did not include control variables, they provided an evaluation of the consistency of indicators commonly used for reporting in databases.

Table B2 Description of selected articles on indicators and methods for health care quality assessment

Author Year	Journal References	Study type	Country	No hospitals or sources	No patients or articles	Financing mode	Teaching hospitals	Duration (months)	Analysis Methods	Independent control variables	Clinical risk adjustment	Clinical outcome indicator
Aelvoet 2010	BMC Health Serv Res. 2010;10:334	observational comparative	Belgium	109	46,287	DRG	ND	48	Fixed-effects model	Patient volume Hospital location and complexity	MONICA scores for Charlson's index, age, gender, per-semester evolution, shock	Acute myocardial infarction in-Hospital case-fatality rates (AMI-CFRs)
Al-ghraiybah 2021	Nurs Open. 2021 Sep;8(5):2262-2271	literature review	Australia	2,122	10	DRG	ND	240	PRISMA Observation of regression coefficient and OR	Number of nurses Nurse education Nursing practice environment (NPE) Nurses' error practices interceptions Organizational nursing factors including NPE Clinical contextual factors	ND	Mortality Medication error Pressure Injury Central line bloodstream infection Catheter-associated Urinary Tract Infections Hospital-acquired infection Patient fall
Cevasco 2011a	J Am Coll Surg. 2011 Jun;212(6):954-61	cross-sectional	USA	49	112	DRG	M	48	Odds ratio, PPV	Age, sex, race Teaching status	Comorbidities (Smoking, Diabetes), Procedure, Postoperative course, Source of infection	Postoperative Sepsis
Cevasco 2011b	J Am Coll Surg. 2011 Jun;212(6):962-7	cross-sectional	USA	28	112	DRG	ND	48	Odds ratio, PPV	Age, sex, race	Comorbidities (COPD, BMI, systemic steroids, albumin) Procedure, Postoperative course, Source of infection	Postoperative wound dehiscence
Chen 2013	Med Care. 2013 Sep;51(9):832-7	retrospective cross-sectional	USA	ND	3,090,489	DRG	M	36	Average weights of structural, process, outcome	Hospital teaching status Age, sex, race Socioeconomic status	Urgency of admission Elixhauser's conditions	Acute myocardial infarction mortality Heart failure mortality Pneumonia mortality

Table B2 (continuation)

Author Year	Journal References	Study type	Country	No hospitals or sources	No patients or articles	Financing mode	Teaching hospitals	Duration (months)	Analysis Methods	Independent control variables	Clinical risk adjustment	Clinical outcome indicator
Cima 2011	Surgery. 2011 Nov;150(5): 943-9	cross-sectional	USA	1	7,606	DRG	ND	38	Sensitivity Specificity PPV, NPV	Age, sex	ND	Renal failure, Infections, sepsis, bleeding, pulmonary emboly/deep vein thrombosis, respiratory failure, wound disruption,
Copnell 2009	Intern Med J. 2009 Jun;39(6):352-60	literature review	Worldwide	22	ND	ND		120	ND	ND	ND	Acute myocardial infarction mortality Mortality indicators for selected surgical cases inpatient conditions Congestive cardiac failure mortality Decubitus ulcer 3rd or 4th degree perineal tear Stroke 30-day mortality Pneumonia mortality
Downey 2011	Health Serv Res. 2012 Feb;47(1 Pt 2):414-30	retrospective cross-sectional	USA	1,045	>69,000,000	DRG	M	108	Joinpoint regression Annual percentage changes(APC)	Number of beds Hospital ownership Teaching status	Age, sex Age–sex interactions Comorbidities DRG cluster	Postoperative pulmonary embolism/deep vein thrombosis Postoperative physiological or metabolic derangement Postoperative sepsis Postoperative hip fracture Postoperative wound dehiscence Postoperative respiratory failure Infections due to medical care Accidental puncture or laceration Obstetric trauma–vaginal with/without instrument Birth trauma injury to neonate Iatrogenic pneumothorax Decubitus ulcer Failure to rescue

Table B2 (continuation)

Author Year	Journal References	Study type	Country	No hospitals or sources	No patients or articles	Financing mode	Teaching hospitals	Duration (months)	Analysis Methods	Independent control variables	Clinical risk adjustment	Clinical outcome indicator
Drösler 2009	Int J Qual Health Care. 2009 Aug;21(4):272-8	retrospective cross-sectional	OECD countries	698	ND	DRG	ND	36	Rate trends analysis	Age Admission status Discharge status	ND	Complications of anesthesia Decubitus ulcer Foreign body left during procedure Infections due to medical care Postoperative hip fracture Postoperative pulmonary embolism or deep vein thrombosis Postoperative sepsis Accidental puncture or laceration Transfusion reaction Birth trauma Obstetric trauma
Hansen 2011	Health Serv Res. 2011 Apr;46(2):596-616	cross-sectional	USA	67	14,010	DRG	ND	12	Multivariate regression	Number of beds Teaching status, Tax status, Region, urban/rural Nurse and Physician perceptions of safety climate Nurses/hours/inpatient days ratio Ratios physician/nurse, senior manager/frontline.	Age, gender Comorbidities	Acute myocardial infarction readmission Heart failure readmission Pneumonia readmission
Isaac 2008	J Gen Intern Med. 2008 Sep;23(9):1373-8	cross-sectional	USA	3878	ND	DRG	M	12	Multivariate regression Spearman correlation test	Number of beds Medical intensive care unit, cardiac care unit Teaching status, region, urban location, % Medicare patients,	Age, gender, Modified DRG Comorbidities	Death in low mortality DRG Decubitus ulcer Failure to rescue Infection due to medical care

Table B2 (continuation)

Author Year	Journal References	Study type	Country	No hospitals or sources	No patients or articles	Financing mode	Teaching hospitals	Duration (months)	Analysis Methods	Independent control variables	Clinical risk adjustment	Clinical outcome indicator
Labella 2020	Eur J Public Health. 2020;30(6):1041-1048	cross-sectional	Italy	88	8,719,910	DRG	ND	24	Logistic regression, GEE All-in model	Volume of cases Structure (research, university, trust, local) Number of safety practices implemented Number of recommendations for preventing adverse events	Average number of secondary diagnoses/ discharge	Malpractice claims for personal injuries and deaths Foreign body left during surgery Postoperative sepsis Dehiscence of surgical wound Deep vein thrombosis Pulmonary embolism
Maass 2015	Int J Qual Health Care. 2015 Aug;27(4):305-13	observational comparative	Germany	ND	3,000	DRG	M	6	Sensitivity, specificity, PPV, Cohen's Kappa(95% CI)	Patient characteristics Low-volume surgeons Cases volume	ND	Pressure ulcer Catheter-related infections, Respiratory failure, Deep vein thrombosis, Hospital-acquired pneumonia, Acute renal failure, Acute myocardial infarction Wound infection

Table B2 (continuation)

Author Year	Journal References	Study type	Country	No hospitals or sources	No patients or articles	Financing mode	Teaching hospitals	Duration (months)	Analysis Methods	Independent control variables	Clinical risk adjustment	Clinical outcome indicator
Maeng 2011	Health Serv Res. 2011 Dec;46(6pt 1):1720-40	cross-sectional	USA	250	1,712,873	DRG	ND	48	Logistic regression models Discrete Factor Approximation	Number of beds Hospital ownership Teaching status	age, gender, race, CSP case-mix (13 chronic conditions) ≤10 DRG diagnoses ≤10 Procedure codes	Aspiration pneumonia Cellulitis/decubitus ulcer Complication due to anesthetic agents Iatrogenic complications In-Hospital hip fracture/fall Mechanical complications Miscellaneous complications Other Postoperative cardiac abnormalities Poisoning due to medication Postoperative coma/stupor Postoperative GI hemorrhage/ulceration Postoperative infections (not pneumonia, wound) Postoperative myocardial infarction Postoperative nervous system complications Postoperative physiologic and metabolic derangements Postoperative pneumonia Postoperative pulmonary compromise Postoperative shock due to anesthesia Postoperative stroke Postoperative urinary tract complications Postprocedure hemorrhage/hematoma Procedure-related perforation/laceration Reopening of surgical site Septicemia Shock/cardiorespiratory arrest in Hospital Technical difficulty with medical care Venous thrombosis/pulmonary embolism Wound infection

Table B2 (continuation)

Author Year	Journal References	Study type	Country	No hospitals or sources	No patients or articles	Financing mode	Teaching hospitals	Duration (months)	Analysis Methods	Independent control variables	Clinical risk adjustment	Clinical outcome indicator
Majholm 2012	Acta Anaesthesiol Scand. 2012 Mar;56(3): 323-31	cross-sectional	Scandinavia	8	57709	DRG	ND	36	Logistic regression	Age, sex, Day surgery center Surgical specialty	ND	Postoperative 0 to 30-day mortality Postoperative haemorrhage/haematoma Postoperative infection Postoperative thromboembolic event
McLoughlin 2006	Int J Qual Health Care. 2006 Sep;18 Suppl 1:14-20	databases review	OECD countries	6	6	ND	ND	12	ND	ND	ND	Ventilator pneumonia Wound infection Infection due to medical care Decubitus ulcer Postoperative hip fracture Postoperative pulmonary embolism or deep vein thrombosis Postoperative sepsis Technical difficulty with procedure Transfusion reaction Wrong blood type Wrong-site surgery Foreign body left in during procedure Medical equipment-related adverse event Medication errors Birth trauma Obstetric trauma Problems with childbirth Patient falls In-Hospital hip fracture or fall
Miyata 2010	BMC Health Serv Res. 2010;10:130	cross-sectional	Japan	469	1,878,767	ND	M	1	Odds ratio	Age, gender	Ambulance at admission, Admission status DPC (includes 18 MDC), Charlson' s index, Performance Status, Fletcher Hugh-Jones Classification	Hospital standardized mortality ratio (HSMR)

Table B2 (continuation)

Author Year	Journal References	Study type	Country	No hospitals or sources	No patients or articles	Financing mode	Teaching hospitals	Duration (months)	Analysis Methods	Independent control variables	Clinical risk adjustment	Clinical outcome indicator
O' Hanlon 2017	J Gen Intern Med. 2017;32(1): 105-121	literature review	USA	ND	69	DRG		120	Peer-reviewed process	Veterans Affairs Insurance (VA/non-VA) Hospital tax status (public/private)	Comorbidities HCUP-NIS risk-adjustment	Mortality rates associated with specific conditions Postoperative morbidity (pancreatectomy, gastric by-pass) Surgical complication (Cataract surgeries, kidney transplant) Central venous Catheter bloodstream infection Surgical mortality Pressure ulcer
Slawomirski (OECD) 2018	Measuring Patient Safety; Opening the Black Box; OECD. 2011;1-17	Databases review	OECD countries	ND	ND	ND	ND	12	ND	ND	ND	Pressure injury Gastrointestinal bleeding Falls resulting in fracture or intracranial Medication complications Health care associated infection Surgical complication with unplanned return to theatre Delirium Persistent incontinence Unplanned intensive care unit admission Malnutrition Respiratory complications Cardiac complications Venous thromboembolism 3rd and fourth degree perineal laceration during delivery Renal failure Neonatal birth trauma

Table B2 (continuation)

Author Year	Journal References	Study type	Country	No hospitals or sources	No patients or articles	Financing mode	Teaching hospitals	Duration (months)	Analysis Methods	Independent control variables	Clinical risk adjustment	Clinical outcome indicator
Pross 2017	Health Policy. 2017 Aug;121(8): 842-852	cross-sectional	Germany	ND	ND	DRG	ND	96	Rate trend analysis on box and whisker plots	Age, gender Patient volume	Comorbidities	Cholecystectomy Risk-adjusted ratio of re-interventions due to complications Cholecystectomy Re-interventions due to complications after laparoscopic surgery Pacemaker Implantation Risk-adjusted inpatient mortality ratio Pacemaker Implantation Inpatient mortality Pacemaker Implantation Surgical complications Hip replacement Risk-adjusted ratio of reinterventions due to complications Hip replacement Revisions due to complications Hip replacement Risk-adjusted inpatient mortality ratio Hip replacement Inpatient mortality Hip replacement Achieving the recanalization target in PCI Stroke 30-day risk-adjusted mortality ratio (SMR) Stroke 30-day mortality Stroke 90-day readmissions Acute Myocardial Infarction 30-day risk-adjusted mortality ratio Acute Myocardial Infarction 30-day mortality Acute Myocardial Infarction 90-day readmissions
Soop 2009	Int J Qual Health Care. 2009 Aug;21(4):285-91	cross-sectional	Sweeden	ND	1967	DRG	ND	12	Logistic regression	ND	Index admission	Bleeding Thrombosis Organ injury Allergic/Immunological reaction Mental suffering or pain Infection Fracture

Table B2 (continuation)

Author Year	Journal References	Study type	Country	No hospitals or sources	No patients or articles	Financing mode	Teaching hospitals	Duration (months)	Analysis Methods	Independent control variables	Clinical risk adjustment	Clinical outcome indicator
Stefan 2013	J Gen Intern Med. 2013 Mar;28(3):377-85	retrospective cohort analysis	USA	2940	328,830	DRG	ND	12	Hierarchical GLM (overall measure and appropriate care measure scores)	Number of beds Teaching status, Region, urban/rural area Age, gender, race, income	Comorbidities, discharge disposition, Number of admissions in the prior year Length of stay	30-day readmission rates: Acute myocardial infarction Heart failure Pneumonia Major surgery
Unruh 2016	Health Serv Res. 2016;51(6):2258-2281	cross-sectional	USA	2,747	ND	DRG	M	12	SFA	Revenue, Profit, Payer mix, System member RN FTE/patient days, Nurse skill mix, Total staff expenses Hospital ownership, region, size, urban/rural Joint Commission accreditation Technology status, Teaching status	Case mix index (CMI)	30-day mortality (Heart failure mortality, Pneumonia) 30-day readmissions (Heart failure mortality, Pneumonia) Heart failure readmission PSI composite of complications IQI composite of mortality surgical procedures IQI composite of mortality medical condition
Van den Heede 2006	Int J Qual Health Care. 2006 Jun;18(3):211-9	retrospective cross-sectional	Belgium	123	1 657 770	DRG	ND	12	Hierarchical Bayesian Gamma and Lognormal Poisson	ND	Patient's pool increased homogeneity APR-DRG illness severity	Urinary tract infection Pressure ulcers Hospital-acquired pneumonia Hospital acquired sepsis Central nervous system complications Shock or cardiac arrest Upper-gastrointestinal bleeding Deep venous thrombosis Pulmonary failure Metabolic derangement Wound infection Failure-to-rescue

Table B2 (continuation)

Author Year	Journal References	Study type	Country	No hospitals or sources	No patients or articles	Financing mode	Teaching hospitals	Duration (months)	Analysis Methods	Independent control variables	Clinical risk adjustment	Clinical outcome indicator
Vartak 2008	Med Care. 2008 Jan;46(1):25-32	cross-sectional	USA	646	ND	DRG	M	12	ANOVA, Pearson, Generalized estimating equation regression (GEE)	RN/bed ratio, Resident/bed ratio, Number of beds, Hospital location, Surgical admissions as % of total, Teaching status Patient age, sex, source of admission, payer, median income	Charlson' s index Average DRG weight to capture case mix	Postoperative hip fracture Postoperative hemorrhage or hematoma Postoperative physiologic and metabolic derangement Postoperative respiratory failure Postoperative pulmonary embolism/deep vein thrombosis Postoperative sepsis
Weeks 2008	Qual Saf Health Care. 2008;17(1):58-64	retrospective cohort analysis	USA	ND	353,570	DRG	ND	36	Rate trends analysis	Veterans Affairs Insurance (VA/non-VA) Hospital tax status (public/private) Patient age, race, gender, date of admission, dates of procedures	DRG cluster, ICD-9-CM codes	Complications of Anesthesia Death in Low Mortality DRGs Decubitus Ulcer Failure to rescue Foreign Body Left in During Procedure Iatrogenic Pneumothorax Infection Due to Medical Care Postoperative Hip Fracture Postoperative Haemorrhage or Haematoma Postoperative Physiological & Metabolic Derangements Postoperative Respiratory Failure Postoperative Pulmonary Embolism or Deep Vein Thrombosis Postoperative Sepsis Postoperative Wound Dehiscence Accidental Puncture or Laceration

Table B2 (continuation)

Author Year	Journal References	Study type	Country	No hospitals or sources	No patients or articles	Financing mode	Teaching hospitals	Duration (months)	Analysis Methods	Control variables	Clinical risk adjustment	Clinical outcome indicator
Weiner 2006	Med Care Res Rev. 2006 Feb;63(1):29-57	cross-sectional	USA	1784	ND	DRG	M	12	Regression models (Quality improvement, and Hospital performance)	Quality improvement (Hospital unit involvement in QI, Hospital staff on QI teams, Managers on QI teams, Physicians on QI teams), Instrumental (CEO participation in QI activities, Board monitoring of QI, Board activity in QI, Perceived barriers to QI, Clinical IS capabilities, Clinical integration, Total expenses on QI, Integrated database, Hospital beds)	age, gender, modified DRG, Comorbidities	Postoperative complications Technical adverse events Technical difficulty Failure to rescue

OECD= Organisation for Economic Co-operation and Development; ND=Not Described in the paper or not applied; T=Teaching Hospitals; M=Mix Hospitals (Teaching and Non-Teaching); NT=Non-Teaching Hospitals; Or=Odds Ratio; DRG=Diagnostic related Group; ABF=Activity-based Financing; OOP=out-of-pocket expenditure. PSI=patient safety indicator; IQI=inpatient quality indicator; PPV=Positive predictive value; NPV=Negative predictive value; BMI=body mass index; COPD=Chronic obstructive pulmonary disease; APR-DRG=All patient refined diagnostic-related groups; Postop=Postoperative; AMI=Acute myocardial infarction; CSP=Complication Screening Program; DPC=Diagnosis Procedure Combination; MDC=major diagnostic categories; HCUP-NIS=Healthcare Cost and Utilization Project Nationwide Inpatient Sample.

Table B3 Selection of health care quality indicators by frequency of use and validity

Indicators	ICD-10 code	No papers(%)	References	PPV, reference
Hospital-wide				
Mortality§				
In-hospital mortality	---	2 (7.4)	Miyata 2010, Al-ghraiybah 2021	---
Acute myocardial infarction	I21	7 (25.9)	Hansen 2011, Stefan 2013, Aelvoet 2010, Pross 2017, Maass 2015, Chen 2013, Copnell 2009	93.8%, Ando 2018
Heart failure	I098, I110, I130, I132, I500–I509	4 (14.8)	Unruh 2016, Hansen 2011, Stefan 2013, Chen 2013	79%, Sundbøll 2016
Ischemic stroke	I63	3 (11.1)	Maeng 2011, Pross 2017, Copnell 2009	82%, McCormick 2015
Gastrointestinal hemorrhage	I850, K226 K250-K922	3 (11.1)	Soop 2009, Van den Heede 2006, OECD 2018	71%, Oger 2019
Pneumonia	J13, J14, J15, J690	9 (33.3)	Unruh 2016, Hansen 2011, Stefan 2013, Maeng 2011, Maass 2015, Van den Heede 2006, Chen 2013, Copnell 2009, McLoughlin 2006	85%, Ibrahim 2012
Hip fracture	S720	6 (22.2)	Vartak 2008, Weeks 2008, Maeng 2011, Pross 2017, Drösler 2009, McLoughlin 2006	90%, Hjelholt 2020
Morbidity†				
Pulmonary embolism	I26	3 (11.1)	Labella 2020, Maeng 2011, OECD 2018	80%, Ibrahim 2012
Deep vein thrombosis	I801–I809, I828, I829	7 (25.9)	Soop 2009, Weeks 2008, Labella 2020, Maeng 2011, Maass 2015, Van den Heede 2006, OECD 2018	88%, Sundbøll 2016
Sepsis	A40, A41, R572, R650, R651,T814	2 (7.4)	Cevasco 2011a, Vartak 2008, Cima 2011, Van den Heede 2006McLoughlin 2006	85%, Öhman 2018
Nosocomial pneumonia	J13, J14, J15, J690	6 (22.2)	Unruh 2016, Hansen 2011, Stefan 2013, Maass 2015, Van den Heede 2006, McLoughlin 2006	81%, Öhman 2018
Pressure ulcers	L892, L893, L899	12 (44.4)	Maass 2015, Van den Heede 2006, Al-ghraiybah 2021, O'Hanlon 2017, OECD 2018, Weeks 2008, Isaac 2008, Maeng 2011, Drösler 2009, Downey 2011, Copnell 2009, McLoughlin 2006	91.7%, Ho 2017
Surgery				
Mortality				
Perioperative mortality	---	3 (11.1)	Unruh 2016, Majholm 2012, O'Hanlon 2017	---
Morbidity†				
Postoperative pulmonary embolism	I26	6 (22.2)	Weeks 2008, Majholm 2012, Maeng 2011, Drösler 2009, Downey 2011, McLoughlin 2006	80%, Ibrahim 2012
Postoperative deep vein thrombosis	I801–I809, I828, I829	6 (22.2)	Weeks 2008, Majholm 2012, Drösler 2009, Downey 2011, McLoughlin 2006	59%, Ibrahim 2012
Postoperative Sepsis	A40, A41, R572, R650, R651, T814	7 (25.9)	Cevasco 2011a, Vartak 2008, Weeks 2008, Labella 2020, Drösler 2009, Downey 2011, McLoughlin 2006	85%, Öhman 2018
Postoperative complication	Y83	7 (25.9)	Unruh 2016, Weeks 2008, Weiner 2006, Maeng 2011, Pross 2017, Drösler 2009, OECD 2018	--
Postoperative pneumonia	J13, J14, J15, J690	1 (3.7)	Maeng 2011	81%, Öhman 2018
Postoperative wound dehiscence	T813	3 (11.1)	Cevasco 2011b, Weeks 2008, Labella 2020	87%, Cevasco 2017
Postoperative wound infection	T814	4 (14.8)	Maeng 2011, Maass 2015, Van denHeede 2006, McLoughlin 2006	98%, Petrosyan 2021

ICD-10=International Classification of Diseases, §=Coded as a principal diagnosis; †=Coded as a secondary diagnosis; PPV=Positive predictive value.

Table B4 Organizations providing a list of clinical outcome indicators to assess health care quality

Acronym	Name	Country	Project	Year	Indicator	Website
ACHS	Australian Council of Healthcare Standards	Australia	Clinical Indicator Program	1989	22	https://www.achs.org.au
AIHW	Australian Institute of Health and Welfare	Australia	Australian Health Performance Framework	2017	330	https://www.aihw.gov.au
AMHOCN	Australian Mental Health Outcomes and Classification	Australia	Key Performance Indicators for Mental Health	2008	NP	https://www.amhocn.org
NSW-TAG	New South Wales Therapeutic Advisory Group	Australia	Medication Safety	2000	NP	https://www.nswtag.org.au
CIHI	Canadian Institute of Health Performance	Canada	Health System Performance Measurement	2012	12	https://www.cihi.ca
DDKM	The Danish Healthcare Quality Programme	Denmark	Danish Healthcare Quality Programme	1999	192	www.dgma.dk/
NIP	National Indicator Project	Denmark	Danish National Indicator Project	2004	8	http://www.nip.dk/
ECHI	European Core Health Indicators	Europe	ECHI data tool	1988	88	https://webgate.ec.europa.eu
IQIP	International Quality Indicator Project	International	International Quality Indicator Project	1980	27	http://www.internationalqip.com
OECD	Organization for Economic Co-operation and Development	International	OECD Health Care Quality Indicators	2001	33	https://www.oecd.org/health
PATH	Performance Assessment Tool for Quality Improvement in Hospitals (WHO)	International	Performance Assessment Tool for Quality Improvement in Hospitals	2008	17	https://apps.who.int
NCHOD	National Center for Health Outcome Development Indicators	UK	UK Quality Indicator Project	1991	27	http://www.nchod.nhs.uk/
CCQ	Care Quality Commission	UK	Hospitals performance indicators	2009	NP	https://www.cqc.org.uk/
RIVM	National Institute for Public Health and the Environment	Netherlands	Dutch Health Care Performance Report	2006	125	https://www.rivm.nl/en
CDC	Center for Disease Control	USA	Healthcare-Associated Infections Progress	2004	7	https://www.cdc.gov/hai
CDC	Center for Disease Control	USA	Data and Statistics on Venous	2004	3	https://www.cdc.gov/ncbddd/dvt
JCAHO	Joint Commission on Accreditation of Healthcare	USA	Accreditation of Healthcare Organizations	1999	15	https://www.jointcommission.or
Leapfrog	Leapfrog Hospital Quality and Safety Survey	USA	Leapfrog Hospital Survey	1999	7	http://www.leapfroggroup.org
AHRQ	Agency for Healthcare Research and Quality	USA	AHRQ Quality Indicators	1989	102	https://qualityindicators.ahrq.go
NQF	National Quality Forum	USA	NQF-Endorsed Performance Measures	1999	550	http://www.qualityforum.org
CMS	Centers for Medicaid and Medicare Services	USA	CMS Measures Inventory Tool: Core measures	2001	551	https://cmit.cms.gov/cmit/#/
AHIP-CMS/ NQF	America's Health Insurance Providers, Centers for Medicare & Medicaid Services, and National Quality Forum	USA	Core Quality Measures Collaborative	2015	NP	https://www.cms.gov

NP=Not precised; WHO=World Health Organization

Article 2 – Hospital activity trends in the French activity-based financing context: an international perspective

Citation

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HOSPITAL ACTIVITY TRENDS IN THE FRENCH ACTIVITY-BASED FINANCING CONTEXT: AN INTERNATIONAL PERSPECTIVE

Angel-Benitez Collante[1] and Patrice Degoulet[2]

INTRODUCTION

In 1997, according to an evaluation by the World Health Organization, France was considered to offer the best health care system among a selection of 191 countries (World Health Organization – WHO, 2000). Six major criteria were considered: disability-adjusted life expectancy (DALE), responsiveness, fairness in financial contribution, overall goal attainment, health expenditure per capita, and performance (Mathers, Sadana, Salomon, Murray & Lopez, 2000). However, international comparisons need to be interpreted with caution. Differences relate to multiple factors, including those that are geopolitical, economic, population, sociocultural and healthcare-system-based (Organisation for Economic Co-operation and Development [OECD], 2017, 2019; International Labour Organization [ILO], 2019; WHO, 2018a, 2018b, 2019; Papanicolas, Woskie, & Jha, 2018). For example, if we consider the six countries shown in Table 1, the United States (US) has the highest GDP, followed by Germany, the UK and France. The highest GP increase between 2000 and 2017 is observed in Germany. The GDP of Brazil is one-quarter of that of the US and showed the lowest increase. Unfortunately, France has the lowest workforce percentage and a high rate of unemployment.

[1] Physician with a specialty in plastic surgery. PhD candidate in Public Health at Paris Descartes University, France.

[2] Professor Emeritus at Paris Descartes University, MD, PhD, FACMI. CMIO at Broussais University Hospital (1989-2008) and CIO/CMIO at Pompidou University Hospital (1999-2017). Head of the Public Health and Medical Informatics Department at Paris University.

TABLE 1
MAIN COUNTRY INDICATORS (2017 OR CLOSEST YEAR)

	France	Germany	UK	US	Brazil	Japan
Population (millions) ¤	66.8	82.7	66.0	325.1	195.5	126.7
Population >= 65 years old (%) ¤	19.5%	21.3%	18.2%	15.6 %	9.5 %	28.1 %
Population >= 75 years old (%) ¤	9.2 %	11.3 %	8.2 %	6.5 %	3.7%	13.8%
Projected population >= 75 years old in 2030 (%) ☐	12.7%	12.7%	10.9%	9.6%	5.4%	18.5%
GDP per capita (US$, current price & PPP) ¤	44 125	52 574	44 909	59 774	15 651	41 985
GDP increase per capita 2010 to 2017 (%) ¤	22.9%	31.7%	24.7%	23.5%	8.8%	20.0%
Workforce 15-64 years old (% of total population) §	44.7%	50.9%	49.5%	47.4%	52.4%	47.0%
Unemployment rate 15-64 years old (%) §	9.5%	3.8%	4.4%	4.4%	13.1%	3.0%
WHO ranking of health systems in 1997 §	1	25	18	37	125	10
Life expectancy at birth (in years) ¤	82.6	81.1	81.3	78.6	75.7	84.2
Infant mortality (deaths/1,000 live births) ¤	3.9	3.3	3.9	5.8	13.2	2.0
Current tobacco smoking (≥15 years) (%) †	28%	27%	16%	21%	14%	20%
Obesity ≥18 years old (BMI ≥ 30/m2) (%) †	23%	26%	30%	37%	22%	4%
Alcohol consumption ≥15 years old (liters/capita/year) †	13	13	11	10	8	8
Diabetes ≥18 years old (%) †	8%	7%	8%	9%	8%	10%

Source: ¤ = OECD (2017, 2019); § = ILO (2019); † = WHO (2018a, 2018b, 2019); ☐ = World Bank Group (2019). PPP = Purchase Power Parity[3]; BMI = Body Mass Index[4].

In a context in which most countries try to limit increasing healthcare costs while preserving outcomes, healthcare system quality may have drastically changed over the last 20 years. Although the US devotes the highest percentage of its GDP to healthcare spending (17.1%), life expectancy compared to Japan and France remains low and infant mortality high. Japan has the highest percentage of its population that is 75 years old or older (13.8%), followed by Germany and France (OECD, 2017, 2019). According to World Bank estimates, this percentage could reach 18.5% in 2030, and 12.7 % for France and Germany (World Bank Group, 2019).

Major risk factors differ between the countries considered. Estimates by WHO for non-communicable diseases are given for the year 2016 (WHO, 2018b). Tobacco consumption and alcohol consumption are highest in France and lowest in Brazil.

To highlight possible trends in hospital activity and selected quality indicators, the present paper describes the French healthcare situation from the international perspective provided by available information for the countries shown in Table 1.

[3] PPPs are the rates of currency conversion that eliminate the differences in price levels between countries.

[4] BMI is the measure of body size based on height and weight.

HEALTHCARE RESOURCES

Healthcare resource statistics are based on OECD 2019 statistical database queries (OECD, 2019) (Table 2). Germany has the highest physician and nurse density per population and the lowest density of pharmacists. Nurse density in France is lower than in Germany, the US and Japan. The highest nurse/physician ratio is observed in Japan and the lowest in the UK, followed by France.

TABLE 2
HEALTHCARE RESOURCES (2017 OR CLOSEST YEAR)

	France	Germany	UK	US	Japan
Physician density (Nb./1,000 population)	3.2	4.3	2.8	2.6	2.5
Nurse density (Nb./1,000 population)	10.5	12.9	7.8	11.7	11.5
Pharmacist density (Nb./1,000 population)	1.1	0.8	0.9	1.0	1.9
Nurse/physician ratio	3.3	3.9	2.8	4.5	5.0
Number of hospitals¤ [1,2]	3 046	3 084	1 920	5 478	8 412
Hospital density (Nb. hospitals/million population)	45.6	37.3	29.1	16.9	66.4
Mean hospital bed size (Nb. beds/hospital)	131	214	87	163	197
Hospital bed density (Nb. beds/1,000 population)	6.0	8.0	2.5	2.7	8.5
• in publicly owned hospitals	3.68	3.26	2.54	0.60	3.55
• in non-profit private hospitals	0.84	2.31	NA	1.67	NA
• in for-profit private hospitals	1.45	2.43	NA	0.45	NA
Hospital bed type (Nb. beds/1,000 population)					
• acute care beds	3.09	6.02	2.11	2.42	7.79
• psychiatric care beds	0.84	1.28	0.38	0.21	2.62
Hospital staff to bed ratio (FTE/bed)	2.9	1.5	NA	6.5	NA
• nurse to bed ratio (FTE/bed)	0.9	0.6	NA	2.4	NA

Source: OECD (2019); FTE = Full Time equivalent; NA = Not available.

Japan has the highest number of hospitals and beds per inhabitant, and the highest number of hospital beds. France has the second highest number of hospitals and beds per inhabitant, but also the highest bed density in publicly owned hospitals, and the US has by far the lowest. Density of acute care beds is the highest in Japan, followed by Germany and France, and the lowest is observed in the UK. The employment to bed ratio is 2.2 times higher in the US than in France and 4.3 times higher than in Germany.

THE FRENCH HEALTHCARE SYSTEM

The French Statutory Health Insurance System (SHI) provides nearly universal coverage, with more than 95% of the population covered since 1970, 99% since 1980, and 99.9% since 1999 (OECD, 2019; Chevreul, Brigham, Durand-Zaleski, & Hernandez-Quevedo, 2015). Complementary and voluntary health insurance has been provided to more than 85% of the population since 2000 and to more than 95% since 2010. Since 1996, SHI expenditures are subject to a national ceiling (ONDAM[5]) managed by the French Social Security system (Sécurité Sociale, 2019a). Healthcare coverage figures are close to those observed in Germany, the UK and Japan. While maintaining its objective of universal coverage, Brazil still has the highest voluntary financing scheme (Table 3).

TABLE 3
HEALTHCARE SYSTEMS (2017)

	France	Germany	UK	US	Brazil	Japan
Total spending on health, % of total national GDP ¤	11.3%	11.2%	9.6%	17.1%	9.2%	10.9%
Mean spending on health per capita (US$, current price and PPP) ¤	4 931	5 848	3 943	10 207	1 365	4 630
Population with healthcare coverage ¤, † (%)	99.9%	99.8%	100%	90%	NA	100%
Government/compulsory financing schemes (as % of GHE) ¤, †	83.4%	84.5%	77.1%	81.8%	44.5%	84.1%
Voluntary financing schemes (as % of GHE)¤,†	6.8%	3.2%	5.4%	7.1%	29.3%	3.0%
Out-of-pocket financing (as % of GHE)¤,†	9.8%	12.4%	15.8%	11.1%	26.6%	12.9%

Source: ¤ = OECD (2018, 2019); § = ILO (2019); † = WHO (2018a); * = WHO (2019). PPP = Purchase Power Parity; GHE = Global Health Expenses; NA = Not available.

Most health expenditures in France are devoted to inpatient curative and rehabilitation care (27.5%), with figures close to those observed in Germany, the UK and Japan (OECD, 2018, 2019), as shown in Table 4.

ENGLISH

[5] ONDAM: Objectif National des Dépenses d'Assurance Maladie (National Objective for Health Insurance Spending).

TABLE 4
NATURE OF HEALTHCARE EXPENDITURES (2017 DATA)

	France	Germany	UK	US	Japan
Inpatient care curative and rehabilitation care (%)	27.5%	26.5%	23.6%	17.3%	26.6%
Day curative and rehabilitation care (%)	4.1%	1.0%	4.9%	NA	0.8%
Outpatient curative and rehabilitation care (%)	18.1%	21.7%	26.1%	45.0%	26.5%
Home-based care (%)	3.7%	0.6%	2.7%	2.9%	2.0%
Long-term care (%)	15.2%	18.3%	18.7%	5.0%	18.7%
Ancillary services (biology, imaging) (%)	5.3%	5.0%	1.8%	NA	0.6%
Medical goods (%)	18.5%	19.3%	14.3%	13.6%	20.2%
Preventive care (%)	1.9%	3.0%	5.2%	2.9%	2.9%
Governance and health system and financing administration (%)	5.7%	4.7%	1.8%	8.3%	1.7%

Source: OECD (2017, 2019); NA = Not available.

Up to 2004, French hospital expenditures both for public hospitals and private non-profits hospitals were financed through a fixed budget revised each year according to the inflation rate and the overall activity evolution. For-profit private hospitals were financed based on day-related rates and services from their practicing physicians. Since 2004, all acute care activities, regardless of the type of hospital (public or private), have been financed within the same DRG-related mechanism (Chevreul et al., 2015). Diagnosis coding is based on the WHO ICD-10 medical classification and used by the French Common Classification of Medical Procedures (Classification Commune des Actes Médicaux - CCAM), a localized hierarchical classification inspired by the US Current Procedural Terminology (CPT) (Assurance Maladie, 2019a). The list of GHM[6]/DRG derived from the coding activity is specific to France. The GHM list, which includes 2,600 GHMs and 670 root groups, is maintained by a central agency, the ATIH[7] (Agencie Technique de L'Information sure L'Hospitalisation, 2019). GHS[8] are financial values attributed to each GHM. Activity-based financing (T2A[9]) directly results from the list of GHMs generated through the coding algorithms. GHM/GHS pricing includes a 4-grade severity index and is adjusted by a list of related and or associated diagnoses.

Additional financing is provided for teaching and general interest activities (MIGAC[10]) and some highly specific procedures such as transplantation, dialysis, and highly expensive drugs (contractual extra T2A financing). Within the overall hospital financing part of ONDAM, T2A acute care financing represented approximately 64% of the expected total financing for 2008 and 67% for 2017.

6 GHM: Groupe Homogène de Malades (Homogeneous Group of Patients);

7 ATIH: Agence Technique de l'Information sur l'Hospitalisation (Technical Agency for Information on Hospital Care);

8 GHS: Groupe Homogène de Séjour (Homogeneous Group of Stays);

9 T2A: Tarification à l'Activité (Activity-based Funding);

10 MIGAC: Mission d'Intérêt Général et d'Aide à la Contractualisation (Missions of General Interest and Support to Contracting).

HEALTHCARE SYSTEM UTILIZATION

Numbers of doctor and dentist consultations are higher in Japan and Germany than in the UK and the US, despite low physician density in Japan (OECD, 2017, 2019; Agency for Healthcare Research and Quality [AHRQ], 2019). The highest childhood immunization rates are observed in Japan, and the highest influenza immunization rates for patients 75 years old or older in the UK.

Germany has the highest hospitalization rate, followed by France (Table 5). Discharge rates are the highest in Germany and France, with occupancy rates of 80% and 76%, respectively.

TABLE 5
HEALTHCARE SYSTEM UTILIZATION (2017 OR NEAREST YEAR)

	France	Germany	UK	US	Japan
Doctor consultations per person (Nb./year)	6.0	9.9	5.0	4.0	12.5
Dentist consultations per person (Nb./year) ¤	1.5	1.5	0.7	0.9	3.2
Immunization: Diphtheria, Tetanus, Pertussis (% children) ¤	96%	95%	94%	95%	99%
Immunization: Measles (% children) ¤	90%	97%	92%	92%	99%
Immunization: Influenza (%≥ 65 years old) ¤	50%	35%	73%	67%	50%
Inpatient care discharge in all hospitals (/1,000 population) ¤*	181	255	131	NA	128
Curative care discharge in all hospitals (/1,000 population) ¤#*	156	235	125	110	120
Curative care length of stay¤*	5.6	7.5	5.9	4.6	16.2
Curative care occupancy rate¤ (%)	76%	80%	84%	76%	64%

Source: ¤ = OECD (2017, 2019); # = AHRQ (2019); * = Stays ≥ One night; NA = Not available.

HOSPITAL ACTIVITY TRENDS IN THE FRENCH ACTIVITY-BASED FINANCING CONTEXT

Evaluation of activity of acute care hospitals was assessed from yearly DREES[11] reports for the years 2003, 2007, 2012, and 2017, i.e., just before the change of the financing system in 2004, its extension in 2008, and 5 and 10 years after the T2A extension (Table 6) (Direction de la Recherche, des Etudes, de l'Evaluation et des Statistiques [DREES], 2019).

The total number of acute care beds diminished by 11.1% between 2003 and 2017, with a steep increase in day care beds and a lower decrease in regular care beds (stays ≥ 1 night). These decreases are more apparent when the figures are reported for the total French population.

The total number of day care stays (0-night) increased by 50.3% between 2003 and 2017. The number of regular stays (≥ 1 night) increased by 3.3%. These increases, associated with the reductions in length of stay and the number of beds, explains the greater turnover of patients and the increased workload for the professional workforce.

[11] DREES : Direction de la Recherche, des Etudes, de l'Evaluation et des Statistiques.

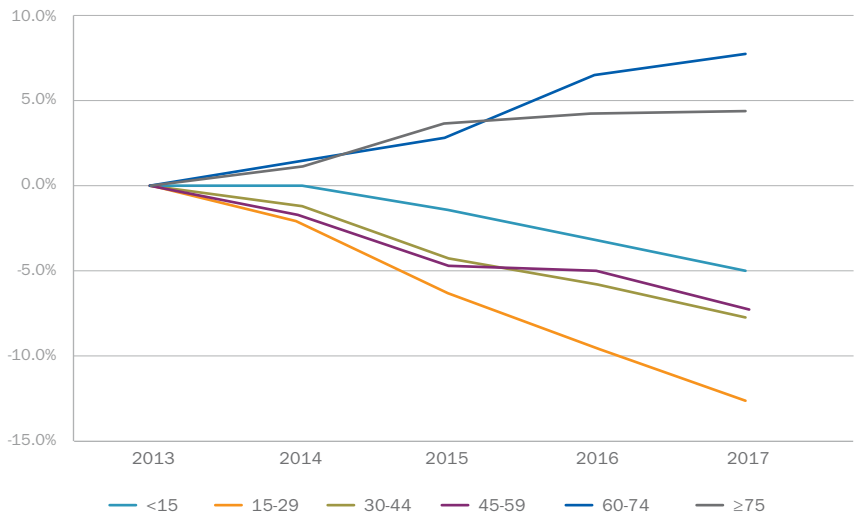
TABLE 6
FRENCH ACUTE CARE HOSPITAL ACTIVITY TRENDS

	2003	2008	2012	2017	Δ 2003-2017 (%)
Nb. acute care beds					
· Day care (0 night)	17 681	21 611	29 000	32 000	81.0%
· Regular care (≥ 1 night)	229 702	226 484	220 000	205 000	-10.8%
Total	247 383	248 095	249 000	237 000	-4.2%
Nb. acute care beds (/1,000 population)					
· Day care (0 night)	0.3	0.3	0.4	0.5	68.0%
· Regular care (≥ 1 night)	3.7	3.6	3.4	3.1	-17.2%
Total	4.0	3.9	3.8	3.5	-11.1%
Number of stays (in millions)					
· Day care (0 night)	5.12	6.12	6.46	7.70	50.3%
· Regular stays (≥ 1 night)	9.98	10.19	10.50	10.30	3.3%
Total	15.09	16.31	16.96	18.00	19.2%
Number of stays (/1,000 population)					
· Day care (0 night)	83	96	99	115	39.6%
· Regular stays (≥ 1 night)	161	160	161	154	-4.1%
Total	243	256	259	269	10.7%
Length of stays (≥ 1 night)					
· Public hospitals	6.8	6.3	6.3	6.0	-12.0%
· Private non-profit hospitals	6.4	5.8	5.7	5.5	-14.7%
· Private for-profit hospitals	4.9	4.6	4.5	4.2	-13.3%
Total	6.1	5.9	5.7	5.5	-9.3%
Nb. health professionals					
· Physicians (FTE)	249 466	284 830	284 461	311 931	11.8%
· Nurses (FTE)	346 838	393 262	398 462	422 203	25.6%
Nb. stays/professionals (≥ 0 night)					
· Nb. stays/physicians	60.5	57.3	59.6	57.7	-4.6%
· Nb. stays/nurse	43.5	41.5	42.6	42.6	-2.0%
ONDAM ceiling (Billion €)					
· T2A acute care financing		41.4	47.1	53.0	
· MIGAC		6.0	7 7	6.6	
· Contractual extra T2A financing		17.1	18 5	19.4	
Total for hospitals	62.7	64 4	72.3	78.8	25.7%
Overall ONDAM ceiling for France	**123.5**	**152.0**	**167.0**	**186.7**	**51.2%**

Source: DREES (2019). ONDAM = *Objectif National des Dépenses d'Assurance Maladie* ; MIGAC : *Mission d'Intérêt Général et d'Aide à la Contractualisation.*

Patient conditions and primary diagnoses recorded in the national database used for T2A financing are obtained from the Maincare/DIMBENCH® analytics platform developed by the AMEDIM® group (Maincare Solutions, 2019). The Armitage trend is used to test the evolution of rates (Armitage, Berry, & Matthews, 2002). For regular stays (≥ 1 night), patients 75 years old and older and patients 60 to 74 years old represent 26.8% and 22.0% of the total number of stays, i.e., a 4.4% and 7.7% increase since 2013 (Chart 1).

CHART 1
AGE STRUCTURE OF THE POPULATION HOSPITALIZED BETWEEN 2013 AND 2017 (STAYS ≥ 1 NIGHT)



Source: Maincare Solutions (2019).

Table 7 illustrates variations observed for different main stay diagnoses. After adjusting for age, increase rates are significant for acute myocardial infarction, cardiac failure, cerebrovascular strokes and hip fractures. The bacterial pneumonia rate is decreasing significantly.

TABLE 7
MAIN DIAGNOSTIC-RELATED STAYS (≥ 1 NIGHT, /1000 POPULATION) (RATES ADJUSTED BY THE STRUCTURE OF THE HOSPITALIZED POPULATION IN 2017)

	2013	2014	2015	2016	2017	Trend Chi², *p*
Nb. stays (millions)	10.60	10.59	10.52	10.53	10.44	
Age ≥ 75 years old (%)	25.3%	25.6%	26.4%	26.5%	26.8%	< 0.001
Bacterial pneumonia § ≥15 years old (‰)	6.5	6.1	6.5	6.4	6.2	< 0.01
Gastrointestinal hemorrhage § ≥15 years old (‰)	6.4	6.3	6.3	6.4	6.4	0.358
Acute myocardial infarction § ≥45 years old (‰)	9.8	9.9	10.8	13.7	14.4	< 0.001
Cardiac failure § ≥45 years old (‰)	32.2	33.0	33.6	33.9	34.2	< 0.001
Cerebrovascular stroke § ≥45 years (‰)	17.0	17.2	17.4	18.0	18.6	< 0.001
Hip fracture § ≥45 years (‰)	13.1	13.1	13.2	13.1	13.4	< 0.001

Source: Maincare Solutions (2019). § = Coded as main diagnosis.

Secondary complications can be estimated from associate diagnoses recorded for stays of 48 hours and over or 72 hours and over (i.e., pressure ulcers) (Table 8). After adjusting for the age distribution of 2017, significant increases are shown for thrombo-embolic events, infectious/ nosocomial infections, pressure ulcers and surgical complications.

TABLE 8
ASSOCIATE DIAGNOSES (STAYS ≥ 48H, /1000 POPULATION, RATES ADJUSTED BY THE 2017 AGE STRUCTURE)

	2013	2014	2015	2016	2017	*p*
Pulmonary embolism † (‰)	9.17	9.37	8.29	8.51	8.89	< 0.01
Peripheral venous thrombosis † (‰)	9.10	8.81	8.00	7.47	7.39	< 0.001
Sepsis † (‰)	30.81	36.15	38.16	40.40	40.43	< 0.001
Bacterial pneumonia † (‰)	2.33	2.25	2.52	2.50	2.74	< 0.001
Nosocomial factors † (‰)	9.83	12.40	13.40	15.42	11.52	< 0.001
Osteoarticular prosthesis infection † (‰)	1.70	1.91	2.04	2.05	2.26	< 0.001
Complication of antibiotics † (‰)	1.09	1.35	1.38	1.52	1.61	< 0.001
Pressure ulcer † (≥72h) (‰)	17.82	19.89	21.21	20.90	21.28	< 0.001
Surgical complications (‰)	10.06	18.35	22.86	29.93	24.81	< 0.001

Source: Maincare Solutions (2019). † = Coded as secondary diagnosis and not as primary diagnosis.

DISCUSSION AND CONCLUSIONS

Selection of an optimal financing scheme is a major issue in both developed and developing countries (Cylus, Papanicolas, & Smith, 2016). Considering that the global-payment approach was a source of structural inefficiency, the T2A activity-based financing approach was deployed in France in 2004 (partially, and later extensively) with two main objectives: 1) improving hospital efficiency; and 2) fostering convergence between the public and private sectors. The main adaptation strategies followed by hospitals were: 1) increased activity in the public and private sectors; 2) selection of patients with the most cost-efficient DRG/GHM, especially in the private sector, with the most complex cases being referred to the public sector. However, GHS pricing is revised every year in March (e.g., reduced from 1% to 2%) to conform to the ONDAM national ceiling strategy, with the secondary effect of maintaining most hospitals in deficit (i.e., their activity-based income diminishes for exactly the same level of activity).

Increased activity was mainly achieved by the development of day care activity, especially day surgery, and reduction in lengths of stay for regular inpatient care. But if this appears more convenient for patients and leads to reduced nosocomial complications, too-early discharges are associated with complications outside the hospital environment and increased incidence of early readmissions (DREES, 2019). Prevalence of patients with multiple conditions increases with population aging. But the stay financing rate is calculated on the basis of the main diagnosis and several structures split one possible long stay for complex patients into several

shorter stays in order to increase their income. This strategy is a departure from the holistic approach recommended for patient care.

Public and private activity has been developed for the optimization of diagnostic coding, i.e., finding from a list of diagnostic and procedure codes the most financially attractive subsets. Increased morbidity rates observed in Table 8 for the period 2013-2018 could result from generalized upcoding. However, it could also be the consequence of a decreasing quality of care if the professional workforce, in particular nurse density, does not increase in parallel with activity. A major positive result of the T2A/DRG approach was the mandatory coding of diagnoses and procedures, with subsequent feeding of national health data warehouses such as SNIIRAM[12] (Assurance Maladie, 2019b). This activity should definitely be maintained. However, the race for always-higher efficiency (i.e., doing more with less) has reached its limit. The incidence of professional burnout for both physicians and nurses (e.g., in emergency departments) has increased, and there is now consensus about reducing the DRG/T2A financing scheme, in combination with the development of process- and outcome-related quality indicators, and including this strategy in the 2022 French health plan (Ministère des Solidarités et de la Santé, 2019).

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Article 3 – Bridging the Universal care inequality gap in South America with a unified health system: a comparison of Brazil with Argentina

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Bridging the Universal Care Inequality Gap in South America with a Unified Health System: a Comparison of Brazil with Argentina

Angel Benitez Collante1,2 MD MSc-MPH

Abstract

Background. Brazil is the only country in South America in having implemented a unified health system, the *Sistema Unico de Saúde*, with the aim of improving access and quality of care. Regardless of the scope of health care policies, a unified system seeks to encourage the participation of all health care sectors and at levels of government, unifying efforts to improve access and quality. This research answers to the question of whether a unified health system could achieve better advances in terms of access and quality of care, by comparing the health care systems of Brazil and Argentina.

Methods. Difference-in-differences regressions were implemented in impact evaluation of Brazil's unified health system, comparing Brazil with Argentina by assessing indicators of health prevention, coverage, activity and selected clinical outcomes, during the period 2000-2016.

Results. Comparative differences were observed in trends of health indicators of Brazil with Argentina, namely decreased in out-of-pocket expenditure as a percentage of current health expenditures (OOPPHE), and age-adjusted rates of mortality from maternal and childcare conditions, cancer, and communicable and noncommunicable diseases. An increase in hospital admissions, medical visits, and deliveries by skilled birth attendants, was observed in Brazil, in comparison with Argentina.

Discussion. By adopting a unified system within a universal care scope, the 1988 Brazil's Constitution reform acted as a catalyst for the design and implementation of policies, namely health insurance policies that consolidated Brazil's Unified Health System in 2001. The comparative increase in hospital admissions, medical visits and deliveries by skilled birth attendants, and the comparative decrease in OOPPHE and rates of mortality from communicable and noncommunicable diseases in Brazil, could be explained by positive impacts of the consolidation of a unified health system in terms of the expansion of access to health services and improvement in health financial protection and clinical outcomes. This study extends prior research to inform health policy reform in South American countries that could follow the example of Brazil's unified health care system.

Keywords. Health policy, Policy analyses, Health care quality, access, and evaluation, Universal health care, Unified health system, Learning health system

Background

In the aftermath of the financial crisis of 2007, public and private international health initiatives focused their attention on how health systems are structured [Nishtar 2010]. Due to the impossibility to achieve the health care targets of the Millennium Development Goals (MDG), the World Health Organization (WHO) has shown increasing interest in health care systems [Evans 2008]. Regardless of the varied political and socio-economic realities among countries, the way in which health systems are organized could be a determinant of the health of the population. The WHO considers the Acheson definition, which defines public health as the "art and science of preventing disease, prolonging life and promoting health through the organized efforts of society" [Acheson 1988]. Therefore, the multidimensional field of public health requires the coordination across different sectors involving political and collective actions, not limited to the treatment of illness and promotion of health, but also including the mastery of health risk. For instance, through different actions, governmental agencies take care of public health by dealing with the protection and improvement of citizen health and hygiene [Smith and Greenblatt 2019]. The concept of health system refers to the way the institutions and individuals that ensure the delivery of care are organized with the primary intent to promote, restore or maintain health [WHO 2007]. At a first level of dichotomy, a health care system can be considered as universal if its goal is to provide coverage the whole population, and therefore, the population could have access to health services without experiencing financial hardship [WHO 2021b]. Universal health care models can have a single-payer system, when a single agency centralizes costs' financing like the United Kingdom through the National Health Service, or a multi-payer system, when more than one actor finances the costs of care like the German Bismarck model. Non-universal health care systems include the private health insurance system and out-of-pocket (OOP) payments, which are borne by individuals as they are not covered by the health insurance, can be found in all health systems. Depending on how health care actors are organized in the marketplace, a health care system can be unified, when a central government coordinates all actors to deliver and finance care, or it can be a mixed model if the privately financed marketplace health care system coexists with the publicly financed care (Nishtar 2007). However, a health model can present aspects of the other models, i.e., OOP, which are borne by individuals, accounting for 20% of the average health care expenditure in rich countries, and marketplace provision of services are also present in universal models [OECD 2019].

The countries compared in this study, Argentina and Brazil, share many cultural, political, and organizational similarities in the delivery of public services. They both have a federal system of government and a universal model of health care. However, the way in which countries face challenges in achieving access and equity in health care vary across the world, influenced by traditions and legal frameworks. Brazil's 1988 constitution reform embraced universal care implemented through the Unified Health System –*Sistema Unico de Saúde,* SUS. Only five countries in the South America have universal health coverage, but only Brazil has adopted a unified system centralizing and coordination actions of insurers and providers from both private and government sectors [Jurberg 2010]. However, since policymaking and policy implementation are decentralized in Brazil's federal system; since 1996, laws transferred a great part of the responsibility for financing and managing health care to the 26 states, including city state Brasilia, and to the 5570 municipalities of Brazil [Jurberg 2010]. The recognition of a constitutional right to health care did not produce a policy shock, but it initiated a 30-year path that expanded health policy at federal, state, and municipal level aiming to improve access and quality of care [Castro 2019]. Brazil's 1988 Constitutional reform acted as a catalyst for the enactment of policy at all state levels that led to the consolidation of the SUS in 2001 through the with the creation of the regulatory agency for private insurance for supplementary health payments. On the other hand, Argentina kept a mixed system of a universal health insurance and delivery of care, never having adopted a unified system. The comparative analysis of this research departs from the assumption that factors resulting from the implementation of a unified system led to different trends in health care outcomes in both countries. The objective was to provide a comparative analysis to highlight the impact of the implementation of a unified health system in Brazil. The hypothesis was that the implementation of a unified health care system is associated with improvements in selected performance indicators of access and quality of care.

Methods

A simple framework implemented here as a guide for assessing the performance of management in health systems consisted of three steps, as follows: 1) the building blocks, including structure and processes, 2) the intermediate outcomes or results consisting of efficiency and coverage aspects 3) the final outcomes, including indicators of clinical outcomes and satisfaction [Hurst 2001]. Argentina had never enacted a unified health care system and

was used as a counterfactual in a comparative analysis with Brazil in this research, due to administrative, geopolitical and cultural similarities.

For the study of health care access, the three dimensions of coverage suggested by The World Health Report, service coverage, financial coverage, and population coverage should be considered [The World health report 2010]. This study selected indicators of preventative care, (rates of immunization, use of modern contraceptive methods, unmet need for family planning, and deliveries by skilled birth attendants), service activity (medical visits, and hospital admissions), health financial protection (OOP as a percentage of current health expenditure, OOP as a percentage of private health expenditure). To assess clinical outcomes, four aggregated mortality rates, recommended in macro medico-economic analyses by the WHO, were selected, as follows: 1) communicable diseases mortality, 2) communicable, maternal, perinatal and nutritional conditions mortality, 3) noncommunicable diseases mortality, 4) and cancer mortality.

Departing from a macro analysis of aggregated data, available in the PAHO-WHO tool Health Information Platform for the Americas (PLISA) [PAHO 2021], in the form of age-adjusted rates to the last available year, 2016, regression models were conducted in STATA® 16 software to assess the association of the implementation of a unified health system in Brazil with variation in rates of indicators. Multivariate regressions were performed adjusting for socio-economic variables influencing populations' health, as follows: adjustment by domestic general government health expenditure as a percentage of GDP, and domestic general government health expenditure as a percentage of current health expenditure, in the cases of preventative care, service activity and health financial protection indicator, and adjustment by sanitation and drinkable water improvements in the case of clinical outcomes. Difference-in-differences regression models were conducted assuming the clinical outcome rate values in the year 2000 as baseline, and values in the last available data year, 2016, as an end state, and formalized as follows:

$$y = \beta_0 + \beta_1\, unified + \beta_2\, year2016 + \beta_3\, unified2016 + \varepsilon$$

Notation:

year2016=dummy variable for year; β_3=difference-in-differences estimate; y= indicator rate; *year2016*=0 in 2000: *year2016*=1 in 2016;

unified=treatment, the implementation of a unified health system;

unified2016=interaction term, product of *year2016* and treatment *unified*;

Results

A first graphical observation of the distribution trends on indicators was conducted by observing graphs of regression of indicators by year for both, Argentina and Brazil (Figures 1–12). Through the period of analysis, rates of mortality from communicable diseases (CDs) and noncommunicable diseases (NCDs) observed a constant decrease in Brazil and were smaller than in Argentina in the last year of this period, partly due to a sudden increase in both CDs and NCDs' mortality in Argentina during the last year of the period (Figures 9 and 11). Mortality rates from communicable, maternal, perinatal, and nutritional conditions showed a descending trend in Brazil, while Argentina remained stable over time, albeit showing with yearly oscillations (Figure 10). The mortality from cancer, followed a downturn pattern in both countries, albeit Brazil showed a lower rate across the period (Figure 12).

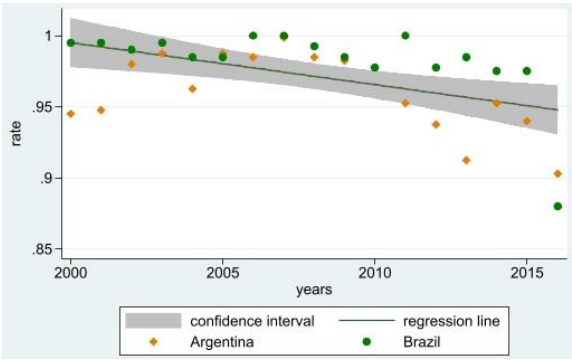

Figure 1 Immunization with BCG, Polio, DPT3cv and MMR1(2000-2016)

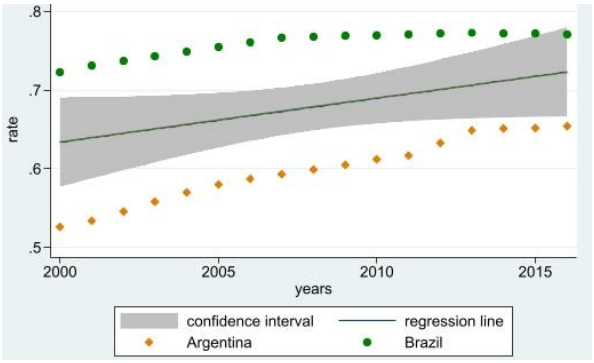

Figure 2 Use of modern contraceptive methods (2000-2016)

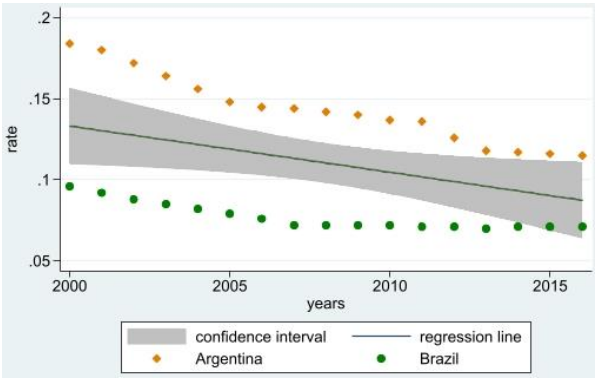

Figure 3 Unmet need for family planning (2000-2016)

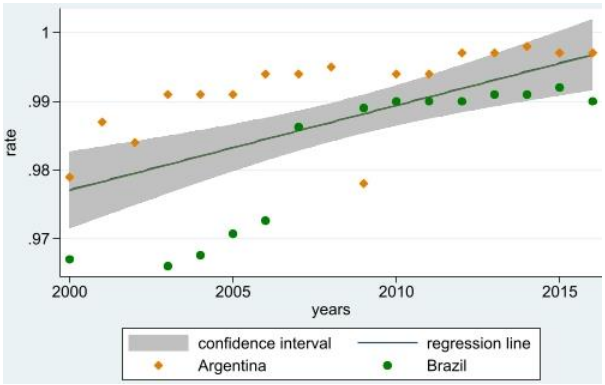

Figure 4 Deliveries by skilled birth attendants (2000-2016)

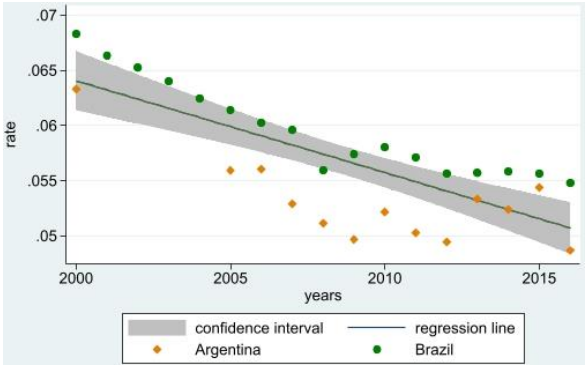

Figure 5 Hospital admissions per population (2000-2016)

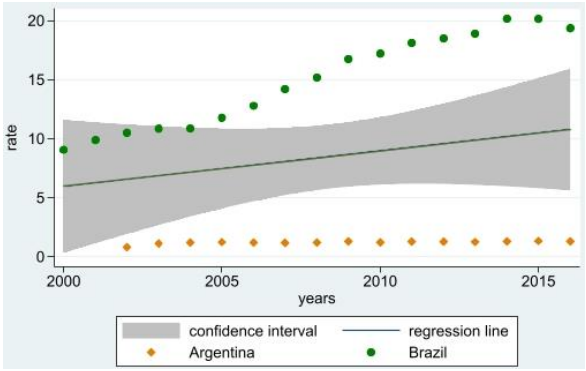

Figure 6 Medical visits per population (2000-2016)

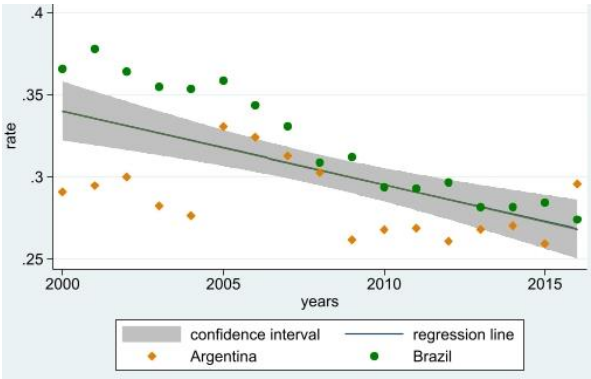

Figure 7 Out-of-pocket expenditure as a percentage of current health expenditure (2000-2016)

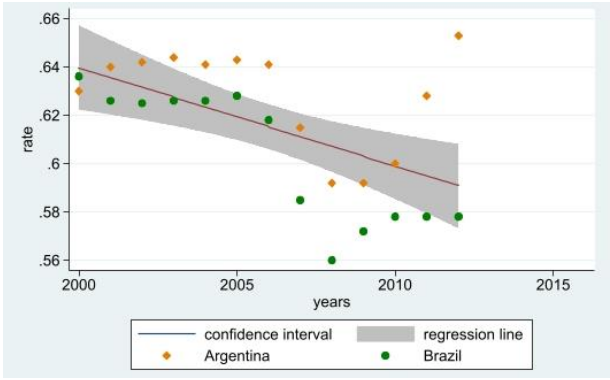

Figure 8 Out-of-pocket expenditure as a percentage of private health expenditure (2000-2012)

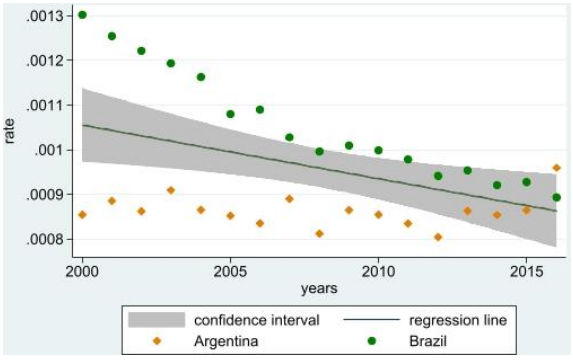

Figure 9 Communicable disease mortality (2000-2016)

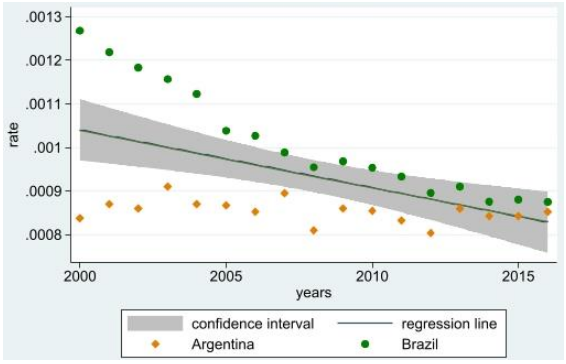

Figure 10 Communicable, maternal, perinatal, and nutritional condition mortality (2000-2016)

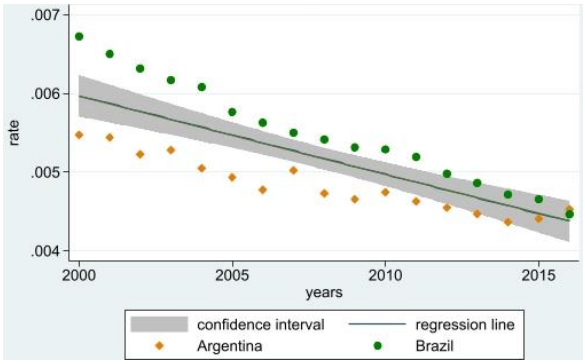

Figure 11 Noncommunicable disease mortality (2000-2016)

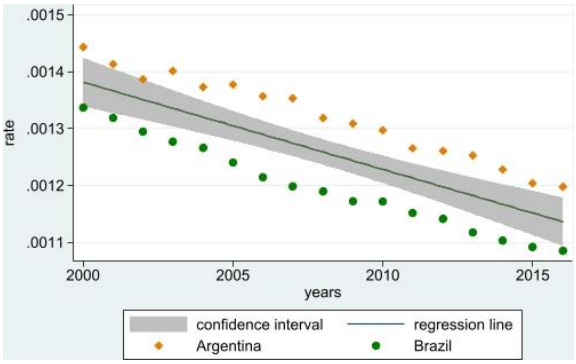

Figure 12 Cancer mortality (2000-2016)

Log-log Multivariate Regressions showed that unmet need for family planning was significantly lower in Brazil (-.805, p<.001) and the use of modern contraceptive methods was significantly higher (.337, p<.001) probably due to strong actions in primary care. A bigger rate of medical visits (2.31, p<.001) and hospital admissions per population (.130, p=.015) were associated with Brazil's SUS. Regarding clinical outcomes Brazil's SUS was associated with significantly higher mortality rate from noncommunicable diseases (.157, p<.001) and lower mortality rate from cancer (-.110, p<.001) (Tables 1, 2 and 3).

However, significant differences between Argentina and Brazil were observed through analysis of difference-in-difference estimates (Tables 1, 2 and 3). After the implementation of SUS in Brazil, the deliveries by skilled birth attendants were likely to increase by 0.5% (β_3=.005), medical visits and hospital admissions were likely to increase by 31.0% and 4.3%, respectively, and the OOP as a percentage of current health expenditure was likely to decrease by 30.5%. The effect of a unified system in Brazil at the end of the period was likely to explain a decrease in the rates of the four aggregated clinical outcome rates, as follows: by 38.8 % in mortality from communicable, maternal, perinatal, and nutritional conditions decreased (β_3 = –.387), by 49.3% in mortality from communicable diseases (β_3 = – .493), by 22.1% in mortality from noncommunicable diseases (β_3 = .22) and by 2.2% the mortality from cancer (β_3 = .022). In the case of four selected mortality indicators, the difference between 2000 and 2016 outweighed the difference between Argentina and Brazil in case the unified system was not implemented.

Table 1 Regression output for unified health system on preventative care rates (2000-2016)

Variable unified health system	Estimate	Standard error	t	P>t	[95% Conf. Interval]	
Multivariate†						
Immunization	.003	.037	.070	.942	–.072	.078
Use of modern contraceptive methods	.181	.019	9.36	.000	.142	.221
Unmet need for family planning	–.068	.012	–5.54	.000	–.094	–.043
Deliveries by skilled birth attendants	–.016	.007	–2.16	.041	–.031	–.001
Log–log multivariate†						
Immunization	.054	.051	1.07	.293	–.050	.158
Use of modern contraceptive methods	.337	.037	9.01	.000	.260	.413
Unmet need for family planning	–.805	.072	–11.2	.000	–.952	–.658
Deliveries by skilled birth attendants	–.015	.005	–3.29	.003	–.025	–.006
Difference-in-differences log-level‡						
Immunization	–.077	--	--	--	--	--
Use of modern contraceptive methods	–.154	--	--	--	--	--
Unmet need for family planning	.168	--	--	--	--	--
Deliveries by skilled birth attendants	.005	--	--	--	--	--

†=adjusted for current health expenditure as a percentage of GDP; domestic general government health expenditure as a percentage of GDP, and domestic general government health expenditure as a percentage of current health expenditure; t=t-statistics; p=p-value Pearson; *=pooled rate of vaccination for BCG, Polio, MMR1 and DPT3; ‡=difference-in-differences estimate for interaction term unified system in last year of the period.

Table 2 Regression output for unified health system on health access and financial protection rates (2000-2016)

Variable unified health system	Estimate	Standard error	t	P>t	[95% Conf. Interval]	
Multivariate†						
Medical visits	11.4	2.93	3.88	.001	5.34	17.9
Hospital admissions	.005	.004	1.42	.168	–.002	.013
OOP as a % of current health expenditure	.002	.054	.040	.968	–.109	.113
OOP as a % of private health expenditure*	–.045	.031	–1.46	.160	–.110	.019
Log-log multivariate†						
Medical visits	2.31	.088	26.2	<.001	2.13	2.48
Hospital admissions	.130	.049	2.63	.015	.028	.232
OOP as a % of current health expenditure	.028	.102	.280	.785	–.180	.236
OOP as a % of private health expenditure*	–.056	.062	–.890	.383	–.186	.074
Difference-in-differences log-level‡						
Medical visits	.310	--	--	--	--	--
Hospital admissions	.043	--	--	--	--	--
OOP as a % of current health expenditure	–.305	--	--	--	--	--
OOP as a % of private health expenditure*	.131	--	--	--	--	--

†=adjusted for current health expenditure as a percentage of GDP; domestic general government health expenditure as a percentage of GDP, and domestic general government health expenditure as a percentage of current health expenditure; t=t-statistics; p=p-value Pearson; *=2012 was the latest year; OOP=Out-of-pocket payments; ‡=difference-in-differences estimate for interaction term unified system in last year of the period.

Table 3 Regression output for unified health system on age-adjusted mortality rates (2000-2016)

Variable unified health system	Estimate	Standard error	t	P>t	[95% Conf.	Interval]
Multivariate†						
Communicable maternal, perinatal, nutritional conditions	5.2e-05	5.7e-05	.910	.370	-6.5e-05	1.7e-04
Communicable diseases	4.8e-04	2.1e-04	2.32	.028	5.5e-05	.001
Noncommunicable diseases	4.8e-04	2.1e-04	2.32	.028	5.5e-05	.001
Cancer	–1.7e-04	1.9e-05	–8.95	<.001	–2.0e-04	1.3e-04
Log-log multivariate†						
Communicable maternal, perinatal, nutritional conditions	.078	.061	1.290	.208	-.046	.203
Communicable diseases	.131	.058	2.25	.033	.012	.250
Noncommunicable diseases	.157	.037	4.27	<.001	.082	.233
Cancer	–.110	.017	–6.41	<.001	–.145	–.075
Difference-in-differences·‡·						
Communicable maternal, perinatal, nutritional conditions	–.388	--	--	--	--	--
Communicable diseases	–.493	--	--	--	--	--
Noncommunicable diseases	–.221	--	--	--	--	--
Cancer	–.022	--	--	--	--	--

†=adjusted for rates of urban improved sanitation facilities and water supplies; *t*=t-statistics; *p*=p-value Pearson; ·‡·=difference-in-differences estimate for interaction term unified system in last year of the period.

Discussion

Results Observed

Achieving universal health care is one of the Sustainable Development Goals targets adopted in 2015 by the UN, which propose a comprehensive definition of universal care, including health financial protection [UN 2015]. However, this framework should be paired of quality standards that can only be maintained and improved with permanent evaluation of quality indicators. Even if reductionist, the analysis of health system in three steps proposed by Hurst 2001 is useful to infer why some countries, following their traditions and a strong path dependence in policymaking around public services, may choose one system over another, in order to meet the needs of the population. In the case of analysis of this article, the differences in the statistical analysis results could be explained to the unification of resources and efforts of all health care actors, or due to other local factors to be determined in further research reframing the study from the three-step basis. The catalytic effect of Medicaid program implementation in the United States on policy expansion at federal, state, and local level could have an analogy with the implementation of the SUS in Brazil [Thompson 2012].

The difference-in-differences method allowed to quantify for the difference between the expected result in the case a policy was not implemented, and the results of the policy path chosen. Since multivariate regressions don’t account for the difference in trends between the

expected and the observed rates at the end of the period, they are limited in assessing the impact of policies. Difference-in-differences method applies to this case, particularly because the two countries presented very different baseline rates, especially in the case of Brazil that departed from a very low level of health care by the time of implementation of the SUS, with high mortality rates.

The consolidation of Brazil's unified health system was associated with an important expansion in the access to medical visits and a reduction in the out-of-pocket expenditure rate as a percentage current health expenditure by 30.4%, suggesting a global increase in health financial protection. Even if both countries, Argentina and Brazil, have made progress in terms of coverage and quality of care, the unified model of delivery of care has obtained greater improvements in clinical outcome indicators in Brazil's population. The comparative decreasing trends in the four selected aggregated mortality rates provide consistent evidence for the association of the unified health system to an improvement in quality indicators at the population level. However, another reason could be that Argentina is living a stagnant period in its economy and population health indicators, while Brazil is expanding its industry and quality of life, while high levels of inequalities persist in both countries. Trends in clinical indicators in Argentina could also relate to the vicious cycle in which mixed health systems may get captured, called the mixed health systems syndrome, by which the system losses its balance and fails to affect the quality because of financing deficits [Nishtar, 2009]. The permanent increase in out-of-pocket expenditure as a percentage of private expenditure on health care in Argentina is a clear sign of mixed health systems syndrome (Figure 8). More research must be done to highlight the deficiencies of Argentina's mixed health care model as well as challenges encountered.

The nonlinear path that Brazil has transited can bring insights for health policy reform to Latin America settings, in which the national health spending, the sum of public and private spending could significantly decrease only by centralizing administrative procedures under a unified health system.

Limits of the study

The cross-sectional data extracted from the PLISA tool consisted of aggregated age-adjusted rates, resulting not possible to adjust for sex. Additionally, the type of available data collected

by international organizations on the basis of traditional health economics, presented limitations to this work. Novel behavioral economics or value-based approaches to the delivery of care could be gradually incorporated by organizations, making it available for further research to assess other dimensions of quality of care. Even if the study of health coverage adjusted rates by macro-economic measures of health-financing, and the study of the quality included socio-economic indicators, this work could not include the myriad of factors that affect the health of populations.

Perspectives

The question about how to achieve better access and quality of care, by opting for a better model of health care is in the interest of several Latin American countries. This seminal research work provides some evidence to justify further research on the impact of health care models. Starting in the 1990, the strategy for delivering universal care to populations has been family-centered in Latin America at large, affecting the planning of the structure of the services as well as the social infrastructure (health centers). However, new challenges arise with the aging of the population and the increase in the rates of noncommunicable disease risk factors, requiring a shift from a predominantly primary health scope to a more comprehensive scope

Furthermore, a more in-depth discussion on the main leading noncommunicable diseases should focus on behavioral and lifestyle aspects of risk factors, namely healthy habits, which are the factors that strengthen a health system from bottom-up by making the health of their population more resilient. Because health care is a multidimensional field, which involves every aspect of life, in order to achieve a more comprehensive performance evaluation, a good recommendation could be to conduct research beyond medical assistance indicators, by adding new dimensions to the classic list of indicators used in research in this field. For instance, in addition to patient satisfaction, some indicators of patient education would be useful to measure healthy habits that make the whole system more resilient. Moreover, in order to adapt to the changing epidemiological profile in populations, health systems are increasingly investing in education and wellbeing activities to balance physical and mental health, as well as curative and palliative care for chronic conditions.

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Angel E Benitez Collante

Cornell Institute For Public Affairs, Cornell University

Manuscript Title:

Bridging the Universal Care Inequality Gap in South America With a Unified Health System: A Comparison of Brazil With Argentina

2021 NASPAA Annual Conference

David Marshall, Pi Alpha Alpha Global Manager

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September 17, 2021

Mr. Angel Eugenio Benitez Collante
Cornell Institute For Public Affairs
College of Human Ecology
Cornell University
2201 Martha Van Rensselaer Hall
Ithaca, NY 14853

Dear Mr. Benitez Collante:

I am pleased to inform you that your paper, *Bridging the Universal Care Inequality Gap in South America With a Unified Health System: A Comparison of Brazil With Argentina* has been selected to receive the 2021 Pi Alpha Alpha Master's Student Manuscript Award. Your paper was reviewed by faculty from across the public service education field and chosen as one of the best from a pool of applicants. Congratulations on this honor!

NASPAA would like to award you a $300 prize for your work, and we invite you to participate in the virtual NASPAA Annual Conference October 27-29. Additionally, the Pi Alpha Alpha Steering Committee is sponsoring its Inaugural Pi Alpha Alpha Summit for students, alumni, and advisors on October 25-26. As an award winner we hope you will join us. We will be reaching out to you soon to see if you can participate on a panel during the summit. Finally, we will provide complimentary conference registration and we hope you will participate in as much of the conference as possible. Additional information about the conference can be found at https://www.naspaa.org/events/2021-naspaa-annual-conference.

In the meantime, it would be great if you could provide us with the following items preferably by September 27.

- a photo of you (preferably on campus, in class, or front of your school's logo)
- a short video (again preferably on campus) of you accepting the award and/or summarizing a few details about your chapter which will be posted on the conference platform/website.

Please contact me at your earliest convenience at marshall@naspaa.org, to confirm your attendance and to provide me with your preferred mailing address for your prize and certificate. Again, congratulations!

Kindest regards,

David Marshall
NASPAA Director of Membership Development & Pi Alpha Alpha Manager
marshall@naspaa.org | 202.628.8965 x114

CC: Thomas O'Toole, Executive Director, Cornell Institute For Public Affairs
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Chapter III

Relationships between hospital efficiency and quality of care

3.1 Hospital resource management and health care quality

Health care quality has been historically defined from the perspective of hospital administrators and, more recently clinicians and specialists (Sachdeva 2009). In current times, besides hospital efficiency, policymakers, health insurers and several different actors are increasingly interested in models that could integrate both aspects, efficiency, and the quality of care, to inform decision-making. A comprehensive model for hospital performance assessment should integrate key aspects of hospital performance, namely activity, financial efficiency, and health care quality, which relates to efficiency and quality dimensions of care (Hadji 2014). Therefore, the assessment of efficiency and health care quality integrates the measure of effectiveness of a health system [Degoulet 2017]. The simultaneous focus on efficiency and quality indicators for hospital performance assessment brings a more comprehensive assessment into a context of effectiveness assessment [IOM 2001; Arah 2003; Chang 2011]. Additionally, investments in prevention of safety incidents could also lead to a significant improvement in hospital efficiency by avoiding additional expenses in preventable adverse events [Oliveira 2008, Lasater 2021].

The analysis of the determinants of hospital efficiency and health care quality is essential in a framework of the budgetary contraction established in an activity-based financing system. Hospitals are faced with increasingly important financial constraints, which leads them to deploy strategies to optimize resources, at the risk of lowering the quality of care [Ramírez-Valdivia 2011; Valdmanis 2008]. The reduction of hospital beds and medical care staffing could lead to important financial savings [Hadji 2014; Kroneman 2004]. One of the oldest worldwide measures in search of hospital efficiency is the reduction of bed capacity [Saltman 1998, Kroneman 2004, Gaynor 1995]. An estimated decrease in hospital cost of about .3% could be achieved by a reduction of about 1.0% in hospital beds' number [Gaynor 1995]. Another measure is the reduction of hospital staff as a strategy to reduce hospital costs, which

are estimated on about 41% of hospital operating costs [Hancock 1987, Bai 2020].However, a reduction in the number of nurses per patient could be accompanied by an increase in job dissatisfaction, higher nurse turnover and burnout, as well as in-hospital mortality and adverse event rates [Aiken 2002; Mark, 2007; Nelson 2007; Valdmanis 2008]. Additionally, reductions in length of stays could also be the adaptation of hospital management to reduced bed capacity and constrained staff resources, and only due to an increase in activity [Walsh 2021].

The systematic review of study C, included in this chapter, allowed to select a set of indicators of resources, activity, and clinical outcomes relevant to the assessment of hospital performance in acute care hospital settings, in France. The indicators of hospital resources and activity were extracted from the DREES-SAE Diffusion database, as described in Chapter 1. Similarly, clinical outcome indicators were extracted from PMSI database, eased by the Maincare-DimBench® tool for all acute care hospital stays in France, during the period 2013-2017. All data were obtained separately by tax nature of hospitals acting as a confounding variable, in for not-for-profit (NPF) and for-profit (FP) hospitals, based on the assumption that both pursued different adaptations to financial constraints [Rotarius 2005; Mark 2007; Chevreul 2015]

3.2 The relationships of hospital efficiency with health care quality in France

The objective of observational study in article 4, included in this chapter, was to propose to propose a simplified model for the assessment of hospital performance in France integrating selected hospital activity and health care quality indicators. The statistical significance of trends of hospital resources, activity, and selected clinical outcomes was tested by variance analysis on on the assessment of mean value trends, and Cochran-Armitage chi2 test for trend on the assessment of rate trends. A structural equation model for the assessment of hospital performance was then proposed, adjusting by patient characteristics, and adjusting case-mix by relying on the MWTC as a dual clinical risk and cost of care indicator.

The study 4, included in this chapter provided with an observational longitudinal analysis of relationships between hospital efficiency and the quality of care in French acute care hospitals. The first hypothesis stated that an increase in hospital activity could have a negative association with the number of hospital beds and staff densities, suggesting a high patient turnover and

staff workload, respectively. A second hypothesis stated that the coding of adverse events in hospital discharges is not highly positive correlation with the MWTC, as an index of clinical severity, suggesting an upcoding of adverse events as a strategy to increase revenue. The structural equation model in this study assessed the direct and indirect association of hospital type and hospital morbidity with the MWTC, controlling for year and patient age and sex.

Two composite indicators were proposed for the assessment of hospital mortality and morbidity into statistical model. A selected conditions' composite mortality indicator consisted of the weighted average of six rates of conditions coded as a primary diagnosis were considered: acute myocardial infarction, ischemic stroke, gastro-intestinal haemorrhage, and hip fracture. In the case of composite morbidity indicator six rates of adverse events coded as a secondary diagnosis were considered as components of the composite indicator: pulmonary embolism, deep vein thrombosis, sepsis, nosocomial pneumonia, osteoarticular prosthesis infections, and pressure ulcers.

The proposed composite morbidity indicator formalization was proposed, as follows:

$$Composite\ indicator\ rate\ = \sum_{i=1}^{n} [\ coefficient_{\ i}\ *\ p_i\ ]$$

Notation:

coefficient=distribution coefficient *n*=Number of indicators considered;

i=indicator rate component; *p*=rate of each component indicator per year

Where the distribution coefficient is:

$$coefficient\ =\ \sum_{i=1}^{n} \left[\left(\frac{p-\mu}{\sigma} \right) \right]$$

Notation:

n=Number of indicators considered; *i*=indicator denominator; *p*=Number of age-sex-adjusted stays per year of the study period; μ=Mean of stays per indicator; *σ*=Standard deviation of number of stays.

Trends in the proposed composite mortality or morbidity indicators were tested to have a significant p-value, by Cochrne-Armitage Chi^2 test during the period of study, and they were considered as a response variable in eanch structural equation models. Despite the theoretically limited application of MWTC for comparing NFP and FP hospitals, the findings in article 4

validated significant trends in the reduction in hospital beds and staff per stays and the increase in hospital stays, as an adaptation of hospitals to the activity-based financing scheme, and a decline in the assessed quality of care, in France, which was different in NFP from FP hospitals

3.3 Risk-adjusted health care quality assessment

In a quality improvement framework, practicing case-mix adjustment on longitudinal evaluations to compare the quality of care among hospitals allows to account for imbalances between groups and stands for a good quality of research [Nicholl 2007]. International organizations present aggregated data of clinical outcomes in the form of age-adjusted rates, to allow comparisons that could inform policy, i.e., OECD statistics and PAHO-PLISA sites. However, adjusting clinical outcomes only by sex and age, which are not clinical factors themselves, is limited because clinical risk factors change with aging [Nicholl 2007]; i.e., as people age, the prevalence for heart diseases and cancer increases, but decreases for HIV/AIDS and obesity, in addition to an increased cancer patients' survivorship due to advances in clinical intervention [Piccirillo 2015].

Clinical risk-adjustments of clinical outcomes obtained from discharge records are necessary to accurately assess the quality of care in acute care hospital settings in the French activity-based financing context. However, depending on the risk-adjustment method, the use of certain indicators can be limited to accurately assess the quality of care, i.e., mortality rates could show high variations depending on the risk-adjustment approach in addition to be considered as poor indicators of quality of care [Vartak 2008]. Additionally, an accurate adjustment of patient discharges by clinical risk is of interest in the design of policies aimed to a most fair reimbursement of medical services. For instance, the US Department of Commerce proposed Clinical Risk Groups method (CRG) based on diagnoses and procedures to determine the risk-adjusted equalization of payments for insured of all ages [Juhnke 2016].

Therefore, several severity indexes composed of DRG-diagnosis which are associated with an increased length of stay and mortality are commonly implemented to risk-adjust clinical outcomes, accounting for differences in clinical severity [Charlson 1987, Elixhauser 1998]. Risk scoring methods, including a set of comorbidities and risk factors, namely Charlson and

Elixhauser's indexes, assuming unbiased comparisons in removing case-mix differences, by adjusting clinical outcome rates by constant and nonconstant risks [Charlson 1987, Elixhauser 1998]. However, the constant risk fallacy, which accounts for differences in the coding of the same comorbidities in different populations, could increase bias instead of mitigating them [Nicholl 2007].

In France, the MWTC, as a dual index of cost of care and clinical severity, is not appropriate to estimate and compare actual costs of care among hospitals, because practitioners in FP hospitals receive supplementary payments for several procedures, which are not factored in the MWTC calculation. The longitudinal analysis in article 5, included in this chapter, proposed a model of hospital performance adjusting by patient characteristics, and a proposed severity index. The MWTC was not factored into models due to its limited use in assessing differences between NFP and FP hospitals. However, further research is required to validate or improve its applicability to adjust clinical outcomes in the assessment of health care quality.

Study C – Systematic review on the assessment of hospital efficiency and health care quality

C.1 Methods

A systematic review of literature was conducted looking for articles, introducing models to assess hospital performance accounting for both, hospital efficiency and quality of care, published between year 1990 to 2022, following the PRISMA protocol [Moher 2009], oriented to MeSH terms in Figure C1 and 2, fulfilling validity criteria in Table C2.

Medline and Cochrane

Hospitals (MeSH) AND Quality of Health Care (MeSH) AND (Efficiency, Organizational (MeSH) OR Hospital Financial Management (MeSH) OR Costs and Cost Analysis (MeSH) OR Cost-Benefit Analysis (MeSH) OR Benchmarking (MeSH)) AND (Outcome Assessment, Health Care (MeSH) OR Quality Assurance, Health Care (MeSH)) AND Quality Indicators, Health Care (MeSH)

Web of Knowledge

(Hospitals) AND (Quality of Health Care) AND (Efficiency OR Hospital Financial Management OR Cost Analysis OR Cost-Benefit Analysis OR Benchmarking) AND ((Outcome Assessment, Health Care) OR (Quality Assurance, Health Care)) AND (Quality Indicators, Health Care)

Figure C1 Search of databases strategy for a systematic review on the assessment of hospital efficiency and health care quality.

Table C1 Validity criteria for the selection of articles

Design
Only observational studies
Defined study period
Sample
Justified sample size justified
The study includes acute-care and/or general hospitals
Indicators
Reliable and valid hospital input, output, and clinical outcome indicators
Indicators were quantified
Several inputs, outputs, and clinical outcomes were selected
Several adverse event measures were used as clinical outcome indicators in hospital-wide and/or surgical domain
Statistical analysis
Statistical methods were used to assess relationships between hospital efficiency and health care quality indicators

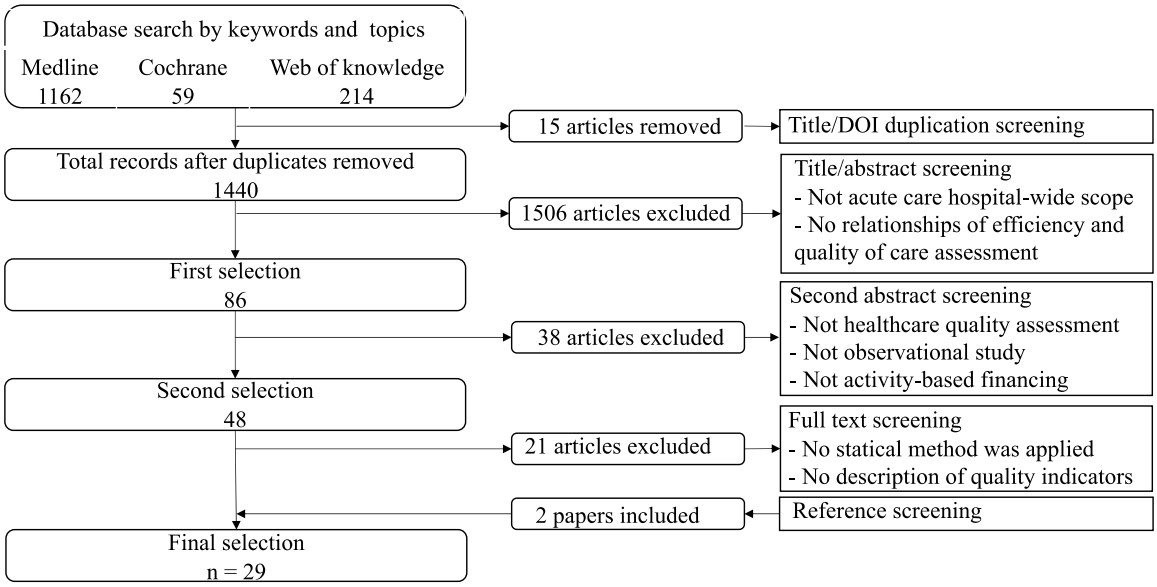

Figure C2 Flowchart of retrieval process of articles on the assessment of hospital efficiency and health care quality.

C.2 Results

A total of 29 articles presenting cross-sectional studies and a formal statistical model of the relationships between hospital productivity and clinical outcome indicators of acute care activity were selected (Figure C1). The articles selected were summarized considering hospital inputs, outputs and clinical outcome measures implemented in statistical models in hospital performance assessment, as well as the variables used for clinical risk adjustment (Tables C2). The methods applied in the assessment of hospital performance were multivariate regression models, in 14 articles, DEA in 4 articles, SFA in 2 articles, and 2 articles applied structural equation models (Table C2).

The hospital inputs most frequently used were the number of beds, in 8 articles, and both, service complexity and the number of registered nurses in 6 articles (Tables C3). The hospital outputs most frequently used were the number of patients of patients in 11 articles, and the registered nurse/patient ratio in 9 articles (Tables C3). In the hospital-wide domain, the clinical outcomes most frequently included were inpatient mortality, pressure ulcer and nosocomial infection in 11, 10 and 9 articles respectively (Tables C3). The mortality rates from heart failure mortality, acute myocardial infarction and pneumonia were assessed in 4 articles each indicator, respectively (Tables C3 and C4). In the surgical domain, postoperative sepsis and

postoperative deep vein thrombosis were the most used indicators, in 7 and 4 articles, respectively (Tables C3 and C4).

The frequencies of associations of hospital productivity inputs and outputs with the clinical outcomes integrated into hospital performance models were assessed (Tables C5 and C6). At hospital-wide level, the most relevant associations of hospital inputs and clinical outcomes were as follows: the number of beds with in-hospital mortality in 5 articles (17.2%) and with pressure ulcers and nosocomial infection in 3 articles, respectively (10.3%); the number of registered nurses was associated with in-hospital mortality and with pressure ulcers in 3 articles, respectively (10.3%) (Table C5). Regarding hospital outputs, the most observed associations were : the number of beds with in-hospital mortality in 5 articles (17.2%); registered nurse/patient ratio associated with failure to rescue, pressure ulcers and nosocomial infection in 5 articles, respectively (17.2%); the number of patients with in-hospital mortality in 4 articles (13.8%). In the surgical domain, the most considered associations were the number of beds with postoperative pulmonary embolism, deep vein thrombosis and sepsis, in 2 articles respectively (6.9%) (Table C6). Regarding hospital outputs, the most considered association was the number of patients with postoperative sepsis, 3 articles (10.3%).

Table C2 Description of the selected articles on the assessment of hospital efficiency and health care quality.

Author Year	Journal References	Country	Financing mode	Duration (months)	No hospitals	No patients	Analysis Methods	Activity input Indicators	Activity output Indicators	Clinical outcome indicators	Clinical risk adjustment	Independent and control variables
Aelvoet 2010	BMC Health Serv Res. 2010;10 :334	Belgium	DRG	48	109	46,287	Fixed-effects model	Hospital complexity	Patient volume	Acute myocardial infarction case-fatality rates (AMI-CFR)	Charlson's index, age, gender, AMI-CFR semester evolution Shock	Hospital location
Aiken 2021	Lancet Glob Health. 2021 Aug;9(8):e1145 -e1153	Chile	DRG	12	40	ND	Multilevel random-effects logistic regression Zero-truncated negative binomial	ND	Work environment (PES-NWI) Patient/Nurse ratio	30-day mortality 30-day readmission Length of stay (surgical patients)	Illness severity Elixhauser' s 31 comorbidities	Sex, age
Allin 2016	Health Econ Policy Law. 2016;11 (1):39-65	Canada	DRG	36	ND	ND	DEA	Hospitals spending per capita Prescription drugs spending per capita Physicians spending per capita Residential care facilities spending per capita	ND	Potential years of life lost from treatable causes Mortality from treatable causes Survival rate from treatable causes	ND	Managerial factors Environmental factors
Almeida Neves 2020	J Nurs Manag. 2021 Jul;29(5):1246-1255	Brazil	DRG	12	12	ND	Nurse survey Structural equation model	Nurses/bed ratio Nurse education Nurse work environment	Nurse commitment on the quality of care	30-day mortality Patient falls Pressure ulcers Health care-associated infections Medication errors Failures in surveillance and clinical judgment (RWFS) complications	ND	ND

Table C2 (continued)

Author Year	Journal References	Country	Financing mode	Duration (months)	No hospitals	No patients	Analysis Methods	Activity input Indicators	Activity output Indicators	Clinical outcome indicators	Clinical risk adjustment	Independent and control variables
Ayuso-Fernandez 2021	Enferm Clin (Engl Ed). 2021 Nov-Dec;31(6):344-354	Spain	DRG	12	26	ND	Univariate analysis Spearman Rho non-parametric test		RN/patient/ day ratio	hospital-acquired nosocomial infection Catheter-associated bacteraemia in ICU Pneumonia associated with mechanical ventilation in ICU Urinary tract infection associated with a bladder catheter in ICU Surgical site infection in hip arthroplasty Infections associated with medical care Infection in knee arthroplasty surgical site Percentage of compliance with hand hygiene instructions Percentage of compliance with zero bacteraemia verification Postoperative metabolic disorder Postoperative respiratory failure Postoperative sepsis Postoperative wound dehiscence Pressure ulcers Congestive heart failure Mortality Acute myocardial infarct Mortality Acute cerebrovascular accident Mortality Hip fracture mortality Pneumonia mortality	ND	Number of beds/nursing station and unit Number of nurses per shift and day of the week Average stay Number of stays Complexity index
Bağci 2021	Hosp Top. 2021;99(2):49-63	Turkey	DRG	48	92	ND	DEA, Malmquist, Tobit	Number of beds Number of specialist physicians, assistant physicians, nurses and midwives, and other medical staff	Number of polyclinic examinations Number of inpatients Number of hospitalization days Number of surgical operations by complexity	Mortality rate	ND	>400 beds Hospital ownership Metropolitan area Teaching status (Training/research /university)

Table C2 (continued)

Author Year	Journal References	Country	Financing mode	Duration (months)	No hospitals	No patients	Analysis Methods	Activity input Indicators	Activity output Indicators	Clinical outcome indicators	Clinical risk adjustment	Independent and control variables
Bashir 2022	Int J Health Plann Manage. 2022 Jul;37(4):2240-2255	Pakistan	DRG	8	843	31,452	SFA	Number of Specialists, Women medical officer, Nurses, Other staff, Technical staff	Deliveries	Maternal mortality Neonatal mortality	ND	Specialists' residence Ratios of ambulances, equipment, medicines, specialists, women medical officers Literacy rate, Population Hospital level Laboratory, ambulance, radiology support
Blegen 2011	Med Care. 2011 Apr;49(4):406-14	USA	DRG	12	54	872	Multi-variate regression	ND	RN, LPN, and NA hours/patient/day Total nursing hours/patient/day RN/hours/day over the total hours/patient/day	Congestive heart failure mortality Failure to rescue Infections due to medical care Excessive length of stay	AHRQ ratio of observed to expected	Hospital Medicare case mix index Technology Safety-net status
Cho 2015	Int J Nurs Stud. 2015 Feb;52(2):535-42	USA	DRG	12	14	76,036	Logistic regression models	Nurse work environment Nurse education level	Ratio patients/nurse	30-day Mortality	Elixhauser' s comorbidities (excluding HIV/AIDS, obesity, blood loss anemia, drug abuse) MDCs surgery, orthopedic or vascular surgery	Age, Male sex, Admission status or transfer Hospital Location, Hospital Unit, Number of beds

Table C2 (continued)

Author Year	Journal References	Country	Financing mode	Duration (months)	No hospitals	No patients	Analysis Methods	Activity input Indicators	Activity output Indicators	Clinical outcome indicators	Clinical risk adjustment	Independent and control variables
Hansen 2011	Health Serv Res. 2011 Apr;46(2):596-616	USA	DRG	12	67	ND	Multiple regression	Bed size Nurse staffing ratio	Nurse and physician perceptions of safety climate Volume of cases	30-day Acute myocardial infarction readmission 30-day Heart failure readmission 30-day Pneumonia readmission	age, gender selected comorbidities	Region Metropolitan Teaching status Tax status
Isaac 2008	J Gen Intern Med. 2008 Sep;23(9):1373-8	USA	DRG	12	4504	ND	Spearman correlation	bed size, medical intensive care unit, cardiac care unit,	% Medicare patients % Medicaid patients	Death in low mortality DRG Decubitus ulcer Failure to rescue Selected infection due to medical care	PSI software (age, gender, modified DRG, comorbidities)	Teaching status, Region, urban location
Junttila 2016	Int J Nurs Stud. 2016 Aug;60:46-53	Finland	DRG	24	2	ND	Negative binomial regression	ND	Nurse/patient/day ratio	In-hospital mortality	ND	Hospital unit
Khan 2006	J Gen Intern Med. 2006 Feb;21(2):177-80	Canada	DRG	21	1	7,457	Log-Level Regression	Hospital costs (adjusted for preoperative and surgical characteristics)	Length of stay	Postoperative complication Postoperative pneumonia, Postoperative stroke Postoperative hemorrhage, Postoperative infection Postoperative AMI Postoperative Acute respiratory failure Postoperative DVT/PE Perioperative Mortality	Major surgery Urgent surgery Surgery procedure Comorbidities	Age Female sex

Table C2 (continued)

Author Year	Journal References	Country	Financing mode	Duration (months)	No hospitals	No patients	Analysis Methods	Activity input Indicators	Activity output Indicators	Clinical outcome indicators	Clinical risk adjustment	Independent and control variables
Kim 2018	Int J Nurs Stud. 2018 Apr;80:155-164	South Korea	DRG	24	46	3,665,307	Multivariate logistic regression	Number of RN FTEs	ND	In-hospital mortality Urinary tract infection Upper gastrointestinal tract bleeding Deep vein thrombosis Hospital-acquired pneumonia Pressure ulcer Sepsis Shock/cardiac arrest, Central nervous system complication Physiologic/metabolic derangement Pulmonary failure Wound infection	Admission status Surgical operation, use of ICU Charlson' s comorbidity score	Age, sex, health security ≥30 diagnoses Number of beds Hospital location
Kittelsen 2015	Health Econ. 2015 Dec;24 Suppl 2:140-63	Sweden Denmark Finland	DRG	24	160	ND	DEA	Average Costs Case-mix index University Hospital Bed capacity	Number of Patients	Length of stay 30-day Readmission inpatient and emergency 30-day, 90-day, 180-day, 365-day Mortality Accidental puncture or laceration Obstetric trauma Bed sores	DRG cluster Charlson's index	Age, male sex, Treatment at own/other hospital Number of secondary diagnoses Municipality (population, unemployment, social assistance, single families, foreign) Travel time

Table C2 (continued)

Author Year	Journal References	Country	Financing mode	Duration (months)	No hospitals	No patients	Analysis Methods	Activity input Indicators	Activity output Indicators	Clinical outcome indicators	Clinical risk adjustment	Independent and control variables
Labella 2020	Eur J Public Health. 2020;30(6): 1041-1048	Italy	DRG	24	ND	ND	Logistic regression, Generalized Estimation Equation Model All-in GEE	Teaching status (Training/research/university)	Patient volume Number of safety practices and recommendations for preventing adverse events Average number of secondary diagnoses	Malpractice claims for injuries and deaths Foreign body left during surgery Postoperative sepsis Surgical wound dehiscence Deep vein thrombosis Pulmonary embolism	Average number of secondary diagnoses/ discharge	ND
Lin 2020	Medicine (Baltimore) . 2020 Jul 31;99(31):e 21182	USA	DRG	50	1	262,569	Chi² test, ANOVA Multivariate Cox regression	Electronic Medical Records (EMR) utilization	Only severe conditions (higher than average mixed case index)	Length of stay Discharge against medical advice Inpatient mortality 14-day readmission by disease 48-hour postoperative mortality	ND	Sex, age, Physician in charge Medical/surgical settings Hospital Departments
Mark 2009	Policy Polit Nurs Pract. 2009 Aug;10(3): 180-6	USA	DRG	6	118	1,600	DEA	Operating expenses Number of beds	Hospital discharges RN, LPN, and UAP hours/patient/day	Patient satisfaction Medication errors Patient falls	CMS case mix index	Medicaid wage index CMS case mix index
Needleman 2002	N Engl J Med. 2002 May 30;346(22): 1715-22	USA	DRG	12	799	ND	Patient-level logistic-regression	Number of RN/LPN hours	Ratio RN/hours/patient/day Ratio LPN/hours/patient/day Ratio NA/hours/patient/day	Length of stay Urinary tract infection Pressure ulcers Hospital-acquired pneumonia Shock or cardiac arrest Upper gastrointestinal bleeding Hospital-acquired sepsis Deep venous thrombosis Central nervous system complication In-hospital mortality Failure to rescue Wound infection Pulmonary failure Metabolic derangement	DRG cluster 13 chronic diseases	Number of beds Teaching status Location State, Age, sex Health insurer Emergency admission

Table C2 (continued)

Author Year	Journal References	Country	Financing mode	Duration (months)	No hospitals	No patients	Analysis Methods	Activity input Indicators	Activity output Indicators	Clinical outcome indicators	Clinical risk adjustment	Independent and control variables
Park 2015	Med Care. 2015 Jan;53(1):e 1-8	USA	DRG	12	54	>1,000,000	Multivariate regression	Ratio worked/paid hours	RN hours/patient/day (ICU and non-ICU) LPN hours/patient/day CNA hours/patient/day	Failure to rescue Decubitus ulcers Infections due to medical care	Patient case mix Hospital Service mix (technology Saidin Index)	Patient case mix
Smeds-Alenius 2016	Int J Nurs Stud. 2016 Sep;61:117 -24	Sweden	DRG	24	67	>200,000	Survey Multivariate logistic regression One-way ANOVA	ND	Quality of care report by RNs Surgeries by DRG	30-day inpatient postoperative mortality	Charlson's index	Age, sex, Admission status, Hospital size, Teaching and Technology status
Unruh 2012	Nurs Res. 2012 Jan-Feb;61(1): 3-12	USA	DRG	118	124	ND	Systems framework for quality model Latent growth curve model	Number of RN (FTE) Number of RN/APD	RN/patient/day	Decubitus ulcers Failure to rescue Selected infections Postoperative sepsis	Comorbidities (AHRQ software)	Case mix Urban status hospital ownership hospital size
Unruh 2016	Health Serv Res. 2016;51(6) :2258-2281	USA	DRG	12	2,747	ND	SFA	System member RN FTEs/total Nurse skill mix Total personnel expenses Technology Index	Net revenue Profit margin Payer mix	30-day Pneumonia mortality 30-day Pneumonia readmission 30-day Heart failure mortality 30-day Heart failure readmission PSI composite of complication IQI composite of surgical procedures mortality IQI composite of medical condition mortality	Elixhauser' s index	CMS case mix index Joint Commission Accreditation Hospital Ownership and size Region, location Teaching status

Table C2 (continued)

Author Year	Journal References	Country	Financing mode	Duration (months)	No hospitals	No patients	Analysis Methods	Activity input Indicators	Activity output Indicators	Clinical outcome indicators	Clinical risk adjustment	Independent and control variables
Vartak 2008	Med Care. 2008 Jan;46(1): 25-32	USA	DRG	12	646	ND	ANOVA, Pearson Chi^2	RN-to-bed ratio Resident-to-bed ratio Hospital bed size Hospital location	Surgical admissions/total	Postoperative hip fracture Postoperative hemorrhage or hematoma Postoperative physiologic and metabolic derangement Postoperative respiratory failure Postoperative pulmonary embolism/deep vein thrombosis Postoperative sepsis	Charlson's index DRG weight to capture case mix	Teaching status Hospital bed size Hospital ownership Hospital location Sex Primary payer Admission status
Wakeam 2014	JAMA Surg. 2014 Mar;149(3):229-35	USA	DRG	48	2898	46,519	Bivariate and multivariate analyses	Safety-net category Advanced cardiology, endoscopy or internal medicine, ICU, EMR, technology, cardiac surgery, solid-organ transplantation, ERCP, ABE, PET RN/nurse ratio Respiratory therapist/bed ratio	Nurse/patient ratio	Failure to Rescue	>3 Comorbidities Elective procedure Type of Procedure	Patient Demographics (Age, Female sex, race) Payer (insurance) Teaching status Hospital bed size Hospital region Procedure Clinical resources

Table C2 (continued)

Author Year	Journal References	Country	Financing mode	Duration (months)	No hospitals	No patients	Analysis Methods	Activity input Indicators	Activity output Indicators	Clinical outcome indicators	Clinical risk adjustment	Independent and control variables
Ward 2019	Ann Surg. 2019 Jul;270(1): 91-94	USA	DRG	6	52	44,567	Chi² test ANOVA Kruskal-Wallis test	ICU type Hospitalists and residents, Advanced practice providers (APPs) Overnight coverage 24-hour rapid response teams (RRTs).	ND	30-day Mortality Failure to Rescue Major Complication (deep incisional and organ-space infections, acute renal failure and/or insufficiency, post-operative bleeding requiring transfusion, myocardial infarction, cardiac arrest, pneumonia, pulmonary embolism, stroke, unplanned intubation, and septic shock)	>3 Comorbidities	Age, sex, race Hospital Failure to Rescue Tertile
Zhu 2019	Int J Environ Res Public Health. 2019 May 14;16(10): 1672	China	DRG	ND	181	5,430	Structural equation model	ND	RN/patient/ day ratio	Wrong medication Pressure ulcers Falls with injury Physical restraints Surgical site infections Urinary tract infections Patient-reported dissatisfaction Nurse-reported quality assessments	ND	Hospital level, and location Hospital unit type Nurse skill mix (education and working time) Length of stay Patient self-rated health status and education

ND=Not Described in the paper or not applied; CMS=Centers for Medicare and Medicaid Services; EMR=Electronic Medical Records; DRG=Diagnostic related Group; ABF=Activity-based Financing; FTE=full-time employees (FTEs); LPN=licensed practical nurses; LVN=licensed vocational nurses; RN=registered nurse; NA=nursing assistants; CNA=Certified nursing assistants; APD=Adjusted patient day; PES-NWI=Practice Environment Scale of the Nursing Work Index; SFA=stochastic frontier analysis; DEA=data envelopment analysis; ICU=intensive care unit; EMR=Electronic medical records; EP=Electrophysiology; ERCP=Endoscopic retrograde cholangiopancreatography; ABE=Ablation of Barrett esophagus; PET=Positron emission tomography; MDC=Major Diagnostic Category.

Table C3 Associations of hospital inputs with clinical outcomes

Input indicators	Clinical outcome indicators	No papers	References
Hospital-wide			
Number of beds	Length of stay	1	Kittelsen 2015
	Readmission	2	Hansen 2011, Kittelsen 2015
	In-hospital mortality	5	Kittelsen 2015, Bağci 2021, Isaac 2008, Cho 2015, Almeida Neves 2020
	AMI mortality	1	Hansen 2011
	Heart failure mortality	1	Hansen 2011
	Pneumonia mortality	1	Hansen 2011
	Failure to rescue	2	Wakeam 2014, Isaac 2008
	Pressure ulcers	3	Isaac 2008, Downey 2011,AlmeidaNeves 2020
	Nosocomial pneumonia	1	Hansen 2011
	Nosocomial infection	3	Isaac 2008, Downey 2011,AlmeidaNeves 2020
Service complexity	Length of stay	1	Kittelsen 2015
	Readmission	2	Kittelsen 2015, Park 2015
	In-hospital mortality	3	Ayuso-Fernandez2021,Kittelsen2015,Unruh2016
	AMI mortality	2	Aelvoet 2010, Ayuso-Fernandez 2021
	Heart failure mortality	2	Ayuso-Fernandez 2021, Unruh 2016
	Stroke mortality	1	Ayuso-Fernandez 2021
	Pneumonia mortality	2	Ayuso-Fernandez 2021, Unruh 2016
	Failure to rescue	2	Wakeam 2014, Park 2015
	Pressure ulcers	2	Ayuso-Fernandez 2021, Park 2015
	Nosocomial pneumonia	1	Ayuso-Fernandez 2021
	Nosocomial infection	2	Ayuso-Fernandez 2021, Park 2015
No Physicians	In-hospital mortality	2	Allin, 2016, Bağci 2021
No Specialists	In-hospital mortality	2	Bashir 2022, Bağci 2021
No RN	Readmission	1	Unruh 2016
	In-hospital mortality	3	Bağci 2021, Aiken 2021, Kim 2018
	AMI / Heart failure mortality	1	Unruh 2016
	Pneumonia mortality	1	Unruh 2016, Kim 2018
	Failure to rescue	1	Unruh 2012
	Pressure ulcers	3	Unruh 2012, Furukawa 2010, Kim 2018
	Deep vein thrombosis	1	Kim 2018
	Nosocomial pneumonia	1	Unruh 2016
	Nosocomial infection	2	Unruh 2012, Kim 2018
	Sepsis	1	Kim 2018
RN/bed ratio	In-hospital mortality	1	Almeida Neves 2020
	Failure to rescue	1	Wakeam 2014
	Pressure ulcers	1	Almeida Neves 2020
	Nosocomial infection	1	Almeida Neves 2020
Hospital costs	Length of stay	1	Kittelsen 2015
	Readmission	2	Kittelsen 2015, Allin 2016
	In-hospital mortality	1	Kittelsen 2015
Personnel expenses	Readmission	1	Unruh 2016
	Heart failure mortality	1	Unruh 2016
	Pneumonia mortality	1	Unruh 2016
Nurses spending	In-hospital mortality	1	Allin 2016
Physicians spending	In-hospital mortality	1	Allin 2016
Surgery			
Number of beds	Postoperative DVT/PE	2	Vartak 2008, Downey 2011
	Postoperative sepsis	2	Vartak 2008, Downey 2011
Service complexity	Postoperative sepsis	1	Ayuso-Fernandez 2021
	Postoperative wound dehiscence	1	Ayuso-Fernandez 2021
No RN	Postoperative deep vein thrombosis	1	Kim 2018
	Postoperative sepsis	2	Unruh 2012, Kim 2018
	Postoperative wound infection	1	Kim 2018
RN/bed ratio	Postoperative DVT/PE	1	Vartak 2008
	Postoperative sepsis	1	Vartak 2008
Hospital costs	Perioperative Mortality	1	Khan 2006
	Postoperative complications, Postoperative pneumonia, stroke, hemorrhage, infection, AMI, Acute respiratory failure, and DVT/PE		

RN=registered nurse; NA=nursing assistants; PE=Pulmonary embolism; DVT= Deep vein thrombosis; AMI=Acute myocardial infarction

Table C4 Associations of hospital outputs with clinical outcomes

Output indicators	Clinical outcome indicators	No papers	References
Hospital-wide			
Number of patients	Length of stay	2	Kittelsen 2015, Aiken 2021
	Readmission	2	Kittelsen 2015, Aiken 2021
	In-hospital mortality	4	Bağci 2021, Kittelsen 2015, Aiken 2021, Isaac 2008
	Acute myocardial infarction mortality	2	Aelvoet 2010, Ayuso-Fernandez 2021
	Heart failure mortality	1	Ayuso-Fernandez 2021
	Stroke mortality	1	Ayuso-Fernandez 2021
	Failure to rescue	1	Isaac 2008
	Pressure ulcers	3	Furukawa 2010, Ayuso-Fernandez 2021, Isaac 2008
	Nosocomial pneumonia	1	Ayuso-Fernandez 2021
	Nosocomial infection	2	Ayuso-Fernandez 2021, Isaac 2008
RN/patient ratio	Length of stay	2	Needleman 2002, Blegen 2011
	In-hospital mortality	1	Cho 2015
	Acute myocardial infarction mortality	1	Ayuso-Fernandez 2021
	Heart failure mortality	2	Ayuso-Fernandez 2021, Blegen 2011
	Stroke mortality	1	Ayuso-Fernandez 2021
	Failure to rescue	5	Unruh 2012, Park 2015, Needleman 2002, Wakeam 2014, Blegen 2011
	Pressure ulcers	5	Unruh 2012, Park 2015, Needleman 2002, Furukawa 2010, Ayuso-Fernandez 2021
	deep vein thrombosis	1	Needleman 2002
	Nosocomial pneumonia	2	Ayuso-Fernandez 2021, Needleman 2002
	Nosocomial infection	5	Unruh 2012, Park 2015, Needleman 2002, Ayuso-Fernandez 2021, Blegen 2011
	Sepsis	1	Needleman 2002
NA/patient ratio	Length of stay	1	Blegen 2011
	Heart failure mortality	1	Blegen 2011
	Failure to rescue	2	Park 2015, Blegen 2011
	Pressure ulcers	1	Park 2015
	Nosocomial infection	2	Park 2015, Blegen 2011
Hospital revenue	Readmission	1	Unruh 2016
	Heart failure mortality	1	Unruh 2016
	Pneumonia mortality	1	Unruh 2016
Hospital profit margin	Readmission	1	Unruh 2016
	Heart failure mortality	1	Unruh 2016
	Pneumonia mortality	1	Unruh 2016
Surgery			
Number of patients	In-hospital mortality	1	Bağci 2021
	Postoperative pulmonary embolism	1	Vartak 2008
	Postoperative deep vein thrombosis	1	Vartak 2008
	Postoperative sepsis	3	Ayuso-Fernandez 2021, Labella 2020, Vartak 2008
	Postoperative wound dehiscence	1	Ayuso-Fernandez 2021
	Postoperative deep vein thrombosis	1	Vartak 2008
	Postoperative sepsis	1	Unruh 2016
	Postoperative wound dehiscence	1	Ayuso-Fernandez 2021
	Postoperative wound infection	1	Needleman 2002
Hospital revenue	Perioperative mortality	1	Unruh 2016
Hospital profit margin	Perioperative mortality	1	Unruh 2016

RN=registered nurse; NA=nursing assistants.

Table C5 Frequency of associations of hospital inputs and outputs with hospital-wide clinical outcomes

Inputs and outputs / Clinical outcomes	Length of stay	Readmission	In-hospital mortality	AMI mortality	HF mortality	Stroke mortality	GIH mortality	Pneumonia mortality	Failure to rescue	Pressure ulcers	PE	DVT	Nosocomial pneumonia	Nosocomial infection	Sepsis
Inputs															
Hospital capacity															
No Beds	1 (3.4%)	2 (6.9%)	5 (17.2%)	1 (3.4%)	1 (3.4%)	--	--	1 (3.4%)	2 (6.9%)	3 (10.3%)	--	--	1 (3.4%)	3 (10.3%)	--
Service complexity	1 (3.4%)	2 (6.9%)	3 (10.3%)	2 (6.9%)	2 (6.9%)	1 (3.4%)	--	2 (6.9%)	2 (6.9%)	2 (6.9%)	--	--	1 (3.4%)	2 (6.9%)	--
Staff resources															
No Physicians	--	--	2 (6.9%)	--	--	--	--	--	--	--	--	--	--	--	--
No Specialists	--	--	2 (6.9%)	--	--	--	--	--	--	--	--	--	--	--	--
No RN	--	1 (3.4%)	3 (10.3%)	1 (3.4%)	--	--	--	1 (3.4%)	1 (3.4%)	1 (3.4%)	--	--	3 (10.3%)	1 (3.4%)	--
RN/bed ratio	--	--	1 (3.4%)	--	--	--	--	--	1 (3.4%)	1 (3.4%)	--	--	--	1 (3.4%)	--
Financial inputs															
Hospital costs	1 (3.4%)	2 (6.9%)	1 (3.4%)	--	--	--	--	--	--	--	--	--	--	--	--
Personnel expenses	--	1 (3.4%)	--	--	1 (3.4%)	--	--	1 (3.4%)	--	--	--	--	--	--	--
Nurses spending	--	--	1 (3.4%)	--	--	--	--	--	--	--	--	--	--	--	--
Physicians spending	--	--	1 (3.4%)	--	--	--	--	--	--	--	--	--	--	--	--
Outputs															
Activity indicators															
No Patients	2 (6.9%)	2 (6.9%)	4 (13.8%)	2 (6.9%)	1 (3.4%)	1 (3.4%)	--	--	1 (3.4%)	3 (10.3%)	--	1 (3.4%)	2 (6.9%)	--	--
RN/patient ratio	2 (6.9%)	--	1 (3.4%)	1 (3.4%)	2 (6.9%)	1 (3.4%)	--	--	5 (17.2%)	5 (17.2%)	--	1 (3.4%)	2 (6.9%)	5 (17.2%)	1 (3.4%)
NA/patient ratio	1 (3.4%)	--	--	--	1 (3.4%)	--	--	--	2 (6.9%)	1 (3.4%)	--	--	--	2 (6.9%)	--
Financial outputs															
Hospital revenue	--	1 (3.4%)	--	--	1 (3.4%)	--	--	1 (3.4%)	--	--	--	--	--	--	--
Hospital profit margin	--	1 (3.4%)	--	--	1 (3.4%)	--	--	1 (3.4%)	--	--	--	--	--	--	--

RN=registered nurse; NA=nursing assistants; CNA=Certified nursing assistants; AMI=Acute myocardial infarction; HF=Heart failure; GIH=Gastrointestinal hemorrhage; PU=Pressure ulcers; PE=Pulmonary embolism; DVT= Deep vein thrombosis.

Table C6 Frequency of associations of hospital inputs and outputs with surgical clinical outcomes

Inputs and outputs / Clinical outcomes	Perioperative mortality	Postoperative PE	Postoperative DVT	Postoperative sepsis	Postoperative complications	Postoperative wound dehiscence	Postoperative wound infection
Inputs							
Hospital capacity							
No Beds	--	2 (6.9%)	2 (6.9%)	2 (6.9%)	--	--	--
Service complexity	--	--	--	1 (3.4%)	--	1 (3.4%)	--
Staff resources							
No Physicians	--	--	--	--	--	--	--
No Specialists	--	--	--	--	--	--	--
No RN	--	--	1 (3.4%)	2 (6.9%)	--	--	1 (3.4%)
RN/bed ratio	--	1 (3.4%)	1 (3.4%)	1 (3.4%)	--	--	--
Financial inputs							
Hospital costs	1 (3.4%)	1 (3.4%)	1 (3.4%)	--	1 (3.4%)	--	1 (3.4%)
Personnel expenses	--	--	--	--	--	--	--
Nurses spending	--	--	--	--	--	--	--
Physicians spending	--	--	--	--	--	--	--
Outputs							
Activity indicators							
No Patients	1 (3.4%)	1 (3.4%)	1 (3.4%)	3 (10.3%)	--	1 (3.4%)	1 (3.4%)
RN/patient ratio	--	--	--	--	--	--	--
NA/patient ratio	--	--	--	--	--	--	--
Financial outputs							
Hospital revenue	1 (3.4%)	--	--	--	--	--	--
Hospital profit margin	1 (3.4%)	--	--	--	--	--	--

RN=registered nurse; NA=nursing assistants; CNA=Certified nursing assistants; PE=Pulmonary embolism; DVT=Deep vein thrombosis.

Article 4 – Activity and Quality of Care in the French activity-based financing system: differentiated evolution between not-for-profit and for-profit hospitals

Citation

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Activity and Quality of Care in the French activity-based financing system: differentiated evolution between not-for-profit and for-profit acute care hospitals

Angel Benitez Collante[1,2] MD MSc-MPH, Joseph Noussa Yao[1,2] Ing MSc, Patrice Degoulet[1,2] MD PhD

[1]Université Sorbonne Paris Cité
[2]Laboratory Information Sciences to support Personalized Medicine, INSERM-UMR1138
15, Rue École de Médecine, 75006 Paris, France

Abstract

Background. Within an activity-based financing system, quality of care management is a major issue. A longitudinal analysis was performed to evaluate the association between indicators of resources, activity, and clinical outcomes in France during the period 2013-2017.
Methods. All not-for-profit (NFP) and for-profit (FP) acute care hospitals were considered. The number of beds, health staffing, stays, and Mean weight of treated cases (MWTC) were compared for day-care (DC) and regular care (RC) sectors. Outcome indicators included in-hospital mortality, and selected conditions of medical and surgical mortality and morbidity.
Results. The total number of acute care beds decreases in NFP and FP hospitals (-4.2% and -7.5% respectively, p<.001), in association with an increase in day-care beds' share (5.8% vs.5.7%, p<.001). Densities of physicians, nurses and nursing assistants per bed are respectively 0.9, 1.8 and 2.2 times higher in NFP than in FP hospitals. MWTC decreases in NFP and FP hospitals (-0.8% and -4.1%). Age-sex adjusted mortality rates for regular stays (≥24-hour) decreases in NFP hospitals and increases in FP hospitals (-1.0% vs. 3.2%). Composite morbidity rates increased in NFP and FP hospitals for ≥48-hour stays (38.8% vs. 33.6%, p<.001), and particularly for ≥48-hour surgical stays (51.2% and 22.2%, p<.001).
Discussion and conclusion. The increased activity in NFP and FP hospitals under restrained nursing resources is a marker of the constant search of better financial efficiency. The adverse events' increase, associated with a reduced nursing staff per stays' ratio, suggests the need for an in-depth revision of current strategies in terms of optimal hospital staffing, and studies to evaluate what results from changes in case-mix and plausible upcoding practice guidance.
Keywords. Healthcare quality improvement, Continuous quality improvement, Quality measurement, Patient safety, Health policy

Introduction

Hospitals face increasing financial constraints, which leads them to optimize their human resources and increase their activity with the risk of lowering the quality of care [1-3]. France, with a financing system mainly based on activity and imposed in 2004 to not-for-profit (NFP), as well as for-profit (FP) hospitals, has mainly focused its efforts in improving financial efficiency [4-5]. Diagnosis coding is based on WHO ICD-10 diagnosis classification, and procedure coding on the CCAM classification (*Classification Commune des Actes Médicaux*), a hierarchical classification inspired from the US Current Procedural Terminology [6]. In France, the list of Diagnosis Related Group (DRG) in the PMSI (*Programme de médicalisation des systèmes d'information*) was inspired by the US Health Care Financing Group. The current version, which includes 2600 DRGs and 670 root groups, is maintained by the ATIH (*Agence Technique de l'Information sur l'Hospitalisation*), a central governmental agency [7].

Homogenous groups of stays - referred as *Groupe Homogène de Séjours* in France, GHS - combine through specific ATIH algorithms a grade severity index and the list of related and associated diagnoses. They are associated with financial values paid in lump sums to the hospitals. Financial values are calculated separately for NFP and FP hospitals. They include health professional and investigation exams for NFP hospitals, but not for FP hospitals, where they are separately charged to patients. The T2A (*Tarification à l'Activité*) acute care financing derived from coding of stays represented approximately 67% of the total hospital financing in 2017 [8]. Complementary payments for hospital structures are provided for education, research, innovation related activities, urgency activities, expensive drugs, and preventive care whatever the hospital status.

Policies to improve efficiency has focused on the reduction of hospital beds and medical care staffing, resulting in a reduction of the length of stays and financial savings [9-11]. Investments in the prevention of safety incidents could also lead to significant increased hospital efficiency [12-13]. While hospital evaluation was historically focused on processes and structures, clinical outcome measures are particularly relevant to assess the quality of care. Quality measures are frequently based on WHO ICD-10 codes [14]. However, quality indicators developed without considering the purpose, feasibility, or health care context, can lead to measurement incoherence [15]. Quality indicators driven by data availability ease the evaluation process but are not necessarily the best ones in terms of their intrinsic value [16]. Technical issues, such availability and reliability of data, as well as coding validity, robustness, sensitivity, and specificity, should condition the preferred use of some measures over others [17]. Additionally, financial incentives to improve efficiency and effectiveness by over- or under-coding undermines the potential of clinical codes to assess quality.

The objective of this longitudinal association study was to simultaneously analyse trends on a limited and selected number of indicators of resources, activity, and outcomes relevant to acute care hospitals, in France during the period 2013-2017. The hypothesis was that, for an ageing population, increased activity under human resource contention could be associated with significant changes, justifying further epidemiological explanatory analysis. NFP and FP hospitals followed different adaptation responses to financial constraints, and therefore behave as a major confounding factor [4,18,19], are studied separately in this article.

Methods

Population study

All acute care hospitals in metropolitan France were considered in the trend analysis (Table 1). Population estimates were obtained from INSEE [20]. The estimation of beds and human resources for acute care activity (i.e., medicine, surgery, and obstetrics) were obtained from the French Ministry of Health [21]. Two categories of hospitals were considered in this study: not-for profit (NFP) hospitals including public and not-for profit private hospitals, and strictly for-profit (FP) hospitals. The nursing staff was divided in nurses and nursing assistants.

Activity and quality indicators

Activity and quality of care data were extracted from the Maincare-DimBench® reporting tool that covers all acute care hospital stays in France. Diagnosis and act coding, which are mandatory for hospital financing, are considered to be close to 100% for the 2013-2017 period of study. Stays were divided into two groups: day care (DC) stays and non-day care or regular

care (RC) stays. Six age categories ranked from 1 to 6 were considered (0-14, 15-29, 30-44, 45-59, 60-74, and ≥75). Each stay summary includes one and only one primary diagnosis code, an optional related diagnosis, and as many as needed secondary ICD10 diagnosis and/or CCAM procedural acts. The Mean weight of treated cases (MWTC) is calculated by an ATIH algorithm from the discharge record summary, referred as RSS (*Résumé de Sortie Standardisé*) in France [7]. The MWTC index combines elements of clinical severity and cost of care [5, 22].

In-hospital mortality was adjusted for sex and age category on the basis of the age and sex repartition of patients that were admitted in DC or RC stays in 2017. Mortality rates for the six specific inpatient conditions integrated in the AHRQ Inpatient Quality Indicator IQ91, namely acute myocardial infarction, heart failure, ischemic stroke, gastrointestinal haemorrhage, hip fracture, and pneumonia [23], were calculated for patients age ≥30 years. A volume-adjusted composite mortality indicator was calculated from the six specific mortality indicators. For the assessment of hospital morbidity, six conditions coded as secondary diagnosis and not a primary diagnosis were analysed: pulmonary embolism, deep vein thrombosis, sepsis, nosocomial pneumonia, osteoarticular prosthesis infections, and pressure ulcers. All these conditions are possibly avoidable under specific drug or nursing prevention procedures [24-28]. Age-sex adjusted morbidity rates were computed for ≥48-hour stays except for pressure ulcers, where only ≥72-hour stays were considered. For surgical stays age-sex adjusted inpatient mortality and five morbidity events previously related to nurse staffing (postoperative complications, pulmonary embolism, deep vein thrombosis, sepsis, and wound dehiscence) [29] were estimated for ≥48-hour stays.

Statistical analysis

Trends in rates were validated by Cochrane-Armitage Chi^2 test [30], and comparisons of several means were tested by variance analysis. Multivariate analyses of associations were performed with structural equation modelling (SEM) using the Piecewise R® package [31,32]. Six hypotheses shown in figure 1: sex, age group, year, and not-for-profit hospital type are positively associated with the composite morbidity rate (H1 to H4); the hospital type and the composite morbidity rate with the Mean weight of treated cases (H5 and H6).

Results

Hospital resources and activity

Despite the regular increase of the French metropolitan population, the number of acute care hospitals decreases during the 2013-2017 study period with a total loss of 12,716 beds (-5.1%) (Table 1). Bed reduction was significantly lower in NFP hospitals (-4.2%) than in FP hospitals (-7.5%). Day-care beds' share increased, being of 10.9% in NFP hospitals, and 20.9% in FP hospitals in 2017.

Over the 2013-2017 period the number of physicians per 1000 population in France increases by 1.3%, and the number of nurses by 0.7%. The number of nursing assistants decreased by 4.3%. The reduction of nursing assistants was significantly lower in NFP hospitals than in FP hospitals (-3.6% vs.-8.2%, $p<.001$) despite higher initial values. Densities of physicians, nurses and nursing assistants per bed were respectively 0.9, 1.8 and 2.2 times higher in NFP than in FP hospitals. MWTC decreases in NFP and FP hospitals (-0.8% and -4.1%).

Table 1 Acute care hospitals' resources in France (2013-2017) ✢

Year	2013	2014	2015	2016	2017	Δ%*
France						
Population in millions‡	63.70	64.03	64.30	64.47	64.64	1.5
<15 yr — no. (%)	11.8 (18.5)	11.8 (18.4)	11.8 (18.3)	11.7 (18.1)	11.6 (18.0)	-2.2 (-2.7)
≥60 yr — no. (%)	15.5 (24.3)	15.8 (24.7)	16.1 (25.1)	16.4 (25.4)	16.7 (25.8)	7.8 (6.2)
Acute care beds in thousands — no.	250.3	246.3	242.5	240.3	237.6	-5.1
Day care — no. (%)	31.9 (12.8)	31.2 (12.7)	30.5 (12.6)	31.6 (13.2)	31.9 (13.4)	-0.2 (5.2)
Regular care — no. (%)	218.4 (87.2)	215.2 (87.3)	212 (87.4)	208.7 (86.8)	205.7 (86.6)	-5.8 (-0.8)
Physicians in thousands — no.	122.3	123.3	124.0	124.9	125.7	2.8
Physicians per 1000 people	1.92	1.93	1.93	1.94	1.95	1.3
Nurses in thousands — no.	254.1	256.4	255.9	259.0	259.7	2.2
Nurses per 1000 people	3.99	4.00	3.98	4.02	4.02	0.7
Nursing assistants in thousands — no.	173.8	170.9	169.5	170.0	168.8	-2.8
Nursing assistants per 1000 people	2.73	2.67	2.64	2.64	2.61	-4.3
Not for profit hospitals						
Acute care beds in thousands — no.	184.8	183.5	180.3	179.0	177.1	-4.2
Day care — no. (%)	19.0 (10.3)	18.9 (10.3)	18.3 (10.1)	19 (10.6)	19.2 (10.9)	1.3 (5.8)
Regular care — no. (%)	165.9 (89.7)	164.6 (89.7)	162.1 (89.9)	159.9 (89.4)	157.8 (89.1)	-4.8 (-0.7)
Physicians in thousands — no.	87.4	88.2	88.5	89.2	89.8	2.8
Physicians per bed	0.47	0.48	0.49	0.50	0.51	7.3
Nurses in thousands — no.	212.8	215.2	214.5	217.4	217.3	2.1
Nurses per bed	1.15	1.17	1.19	1.22	1.23	6.6
Nursing assistants in thousands — no.	149.5	147.2	146.1	146.9	146.2	-2.2
Nursing assistants per bed	0.81	0.80	0.81	0.82	0.83	2.1
For profit hospitals						
Acute care beds in thousands — no.	65.50	62.81	62.16	61.35	60.56	-7.5
Day care — no. (%)	13.0 (19.8)	12.3 (19.6)	12.2 (19.7)	12.6 (20.5)	12.7 (20.9)	-2.3 (5.6)
Regular care — no. (%)	52.5 (80.2)	50.5 (80.4)	49.9 (80.3)	48.7 (79.5)	47.9 (79.1)	-8.8 (-1.4)
Physicians in thousands — no.	34.9	35.1	35.5	35.7	35.9	3.0
Physicians per bed	0.53	0.56	0.57	0.58	0.59	11.4
Nurses in thousands — no.	41.2	41.3	41.4	41.6	42.4	2.7
Nurses per bed	0.63	0.66	0.67	0.68	0.70	11.1
Nursing assistants in thousands — no.	24.3	23.7	23.4	23.1	22.6	-6.8
Nursing assistants per bed	0.37	0.38	0.38	0.38	0.37	0.7

Δ%= Difference 2013-2017; *=All p-value <0.001 by Cochran-Armitage test for rate trends or variance analysis for mean values; ✢=DREES-SAE; ‡=INSEE.

Hospital Activity

The total number of stays significantly increased in both NFP and FP hospitals, by 7.0% and 2.9%, respectively, mainly through a steep increase in day care activity (Table 2). The number of regular care stays increased by 1.8% in NFP hospitals and decreased by 10.5% in FP hospitals. The day-care share of hospitalizations was much lower in NFP hospitals than in FP hospitals (32.7% vs. 59.9% in 2017, p<.001). Among day care stays surgical share was much lower in NFP than in FP hospitals (26.8% vs. 49.1% in 2017).

The number of physicians and nurses per 1000 stays significantly decreased by in NFP hospitals (-3.9% and -4.5%) and was maintained in FP hospitals (+0.1% and -0,2%). Rates of nursing assistants per 1000 stays significantly decreased in NFT and FP hospitals (-8.5% and -9.5%). Ratios of physicians, nurses, hand nursing assistants per 1000 stays were respectively 1.4, 2.8 and 3.5 times higher in NFP than in FP hospitals.

Mean weight of treated cases and hospital mortality

Day care MWTC and regular care MWTC increased in both NFP and FP hospitals. The increase in day-care stays' share during the study period explains the small but significant reduction in the MWTC over the study period, with MWTC more than half lower in FP hospitals than in NFP hospitals (Table 2).

Age-sex adjusted DC mortality was about ten times higher in NFP hospitals than in FP hospitals, while age-sex adjusted RC mortality was 2.2 times higher. Day care mortality decreased by 13.2% in NFP hospitals and by 15.2% in FP hospitals during the study period.

Table 2 Activity and mortality according to hospital type (France, 2013-2017)✣

Year	2013	2014	2015	2016	2017	Δ%*
Not-for-profit hospitals						
All stays						
Stays in thousands — no.	10 929	11 094	11 254	11 539	11 690	7.0
Surgical stays — no. (%)	5274 (20.7)	5377 (20.9)	5425 (21.0)	5534 (20.9)	5615 (21.5)	9.9 (3.6)
≥60 years old — no. (%)	7447 (42.7)	7643 (43.1)	7911 (44.2)	8262 (45.0)	8403 (45.5)	12.8 (6.7)
MWTC (SD)	2679 (493)	2699 (496)	2705 (489)	2674 (480)	2658 (497)	-0.8
Physicians per 1000 stays	8.00	7.95	7.87	7.73	7.68	-3.9
Nurses per 1000 stays	19.47	19.40	19.06	18.85	18.59	-4.5
Nursing assistants per 1000 stays	13.68	13.27	12.98	12.73	12.51	-8.5
Day care						
Stays in thousands — no. (%)	3197 (29.3)	3310 (29.8)	3447 (30.6)	3671 (31.8)	3819 (32.7)	19.5 (11.7)
Surgical stays — no. (% day care)	714 (22.3)	782 (23.6)	847 (24.6)	923 (25.1)	1024 (26.8)	43.4 (20.1)
Hospital mortality per 1000 stays	8.04	7.61	7.58	7.17	6.98	-13.2
Regular care						
Stays in thousands — no. (%)	7732 (70.7)	7784 (70.2)	7807 (69.4)	7867 (68.2)	7870 (67.3)	1.8 (-4.8)
Surgical stays — no. (% regular care)	1549 (20.0)	1539 (19.8)	1513 (19.4)	1489 (18.9)	1484 (18.9)	-4.2 (-5.9)
Mean length of stays (SD)	6.15 (1.3)	6.09 (1.3)	6.05 (1.3)	5.95 (1.2)	5.9 (1.2)	-4.0
Hospital mortality per 1000 stays	29.3	28.6	29.3	28.9	29.0	-1.0
For-profit hospitals						
All stays						
Stays in thousands — no.	6221	6292	6305	6473	6401	2.9
Surgical stays — no. (%)	3010 (48.4)	3056 (48.6)	3064 (48.6)	3122 (48.2)	3107 (48.5)	3.2 (0.3)
≥60 years old — no. (%)	2785 (44.8)	2858 (45.4)	2932 (46.5)	3066 (47.4)	3080 (48.1)	10.6 (7.5)
MWTC (SD)	1113 (329)	1115 (334)	1102 (337)	1078 (334)	1068 (338)	-4.1
Physicians per 1000 stays	5.60	5.58	5.62	5.52	5.61	0.1
Nurses per 1000 stays	6.63	6.56	6.56	6.43	6.62	-0.2
Nursing assistants per 1000 stays	3.90	3.77	3.71	3.56	3.53	-9.5
Day care						
Stays in thousands — no. (%)	3356 (53.9)	3487 (55.4)	3587 (56.9)	3807 (58.8)	3835 (59.9)	14.3 (11.1)
Surgical stays — no. (% day care)	1536 (45.8)	1636 (46.9)	1714 (47.8)	1826 (48.0)	1882 (49.1)	22.6 (7.2)
Hospital mortality per 1000 stays	0.71	0.67	0.67	0.62	0.60	-15.2
Regular care						
Stays in thousands — no. (%)	2865 (46.1)	2805 (44.6)	2718 (43.1)	2666 (41.2)	2565 (40.1)	-10.5 (-13.0)
Surgical stays — no. (% regular care)	1475 (51.5)	1420 (50.6)	1349 (49.6)	1297 (48.6)	1,225 (47.7)	-17.0 (-7.2)
Mean length of stays (SD)	4.49 (1.9)	4.42 (1.1)	4.36 (1.2)	4.30 (1.1)	4.26 (1.1)	-5.2
Hospital mortality per 1000 stays	12.9	12.7	13.3	13.1	13.3	3.2

Δ%= Difference 2013-2017; *= All p-value <0.001 by Cochran-Armitage test for rate trends or variance analysis for mean values; MWTC= Mean Weight of Treated Cases; SD=Standard Deviation; ✣Source=Maincare DimBench®.

Selected conditions' composite mortality

Age-sex adjusted mortality rates for the six conditions selected in Table 3 was estimated for patients ≥30 years during all RC stays. Decreases in rates were significant for acute myocardial infarction, ischemic stroke, gastro-intestinal haemorrhage, and hip fracture in NFP, as well as in FP hospitals. Variations were not significant for heart failure and pneumonia. The composite mortality rate for these six selected conditions decreased less in NFP hospitals (-5.9%) than in FP hospitals (-10.6%) despite higher starting values in NFP hospitals in 2013. Overall mortality in this selected group of patients does not change significantly in NFP hospitals (-1.0) but increased significantly by 3.2% in FP hospitals.

Table 3 Age-sex-adjusted hospital mortality per 1000 stays (regular care, ≥30 years old)§✢

Year	2013	2014	2015	2016	2017	Δ (%)	*p**
Not-for-profit hospitals							
Hospital mortality	38.4	37.4	38.4	37.8	38.0	-1.0%	0.094
Acute myocardial infarction	78.9	78.0	76.0	59.8	58.7	-25.6%	<0.001
Heart failure	79.9	76.9	79.9	78.2	80.0	0.1%	0.446
Ischemic stroke	85.7	85.4	83.1	81.2	80.5	-6.0%	<0.001
Gastrointestinal hemorrhage	50.8	55.3	48.5	45.0	45.9	-9.7%	<0.001
Hip fracture	40.3	35.8	35.2	34.3	32.7	-18.7%	<0.001
Pneumonia	86.2	84.4	86.2	82.8	84.9	-1.5%	0.070
Selected conditions' composite mortality	76.3	74.8	75.1	71.0	71.8	-5.9%	<0.001
For-profit hospitals							
Hospital mortality	15.4	15.2	15.8	15.6	15.9	3.2%	<0.001
Acute myocardial infarction	37.4	33.2	31.2	25.8	23.8	-36.2%	<0.001
Heart failure	62.4	59.7	61.3	58.7	61.5	-1.5%	0.633
Ischemic stroke	84.1	81.4	76.2	73.4	67.8	-19.4%	0.015
Gastrointestinal hemorrhage	25.1	26.7	25.1	25.2	22.4	-10.6%	<0.001
Hip fracture	32.3	31.0	29.7	27.5	28.6	-11.5%	0.024
Pneumonia	64.1	61.3	60.8	60.7	58.4	-8.9%	0.045
Selected conditions' composite mortality	56.9	54.5	53.7	51.7	50.9	-10.6%	<0.001

Δ%= Difference 2013-2017; *=p-value by Cochran-Armitage for trends analysis; ‡= ≥30 Years old; §= Coded as a principal diagnosis; ✢=Maincare DimBench®.

Hospital morbidity

Six secondary diagnoses were estimated for ≥48-hour stays (Table 4). Although the number of corresponding stays was relatively stable in NFP hospitals, this number decreased by 15.9% in FP hospitals. All age-sex adjusted rates were significantly higher in NFP hospitals than in FP hospitals, including an increase in the derived composite morbidity rate, by 38.8% and 33.6%, respectively. The highest increases were sepsis, pressure ulcers and nosocomial pneumonia in NFP hospitals, and sepsis, nosocomial pneumonia, osteoarticular prosthesis infections, and pulmonary embolisms in FP hospitals. The MWTC was highly correlated with the composite morbidity rate as shown in figures 1 and 2. All six hypothesized relationships between variables were tested in the structural equation model, i.e.: a positive association between male sex, age, and year; a positive association between NFP hospital type and the composite morbidity rate; and a direct association between NFP hospital type and MWTC. Moreover, the indirect, and the total effect of NFP hospital type on MWTC, through composite morbidity, was assessed to be positive and significant (figure 1 and Table Appendix A2).

Table 4 Age-sex-adjusted morbidity per 1000 stays (≥48 hours)†✣

Year	2013	2014	2015	2016	2017	Δ%*
France not-for-profit						
Stays in millions — no.	6.12	6.14	6.13	6.14	6.11	-0.2
MWTC (SD)	4075 (852)	4128 (864)	4180 (862)	4202 (857)	4228 (871)	3.7
Pulmonary embolism	3.99	4.09	3.98	4.26	4.45	11.4
Deep vein thrombosis	8.25	8.52	8.98	9.22	9.73	17.8
Sepsis	23.4	28.4	31.3	33.9	36.5	55.8
Nosocomial pneumonia	7.53	7.83	8.37	8.85	9.36	24.2
Osteoarticular prosthesis infections	1.10	1.14	1.26	1.37	1.50	36.5
Pressure ulcers ‡	1.34	1.39	1.53	1.68	1.84	37.5
Composite morbidity	7.83	8.82	9.51	10.16	10.87	38.8
France for-profit						
Stays in millions — no.	2.24	2.15	2.04	1.97	1.87	-16.3
MWTC (SD)	2104 (542)	2153 (565)	2185 (586)	2223 (597)	2253 (611)	7.1
Pulmonary embolism	1.83	1.89	1.99	2.08	2.22	21.3
Deep vein thrombosis	7.61	7.42	7.35	7.88	7.99	5.0
Sepsis	17.1	20.2	22.6	24.3	25.0	45.9
Nosocomial pneumonia	1.06	1.10	1.23	1.39	1.45	37.5
Osteoarticular prosthesis infections	0.23	0.25	0.31	0.40	0.42	85.7
Pressure ulcers ‡	0.30	0.34	0.41	0.53	0.56	86.9
Composite morbidity	4.84	5.37	5.82	6.28	6.47	33.6

Δ%= difference 2013-2017; *=p-value <0.001 by Cochran-Armitage test for rate trends or variance analysis for mean values; †= Coded as secondary diagnosis and not as primary diagnosis; ‡= ≥72-hour stays, ✣=Source DimBench®.

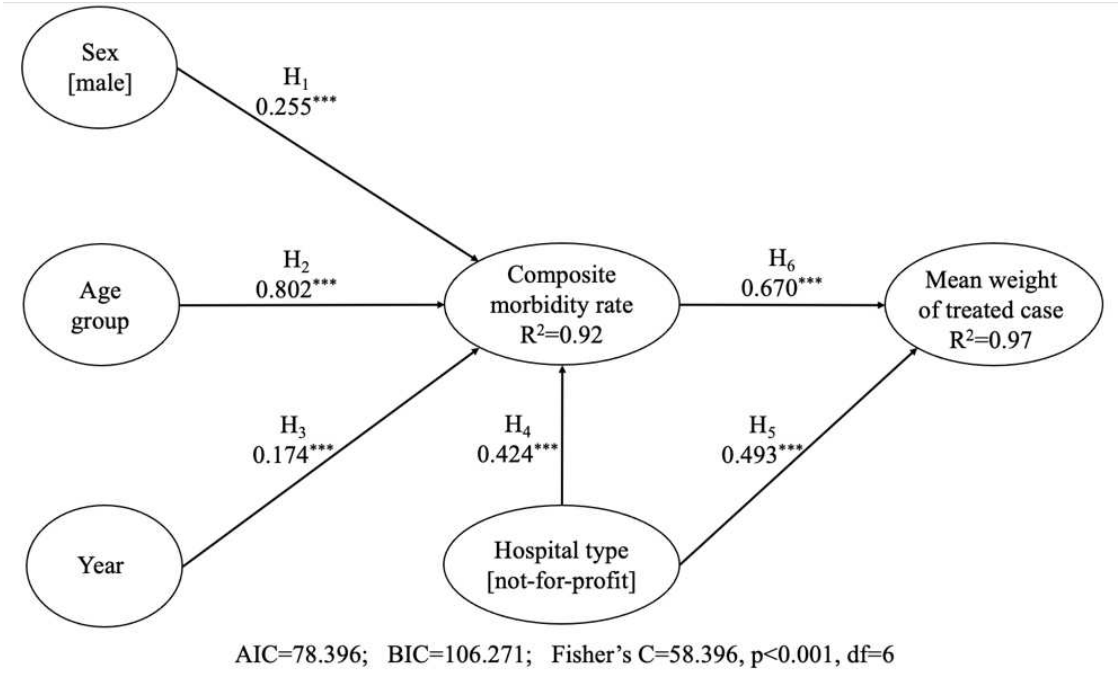

Figure 1 Structural equation model on composite morbidity rate and MWTC (France, 2013-2017).

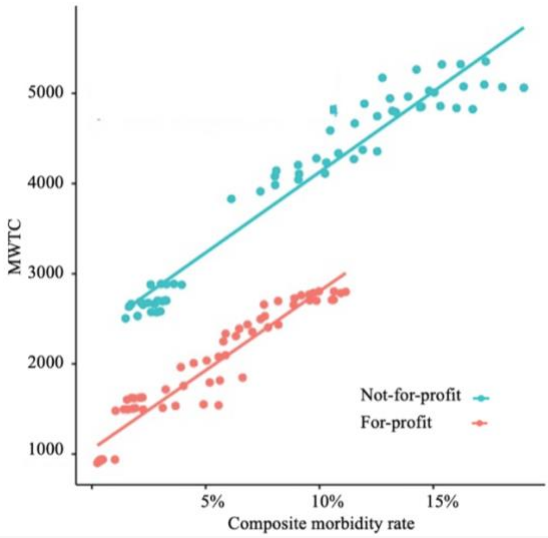

Figure 2 Composite morbidity rates and MWTC according to hospital type (France, 2013-2017)

Surgical stays morbidity

Five secondary diagnoses were estimated for ≥48-hour surgical stays (Table 5). The number of surgical associated stays decreased by 7.1% in NFP hospitals, and by 24.6% in FP hospitals, coupled with a significant MWTC increase during the same period. The age-sex adjusted perioperative mortality rate decreases significantly in NFP and FP hospitals (-5.7% and -3.9%, respectively). Contrasting with the perioperative mortality rate trend, surgical morbidity rates increased significantly for postoperative complications, pulmonary embolism, and sepsis in NFP and FP hospitals. Rates of deep vein thrombosis and wound dehiscence rates increased in NFP hospitals but decreased in FP hospitals. The surgical composite morbidity rate significantly increased in both FP and NFP hospitals, by 51.2% and 22.2%, respectively.

Table 5 Age-sex-adjusted perioperative mortality and morbidity per 1000 stays (≥48 hours)†✣

Year	2013	2014	2015	2016	2017	Δ%	*p**
France not-for-profit							
Stays in millions — no.	1.31	1.29	1.26	1.23	1.21	-7.7	<0.001
MWTC (SD)	6111 (1555)	6242 (1579)	6376 (1605)	6476 (1599)	6540 (1643)	7.0	<0.001
Perioperative mortality	15.58	15.18	15.05	15.31	14.70	-5.7	<0.001
Postoperative complications	21.79	25.01	29.97	36.76	42.60	95.5	<0.001
Pulmonary embolism	3.72	3.80	3.74	3.91	4.10	10.3	<0.001
Deep vein thrombosis	6.63	6.66	7.07	7.15	7.30	10.2	<0.001
Sepsis	32.36	38.52	42.34	47.34	50.31	55.5	<0.001
Wound Dehiscence	11.48	11.18	10.37	12.42	11.80	2.8	<0.001
Composite morbidity	15.19	17.03	18.70	21.52	23.22	52.8	<0.001
France for-profit							
Stays in millions — no.	1.16	1.08	1.00	0.94	0.87	-25.1	<0.001
MWTC (SD)	2534 (791)	2609 (831)	2679 (856)	2746 (877)	2792 (904)	10.2	<0.001
Perioperative mortality	5.33	5.08	5.25	5.07	5.13	-3.9	0.048
Postoperative complications	29.97	32.56	51.61	39.22	41.61	38.8	<0.001
Pulmonary embolism	0.90	0.95	1.03	0.97	1.08	20.8	<0.001
Deep vein thrombosis	7.09	6.63	6.37	6.35	6.25	-11.9	<0.001
Sepsis	18.04	20.37	22.67	24.75	25.75	42.8	<0.001
Wound Dehiscence	10.61	10.00	7.59	6.82	7.02	-33.9	<0.001
Composite morbidity	13.32	14.10	17.86	15.62	16.34	22.7	<0.001

Δ% = difference 2013-2017; *=p-value by Cochran-Armitage test for trends or variance analysis for mean values;
†= Coded as secondary diagnosis and not as primary diagnosis; ✣=Maincare DimBench®.

Discussion and Conclusion

Results observed

In a context in which most countries try to limit the constant increasing in healthcare costs, objectively measuring the quality of care is a major objective. This paper proposes a longitudinal analysis in France of the association between indicators of resources, activity, and outcomes in acute care hospitals during the period 2013-2017. The results were analysed separately for not-for-profit hospitals and for-profit hospitals, which roughly represented respectively, in 2017, 74.5% and 25.5% of total bed resources, and 60.3% and 39.7% of day-care beds [8].

Efforts to improve hospital efficiency found their translation into the increase of stays, mainly through an increase in day-care stays in association with a reduction of the length of stays and an increase of stays per health professionals. A different response adaptation of NFP and FP hospitals, already observed five years after the introduction of T2A financing systems, continues to shift toward day care and, particularly towards day surgery [4]. The reduction of the number of health professionals per stays strongly suggest an increased workload for health professionals, in particular for nurses and nursing assistants. The increase in workload is possibly minimized in FP hospitals by the selection of less severe cases, as observed here. This was not the case in NFP hospitals, which must support the simultaneous increase of patients' MWTC.

The increase in age distribution toward older age-groups makes data adjustments for age and sex necessary for mortality and morbidity analyses in this study. Day care mortality and to a less extent regular care mortality decreased in NFP hospitals. The increase in regular care mortality in FP hospitals is an issue that could be related to the lower density of certified nurses and midwives, and the insufficient number of nursing assistants, which represent a large proportion of nursing professionals in French NFP hospitals (i.e., 19.7% in NFP hospitals and 3.5% in FP hospitals in 2017, according to DREES statistics [8,33].

One major concern is the interpretation of the increasing rate of partly avoidable adverse events that vary in an opposite direction to mortality and selected condition mortality rates. Three issues should be discussed: 1) the validity of the selected codes; 2) the upcoding of diagnoses, susceptible to increase MWTC and the DRG part of hospital financing; 3) a true increase of avoidable events associated with a reduced nursing density per stay.

Within stay mortality coding is mandatory and represents a highly reliable indicator. The reduction of stays' mortality rates for acute myocardial infarction and ischemic stroke observed here are compatible with the respective 50% and 45% reduction of mortality rates in France during the period 2000-2019 [14]. Earlier disease detection and percutaneous interventions are considered two major explanatory conditions [34]. Modest but steady improvements in survival for heart failure associated stays have been reported by Taylor *et al*. [35,36]. The hip fracture mortality decrease is possibly associated with earlier and more efficient management [37].

Definitions of morbidity codes that are given in Appendix Table 2A are as close as possible as the AHRQ definitions. The indicators' positive predictive values (PPV) were found to be of 80.7% for pulmonary embolism (ICD code I.26), 59.2% for deep venous thrombosis, 85% for sepsis (ICD code A40), 81% for pneumonia, 85% for osteoarticular prosthesis infections (ICD

code T845), 91.7% for pressure ulcers, and 87% for wound dehiscence [38-42]. Except for nosocomial pneumonia and osteoarticular prothesis infections indicators, which clearly integrate acquired conditions in their formulation, the selection criteria for the other adverse events in this study are to be neither coded as primary nor as related diagnosis. Whether they are strictly nosocomial or just coexisting conditions raises the issue of their prevention and their relationship with a decreased nursing staff density [24].

Considering the extreme correlation between the MWTC and the composite morbidity rate, the selection in coding of associated diagnosis is likely to increase the MWTC, and therefore the DRG financing of hospitals as a tempting strategy. The diagnosis codes are entered by the involved physicians themselves, or by specialized clerks, and then validated by the coding hospital structure, under the responsibility of dedicated physicians. Companies specialized in coding optimisation and/or artificial intelligence programs provide facilities to optimize coding and therefore maximise hospital incomes.

The reduction in nurse staffing associated with an increase in hospital-wide and perioperative adverse events, namely sepsis and pulmonary embolism, is consistent with the literature [28,29]. The increase in rates of deep vein thrombosis and wound dehiscence in NFP hospitals, for which nurse staff reduction are essential factors, contrasts with their decrease in FP hospitals, which select less severe patients.

Limitations of the study

The period of 5 years used here can be considered as short for an epidemiological study. A longer study period would have shown higher reductions in bed resources and health staff and possible effect on inpatient mortality. Mortality at 30 days with record chaining was not analysed here and would bring additional information. In the 2021 OECD report, for example, thirty-day mortality after admission for acute myocardial infarction was estimated to 51 per 1000 admissions in 2019 for unlinked data and 72 on linked data [14]. Discrepancies between hospital mortality changes and more profound selected conditions composite mortality decrease suggest than the six conditions' mortality AHRQ composite rate should be completed by more representative indicators adapted to each specific population studied.

In France, DRG coding is directly accomplished by health professionals and/or professional coders, from the knowledge they have of patients, and access to their medical records. The validity of coding is verified by the national insurance on the basis of randomly selected records. Coding of associated diagnoses, such as the six preventable adverse events analysed here, increase patients' MWTC and, by consequence, hospital financing. The respective roles of case-mix changes, coding management and side effects of staffing changes cannot be determined more precisely in this study. It remains plausible that the explanation for upcoding may be too simple, and that increased rates of avoidable morbidity indicators should be considered as a strong alert for health decision-makers. For instance, the increasing incidence of postoperative sepsis was associated with an increase in the one-year post-discharge mortality among sepsis survivors, suggesting that the incidence increase was due not to upcoding but to a better coding of less severe cases [43]. The increasing demand for joint replacement in an ageing population combined with nursing staff constraints is susceptible to explain the increasing rate of osteoarticular prothesis infection [44, 45]. The too early discharge of post-operative patients to reduce the length of stay could lead to an increase in wound dehiscence [46].

Conclusion and perspectives

While the increased activity observed in both NF and NFP hospitals under restrained professional resources can be explained by the search of better efficiency in an activity-based financing system, the significant increase in six hospital adverse events and five perioperative adverse events was associated with insufficient nurse density per stays. Even if a direct causal relationship cannot be concluded in this association study, the results should be considered as sufficiently strong alerts to engage further epidemiologic studies to better separate what could result from changes in human resources, case-mix application trends, and coding strategies to obtain increased MWTC, and finally better financial outcomes.

The introduction of an outcome adapted-based systematic coding of adverse events could, on the contrary, lead to under-coding of these conditions, without achieving the expected effectiveness improvements. Whatever the final selected strategy selected several directions seem essential, at least for the French health system: 1) quickly reducing the part of financing attributed to DRG coding; 2) avoiding the installation of negative incentive on avoidable conditions' rates that could induce under-coding; 3) maintaining the 100% coding of diagnosis and procedures but moving from an accounting role to an internal quality improvement approach, including its specific incentive financial mechanisms.

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Summary

What is already known

- French health financing is based on a DRG-based coding approach applied to non-for-profit (NFP) as well as for-profit (FP) hospitals.
- NFP hospitals naturally admit the most severe cases, whatever their patients' insurance coverage.
- Hospitals try to increase their income by increasing their day-care activity and imposing constraints on nursing staffing.

What this paper adds

- The total number of stays increased during the 2013-2017 period, mainly through day-care activity increase, while the density of nurses and nursing assistants significantly decreased.
- For ≥48-hour stays, the hospital and surgical morbidity significantly increased in both NFP and FP hospitals.

How might this study affect research, practice, or policy

- An in-depth revision of the current French strategy in terms of optimal health staffing and DRG mode of calculation is stressed.
- Further epidemiological studies are necessary to better separate what could result from changes in human resource allocation, case-mix application trends, and coding strategies in an activity-based financing system.

Appendix

Table A1 Sources and coding of clinical outcome indicators

Indicator†	ICD-10 code	PPV%	PPV Reference
Pulmonary embolism	I26	80%	Ibrahim, 2012
Deep vein thrombosis	I801, I802, I803, I808, I809, I828, I829	59%	Ibrahim, 2012
Sepsis	A40, A41, R572, R650, R651, T814	85%	Öhman 2018
Nosocomial pneumonia	J13, J14, J15, J690	81%	Öhman 2018
Osteoarticular prosthesis infection	T845	85%	Lange, 2015
Pressure ulcers	L892, L893, L899	92%	Ho, 2017
Postoperative complication	Y83	--	--
Wound Dehiscence	T813	87	Cevasco, 2017

†=Coded as a secondary diagnosis, not principal diagnosis; ICD-10=International Classification of Diseases; PPV=Positive predictive value

Table A2 Structural equation model on composite morbidity rate and MWTC (France, 2013-2017)⁺

Hypothesis (from → to)		Fixed effect factors			
		Type of effect	Standardized coefficient	*z*	*p*
Morbidity rate	→ MWTC	direct	0.670	39.0	<0.001
Hospital [not-for-profit]	→ MWTC	direct	0.493	28.7	<0.001
Hospital [not-for-profit]	→ MWTC	indirect	0.284	28.7	<0.001
Hospital [not-for-profit]	→ MWTC	total	0.777	28.7	<0.001
Hospital [not-for-profit]	→ Morbidity rate	direct	0.424	15.9	<0.001
Age group	→ Morbidity rate	direct	0.802	30.1	<0.001
Sex [male]	→ Morbidity rate	direct	0.255	9.55	<0.001
Year	→ Morbidity rate	direct	0.174	6.52	<0.001

⁺Source=Maincare DimBench®.

List of abbreviations

MWTC	mean weights of treated cases
NFP	not-for-profit
FP	for-profit
DC	day-care
RC	regular care
CCAM	*Classification Commune des Actes Médicaux* – Common Classification of Medical Acts
PMSI	*Programme de médicalisation des systèmes d'information* – Information systems medicalization program
DREES	*Direction de la recherche, des études, de l'évaluation et des statistiques* – Department of Research, Studies, Evaluation and Statistics
ATIH	*Agence Technique de l'Information sur l'Hospitalisation* – Technical Agency for Information on Hospitalization
GHS	*Groupe Homogène de Séjours* – Homogenous groups of stays
T2A	*Tarification à l'Activité* – French activity-based system
RSS	*Résumé de Sortie Standardisé* – discharge record summary

Statements and declarations

Ethics approval and consent to participate
This translational research study is using only aggregated data available in public data warehouses.
All studies are effected on aggregated data with no access to individual patient data.
All experimental protocols were approved by the PhD thesis committee.

Guidelines and regulations statements
All methods were carried out in accordance with SQUIRE 2.0 guidelines as a research checklist for studies on quality, safety, and value of healthcare.

Consent for publication
The authors consent the publication of this original research article.

Availability of data and materials
The datasets supporting this article, namely from INSEE, DREES and PMSI, are publicly consultable in the form of aggregated data and cited in the references section of the main document of the article.

Competing interests
We declare we have no current or potential competing interests.

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Author's contributions
All authors gave final approval for publication and agree to be held accountable for the work performed therein. Angel E. Benitez Collante reviewed literature, collected data, conducted the analysis, and drafted the manuscript. Joseph Noussa Yao collaborated with coding, conducted statistical verifications as well as comments and discussions. Patrice Degoulet, as A. Benitez's Ph.D. thesis mentor, supervised the whole research work and participated in the writing of the article.

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Article 5 – Is the increase in hospital activity associated with a quality outcome decrease during full-admission stays in France?

Citation

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[Draft paper version]

Is the increase in hospital activity associated with a clinical outcome quality decrease during full admission stays in France

Angel Benitez Collante[1,2] MD MSc-MPH, Joseph Noussa Yao[1,2] Ing MSc, Patrice Degoulet[1,2] MD PhD

[1]Université Sorbonne Paris Cité
[2]Laboratory of Information Sciences to support Personalized Medicine, INSERM-UMR1138
15, Rue École de Médecine, 75006 Paris, France

Abstract

Background. Hospitals are faced with the challenge of searching for efficiency at the risk of reducing the quality of care, making necessary a continuous health care quality monitoring. The objective of this longitudinal association study was to observe trends on a selected number of indicators of activity, comorbidity, and risk-adjusted clinical outcomes during full-admission acute care stays (≥48-hour stays in France, and during the period 2013-2017.

Methods**.** Analyses concern full admission stays (≥48-hour stays) and are performed separately for non-for-profit (NFP) and for-profit (FP) acute care hospitals. Main indicators include the numbers of beds and stays, the length of stay and an estimate of staff density. Outcome indicators include within-stay mortality and 6 morbidity conditions combined in a composite morbidity indicator. Statistical methods include Armitage Chi2 for trends for the evolution of rates, variance analyses for quantitative variables, and structural equation modelling to test various hypothesis on the relationships between inputs and outputs. Outcomes were adjusted for age, sex, a comorbidity index, the hospital type, and the year of admission.

Results. The number of acute care beds dedicated to full-admission (≥48-hour stays) decreases in NFP and FP hospitals (–5.1% and –8.9% respectively, p<.001), in association with an increase in partial-admission beds' share (6.4% vs 5.7%, p<.001). The number of full-admission stays significantly decreases in NFP and FP hospitals (–6.7% and –18.7%). Densities of nurses and nursing assistants per stays decrease in both NFP (–4.6 and –8.5, respectively, p<.001), and FP (–0.83% and –9.5% respectively, p<.001) hospital**s**. Patients' age and the composite comorbidity increased significantly. Mortality increase is lower in NFP hospitals than in FP hospitals (0.8% vs. 8.0% in NFP hospitals). The composite morbidity index is significantly higher in NFP than in FP hospitals but with a lower increase in NFP than in FP hospitals. In the SEM analyses the comorbidity index is positively associated with age, the male sex, a NFP hospital type but not with the year of admission. Mortality is mainly associated with the comorbidity index but slowly declines through the years of admission when adjusting for the other parameters. The morbidity index is strongly associated with age, male sex, NFP hospital type and the year of admission.

Discussion and conclusion. Hospital mortality and morbidity are associated with a higher comorbidity during ≥48-hour stays. Nursing assistants' density decrease could be related to the increase in preventable adverse events' rates. Increased morbidity is higher in NFP hospitals that in FP hospitals and should be considered as a strong alert for the health system managers. Discrepancies between the simultaneous evolution of determining factors of morbidity and mortality suggest the simultaneous upcoding of the selected comorbidity and morbidity

conditions. Additional analysis integrating the direct access to the electronic patient records could help to better differentiate what could result from changes in population characteristics and associated comorbidities with the observed changes in outcome quality indicators.

Keywords. Healthcare quality improvement, Continuous healthcare quality improvement, Quality measurement, Patient safety, Risk adjustment, Coding practice

Introduction

Practicing case-mix adjustment, namely by patient demographics and clinical risk, allows to account for imbalances between groups and stands for a good quality of research on longitudinal evaluations [Nicholl 2007]. However, age or sex are not risk factors themselves, and relationships of age with risk factors changes according to the structure of the population considered. For instance, the prevalence of risk factors for heart diseases or cancer changes over time [Piccirillo 2015]. Additionally, advances in clinical interventions have increased vascular and cancer disease survivorship. Adjustments by DRG-codes associated with increases in length of stay and mortality are implemented in adjustments to better explain differences in clinical outcomes in hospitalized population. Risk scoring methods such as Charlson and Elixhauser's indexes, aim to adjust clinical outcomes by risks removing the case-mix differences conditioning outcomes [Charlson 1987, Elixhauser 1998]. However, their use introduces a constant risk fallacy, which accounts for the differences in prevalence of coded risk factors in different populations, increasing bias in comparisons [Nicholl 2007]. The accuracy in implementing these methods is limited because the considered factors can be proxies to actual risk factors with impact on clinical outcomes. Despite Elixhauser's index includes nonconstant risk diagnosis groups, these could also become a source of bias in longitudinal studies of comorbidity-adjusted outcomes due to the coding of mild or uncertain conditions [Nicholl 2007, Nimptsch 2015]. Additionally, several of the 31 Elixhauser's DRG codes are hospital complications coded as a secondary diagnosis in new admissions (i.e., complications of diabetes and fluid and electrolyte disorders like hypokalemia) confounded in the list of secondary diagnosis acquired at hospital in the patients' records, limiting its use to predict similar adverse events in hospital quality assessment [Nimptsch 2015]. The implementation of activity-based payment systems is likely to increase coding of secondary diagnosis in order to increase hospital reimbursements [Hsia 1992]. However, the increase in the coding of secondary diagnosis could also be due to upcoding, also called DRG creep, relevant to increase payment, but also to improving the completeness of coding by capturing prevalent comorbidities and clinical events often misclassified in early periods leading to better care [Nimptsch 2015].

The objective of this longitudinal association study was to observe the trends on a selected number of indicators of activity, comorbidity, and risk-adjusted clinical outcomes during full-admission acute care stays (≥48-hour stays) in France, and during the period 2013-2017. The study was performed separately in not-for profit (NFP) and for-profit (FP) hospitals. The hypothesis is that the differentiate changes when observed could be related to changes in case-mix but also in coding optimization in the French activity-based financing system.

Methods

Population study

Population estimates are obtained from public data by the "*Institut national de la statistique et des études économiques*'' (INSEE) [INSEE 2022]. Hospital staff densities were obtained from public estimations of the French Ministry of Health [DREES 2022], considering the numbers of medical doctors, nurses including midwives, and nursing assistants, during the period 2013-2017.
The aggregated number of hospital stays, stays by selected for selected primary diagnosis and clinical outcomes identified as DRG-codes during the period 2013-2017 was extracted from French public databases, by using Maincare-DimBench® reporting tool. Sex was coded as 1 for male and zero for female. Patients' age was stratified into six categories considered raking from 1 to 6 (0-14, 15-29, 30-44, 45-59, 60-74, and ≥75 years old). Two categories of hospitals were considered separately in this study: not-for profit (NFP) hospitals including public and not-for profit private hospitals, and strictly for-profit (FP) hospitals. NFP and FP hospitals which have followed different adaptation responses to financial constraints, and therefore behave as a major confounding factor [Or 2014, Rotarius 2005, Mark 2007].

Clinical risk-adjustment

A comorbidity index reflecting the underlying clinical severity of population hospitalized in ≥48-hour stays is proposed. The proposed comorbidity index is built upon seven severe clinical conditions coded as a principal diagnosis, including myocardial infarction, heart failure, ischemic stroke, gastrointestinal haemorrhage, and lung and colon cancer. Associated ICD10 codes and positive predictive values for theses codes are given in Table A1. For each comorbidity condition, the normalized z transformation was calculated as regards to the mean prevalence of the condition for all the full-admission stays in France during the entire 2013-2017 period. A similar weight was given for each condition and the cumulate composite comorbidity index centred on 1 after volume of stays adjustment. A value of 1.3 for the composite comorbidity index can roughly be interpreted as a 30% increase as regards the mean index for acute-care/full admissions in France.

Clinical outcome measures

The healthcare quality indicators include in-hospital mortality, six selected conditions' mortality rates coded as a principal diagnosis, and six selected morbidity rates coded as secondary diagnosis and not as a primary diagnosis during the considered stays. Selected medical and surgical morbidity rates concern pulmonary embolisms, deep vein thrombosis, sepsis, nosocomial pneumonia, osteoarticular prosthesis infections, and pressure ulcers. They are considered as possibly avoidable adverse events under specific drug or nursing prevention/follow-up procedures [Aiken 2017, Kane 2017, Griffith 2019, Wang 2020, Clemens 2021]. Related ICD10 codes and their positive predictive value (PPV) are given in Appendix table A2. A composite comorbidity index was calculated from the six selected rates as described above.

Statistical analysis

Statistical methods include Armitage Chi^2 for trends in the evolution of rates, variance analyses for quantitative variables and structural equation modelling (SEM) to test various hypothesis on the relationships between resources, activity, and outcome indicators. [Armitage 2008, Gefen 2000, Lefcheck 2016]. Structural equation models were conducted to assess the association of the comorbidity index with hospital mortality and composite morbidity rates, by

using the Piecewise R® package. Considering the stratification of the DRG stays into 120 groups (i.e., 5 years x 2 hospital types x 6 age subgroups x 2 sex groups), the hypothesized relationships between the variables integrated into the SEM analyses were tested as follows: 1) a positive relationship between age group, male sex, NFP hospital, and year of admission with the comorbidity index (hypothesis H1 to H4), 2) a positive association between age group, comorbidity, NFP hospital and year of admission with morbidity (H5 to H8), and 3) a positive association of age, morbidity, the NFP hospital type, and the year of admission with within-stay mortality (H9 to H13). (Figure 1).

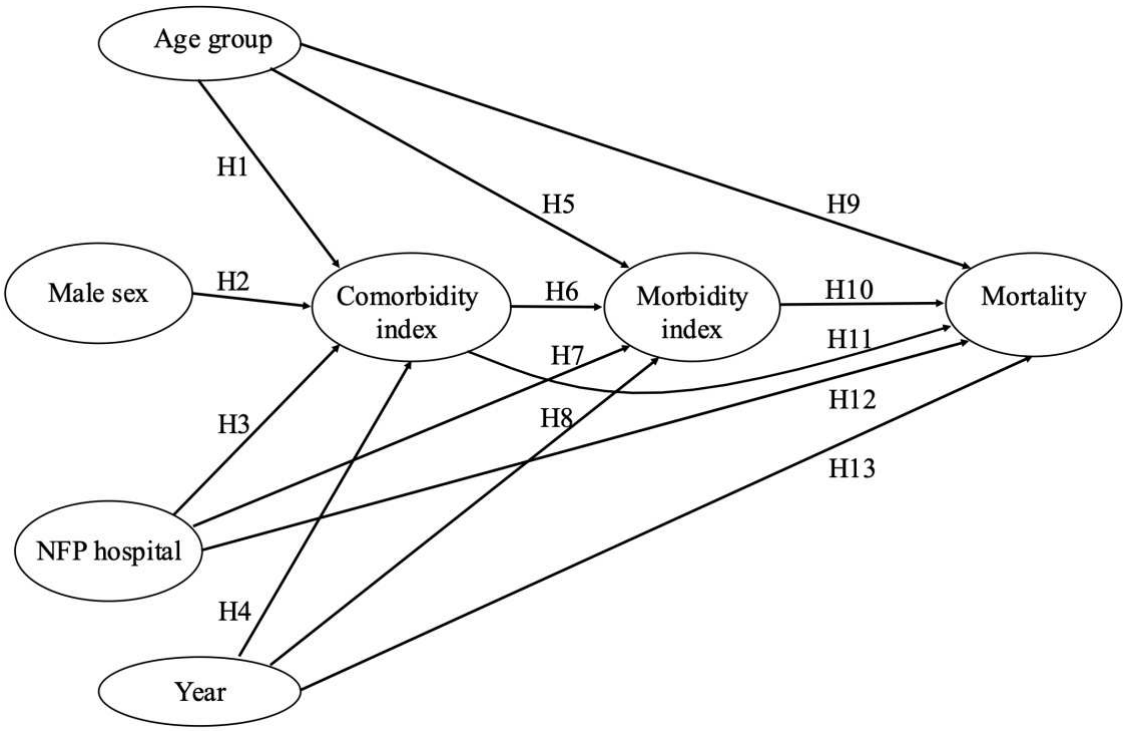

Figure 1 Structural equation model

Results

Hospital resources and activity

Table 1 summarizes the evolution of resources and activity for the NFP and FP hospitals during the period 2013-2017. The number of full-admission beds decreases in both, NFP and FP hospitals (–5.1 and-8.9, p<.001. The staff numbers of health professional dedicated to full admission are not available in DRESS reports. However, the number of physicians per 1000 population covering both partial and full admissions increased by 1.3% and by 1.5%, in NFP and in FP hospitals, respectively. Similarly, the number of nurses per population increased in NFP and in FP hospitals (.54%, .55% p<.001). The number of nursing assistants per population decreased in both NFP hospitals and FP hospitals (–3.6%, –8.2%, p<.001). The densities of nurses and nursing assistants per bed were respectively 1.8 and 2.2 times higher in NFP than in FP hospitals in 2017. Despite the observation that the number of all three staff categories per bed increases during the period of analysis due to important decreases in hospital beds, the number of physicians, nurses and nursing assistants per stays (partial and full-admissions) significantly decreases in NFP hospitals (–3.9%, –4.5% and –8.5%, p<.001). In FP hospitals, the number of physicians per stays increased only by .13%, while the number of nurses and nursing assistants per stays significantly decreased by .18% and 9.5%, respectively).

The increase on the number of stays in partial-care (<48 hours) contrast with a decrease of stays in full-admission in both NFP and FP hospitals (–0.2% and –16.3%, p<.001). Nonetheless, the average length of full admission stays significantly decreased in both, NFP and FP hospitals (–2.5% and –.4%, p<.001).

Table 1 Hospital resources and activity according to hospital type (France, 2013-2017)✣

Year	2013	2014	2015	2016	2017	Δ%	*p*
French population in million — no.‡	63.7	64.0	64.3	64.5	64.6	1.5	<.001
<15 yr — no. (%)	11.8 (18.5)	11.8 (18.4)	11.8 (18.3)	11.7 (18.1)	11.6 (18.0)	-1.2 (-2.7)	<.001
≥60 yr — no. (%)	15.5 (24.3)	15.8 (24.7)	16.1 (25.1)	16.4 (25.4)	16.7 (25.8)	7.8 (6.2)	<.001
Not-for-profit hospitals							
Stays in million — no.	10.9	11.1	11.3	11.5	11.7	7.0	<.001
≥60 years old — no. (%)	4.66 (42.7)	4.79 (43.1)	4.98 (44.2)	5.2 (45)	5.32 (45.5)	12.8 (6.7)	<.001
Full-admission — no. (%)	6.12 (56)	6.14 (55.3)	6.13 (54.5)	6.14 (53.2)	6.11 (52.2)	-0.2 (-6.7)	<.001
Surgical stays — no. (%)	2.26 (20.7)	2.32 (20.9)	2.36 (21)	2.41 (20.9)	2.51 (21.5)	10.8 (3.6)	<.001
Length of stays full-admission (SD)	7.5 (1.3)	7.5 (1.4)	7.4 (1.3)	7.4 (1.3)	7.3 (1.3)	-2.5	<.001
MWTC full-admission (SD)	4074 (852)	4128 (864)	4179 (862)	4202 (857)	4227 (871)	3.7	<.001
Acute care beds in thousands — no.	184.8	183.5	180.3	179.0	177.1	-4.2	<.001
Full-admission beds — no. (%)	162.4 (87.9)	161.1 (87.8)	158.5 (87.9)	156.4 (87.4)	154.2 (87.1)	-5.1 (-0.9)	<.001
Physicians in thousands — no.	87.4	88.2	88.5	89.2	89.8	2.8	<.001
Physicians per 1000 population	1.37	1.38	1.38	1.38	1.39	1.3	.007
Physicians per 1000 stays	8.00	7.95	7.87	7.73	7.68	-3.9	<.001
Nurses in thousands — no.	226.0	228.4	227.8	230.8	230.6	2.0	<.001
Nurses per 1000 population	3.55	3.57	3.54	3.58	3.57	.54	.033
Nurses per 1000 stays	20.7	20.6	20.2	20.0	19.7	-4.6	<.001
Nursing assistants in thousands — no.	149.5	147.2	146.1	146.9	146.2	-2.2	<.001
Nursing assistants per 1000 population	2.35	2.30	2.27	2.28	2.26	-3.6	<.001
Nursing assistants per 1000 stays	13.7	13.3	13.0	12.7	12.5	-8.5	<.001
For-profit hospitals							
Stays in million — no.	6.22	6.29	6.30	6.47	6.40	2.9	<.001
≥60 years old — no. (%)	2.78 (44.8)	2.86 (45.4)	2.93 (46.5)	3.07 (47.4)	3.08 (48.1)	10.6 (7.5)	<.001
Full-admission — no. (%)	2.24 (35.9)	2.15 (34.2)	2.04 (32.4)	1.97 (30.5)	1.87 (29.2)	-16.3 (-18.7)	<.001
Surgical stays — no. (%)	3.01 (48.4)	3.06 (48.6)	3.06 (48.6)	3.12 (48.2)	3.11 (48.5)	3.2 (0.3)	.523
Length of stays full-admission (SD)	5.5 (2)	5.5 (1.1)	5.5 (1.2)	5.5 (1.1)	5.5 (1.2)	-.4	<.001
MWTC full-admission (SD)	2103 (542)	2152 (565)	2185 (586)	2222 (597)	2253 (611)	3.1	<.001
Acute care beds in thousands — no.	65.5	62.8	62.2	61.4	60.6	-7.5	<.001
Full-admission beds — no. (%)	51.9 (79.3)	49.9 (79.4)	49.3 (79.3)	48.1 (78.5)	47.3 (78.1)	-8.9 (-1.5)	<.001
Physicians in thousands — no.	34.9	35.1	35.5	35.7	35.9	3.0	<.001
Physicians per 1000 population	.55	.55	.55	.55	.56	1.5	.014
Physicians per 1000 stays	5.60	5.58	5.62	5.52	5.61	.13	<.001
Nurses in thousands — no.	44.0	44.0	44.0	44.2	44.9	2.0	<.001
Nurses per 1000 population	.69	.69	.68	.69	.69	.55	.501
Nurses per 1000 stays	7.07	6.99	6.98	6.83	7.01	-.83	<.001
Nursing assistants in thousands — no.	24.3	23.7	23.4	23.1	22.6	-6.8	<.001
Nursing assistants per 1000 population	.38	.37	.36	.36	.35	-8.2	<.001
Nursing assistants per 1000 stays	3.90	3.77	3.71	3.56	3.53	-9.5	<.001

Δ%= Difference 2013-2017; p=p-value by Cochran-Armitage test for rate trends or variance analysis for mean values; MWTC= Mean Weight of Treated Cases; SD=Standard Deviation; ✣= Maincare DimBench®.

Clinical risk-adjustment

For each of the six selected comorbidities, the prevalence rates are higher in NFP hospitals, except for colon cancer. These rates increase significantly more in FP hospitals than in NFP hospitals, during the 5-year period (Table 2). The composite comorbidity index is 1.68 times higher in NFP than FP in the year 2017 (1.209 vs.0.720, p<.001), but the increasing trend was smaller in NFP than in FP hospitals (8.1% vs. 23.7%, p<.001). The mean weight of treated cases (MWTC) considered a dual index of cost of care and clinical severity, significantly increases in both NFP and FP hospitals (3.7% vs. 3.1, p<.001)

Table 2 Comorbidity rates per 1000 stays (≥48 hours)†✣

Year	2013	2014	2015	2016	2017	Δ%*
France not-for-profit						
Nb stays (million)	6.12	6.14	6.13	6.14	6.11	-.2
Acute myocardial infarction	7.99	8.25	9.03	11.01	11.60	45.1
Heart failure	27.09	28.02	29.09	29.42	29.75	9.8
Ischemic stroke	12.22	12.62	13.12	13.79	14.12	15.5
Gastrointestinal hemorrhage	6.45	5.61	6.36	6.52	6.50	.7
Hip Fracture	6.59	6.52	6.73	6.82	6.99	6.0
Pneumonia	23.14	21.70	24.63	24.45	24.50	5.8
Lung Cancer	4.82	4.98	4.97	5.06	5.05	4.9
Colon Cancer	3.17	3.23	3.27	3.52	3.48	9.7
Comorbidity index	1.06 (.89)	1.05 (.88)	1.12 (.91)	1.17 (.92)	1.19 (.93)	12.6
MWTC (SD)	4074 (852)	4128 (864)	4179 (862)	4202 (857)	4227 (871)	3.7
France for-profit						
Nb stays (million)	2.24	2.15	2.04	1.97	1.87	-16.3
Acute myocardial infarction	6.01	6.15	6.94	10.00	10.92	81.6
Heart failure	14.36	15.23	16.23	17.24	18.42	28.3
Ischemic stroke	1.03	1.12	1.20	1.24	1.27	23.2
Gastrointestinal hemorrhage	3.44	3.44	3.60	3.79	3.81	10.7
Hip Fracture	5.50	5.60	5.82	6.05	6.19	12.6
Pneumonia	5.81	6.12	7.44	7.99	9.02	55.2
Lung Cancer	3.60	3.64	6.82	4.24	4.46	24.1
Colon Cancer	5.57	5.76	5.73	7.00	6.69	20.0
Comorbidity index	.55 (.54)	.57 (.54)	.67 (.58)	.71 (.59)	.75 (.60)	36.5
MWTC (SD)	2103 (542)	2152 (565)	2185 (586)	2222 (597)	2253 (611)	7.1

Δ%= Difference 2013-2017; *=*p*-value <.001 by Cochran-Armitage test for rate trends or variance analysis for mean values; MWTC=Mean Weight of Treated Cases; SD=Standard Deviation; †=Coded as a principal diagnosis; ✣=Maincare DimBench®.

Hospital mortality

Inpatient mortality within ≥48-hour stays increases by 0.9% in NFP hospitals and by 8.0% in FP hospitals (Table 3). Except for heart failure related mortality that increases in NFP hospital, all five primary diagnosis related mortality rates decreases both in NFP and FP hospitals.

Table 3 Age-sex-adjusted hospital mortality per 1000 stays (≥48 hours, France, 2013-2017)†✣

Year	2013	2014	2015	2016	2017	Δ (%)	*p*
Not-for-profit hospitals							
Hospital mortality	32.2	31.6	32.4	32.1	32.5	.9	<.001
Acute myocardial infarction	64.5	62.7	62.1	49.4	49.6	–23.0	<.001
Heart failure	74.6	71.7	74.5	73.6	75.2	.7	.125
Ischemic stroke	82.5	82.4	80.3	78.7	78.0	–5.4	<.001
Gastrointestinal hemorrhage	45.2	51.2	44.4	41.2	41.7	–7.9	<.001
Hip fracture	38.3	34.3	33.6	32.8	31.3	–18.2	<.001
Pneumonia	74.6	72.6	75.1	72.7	74.2	–.6	.685
For-profit hospitals							
Hospital mortality	15.3	15.4	16.2	16.2	16.6	8.0	<.001
Acute myocardial infarction	29.5	26.6	26.2	21.7	18.7	–36.5	<.001
Heart failure	58.5	55.4	57.5	56.0	57.5	–1.8	.798
Ischemic stroke	81.9	79.7	76.2	73.5	66.9	–18.3	.035
Gastrointestinal hemorrhage	26.9	28.3	26.7	28.4	23.4	–12.7	.269
Hip fracture	30.0	29.1	27.4	25.8	27.6	–7.9	.087
Pneumonia	62.3	60.4	59.6	59.9	57.0	–8.5	.070

Δ%= Difference 2013-2017*; p*=p-value by Cochran-Armitage test for rate trends;
†= Coded as a principal diagnosis; ✣=Maincare DimBench®.

In the global SEM model of figure 2, the comorbidity composite index appears as the main determinant of within-stay mortality was highly correlated with hospital mortality rates in both NPF and FP hospitals (Figure 2). The association between age and mortality is not significant in direct effect but is positive and significant indirectly through the comorbidity index (Appendix table A3).

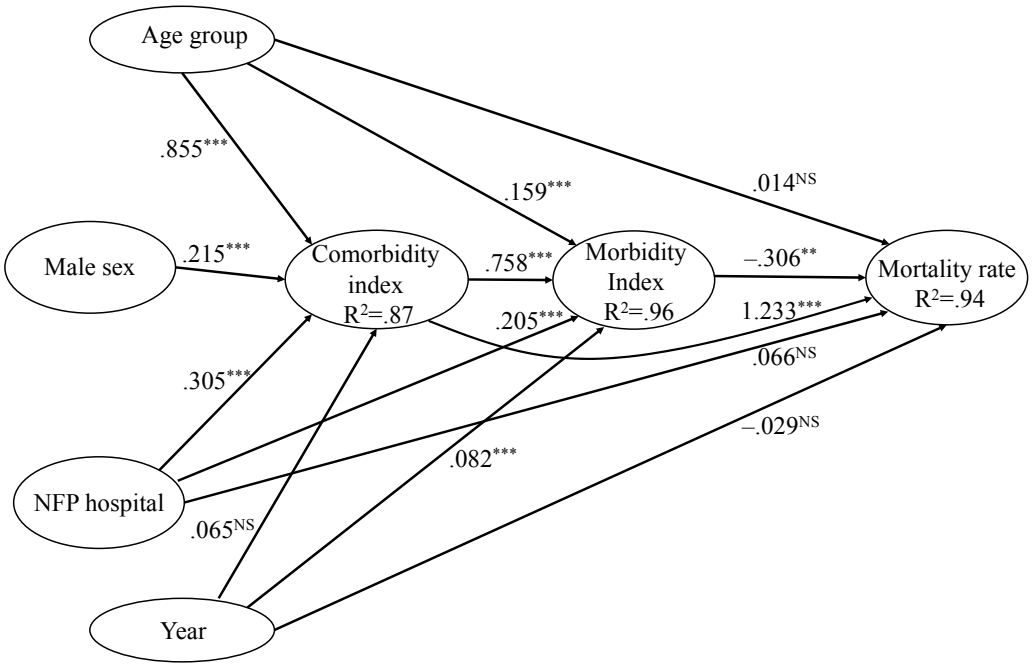

Figure 2 - Structural equation model relating comorbidity, morbidity, and hospital mortality (≥48 hours, France, 2013-2017); Fisher's C=30.1, p<.001, df=4; AIC=68.1; BIC=121.1

As indicated in figure 3 relationships between the comorbidity index and mortality are very similar in NFP and FP hospital, but with distribution of the mortality rate in the high range compared to FP hospitals.

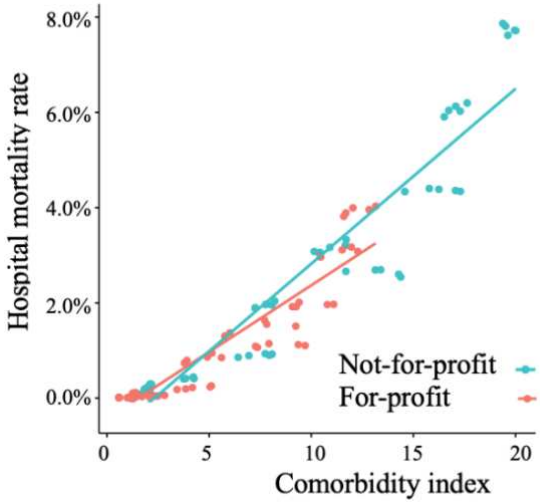

Figure 3 Comorbidity index and mortality rates according to hospital type (≥48 hours, France, 2013-2017).

Within stay morbidity

All age-sex adjusted morbidity rates are significantly higher in NFP hospitals than in FP hospitals, including an increase in the derived composite morbidity rate, by 28.0% and 22.9%, respectively (Table 4). The comorbidity index was highly correlated with the composite morbidity rate (Figure 2).
In the structural equation model, the morbidity index is significantly associated with age, the comorbidity index, the NFP hospital type, and the year of admission (Appendix Table A3). The slope relationship of comorbidity index with the morbidity index is higher in NFP than and in FP hospitals (Figure 4)

Table 4 Age-sex-adjusted morbidity per 1000 stays (≥48 hours, France, 2013-2017)†✣

Year	2013	2014	2015	2016	2017	Δ%*	*p*
France not-for-profit							
Pulmonary embolism	3.99	4.09	3.98	4.26	4.45	11.4	<0.001
Deep vein thrombosis	8.25	8.52	8.98	9.22	9.73	17.8	<0.001
Sepsis	23.4	28.4	31.3	33.9	36.5	55.8	<0.001
Nosocomial pneumonia	7.53	7.83	8.37	8.85	9.36	24.2	<0.001
Osteoarticular prosthesis infections	1.10	1.14	1.26	1.37	1.50	36.5	<0.001
Pressure ulcers ‡	1.34	1.39	1.53	1.68	1.84	37.5	<0.001
Composite morbidity index	.996	1.069	1.145	1.206	1.275	28.0	<0.001
France for-profit							
Pulmonary embolism	1.83	1.89	1.99	2.08	2.22	21.3	<0.001
Deep vein thrombosis	7.61	7.42	7.35	7.88	7.99	5.0	<0.001
Sepsis	17.1	20.2	22.6	24.3	25.0	45.9	<0.001
Nosocomial pneumonia	1.06	1.10	1.23	1.39	1.45	37.5	<0.001
Osteoarticular prosthesis infections	0.23	0.25	0.31	0.40	0.42	85.7	<0.001
Pressure ulcers ‡	0.59	0.64	0.70	0.78	0.83	40.8	<0.001
Composite morbidity index	.619	.652	.693	.733	.760	22.9	<0.001

†= Coded as a secondary diagnosis, and not as a principal diagnosis; ✣=Maincare DimBench®; Δ%= difference 2013-2017; ‡= ≥72-hour stays; *=*p*-value <0.001 by Cochran-Armitage test for rate trends.

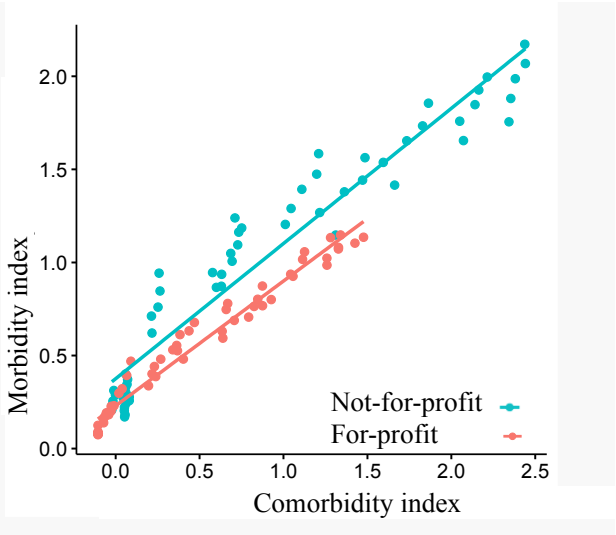

Figure 4 Comorbidity index and composite morbidity index according to hospital type (≥48 hours, France, 2013-2017).

Discussion and Conclusion

Results observed

This study proposes a longitudinal analysis of the associations between different hospital resources, activity, and clinical outcome indicators for French acute care hospitals during the period 2013-2017. The differentiate adaptation of the NFP and FP hospitals to T2A activity-based financing system shows an overall increase of all stays with a transfer from full-admission stays (≥48 hours) towards day-care and one-night care as observed in many countries [Or 2014]. Considering simultaneously the total number of beds and the number of health professionals per bed and per stays, physician workload appears to be maintained, but nurse workload appears to increase significantly, in particular for assistant nurses, and more significantly in FP hospitals than in NFP hospitals.

Higher case-mix severity of patients hospitalized for full admission in NFP than in FP hospitals has a direct translation in significantly increased length of stays, higher MWTC, and higher comorbidity indexes. However, in an activity-based financing system such as in France, upcoding of comorbidities increases the MWCT and the hospital financial income. Several hypotheses were therefore tested in the SEM models: 1- H3: Higher severity is positively associated with the preferred selection of the NFP hospital sector; 2- H3, H7: Comorbidity and morbidity upcoding possibly differ between NFP and FP hospitals and could participate to optimize financing; 3- H4, H8 - Hospital improve their optimization coding over time. Validation of hypothesis H3, H7, and H8 could suggest the existence of upcoding for morbidity indicators and in a less extent for comorbidity ones.

As shown in table 1, in an ageing population, such as in France with a 7.8% increase in population ≥60 years, the comorbidity index and the MWTC are expected to increase of the same order of magnitude. The lower increase of the WMCT observed here could be the translation of the national health insurance strategy to foster hospital efficiency by progressively reducing the reimbursement fee for similar DRG in a vicious cycle of activity increase at the expense of lower staff density and increased morbidity risk. If the MWCT

appears to be lower in FP hospitals than in NFP hospitals, they increase in the same order of magnitude. The much higher comorbidity index in FP than in NFP hospitals can possibly be the reflect of a more financially efficient upcoding strategy but also of the necessity to accept more and more severe patients as it was the case during the COVID pandemic.

Limitations of the study

Four main limitations of this study should be emphasized: 1- The limited period of follow-up of 5 years by comparison on the long-term adjustment of hospital structure to the natural evolution of the population, changes in the efficiency of medical and surgical procedures, as well as short term adaptation in pandemic situations; 2- The limitation of the composite comorbidity index that cannot integrate the multitude of indicators that could be obtained from a direct access to the patient electronic records; 3- The limitation of the mortality index to the within stay mortality without integration of 30 days mortality and DRG chaining; 4- The analysis limited to acute care activity and not including mid- and long-term hospitals stays. The reduction in the number of health professionals per stays suggests an increased workload, in particular for nurses and nursing assistants. However, it was not possible to separate the staff providing medical assistance in partial admission patients from the staff taking care of full admission patients.

Conclusion and perspectives

The results of this study should be strongly considered in further epidemiologic studies to better identify what could result from variations in population characteristics, human resources, case-mix trends, and coding strategies seeking for better financial outcomes. The optimization of DRG-codes in the hospital billing departments fosters the resequencing of secondary diagnosis in search of better financially efficient diagnostic combinations. Conversely, the introduction of an outcome-based adapted coding of adverse events into a value-based care framework could lead to under-coding of adverse events. Better policies in health care financing should aim to foster hospital effectiveness in addition to financial efficiency, for example by: 1) reducing the part of financing attributed to DRG coding to less than 50% to discourage upcoding; 2) avoiding negative incentives for coding of avoidable conditions that could induce under-coding; 3) shifting the accounting approach of coding of diagnosis and procedures to an internal quality improvement approach, by globally rethinking the specific financial incentive mechanisms.

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Appendix

Table A1 Validity of ICD-10 codes for selected conditions of clinical severity

Quality indicators§	ICD-10 code	PPV%	PPV Reference
Acute myocardial infarction	I21	93.80%	Ando, 2018
Heart failure	I098, I110, I130, I132, I500, I501, I509	79%	Sundbøll, 2016
Ischemic stroke	I63	82%	McCormick 2015
Gastrointestinal hemorrhage	I850, K226, K250, K252, K254, K256, K260, K262, K264, K266, K270, K272, K274, K276, K280, K282, K284, K286, K290, K518, K519, K625, K920, K921, K922	71%	Oger 2019
Pneumonia	J13, J14, J15, J690	85%	Ibrahim, 2012
Lung Cancer	C34	--	--
Colon Cancer	C18	--	--

ICD-10= International Classification of Diseases, §=coded as primary diagnosis, not principal diagnosis.

Table A2 Validity of ICD-10 codes for adverse events

Indicator†	ICD-10 code	PPV%	PPV Reference
Pulmonary embolism	I26	80%	Ibrahim, 2012
Deep vein thrombosis	I801, I802, I803, I808, I809, I828, I829	59%	Ibrahim, 2012
Sepsis	A40, A41, R572, R650, R651, T814	85%	Öhman 2018
Nosocomial pneumonia	J13, J14, J15, J690	81%	Öhman 2018
Osteoarticular prosthesis infection	T845	85%	Lange, 2015
Pressure ulcers	L892, L893, L899	92%	Ho, 2017
Postoperative complication	Y83	--	--
Wound Dehiscence	T813	87	Cevasco, 2017

†=Coded as a secondary diagnosis, not principal diagnosis; ICD-10=International Classification of Diseases; PPV=Positive predictive value.

Table A3 Structural equation model on comorbidity, morbidity and in-hospital mortality (≥48 hours, France, 2013-2017)✣

Hypothesis	Variable relationship (from→to)		Fixed effect factors			
			Type of effect	Standardized coefficient	z	*p*
H1	Age group	→ Comorbidity index	direct	.855	25.8	<.001
H2	Sex male	→ Comorbidity index	direct	.215	6.50	<.001
H3	Not-for-profit hospital	→ Comorbidity index	direct	.305	9.20	<.001
H4	Year	→ Comorbidity index	direct	.065	1.96	.052
H5	Age group	→ Morbidity index	direct	.159	3.64	<.001
H6	Comorbidity index	→ Morbidity index	direct	.758	16.5	<.001
H7	Not-for-profit hospital	→ Morbidity index	*direct*	*.205*	8.63	<.001
	Not-for-profit hospital	→ Morbidity index	*indirect**	*.231*	--	--
	Not-for-profit hospital	→ Morbidity index	total	.436	--	--
H8	Year	→ Morbidity index	direct	.082	4.23	<.001
	Year	→ Morbidity index	indirect*	.049	--	--
	Year	→ Morbidity index	total	.131	--	--
H9	Age group	→ Mortality rate	direct	.014	0.27	.790
	Age group	→ Mortality rate	indirect*	1.05	--	--
	Age group	→ Mortality rate	indirect†	-.049	--	--
	Age group	→ Mortality rate	total	1.02	--	--
H10	Morbidity index	→ Mortality rate	direct	-.306	–2.85	.005
H11	Comorbidity index	→ Mortality rate	direct	1.23	12.7	<.001
H11	Not-for-profit hospital	→ Mortality rate	*direct*	*.066*	1.89	.062
	Not-for-profit hospital	→ Mortality rate	*indirect**	*.375*	--	--
	Not-for-profit hospital	→ Mortality rate	*indirect†*	*-.063*	--	--
	Not-for-profit hospital	→ Mortality rate	total	.379	--	--
H12	Year	→ Mortality rate	*direct*	*-.029*	–1.22	.224
	Year	→ Mortality rate	*indirect**	*.080*	--	--
	Year	→ Mortality rate	*indirect†*	*-.025*	--	--
	Year	→ Mortality rate	total	.026	--	--

✣=DimBench®; z=critical value; p=p-value Pearson ✣; *=path through comorbidity; †=path through morbidity

Chapter IV

Discussion and perspectives

5.1 Context of the thesis work

Hospitals are faced with increasing financial constraints, which lead them to optimize their resources and increase their activity at the risk of lowering the quality of care. France, with a financing system mainly based on activity and imposed in 2004 to not-for-profit (NFP), as well as for-profit (FP) hospitals, has mainly focused its efforts in improving financial efficiency. The main objective of this thesis was to evaluate on a longitudinal basis the simultaneous evolution of resources, efficiency and outcome indicators in France during the period 2013-2017.

The achievement of three systematic reviews allowed the selection of indicators of efficiency and effectiveness, namely through the analysis of literature and reports from AHRQ, OECD, DREES, and the ATIH site [OECD 2021, AHRQ 2021, DREES 2022, and ATIH 2022].

All not-for-profit (NFP) and for-profit (FP) acute care hospitals were considered. Private NFP hospitals were combined with public NFP hospitals. The number of beds, health staffing, stays, and mean weight of treated cases (MWTC) were compared for day-care (DC, <24-hours stays) and regular care (RC, ≥24-hours stays). Six comorbidity indicators were retained. Outcome indicators included in-hospital mortality, in-patient mortality in six selected conditions, and six morbidity indicators. Mortality and morbidity trends were adjusted for age and sex, comorbidity, and the hospital NFP and FP type. The results were analysed separately for not-for-profit hospitals and for-profit hospitals, which roughly represented respectively, in 2017, 74.5% and 25.5% of total bed resources, and 60.3% and 39.7% of day-care beds [Gonzalez 2018].

5.2 Results observed

Efforts to improve hospital efficiency found their translation into the reduction of the number of beds, the increasing number of stays of stays, mainly through an increase in day-care stays, the reduction of the length of RC stays and an increase of stays per health professionals. A different response adaptation of NFP and FP hospitals, already observed five years after the introduction of T2A financing systems, continues to shift toward day care and, particularly towards day surgery [Oz 2014]. The reduction of the number of health professionals per stays strongly suggest an increased workload for health professionals, in particular for nurses and nursing assistants. The increase in workload is possibly minimized in FP hospitals by the selection of less severe cases, as observed here. This was not the case in NFP hospitals, which must support the simultaneous increase of patients' MWTC and higher composite severity index.

The increase in age distribution toward older age-groups makes data adjustments for age and sex necessary for mortality and morbidity analyses in this study. Day care mortality and to a less extent regular care mortality decreased in NFP hospitals. The increase in regular care mortality in FP hospitals (+3.2% for ≥24-hours stays and +8.0% for ≥24-hours stays) is an issue that could be related to the lower density of certified nurses and midwives, and the insufficient number of nursing assistants, which represent a large proportion of nursing professionals in French NFP hospitals (i.e., 19.7% in NFP hospitals and 3.5% in FP hospitals in 2017, according to DREES statistics [Gonzalez 2017, Aubert 2017].

One major concern is the interpretation of the increasing rate of partly avoidable adverse events that vary in an opposite direction to mortality and selected condition mortality rates. Three issues should be discussed: 1) the validity of the selected codes; 2) the upcoding of diagnoses, susceptible to increase MWTC and the DRG part of hospital financing; 3) a true increase of avoidable events associated with a reduced nursing density per stay.

Within stay mortality coding is mandatory and represents a highly reliable indicator. The reduction of stays' mortality rates for acute myocardial infarction and ischemic stroke observed here are compatible with the respective 50% and 45% reduction of mortality rates in France

during the period 2000-2019 [OECD 2021]. Earlier disease detection and percutaneous interventions are considered two major explanatory conditions [Minucci 2021]. Modest but steady improvements in survival for heart failure associated stays have been reported [Taylor 2019, Buddeke 2020]. The hip fracture mortality decrease is possibly associated with earlier and more efficient management [Bottle 2006].

Definitions of morbidity codes that were used in this study are as close as possible as the AHRQ definitions [AHRQ 2021. The indicators' positive predictive values (PPV) were found to be of 80.7% for pulmonary embolism (ICD code I.26), 59.2% for deep venous thrombosis, 85% for sepsis (ICD code A40), 81% for pneumonia, 85% for osteoarticular prosthesis infections (ICD code T845), 91.7% for pressure ulcers, and 87% for wound dehiscence [Ibrahim 2012, Ohman 2018, Lange 2015, Ho 2017, Cevasco 2011]. Except for nosocomial pneumonia and osteoarticular prothesis infections indicators, which clearly integrate acquired conditions in their formulation, the selection criteria for the other adverse events in this study are to be neither coded as primary nor as related diagnosis. Whether they are strictly nosocomial or just coexisting conditions raises the issue of their prevention and their relationship with a decreased nursing staff density [Aiken 2017].

Considering the extreme correlation between the MWTC and the composite morbidity rate, the selection in coding of associated diagnosis is likely to increase the MWTC, and therefore the DRG financing of hospitals as a tempting strategy. The diagnosis codes are entered by the involved physicians themselves, or by specialized clerks, and then validated by the coding hospital structure, under the responsibility of dedicated physicians. Companies specialized in coding optimisation and/or artificial intelligence programs provide facilities to optimize coding and therefore maximise hospital incomes.

The reduction in nurse staffing associated with an increase in hospital-wide and perioperative adverse events, namely sepsis and pulmonary embolism, is consistent with the literature [Clemens 2021, Amiri 2019]. The increase in rates of deep vein thrombosis and wound dehiscence in NFP hospitals, for which nurse staff reduction are essential factors, contrasts with their decrease in FP hospitals, which select less severe patients.

5.3 Limitations and perspectives

The period of 5 years used here can be considered as short for an epidemiological study. A longer study period would have shown higher reductions in bed resources and health staff and possible effect on inpatient mortality. However, this analysis has the strength of including all nationwide acute care DRG declaration.

The unlinked data available for this work, did not allow to assess mortality at 30 days of admission for initial principal diagnostic, which could have provided a more accurate assessment of quality of hospital care received [OECD 2021]. For instance, the OECD report Health at a Glance estimated 30-day mortality from acute myocardial to be 51 per 1000 admissions in 2019 on unlinked data, but 72 per 1000 admissions on linked data, in OECD countries [OECD 2021]. Discrepancies between hospital mortality changes and more profound selected conditions composite mortality decrease suggest than the six conditions' mortality AHRQ composite rate should be completed by more representative indicators adapted to each specific population studied.

In France, DRG coding is directly accomplished by health professionals and/or professional coders, from the knowledge they have of patients, and access to their medical records. The validity of coding is verified by the national insurance on the basis of randomly selected records. Coding of associated diagnoses, such as the six preventable adverse events analysed here, increase patients' MWTC and, by consequence, hospital financing. Considering the discrepancies in the structural equation models of Study E in this thesis, upcoding of MWCT related comorbidities could be higher in NFP than in FP hospitals and facilitated in NFP hospital by a higher severity of cases.

However, the respective roles of case-mix changes, coding management and side effects of staffing changes cannot be determined more precisely in this study. It remains plausible that the explanation for upcoding is no sufficient, and that increased rates of avoidable morbidity indicators should be considered as a strong alert for health decision-makers. For instance, the increasing incidence of postoperative sepsis was associated with an increase in the one-year post-discharge mortality among sepsis survivors, suggesting that the incidence increase was due not to upcoding but to a better coding of less severe cases [Or 2016]. The increasing

demand for joint replacement in an ageing population combined with nursing staff constraints is susceptible to explain the increasing rate of osteoarticular prothesis infection [Kurz 2015, Tafer]. The too early discharge of post-operative patients to reduce the length of stay could lead to an increase in wound dehiscence [Sinha 2019].

The composite severity index used in this work is limited by comparison to more extensive severity indexes such as Charlson or Elixhauser [Charlson 1987, Elixhauser 1998]. Direct access to the full electronic patient record would have facilitated the introduction of a more comprehensive index including for example cardiovascular or cancer risk factors but could not be achieved in this PMSI based study.

The present study is currently limited to the hospital acute care activity which was the initial target pf the T2A French activity financing system. Introduction of intermediate and long-term activities would be interesting to provide a comprehensive view of hospital activity and possibly analyze the possible transfer of staff, in particular of nursing staff, that could try to compensate the current and crucial shortage in emergencies and intensive care units.

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Glossary of Terms and Acronyms

ABF	Activity-based Financing
AHRQ	Agency for Healthcare Quality and Research
AP-HP	*Assistance Publique des Hôpitaux de Paris* – Public Hospitals of Paris Organization
APR-DRG	All patient refined diagnostic-related groups
ATIH	*Agence Technique de l'Information sur l'Hospitalisation* – Technical Agency for Information on Hospitalization
BMI	body mass index
CCAM	*Classification Commune des Actes Médicaux* – Common Classification of Medical Acts
CEX	*Comptes d'Exploitations* – Operating Accounts
CIS	Clinical Information System
COPD	Chronic obstructive pulmonary disease;
CSP	Complication Screening Program
DC	Day-care
DEA	Data Envelopment Analysis
DPC	Diagnosis Procedure Combination
DREES	*Direction de la recherche, des études, de l'évaluation et des statistiques* – Department of Research, Studies, Evaluation and Statistics
DRG	Diagnosis-Related Group
ESPIC	*Établissement de Santé Privés d'Intérêt Collectif* – Private health care institutions of collective interest
FP	For-profit
GH	*Groupement Hospitalier* – Hospital merger
GHM	*Groupe Homogène de Maladies* – Homogenous groups of conditions
GHS	*Groupe Homogène de Séjours* – Homogenous groups of stays
HCUP-NIS	Healthcare Cost and Utilization Project Nationwide Inpatient Sample
HEGP	*Hôpital Européen Georges Pompidou* – European Hospital Georges Pompidou
HIMSS	Healthcare Information and Management Systems Society
ICD	International Classification of Disease

IQI	Inpatient quality indicator
MCO	*Médecine, Chirurgie, Obstétrique* – Medicine, Surgery, Obstetrics
MCOO	*Médecine, Chirurgie, Obstétrique, Odontologie* – Medicine, Surgery, Obstetrics, Dentistry
MDC	major diagnostic categories
MERRI	*Mission d'Enseignement, de Recherche, de Référence et d'Innovation* – Mission of Teaching, Research, Reference and Innovation
MIGAC	*Mission d'Intérêt Général et d'Aide à la Contractualisation* – Mission of General Interest and Support for Contracting
MWTC	Mean weight of treated cases
NFP	Not-for-profit
NPV	Negative predictive value
OECD	Organization for Economic Co-operation and Development
ONDAM	*Objectif National de Dépenses d'Assurance Maladie* – National Health Insurance Spending Target
OOP	Out-of-pocket expenditure
PIB	*Produit Intérieur Brut* – Gross domestic product
PMCT	*Poids moyen des cas traités* – Mean weight of treated cases
PMSI	*Programme de médicalisation des systèmes d'information* – Information systems' medicalization program
PPV	Positive predictive value
PSI	Patient safety indicator
PSY	Psychiatry
RC	Regular care
RSS	*Résumé de Sortie Standardisé* – Discharge summary
SFA	Stochastic Frontier Analysis
SIC	*Système d'Information Clinique* – Clinical information system
SSR	*Soins de Suite et Réadaptation* – Follow-up and rehabilitation care
T2A	*Tarification à l'Activité* – French activity-based system

Abstract

Introduction. Hospitals face increasing financial constraints, which leads them to optimize their resources and increase their activity, with the risk of lowering the quality of care. France, with an activity-based financing system imposed in 2004 to not-for-profit (NFP) and for-profit (FP) hospitals, has focused its efforts in improving financial efficiency.
Objectives. The main objective of this thesis was to evaluate, on a longitudinal basis, trends in hospital resources, activity, and outcome indicators. Contributing objectives relate to the search of relevant indicators derived from systematic reviews of literature. The assessment of diverging trends between NFP and FP hospitals was considered as a secondary objective. The driving research hypothesis was that an uncontrolled search of better efficiency is associated with a decline in quality of outcomes.
Material and methods. Following the PRISMA approach, three systematic reviews were conducted to facilitate the choice of major indicators. The first review focused on hospital efficiency assessment, including indicators of resources and activity on 47 selected papers. The second review, based on 27 papers, was dedicated to health care quality assessment. The third review was based on 29 papers examining relationships between efficiency and quality indicators.
The core of the thesis was then centered on the analysis of the respective trends in associations between selected indicators of resources, activity, and clinical outcomes in France during the period 2013-2017. The estimates were obtained from INSERM, DREES, ATIH databases, and OCDE for international comparisons. Statistical methods included Armitage Chi2 trend test for rates, variance analyses for quantitative variables, and structural equation modelling to test various hypothesis on the relationships between resource, activity, and outcome indicators.
All NFP and FP acute care hospitals were considered. Private NFP hospitals were combined with public NFP hospitals. The number of beds, health staff, stays, and the mean weight of treated cases (MWTC) were compared in partial-admission (<48 hours) and full-admission (≥48 hours). Eight comorbidity indicators were combined into a comorbidity index. Outcome indicators included in-hospital mortality, in-patient mortality from six selected conditions, and six morbidity indicators combined into medical and surgical composite morbidity indexes. Mortality and morbidity trends were adjusted for age and sex, clinical severity, and hospital type.
Results. The total number of acute care beds decreased in NFP and FP hospitals (–4.2% and –7.5%, respectively, p<.001), in association with an increase in day-care beds' share (5.8% vs 5.7%, p<.001). Densities of physicians, nurses and nursing assistants per bed were respectively .9, 1.8, and 2.2 times higher in NFP than in FP hospitals. The total number of stays significantly increased in NFP and FP hospitals (7.0% and 2.9%). The MWTC decreased in NFP and FP hospitals (–.8% and –4.1%, p<.001). Age-sex adjusted mortality rates in regular stays (≥24-hour) decreased in NFP hospitals and increased in FP hospitals (–1.0% vs. 3.2%). Differences in trends between NFP and FP hospitals were particularly significant in ≥48-hour stay inpatient mortality (8.0% vs .8%. p<.001). Composite morbidity indexes increased in NFP and FP hospitals in ≥48-hour stays (32.6% vs 30.3%, p<.001), particularly in ≥48-hour surgical stays (49.8% and 8.4%, p<.001).
Discussion and conclusion. The increased activity in NFP and FP hospitals under restrained nursing resources is a marker of the constant search of better financial efficiency. The adverse events' increase, associated with a reduced nursing staff per stays' ratio, suggests the need for an in-depth revision of current strategies in terms of optimal hospital staffing as well as studies to evaluate what results from changes in case-mix and plausible upcoding practices aimed to optimize MWCT and DRG related incomes.