BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-018164
Article Type:	Research
Date Submitted by the Author:	16-Jun-2017
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Primary Subject Heading:	Health services research
Secondary Subject Heading:	Surgery
Keywords:	SURGERY, readmissions, acute care, hospital reimbursement, inpatient care

Did case-based payment influence surgical readmission rates in France? A retrospective study

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Brief title: Case-based payment and readmission rate

Manuscript word count: 2,991

ABSTRACT:

Objectives: Hospital readmissions are common after surgery and can be considered a marker of the quality of surgical care. Little is known about the influence of implementing a case-based payment system on the readmission rate. To analyze changes in 30-day all-cause readmission rates following discharge for all surgical procedures performed in all hospitals in France before, during and after the implementation of the case-based payment system.

Setting: Using claims data for all surgical procedures performed in nearly all hospitals (740 hospitals) in France over 11 years (2002–2012; n=51.6 million stays).

Interventions: We analyzed all-cause 30-day readmission rates after surgery using a logistic regression model.

Results: The overall 30-day all-cause readmission rate following surgery discharge significantly increased from 8.8% to 10.0% (p<0.001) for the public sector and from 5.9% to 8.6% (p<0.001) for the private sector. However, there was a marked increase in some specialties, such as ophthalmology (+91%), and a major decrease in patients treated for human immunodeficiency virus (−21%). Both trends were due to an improvement in practices and not the deleterious effect of implementing the case-based payment system for hospital funding.

Conclusion: In France, considering changes in care practices, the increase in the readmission rate appeared to be relatively steady in both the private and public sector and did not appear to be affected by the introduction of a case-based payment system.

Keywords: surgery, readmissions, acute care, hospital reimbursement, inpatient care

Strengths and limitations of this study

- Nationwide population-based analyses using 11 years (2002-2012; N=51.6 millions of surgical stays, 740 hospitals) of linked data.
- Regression was used to explore the relation between the introduction of case-based payment system and readmissions for surgery.

- Readmissions in the main groups of pathologies were analyzed (i.e. 19 French DRG).

1. Introduction

Financing hospitals is a challenge for any healthcare system. Many countries in the Organization for Economic Cooperation and Development (OECD) have chosen payment by disease-related group (DRG). In 1983, the United States was the first to introduce a case-based payment system according to diagnosis-related groups of patients insured by Medicare (1–3). Many countries around the world (4) wished to adopt the principles of this model as a tool to regulate hospital expenditure. Certain countries, including the United States, applied the system to one aspect of hospital activity, such as patients over 65 years (Medicare) or the underprivileged (Medicaid). In other countries, only a part of the hospital financing is paid according to the DRG system, as is the case in Portugal (5,6), where this payment system only concerns certain care activities. To our knowledge, only France and Norway have implemented this case-based payment system to finance all hospital care activities, and this since the early 2000s (7,8) .

Certain countries, like Belgium, are pondering the interest of implementing the case-based payment system (Belgium) (9), and whether it should be extended or reduced. Indeed, the system is thought to induce certain secondary effects, such as encouraging hospitals to unnecessarily increase their activity to improve their profitability. Moreover, although a decrease in length of stay was observed, the real improvement in quality of care (10-12), concerning the effect of the decreased length of stay on mortality and readmission rates, is a matter of debate (13-15). Although questionable, hospital readmission, when considered alone, can be used as an indirect marker of the quality or performance of healthcare (16,17). In addition, certain authors have hypothesized that the implementation of a tariff system based on activity would lead to an increase in rehospitalization so as to maximize income (18–21). This effect was so feared that the United States and England set up an additional rule in the form of penalties for hospitals with abnormally high rehospitalization rates (22-24)

In France, we have an information system that has exhaustively gathered data on hospital activity since 1997 (it has been possible to reliably link these data since 2002), that is to say well before the implementation of case-based tariffs in 2005. It is thus possible measure the evolution in rehospitalization rates from before to after implementation of a case-based payment system. Given that case-based payment is applied to every hospital activity and to the total funding for this activity, it is relatively easy to determine the impact of implementing case-based payment on the evolution of the rehospitalization rate.

The aim of this study was to determine whether the implementation of this case-based payment system led to an increase in rehospitalizations in France. In order to do this, we studied the effect of the period (before the case-based payment system (2002–2004) and after the reform (2010–2012)) on the evolution of rehospitalizations after adjustment for the principal characteristics of patients (age, sex, comorbidities), or stays (type of establishment, mode of admission, length of stay). The previous studies conducted in France did not analyze the evolution of readmission rates with time (25) or only examined certain regions (13), or were based only on predefined diseases (26,27). In the present study, we included all types of surgeries and considered all readmissions, whatever the sector of surgery and readmission.

2. Materials and methods

2.1 Source of data

This study was based on medical and administrative data that have been used for 20 years for medical research and provide a huge amount of epidemiological information concerning hospitalized patients in France (25,26,28-31). This study was approved by the National Committee for Data Protection (registration numbers: 913291 for Dijon University Hospital and 723116 for the Ministry of Health).

2.2 Population

We included all patients admitted to hospital for a surgical procedure (as defined by the French DRG classification) during an 11-year period (2002–2012) in nearly all hospitals (740 hospitals). Hospitals with fewer than 300 stays per year were not included, because many of them closed during the study period.

2.3 Variable of interest: readmission at 30 days

For each selected surgery stay, the time from patient discharge to a new admission was calculated according to the linked information. Initial hospitalizations and stays ending in death or transfer, iterative treatments and neonatology were excluded. Readmission was defined as "a new hospitalization in the 30 days (30) following discharge after a stay for surgery, whatever the reason for this second stay" as done before (25,26). The hospital where the readmission took place was also noted.

2.4 Variables studied: characteristics related to readmission

The characteristics of the stays were studied according to the variables available in the national medical-administrative database, namely year of hospitalization, age, gender, mode of admission (from home, via an emergency service and transfer), the type of hospital, morbidity (Charlson score, French classification in DRG groups) and length of stay (15).

2.5 Statistical analysis

To measure the changes in the readmission rate over time by taking into account the variables defined above, two logistic regression models were created. To determine the evolution of readmissions, all other things being equal, the probability of readmission at 30 days was analyzed separately for the two types of hospital sector (i.e., public and private).

The first model (M0) concerned all hospital stays for surgery.

The second model (M1) excluded DRG groups with low volumes of activity (burns, infectious diseases, HIV diseases, multiple trauma, psychiatry in acute care, other types of care). They also excluded cases with major modifications in care practices during the period, either for changes in care management (e.g., in

ophthalmology) or therapeutic changes for the treatment of human immunodepression virus (HIV). This model thus made it possible to measure the evolution of readmissions over time without the influence of changes in practices.

SAS 9.2 was used for all of the analyses. The threshold of statistical significance was set at $p<0.05$.

3. Results

3.1 Descriptive study

The study sample contained almost 52 million stays, accounting for 81% of all stays with DRGs related to surgery in the medical-administrative database. The remaining 19% included stays for surgery in hospitals with fewer than 300 stays per year (14%) and the absence of linkage information or in-hospital deaths (5%).

The number of stays with surgery selected in the database increased from 4.1 million in 2002 to 5.3 million in 2012, for a total of 51.6 million stays over the 11 years (Table 1). Of the surgeries, 60% and 40% took place in profit-making private and in public or non-profit-making private hospitals, respectively. During the study period, there was a steady increase in the mean age of patients (from 48.6 to 51.3 years) and a decrease in the mean length of stay (from 4.3 to 3.0 days). The disease profile remained relatively stable, except for a slight increase in stays in ophthalmology units.

Between 2002 and 2012, the readmission rate following stays for surgery (Figure 1) increased in both the public and private sector: from 8.8% to 10.0% and 5.9% to 8.6%, respectively). Although the overall readmission rate was higher in public than in private hospitals ($p<0.001$), its increase appeared to be relatively steady in both sectors and was not affected by the implementation of a case-based payment system. However, this increase was significantly greater in the private than in the public sector ($p<0.001$).

The descriptive results underlined the disparity in readmission rates at 30 days between the different DRG groups over the study period (Figure 2), in terms of both volume and evolution. In 2012, the readmission

rate ranged from 2.7% for ear, nose and throat (ENT) stomatology to 26% for hematology and 27% for the surgical treatment of burns. Two types of surgery in particular showed a major change in the readmission rate: ophthalmology and HIV-related surgery. For ophthalmology the readmission rate increased from 9.3% in 2002 to 16.5% in 2012 in the public sector and from 10.0% to 19.7% in the private sector. For HIV-related surgery, the readmission rate in the public sector fell from 31.4% in 2002 to 25.4% in 2012, but peaked at 39.3% in 2006, with major variations from one year to another.

The profile for the evolution of readmission rates by type of surgery also differed according to the type of hospital and surgery (Figure 2). For example, the increase in the readmission rate for ophthalmology was particularly pronounced in private hospitals, rising from 10.0% in 2002 to 19.7% in 2012. Concerning other types of surgery, the readmission rate for the public and private sectors remained quite stable.

3.2 Multivariate models: study of factors associated with readmission

After adjustment for the DRG groups and morbidity, the probability of readmission at 30 days significantly increased with age (Table 2) in both the public and private sector, and the effect was linear. However, the effect of the risk of readmission according to age was greater in the private than in the public sector (for example, for patients aged 80 years and over, OR = 1.9 in the public sector vs. 5.3 in the private sector).

4. Discussion

This nationwide population-based analysis, using an 11-year period (2002–2012) and including 51.6 million hospital stays for surgery, examined 81% of surgical activity in France. The overall readmission rate at 30 days after a stay for surgery increased in both the public and private sector. This increase was greater in the private sector than in the public sector. During this period, there was a steady increase in the mean age at admission and a decrease in the mean length of stay. We showed that the probability of readmission within 30 days increased significantly with age, even after adjustment for the DRG group and comorbidity. The introduction of a case-based payment system in France in the middle of this period did not seem to influence the readmission rate after adjustment for age, gender and comorbidities. The overall increase in the readmission rate found in the M0 model observed in France was regular and did not seem to have been influenced by implementing a case-based payment system. These results suggest that the funding system may not to be the only determinant in the organization of care.

These findings contradict the results of an American retrospective observational study (32), which showed a decreased 30-day readmission rate after inpatient surgery discharge for nine surgical specialties in the Veterans Health Administration (VHA) during a similar 10-year period (2001–2010). However, our work included all types of surgeries and specialties. Moreover, we considered all readmissions, whatever the sector, in contrast with the VHA study, in which patients having surgery at a VHA facility and then readmitted in the private sector could not be captured. In another study comparing patients insured by Medicare before and after the implementation of the case-based payment system, the authors showed that payment according to activity was accompanied by a reduction in the length of stay. In parallel, the mortality rate and the readmission rate did not increase. The same results were found by Kahn et al. with a 24% decrease in the length of stay and an unchanged readmission rate (13). Another early study on the effects of implementing Medicare in the United States reported stable in-hospital mortality rates and care quality (33). At the same time, this stability of in-hospital mortality was put into perspective by Sager et al.,

who reported a significant rise in mortality at home and thus concluded that in-hospital deaths had been converted to at-home deaths in patients not covered by the new system (34). In Europe, it is difficult to say whether mortality rates have been affected by implementation of the case-based payment system. Studies have nonetheless shown that these systems are often accompanied by shorter lengths of stay and an increase in the number of stays and in productivity in healthcare establishments (5, 5, 20,35). Cutler hypothesized that payment linked to activity could have influenced the readmission rate, given that these rates increased in hospitals with deficits and thus under financial pressure (14).

The evolution was slightly different in the public and private sectors. In France, the former generally manages the most complex cases of each disease, including emergency cases. It is therefore not surprising to see a higher overall rate of readmissions in public than in private hospitals in the descriptive analysis. However, the comparison of the two sectors showed that the management of cataract surgery was reorganized faster in the private sector. The greater increase in readmissions in the private sector than in the public sector may be surprising, since the new pricing policy provided the least incentive to change in the private sector. The pricing policy before the case-based payment system already included payment according to activity in the private sector and readmissions were already paid for before the case-based payment system.

As this rise in readmissions did not seem to be related to pricing reform, we could wonder whether it may have been related to changes in care practices. A more specific analysis of our results did not support this hypothesis. Two contrasting examples show the effect of changes in care practices on readmission rates: first ophthalmology: cataract surgery – nearly 500,000 surgeries per year in France – has moved from inpatient to outpatient hospitalization with prompt recovery leading to a shortened delay between surgeries for each eye. Consequently, in this particular case, the increased readmission rate only reflects this shortened delay between surgeries for each eye due to the improvement in practices and not a secondary deleterious influence of hospital funding, secondly, in HIV-related surgery, changes in the opposite direction were

observed, with a decrease in the readmission rate, which may only reflect the improved efficacy of antiretroviral treatments leading to fewer recurrent hospitalizations. These observations underline the fact that to interpret these results, all changes (population, clinical practices and legislation on hospitalization) need to be considered for each group of diseases. At the international level, the financial impact of readmissions to hospital has led to the implementation of different policies aiming to limit such admissions as much as possible. The impact of these measures has been investigated in American studies showing that the decrease in the number of readmissions in the population studied did not stem from the implementation of such policies, but rather from the long-standing adaptation of practices of healthcare staff, as shown in our study (36,37). These results showed that an overall decrease in readmissions at 30 days has to be considered over the long term rather than as a direct and immediate result of healthcare policy. A secondary effect such as a concomitant increase in outpatient consultations needs to be considered as well (38). However, a recent study reported significant effects of such incentives, leading to decreases in readmission rates in small public-sector hospitals located in rural areas (36).

In the US, some hospitals regularly publish their 30-day readmission rates with regard to cardiovascular or pulmonary diseases. However, a recent analysis of factors associated with readmission conducted in a cohort of patients insured by Medicare showed that not all hospitals were equally affected by readmissions (39). After adjustment for the characteristics of individual patients, hospitals recording the highest readmission rates were those with patients who were the most likely to be readmitted to hospital due to the complexity of their illness or a low socioeconomic status (40). Indeed, the use of readmission as a marker of complications after an initial surgical stay remains controversial. Some reported that almost half of readmissions were not associated with a currently assessed complication (41). Moreover, readmissions after surgery can be associated with new post-discharge complications related to the procedure rather than exacerbation of complications related to a prior index hospitalization (42) or confounding issues such as substance abuse or homelessness. Certain authors believe that reduced readmission rates alone cannot be used as an indicator of care quality; their effects must be studied more globally to determine whether such reductions coincide with improved quality of life in patients (43).

To our knowledge, this study is the first to consider all hospital stays resulting from all-cause readmissions within 30 days over such a long period in a given country. This study nevertheless has certain limitations. First, the global nature of readmission, chosen as an indicator in this study, can only be regarded as a partial assessment of the quality of surgical care. Other measurements can be considered, such as the mortality rate after hospitalization. Among the readmissions identified, certain were scheduled and did not result from a complication following the first stay. It was not possible to distinguish between scheduled and unscheduled readmissions, because this information was not recorded. This is why it was decided to exclude stays for ocular surgery in the M1 model, so as to rule out most scheduled readmissions. Second, we could not compute a combined comorbidity score, as suggested by Mehta et al (44), from the information available in discharge abstracts. Further research is needed, first to characterize readmissions, second to study the influence of the type or the location of hospitals in greater detail (45), to consider readmissions after outpatient surgery, and finally to better explain the relationship between readmissions and length of hospital stay (46).

5. Conclusion

This nationwide observational study is the first to consider all hospital stays resulting from all-cause readmissions within 30 days after surgery over such a long period. It allowed us to conclude that despite the slight temporary rise in readmissions during the implementation of the case-based payment system, the case-based pricing reform had no significant long-lasting effect on readmissions at 30 days. The increase in the raw readmission rate at 30 days after a stay for surgery seems to be mainly related to modifications in care practices, notably for cataract surgery and, secondly, to a structural modification associated with the aging population of patients. To interpret these results, further studies are needed to examine the influence of the different changes in population and clinical practices on readmissions for each group of diseases.

Disclosure Statement: The authors have nothing to disclose

Conflicts of Interest: The authors have no conflicts of interest relevant to this article to disclose.

Contribution to Authorship: AV and EY conceptualized and designed the study, interpreted the data and wrote the paper. AR contributed substantially to writing the manuscript. VR, MG, AB and CCG participated in the interpretation of the results reviewed and revised the manuscript drafts. CQ oversaw the data analysis and interpretation, and contributed substantially to writing the manuscript.

All authors accept responsibility for the paper as published.

Data sharing statement: No additional data available.

Ethics: This study was approved by the National Committee for data protection (registration number 1576793) and therefore was conducted in accordance with the Declaration of Helsinki. Written consent was not needed for this study. The PMSI database was transmitted by the national agency for the management of hospitalization data (ATIH number 2015-111111-47-33).

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Availability of data and materials: The PMSI database was transmitted by the national agency for the management of hospitalization data. The use of these data by our department was approved by the National Committee for data protection. We are not allowed to transmit these data.

What is already known on this subject?

High readmission rates within 30 days after discharge of hospital surgical stay have been linked to poorer quality in patient care: adverse events, lack of postoperative care coordination. Hospital funding through prospective payment may rise the 30 days readmission rates since each new stay is associated with additional income.

What this study adds?

It could not be demonstrated in France, that introduction of prospective payment was associated with an increase of 30 days readmission rates after surgery. Nationwide population-based analyses using 11 years (2002-2012; N=51.6 millions of surgical stays, 740 hospitals) of linked data showed, after adjustment for age, gender and comorbidities, no changes in overall 30 days readmission rates associated with prospective payment introduced stepwise in the middle of the period of time. Further analyses on subsets of stays according to kind of surgery, could investigate evolution in process of patient care and 30 days readmission rates.

References:

1. Fetter RB, Freeman JL. Diagnosis Related Groups: Product Line Management within Hospitals. Acad Manage Rev. 1986;11(1):41‑54.
2. Fetter RB. Diagnosis Related Groups: Understanding Hospital Performance. Interfaces. 1991;21(1):6 ‑26.
3. McMahon LF Jr, Fetter RB, Freeman JL, Thompson JD. Hospital matrix management and DRG-based prospective payment. Hosp Health Serv Adm. 1986;31(1):62 ‑74.
4. Roger FH. Case mix use in 25 countries: a migration success but international comparisons failure. Int J Med Inf. 2003;70(2â€“3):215‑9.
5. Dismuke CE, Sena V. Has DRG payment influenced the technical efficiency and productivity of diagnostic technologies in Portuguese public hospitals? An empirical analysis using parametric and non-parametric methods. Health Care Manag Sci. 1999;2(2):107‑16.
6. Dismuke CE, Guimaraes P. Has the caveat of case-mix based payment influenced the quality of inpatient hospital care in Portugal? Appl Econ. 2002;34(10):1301‑7.
7. Or Z. Implementation of DRG Payment in France: Issues and recent developments. Health Policy. 2014;117(2):146‑50.
8. van den Noord PTH a. TI. The Norwegian Health Care System [Internet]. OECD Publishing; 1998. Disponible sur: /content/workingpaper/571585217086 http://dx.doi.org/10.1787/571585217086
9. Pirson M, Van den Bulcke J, Di Pierdomenico L, Martins D, Leclercq P. [Medical and economic evaluation of oncological inpatients in 14 Belgian hospitals]. Bull Cancer (Paris). nov 2015;102(11):923‑31.
10. Lilford RJ, Brown CA, Nicholl J. Use of process measures to monitor the quality of clinical practice. BMJ. 29 sept 2007;335(7621):648‑50.
11. Thomas JW, Guire KE, Horvat GG. Is patient length of stay related to quality of care? Hosp Health Serv Adm. 1997;42(4):489‑507.
12. Martin S, Street A, Han L, Hutton J. Have hospital readmissions increased in the face of reductions in length of stay? Evidence from England. Health Policy. 2016 ;120(1):89-99.
13. Kahn KL, Keeler EB, Sherwood MJ, Rogers WH, Draper D, Bentow SS, et al. Comparing outcomes of care before and after implementation of the DRG-based prospective payment system. JAMA. 17 oct 1990;264(15):1984‑8.
14. Cutler DM. The Incidence of Adverse Medical Outcomes Under Prospective Payments [Internet]. National Bureau of Economic Research; 1993 mars [cité 1 févr 2017]. Report No.: 4300. Disponible sur: http://www.nber.org/papers/w4300
15. Bahrami S, Holstein J, Chatellier G, Le Roux Y-E, Dormont B. [Using administrative data to assess the impact of length of stay on readmissions: study of two procedures in surgery and obstetrics]. Rev Epidemiol Sante Publique. avr 2008;56(2):79‑85.
16. Moghavem N, McDonald K, Ratliff JK, Hernandez-Boussard T. Performance Measures in Neurosurgical Patient Care: Differing Applications of Patient Safety Indicators. Med Care. avr 2016;54(4):359‑64.

17. Rosen AK, Chen Q, Shwartz M, Pilver C, Mull HJ, Itani KFM, et al. Does Use of a Hospital-wide Readmission Measure Versus Condition-specific Readmission Measures Make a Difference for Hospital Profiling and Payment Penalties? Med Care. févr 2016;54(2):155‑61.

18. SerdÃ©n L, Lindqvist R, RosÃ©n M n. Have DRG-based prospective payment systems influenced the number of secondary diagnoses in health care administrative data? Health Policy. 2003;65(2):101‑7.

19. Böcking W, Ahrens U, Kirch W, Milakovic M. First results of the introduction of DRGs in Germany and overview of experience from other DRG countries. J Public Health. 2005;13(3):128‑37.

20. Herwartz H, Strumann C. On the effect of prospective payment on local hospital competition in Germany. Health Care Manag Sci. 2012;15(1):48‑62.

21. Guccio C, Lisi D, Pignataro G. Readmission and Hospital Quality under Prospective Payment System [Internet]. 2014 [cité 1 févr 2017]. Disponible sur: https://mpra.ub.uni-muenchen.de/56490/

22. Abdul-Aziz AA, Hayward RA, Aaronson KD, Hummel SL. Association Between Medicare Hospital Readmission Penalties and 30-Day Combined Excess Readmission and Mortality. JAMA Cardiol. 26 oct 2016;2(2):200‑3.

23. Desai NR, Ross JS, Kwon JY, Herrin J, Dharmarajan K, Bernheim SM, et al. Association Between Hospital Penalty Status Under the Hospital Readmission Reduction Program and Readmission Rates for Target and Nontarget Conditions. JAMA. 27 2016;316(24):2647‑56.

24. Danino JF, Taylor T, Metcalfe CW, Muzaffar SJ, Sinha A. Readmission rates and financial penalties after ear, nose and throat surgery: how can we improve? Br J Hosp Med Lond Engl 2005. nov 2015;76(11):655‑7.

25. Gusmano M, Rodwin V, Weisz D, Cottenet J, Quantin C. Comparison of rehospitalization rates in France and the United States. J Health Serv Res Policy. janv 2015;20(1):18‑25.

26. Lainay C, Benzenine E, Durier J, Daubail B, Giroud M, Quantin C, et al. Hospitalization within the first year after stroke: the Dijon stroke registry. Stroke. janv 2015;46(1):190‑6.

27. Delmas M-C, Marguet C, Raherison C, Nicolau J, Fuhrman C. Readmissions for asthma in France in 2002-2005. Rev Mal Respir. nov 2011;28(9):e115‑22.

28. Abdulmalak C, Cottenet J, Beltramo G, Georges M, Camus P, Bonniaud P, et al. Haemoptysis in adults: a 5-year study using the French nationwide hospital administrative database. Eur Respir J. août 2015;46(2):503‑11.

29. Creuzot-Garcher C, Benzenine E, Mariet A-S, de Lazzer A, Chiquet C, Bron AM, et al. Incidence of Acute Postoperative Endophthalmitis after Cataract Surgery: A Nationwide Study in France from 2005 to 2014. Ophthalmology. juill 2016;123(7):1414‑20.

30. Lorgis L, Cottenet J, Molins G, Benzenine E, Zeller M, Aube H, et al. Outcomes after acute myocardial infarction in HIV-infected patients: analysis of data from a French nationwide hospital medical information database. Circulation. 30 avr 2013;127(17):1767‑74.

31. Pagès P-B, Cottenet J, Mariet A-S, Bernard A, Quantin C. In-hospital mortality following lung cancer resection: nationwide administrative database. Eur Respir J. juin 2016;47(6):1809‑17.

32. Han S, Smith TS, Gunnar W. Descriptive analysis of 30-day readmission after inpatient surgery discharge in the Veterans Health Administration. JAMA Surg. nov 2014;149(11):1162‑8.

33. DesHarnais S, Kobrinski E, Chesney J, Long M, Ament R, Fleming S. The Early Effects of the Prospective Payment System on Inpatient Utilization and the Quality of Care. Inquiry. 1987;24(1):7‑16.

34. Sager MA, Easterling DV, Kindig DA, Anderson OW. Changes in the Location of Death after Passage of Medicare's Prospective Payment System. N Engl J Med. 1989;320(7):433‑9.

35. O'Reilly J, Busse R, HÃ¤kkinen U, Or Z, Street A, Wiley M. Paying for hospital care: the experience with implementing activity-based funding in five European countries. Health Econ Policy Law. 2012;7(1):73‑101.

36. DeVore AD, Hammill BG, Hardy NC, Eapen ZJ, Peterson ED, Hernandez AF. Has Public Reporting of Hospital Readmission Rates Affected Patient Outcomes?: Analysis of Medicare Claims Data. J Am Coll Cardiol. 1 mars 2016;67(8):963‑72.

37. McGarry BE, Blankley AA, Li Y. The Impact of the Medicare Hospital Readmission Reduction Program in New York State. Med Care. févr 2016;54(2):162‑71.

38. Lu N, Huang K-C, Johnson JA. Reducing excess readmissions: promising effect of hospital readmissions reduction program in US hospitals. Int J Qual Health Care J Int Soc Qual Health Care. févr 2016;28(1):53‑8.

39. Barnett ML, Hsu J, McWilliams JM. Patient Characteristics and Differences in Hospital Readmission Rates. JAMA Intern Med. nov 2015;175(11):1803‑12.

40. Leape LL. Hospital readmissions following surgery: turning complications into « treasures ». JAMA. 3 févr 2015;313(5):467‑8.

41. Morris MS, Deierhoi RJ, Richman JS, Altom LK, Hawn MT. The relationship between timing of surgical complications and hospital readmission. JAMA Surg. avr 2014;149(4):348‑54.

42. McIntyre LK, Arbabi S, Robinson EF, Maier RV. Analysis of Risk Factors for Patient Readmission 30 Days Following Discharge From General Surgery. JAMA Surg. 1 sept 2016;151(9):855‑61.

43. Burgess JF, Hockenberry JM. Can all cause readmission policy improve quality or lower expenditures? A historical perspective on current initiatives. Health Econ Policy Law. avr 2014;9(2):193‑213.

44. Mehta HB, Dimou F, Adhikari D, Tamirisa NP, Sieloff E, Williams TP, et al. Comparison of Comorbidity Scores in Predicting Surgical Outcomes. Med Care. févr 2016;54(2):180‑7.

45. Metcalfe D, Olufajo OA, Zogg CK, Gates JD, Weaver MJ, Harris MB, et al. Are Older Adults With Hip Fractures Disadvantaged in Level 1 Trauma Centers? Med Care. juin 2016;54(6):616‑22.

46. Sedrakyan A, Kamel H, Mao J, Ting H, Paul S. Hospital Readmission and Length of Stay Over Time in Patients Undergoing Major Cardiovascular and Orthopedic Surgery: A Tale of 2 States. Med Care. juin 2016;54(6):592‑9.

Legend:

Figure 1: 30-day all-cause readmission rates after surgery according to hospital sector, all surgical procedures (France, 2002-2012)

Figure 2: 30-day all-cause readmission rates after surgery according to the most frequent DRG groups, by hospital sector, all surgical procedures (France, 2002-2012)

Table 1: Characteristics of patients and admissions, all surgical procedures (France, 2002–2012)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Age, mean, y	48.6	49.2	49.5	49.8	49.7	49.8	50.3	50.6	51.0	51.0	51.3
Length of stay, mean, d	4.3	4.2	4.0	3.8	3.7	3.6	3.5	3.4	3.3	3.1	3.0
Gender, male, %	46.9	47.0	47.0	47.2	47.6	48.0	48.0	48.0	48.0	48.0	47.7
Type of hospital, admission %											
Private	60.2	61.3	60.1	60.5	59.9	59.1	58.2	58.4	58.2	58.2	58.6
Public	39.8	38.7	39.9	39.5	40.1	40.9	41.8	41.6	41.8	41.8	41.4
Admission through emergency department, %	-	-	-	-	-	-	9.0	10.1	10.6	11.1	11.4
Groups of surgical diagnosis-related groups, %											
Orthopedics, rheumatology	26.4	26.2	26.5	27.0	27.3	27.4	27.6	27.8	27.7	27.6	27.4
Ophthalmology	11.4	12.2	12.5	12.7	12.9	13.0	13.2	13.7	14.0	14.2	14.5
Ear nose throat, stomatology	12.8	12.7	12.3	12.4	13.2	13.2	12.9	12.7	12.7	12.8	12.8
Abdominal	13.0	12.9	12.4	12.1	11.8	11.7	11.7	11.5	11.6	11.4	11.2
Gynecology	9.3	9.3	8.7	8.4	8.5	8.3	8.2	8.1	7.8	7.8	8.0
Urology	6.8	6.8	6.8	6.9	7.1	7.3	7.3	7.5	7.6	7.7	7.7
Skin	5.9	5.8	6.6	6.8	6.1	5.9	5.9	6.1	6.2	6.4	6.4
Vascular peripheral	5.4	5.3	5.2	5.1	5.2	5.1	5.1	5.0	4.8	4.7	4.7
Nervous system	2.9	2.8	3.0	2.8	2.4	2.5	2.5	2.6	2.6	2.5	2.4
Cardiology	2.0	2.0	1.9	1.9	1.9	1.9	2.0	2.0	2.0	1.9	1.9
Endocrinology	1.2	1.1	1.2	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0
Other	1.0	1.1	1.0	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.6
Pneumology	0.6	0.6	0.5	0.5	0.5	0.5	0.6	0.6	0.5	0.5	0.5
Hematology	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.5
Burns	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Severe trauma	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Infectious diseases (HIV excluded)	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0
Psychiatry, suicide attempts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Patients with HIV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Number of admissions	4,058,201	4,143,632	4,322,156	4,529,058	4,639,829	4,722,789	4,806,150	4,921,823	5,017,772	5,186,634	5,270,938

Table 2: Multiple logistic regression of 30-day all-cause readmission rates according to characteristics of patients and admissions, all surgical procedures (France, 2002–2012)

	Public hospitals (odds ratios)		Private hospitals (odds ratios)	
	Model 0	**Model 1**	**Model 0**	**Model 1**
Year of surgery				
2002	*ref.*	*ref.*	*ref.*	*ref.*
2003	0.993*	0.984**	1.021**	0.999
2004	1.042**	1.039**	1.073**	1.035**
2005	1.035**	1.021**	1.150**	1.094**
2006	1.083**	1.068**	1.211**	1.145**
2007	1.092**	1.073**	1.222**	1.119**
2008	1.102**	1.075**	1.244**	1.125**
2009	1.089**	1.057**	1.304**	1.149**
2010	1.088**	1.038**	1.350**	1.154**
2011	1.101**	1.043**	1.393**	1.164**
2012	1.101**	1.031**	1.446**	1.189**
Comorbidity				
Charlson index, per point	1.944**	2.062**	1.528**	1.811**
Admission				
Home vs transfer from hospital	0.901**	0.852**	0.642**	0.615**
Gender				
Male versus female	1.096**	1.106**	1.024**	1.048**
Age				
less than 10 y	*réf.*	*réf.*	*réf.*	*réf.*
10–19 y	0.916**	1.009**	1.439**	1.404**
20–29 y	1.107**	1.270**	2.637**	2.594**
30–39 y	1.395**	1.621**	3.693**	3.650**
40–49 y	1.395**	1.597**	3.544**	3.399**
50–59 y	1.611**	1.848**	4.150**	3.867**
60–69 y	1.707**	1.959**	4.566**	4.138**
70–79 y	1.772**	2.006**	5.027**	4.573**
80 y and over	1.949**	2.261**	5.304**	5.433**
Fixed effects for each DRG group[1]	Included	Included	Included	Included
Interaction term: DRG group * year	No	No	No	No
Number of observations	21,028,100	18,153,894	30,590,881	24,842,304
Concordance statistic				
concordant pairs, %	66.7	66.2	71.4	69.9

* : $p<0.10$, ** $p<0.01$

1: French Classification of Diagnosis-Related Groups

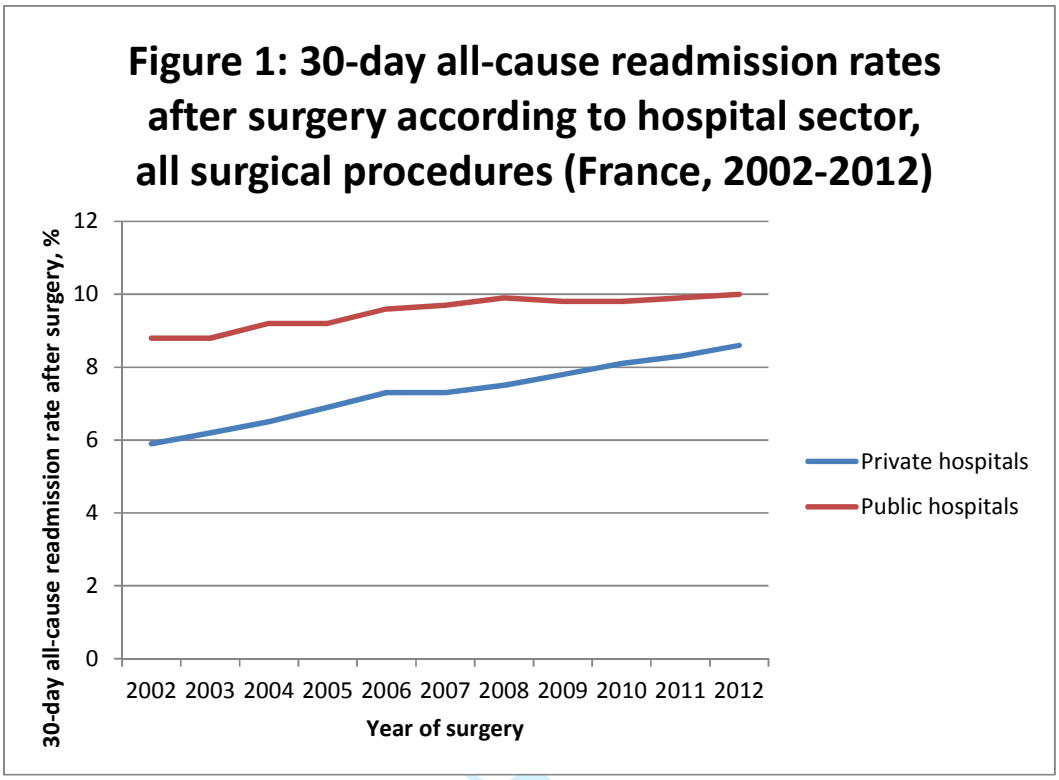
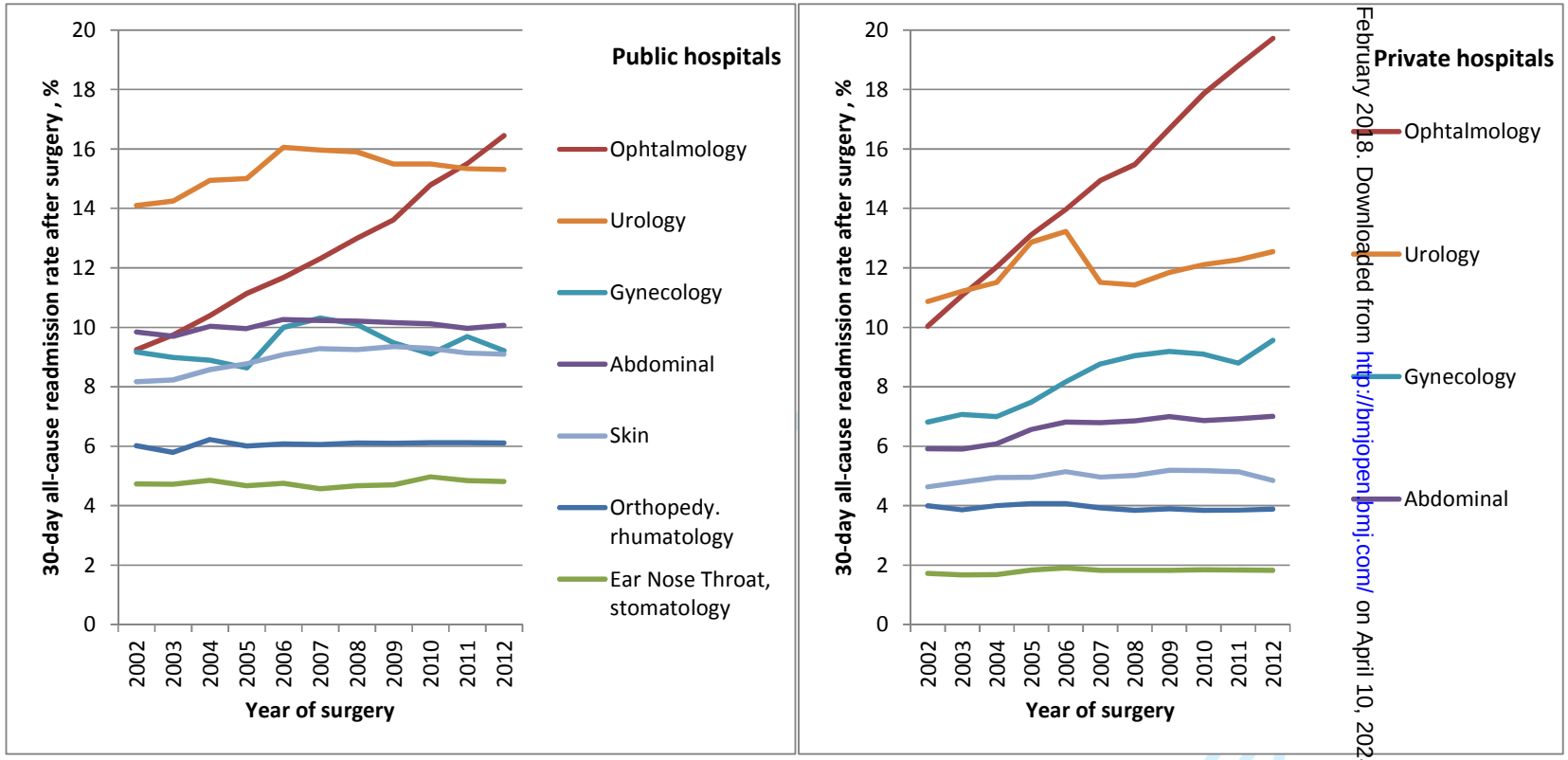


Figure 2: 30-day all-cause readmission rates after surgery according to the most frequent DRG groups, by hospital sector, all surgical procedures (France, 2002-2012)



STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2	This study was a retrospective multicenter study
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	This study aimed to describe trends in the hospital readmissions before, during and after the implementation of the case-based payment system in France from 2002 to 2012, using the national administrative database (PMSI). We found that the overall 30-day all-cause readmission rate following surgery discharge significantly increased, without deleterious effect of implementing the case-based payment system for hospital funding.
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4	
Objectives	3	State specific objectives, including any prespecified hypotheses	5	This study aimed to describe trends in the hospital readmissions before, during and after the implementation of the case-based payment system in France from 2002 to 2012, using the national administrative database (PMSI).
Methods				
Study design	4	Present key elements of study design early in the paper	5-6	This study was a retrospective multicenter study
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6	This study was a retrospective multicenter study based on nationwide PMSI data

				collected between January 2002 and December 2012.
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6	We included all patients admitted to hospital for a surgical procedure (as defined by the French DRG classification) during an 11-year period (2002–2012) in nearly all hospitals (740 hospitals). Hospitals with fewer than 300 stays per year were not included, because many of them closed during the study period
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6	For each selected surgery stay, the time from patient discharge to a new admission was calculated according to the linked information. Initial hospitalizations and stays ending in death or transfer, iterative treatments and neonatology were excluded.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6	Readmission was defined as "a new hospitalization in the 30 days following discharge after a stay for surgery, whatever the reason for this second stay" as done before.
Bias	9	Describe any efforts to address potential sources of bias	6	The fact that these national data are used for the allocation of hospital budgets encourages improvement in data quality in terms of coherence, accuracy and exhaustiveness.
Study size	10	Explain how the study size was arrived at	5	All patients admitted to hospital for a surgical procedure were included.

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why		No quantitative variables
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6	Two logistic regression models were created to measure the changes in the readmission rate over time. To determine the evolution of readmissions, all other things being equal, the probability of readmission at 30 days was analysed separately for the two types of hospital sector (i.e., public and private).
		(*b*) Describe any methods used to examine subgroups and interactions		No subgroups or interactions
		(*c*) Explain how missing data were addressed		No missing data
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy		Not applicable
		(*e*) Describe any sensitivity analyses		No sensitivity analyses
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7	About 52 million hospital stays were identified over the period January 2002 to December 2012 and registered in the national administrative database.
		(b) Give reasons for non-participation at each stage		Not applicable
		(c) Consider use of a flow diagram		Not necessary
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders		
		(b) Indicate number of participants with missing data for each variable of interest		No missing data
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	7	

Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	7	The number of stays with surgery selected in the database increased from 4.1 million in 2002 to 5.3 million in 2012, for a total of 51.6 million stays over the 11 years.
		Case-control study—Report numbers in each exposure category, or summary measures of exposure		
		Cross-sectional study—Report numbers of outcome events or summary measures		
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8	Between 2002 and 2012, the readmission rate following stays for surgery increased in both the public and private sector: from 8.8% to 10.0% and 5.9% to 8.6%, respectively. This increase appeared to be relatively steady in both sectors and was not affected by the implementation of a case-based payment system. This increase was significantly greater in the private than in the public sector ($p<0.001$). After adjustment for the DRG groups and morbidity, the probability of readmission at 30 days significantly increased with age, and the effect was linear. The effect of the risk of readmission according to age was greater in the private than in the public sector.
		(*b*) Report category boundaries when continuous variables were categorized		No continuous variables
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		

Continued on next page

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8	We observed a considerable variability in level of readmission between the different studied DRG groups.
Discussion				
Key results	18	Summarise key results with reference to study objectives	9	In this study, we showed that the probability of readmission within 30 days increased significantly with age, even after adjustment for the DRG group and comorbidity. The introduction of a case-based payment system in France in the middle of this period did not seem to influence the readmission rate after adjustment for age, gender and comorbidities.
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12	It was not possible to distinguish between scheduled and unscheduled readmissions, because this information was not recorded. We could not compute a combined comorbidity score from the information available in discharge abstracts.
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9-11	As the rise in readmissions did not seem to be related to pricing reform, we wondered whether it may have been related to changes in care practices and developed some examples in ophthalmology and HIV-related surgery.

Generalisability	21	Discuss the generalisability (external validity) of the study results	10	Regarding to our results, we studied in the international literature the impact of readmissions in quality of care in different countries. We also studied the impact of the implementation of several policies to limit them.
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	2	This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Did case-based payment influence surgical readmission rates in France? A retrospective study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-018164.R1
Article Type:	Research
Date Submitted by the Author:	30-Oct-2017
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Primary Subject Heading:	Health services research
Secondary Subject Heading:	Surgery
Keywords:	SURGERY, readmissions, acute care, hospital reimbursement, inpatient care

Did case-based payment influence surgical readmission rates in France? A retrospective study

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Brief title: Case-based payment and readmission rate

Manuscript word count: 2,991

ABSTRACT:

Objectives: To determine whether implementation of a case-based payment system changed all-cause readmission rates in the 30 days following discharge after surgery, we analyzed all surgical procedures performed in all hospitals in France before (2002-2004), during (2005-2008) and after (2009-2012) its implementation.

Setting: Our study is based on claims data for all surgical procedures performed in all acute care hospitals with more than 300 surgical admissions per year (740 hospitals) in France over 11 years (2002–2012; n=51.6 million admissions).

Interventions: We analyzed all-cause 30-day readmission rates after surgery using a logistic regression model and an interrupted time series analysis.

Results: The overall 30-day all-cause readmission rate following discharge after surgery increased from 8.8% to 10.0% ($p<0.001$) for the public sector and from 5.9% to 8.6% ($p<0.001$) for the private sector. Interrupted time series models revealed a significant linear increase in readmission rates over the study period in all types of hospitals. However, the implementation of case-based payment was only associated with a significant increase in rehospitalization rates for private hospitals ($p<0.001$).

Conclusion: In France, the increase in the readmission rate appears to be relatively steady in both the private and public sector but appears not to have been affected by the introduction of a case-based payment system after accounting for changes in care practices in the public sector.

Keywords: surgery, readmissions, acute care, hospital reimbursement, inpatient care

Strengths and limitations of this study

- To our knowledge, this is the first study to analyze 30-day all-cause readmission rates before, during and after the introduction of the case based payment system in France.
- We linked individual patient data over 11 years for all surgical procedures performed in all acute care hospitals with more than 300 surgical admissions per year in France (N=51.6 million surgical admissions, 740 hospitals).
- We analyzed rates of readmission for surgery with logistic regression models and with an interrupted time series analysis, in order to measure changes in readmission rates over time.
- One limitation of this study is that we considered all-cause readmissions as it is not possible to rule out planned readmissions in French claims data.

1. Introduction

Financing hospitals is a challenge for any healthcare system. Many countries in the Organization for Economic Cooperation and Development (OECD) have chosen payment by diagnosis-related group (DRG). In 1983, the United States was the first country to introduce a case-based payment system according to diagnosis-related groups of patients insured by Medicare (1–3). Many countries around the world (4) chose to adopt this model as a tool to regulate hospital expenditure. The United States applied DRG-based reimbursement to one specific patient group, those 65 years and over (Medicare) and eventually for the poor (Medicaid). In other countries, only a part of hospital reimbursement is based on the DRG system, as in Portugal (5,6), where this payment system concerns only certain care activities. To our knowledge, only France and Norway have implemented this case-based payment system to finance all hospital care activities since the early 2000s (7,8).

Other countries, like Belgium, are considering the implementation of a similar case-based payment system (9), but wonder whether it would induce certain unintended effects such as encouraging hospitals to increase their activity to improve their financial balance sheets. Moreover, whether or not there was improvement in quality of care (10-12) with regard to the decreased length of stays and in terms of mortality and readmission rates, is a matter of debate (13-15). Although hospital readmissions, when considered alone, can be used as an indirect marker of health care quality, their value in this setting is controversial (16,17). In addition, there is some evidence that the implementation of a tariff system based on activity would lead to an increase in rehospitalization so as to maximize hospital revenues (18–21). This effect was so feared in the United States and England that policymakers imposed penalties for hospitals with abnormally high rehospitalization rates (22-24).

The medical information system in France has gathered exhaustive data on hospital activity since 1997, well before the implementation of case-based reimbursement in 2005. It is thus possible to obtain baseline rehospitalization rates before the implementation of the case-based payment system. Since case-

based payment was applied to all hospital activities, it is relatively easy to measure the evolution of readmissions after surgical procedures over the period of implementation.

The aim of this study is determine whether implementation of case-based payment system was associated with a change in all-cause rehospitalizations rates in France. To do this, we compared rehospitalizations before the implementation of the case-based payment system (2002–2004), which was introduced stepwise in the middle of the study period (2005-2008) and after the implementation (2009–2012), after adjustment for the principal characteristics of patients. Previous studies conducted in France have not analyzed the evolution of readmission rates over time (25) or only examined certain regions (13), or were based only on specific diseases (26,27). In this study, we include all surgical procedures and consider all readmissions, whatever the surgical subspecialty and cause of readmission.

2. Materials and methods

2.1 Source of data

The hospital discharge abstract database (Programme de Médicalisation des Systèmes d'Informations [PMSI]), contains individual, exhaustive and linkable but anonymous data on healthcare use for the whole French population and collects primary and associated diagnoses (secondary events and comorbidities) encoded using the World Health Organization International statistical Classification of Diseases and related health problems 10th revision (ICD-10), and procedures performed during all hospital stays using the common classification system for medical procedures (Classification commune des actes médicaux [CCAM]); The very good quality of the French hospital database has previously been evaluated and has enabled us to carry out several epidemiological and health services research studies concerning hospitalized patients in France (25,26,28-31). The study was approved by the National Committee for Data Protection (registration numbers: 913291 for Dijon University Hospital and 723116 for the Ministry of Health).

2.2 Population

This study was a retrospective multicentre study based on nationwide PMSI data.

We include all patients admitted to all acute care hospitals with surgical wards (740 hospitals including 295 public hospitals and 445 private hospitals) for surgical procedures (as defined by the French DRG classification) over 11 years (2002–2012). Hospitals with fewer than 300 surgical admissions per year were not included, because many of them closed during the study period. We considered separately public and private hospitals, as hospital funding was completely different between these two types before the introduction of case-based payment in all hospitals. The 46 private non for profit hospitals were classified in the public sector, as their hospital funding was the same as for public hospitals.

2.3 Main outcome measure: readmission within 30 days following discharge

For each selected surgery admission, the time from patient discharge to a new admission was calculated according to the linked information. Initial hospitalizations and stays ending in death or transfer, iterative treatments and neonatology were excluded. In "iterative treatments" we considered one-day admissions for treatments such as chemotherapy, radiation therapy and hemodialysis. All-cause readmission was defined as "a new hospitalization within 30 days (30) following discharge after an admissions for surgery, whatever the reason for this second admission" as done before (25,26), i.e. if a patient was readmitted for a reason other than the diagnosis for the first admission, it was still considered a readmission. The hospital where the readmission took place was also noted.

2.4 Variables studied: characteristics related to readmission

The characteristics of the admissions were studied according to the variables available in the national medical-administrative database, namely year of hospitalization, age, gender, mode of admission (from home, via an emergency service and transfer), the type of hospital, morbidity (Charlson score, Major Diagnostic Categories of French classification in DRGs that we called DRG groups) and length of stay (15).

We also added the urban/rural classification of patients' place of residence according to the French institute of statistics and censuses (INSEE). We subdivided information regarding urban areas into three categories: city centers, suburbs of big cities and small towns.

2.5 Statistical analysis

In the first analysis, we studied the influence of the variables defined above (all dichotomized) on readmission at 30 days with two logistic regression models The probability of readmission was analyzed separately for the two types of hospital sector (i.e., public and private). The first model (M0) concerned all hospital admissions for surgery.

The second model (M1) excluded DRG groups with low volumes of activity (burns, infectious diseases, HIV diseases, multiple trauma, psychiatry in acute care, other types of care). They also excluded cases with major modifications in care practices during the period, either for changes in care management (e.g., in ophthalmology) or therapeutic changes for the treatment of human immunodepression virus (HIV). Regarding ophthalmologic surgery, since cataract surgery is more and more frequently performed to one eye and rapidly after to the other (less than one month after), we had to take into account this change with time, which results in an increase in readmission rates in ophthalmology substantially greater than in other specialties.

In the second analysis, an interrupted time series analysis was performed to measure changes in the readmission rate over time while taking into account the variables defined above. This model used monthly readmission rates over the study period and included a linear time trend. Three periods were considered: the pre-case-based payment system period (from 2002 to 2004), the implementation period (from 2005 to 2008) and the post-implementation period (from 2009 to 2012). In accordance with seasonal fluctuations, random error was modeled by an autoregressive model with a parameter at lag 12.

We thus quantified the impact of the implementation as changes in the level and slope were compared with the pre-implementation period. SAS 9.4 was used for all of the analyses. The threshold of statistical significance was set at $p<0.05$.

3. Results

3.1 Descriptive study

The study sample contained almost 52 million admissions, accounting for all admissions with DRGs related to surgery in hospitals with more than 300 admissions per year. Admissions with in-hospital deaths or without linkage information were excluded and represented less than 5% of our admissions.

The number of admissions with surgery selected in the database increased from 4.1 million in 2002 to 5.3 million in 2012, for a total of 51.6 million admissions over the 11 years (Table 1). Of the surgeries, 60% and 40% took place in profit-making private and in public or non-profit-making private hospitals, respectively. During the study period, there was a steady increase in the mean age of patients (from 48.6 to 51.3 years) and a decrease in the mean length of stay (from 4.3 to 3.0 days). The disease profile remained relatively stable, except for a slight increase in admissions in ophthalmology units.

Between 2002 and 2012, the readmission rate following admissions for surgery (Figure 1) increased in both the public and private sector: from 8.8% to 10.0% and 5.9% to 8.6%, respectively). Although the overall readmission rate was higher in public than in private hospitals ($p<0.001$), its increase appeared to be relatively steady in both sectors. However, this increase was significantly greater in the private than in the public sector ($p<0.001$).

The descriptive results underlined the disparity in readmission rates at 30 days between the different DRG groups over the study period (Figure 2), in terms of both volume and evolution. In 2012, the readmission rate ranged from 2.7% for ear, nose and throat (ENT) surgery to 26% for hematology and 27% for the

surgical treatment of burns. Two types of surgery in particular showed a major change in the readmission rate: ophthalmology and HIV-related surgery. For ophthalmology the readmission rate increased from 9.3% in 2002 to 16.5% in 2012 in the public sector and from 10.0% to 19.7% in the private sector. For HIV-related surgery, the readmission rate in the public sector fell from 31.4% in 2002 to 25.4% in 2012, but peaked at 39.3% in 2006, with major variations from one year to another.

The profile for the evolution of readmission rates by type of surgery also differed according to the type of hospital and surgery (Figure 2). For example, the increase in the readmission rate for ophthalmology was particularly pronounced in private hospitals, rising from 10.0% in 2002 to 19.7% in 2012. Concerning other types of surgery, the readmission rate for the public and private sectors remained quite stable.

3.2 Multivariate models: study of factors associated with readmission

After adjustment for the DRG groups and morbidity, the probability of readmission at 30 days increased with time (Table 2, Model M0) in both the public and private sector. We can see that the effect of the risk of readmission also increased with age and that this effect was greater in the private than in the public sector (for example, for patients aged 80 years and over, OR = 1.9 in the public sector vs. 5.3 in the private sector). Moreover, patients living in urban areas were slightly more at risk of readmission, with a more marked risk in small towns.

However, after excluding cases with major modifications in care practices during the period (such as ophthalmologic surgery) or with low volumes of activity, the overall increase in the readmission rate found in model M0 was not retrieved for public hospitals and the readmission rate did not seem to increase with time after the implementation of the case-based payment (Model M1).

3.3 Interrupted time series model

The series exhibited significant linear trends over the period (see Figure 3). Rehospitalization rates increased by 0.0170 percentage points per month in public hospitals ($p < 0.05$) and by 0.0224 percentage points per

month in private hospitals (p<0.001). However, the implementation of case-based payment was associated with a significant increase in rehospitalization rates for private hospitals (p<0.001).

4. Discussion

Our nationwide population-based analysis of 51.6 million hospital admissions for surgery over the 2002–2012 period found that the overall readmission rate within 30 days following discharge increased with time both in the public and private sectors, after adjustment for age, gender and comorbidities. The increase was greater in the private sector than in the public sector. However, after excluding cases with major modifications in care practices during the period, such as ophthalmologic surgery, the overall increase in the readmission rate found in the previous regression logistic model was not retrieved and, for public hospitals, the readmission rate did not seem to have been influenced by the implementation of case-based payment. The interrupted time series analysis confirmed that the implementation of case-based payment was only associated with a significant increase in rehospitalization rates for private hospitals. These results suggest that hospital reimbursement is not the only determinant of readmission.

These findings contradict the results of a retrospective observational study in the U.S. (32), which found a decreased 30-day readmission rate following inpatient discharge for nine surgical specialties in the Veterans Health Administration (VHA) over a similar 10-year period (2001–2010). The fact that in France, no penalty is risked by hospitals in case of increased readmission rate may partially explain this difference. Moreover, our study included all types of surgery and specialties, including ophtalmology. We also considered all readmissions, whatever the sector, in contrast with the VHA study, in which patients having surgery at a VHA facility and then readmitted in the private sector could not be captured. In another study comparing patients insured by Medicare before and after the implementation of the case-based payment system (33), the authors found that case-based payment was accompanied by a reduction in the length of stay. In parallel, the discharge mortality rate and the readmission rate did not increase. The same results were found by Kahn et al. (13) with a 24% decrease in the length of stay and an unchanged readmission rate. Another early study

on the effects of implementing Medicare in the United States reported stable in-hospital mortality rates and care quality (34). At the same time, this stability of in-hospital mortality was put into perspective by Sager et al., who reported a significant rise in mortality at home and thus concluded that in-hospital deaths had been converted to at-home deaths in patients not covered by the new system (35). In Europe, it is difficult to say whether mortality rates have been affected by implementation of the case-based payment system. Studies have nonetheless shown that these systems are often accompanied by shorter lengths of stay and an increase in the number of admissions and in hospital productivity. (5, 6, 20,36). Cutler hypothesized that payment linked to activity could have influenced the readmission rate, given that these rates increased in hospitals with deficits and thus under financial pressure (14).

The evolution of readmission rates was slightly different in the public and private sectors. In France, the former generally manages the most complex cases of each disease, including emergency cases (37). It is therefore not surprising to see a higher overall rate of readmissions in public than in private hospitals. However, comparison of the two sectors showed that the management of cataract surgery was reorganized faster in the private sector. The greater increase in readmissions in the private sector than in the public sector may be surprising, since the new pricing policy provided the least incentive for change in the private sector. The pricing policy before the case-based payment system already included payment according to activity in the private sector and readmissions were already paid for before implementation of the case-based payment system.

As this rise in readmissions did not seem to be only related to the pricing reform, one might wonder whether it was also related to changes in care practices. A more specific analysis of our results did not support this hypothesis. Two contrasting examples show the effect of changes in care practices on readmission rates. First consider the case of cataract surgery - nearly 500,000 surgeries per year in France. These procedures have moved from inpatient to outpatient hospitalization with prompt recovery leading to a shortened delay between surgeries for each eye. Consequently, their increased readmission rates only reflect this shortened

delay between surgeries for each eye due to the improvement in practices and not a secondary deleterious influence of hospital funding. Second, in HIV-related surgery, we observed changes in the opposite direction, with a decrease in the readmission rate, which may only reflect the improved efficacy of antiretroviral treatments leading to fewer recurrent hospitalizations. These observations suggest that to interpret these results, all changes (population, clinical practices and payment incentives) need to be considered for each group of diseases.

At the international level, the financial impact of readmissions to hospitals has led to the implementation of different policies aiming to limit such admissions as much as possible. The impact of these measures has been investigated in American studies showing that the decrease in the number of readmissions in the population studied did not stem from the implementation of such policies, but rather from the long-standing adaptation of practices of healthcare staff, as shown in our study (38,39). These results showed that an overall decrease in readmissions at 30 days has to be considered over the long term rather than as a direct and immediate result of healthcare policy. A secondary effect such as a concomitant increase in outpatient consultations needs to be considered as well (40). However, a recent study reported significant effects of such incentives, leading to decreases in readmission rates in small public-sector hospitals located in rural areas (39). In our study, we considered the place of residence of patients and not the location of the hospital as in France most hospitals are located in urban areas. We only found a slight effect of the patients' place of residence on readmissions. We do not think that this result can be affected by the risk of ecological fallacy as we only included one aggregated variable in our logistic regression model (41).

In the US, some hospitals regularly publish their 30-day readmission rates with regard to cardiovascular or pulmonary diseases. However, a recent analysis of factors associated with readmission conducted in a cohort of patients insured by Medicare showed that not all hospitals were equally affected by readmissions (42). After adjustment for the characteristics of individual patients, hospitals recording the highest readmission rates were those with patients who were the most likely to be readmitted to the hospital due to the

complexity of their illness or a low socioeconomic status (43). In our study, we could not include the socio-economic status of patients. We are aware that one plausible explanation for the increase in hospital readmissions could be related to the patient's socio-economic environment, as social and economic support at home may not be sustained and place the patient at a higher risk of readmission. Indeed, the use of readmission as a marker of complications after an initial surgical admission remains controversial. Some studies reported that almost half of readmissions were not associated with a currently assessed complication (44). Moreover, readmissions after surgery may be associated with new post-discharge complications related to the procedure rather than exacerbation of complications related to a prior index hospitalization (45) or confounding issues such as substance abuse or homelessness. Some authors believe that reduced readmission rates alone cannot be used as an indicator of care quality; their effects must be studied more globally to determine whether such reductions coincide with improved quality of life in patients (46).

To our knowledge, this study is the first to consider all hospital admissions resulting from all-cause readmissions within 30 days over such a long period in a given country. This study nevertheless has certain limitations. First, the global nature of readmission, chosen as an indicator in this study, can only be regarded as a partial assessment of the quality of surgical care. Other measurements should be considered, such as the mortality rate after hospitalization. Among the readmissions identified, certain were scheduled and did not result from a complication following the first admission. It was not possible to distinguish between scheduled and unscheduled readmissions, because this information is not recorded in French claims data. This is why we decided to exclude admissions for ocular surgery in the M1 model so as to rule out most scheduled readmissions. Second, we could not compute a combined comorbidity score, as suggested by Mehta et al (47), from the information available in discharge abstracts. Further research is needed, first to characterize readmissions, second to study the influence of the type or the location of hospitals in greater detail (48), to consider readmissions after outpatient surgery, and finally to better explain the relationship between readmissions and length of hospital stay (49).

5. Conclusion

Our nationwide observational study is the first to consider all hospital admissions resulting from all-cause readmissions within 30 days after surgery over such a long period. It suggests that despite the slight temporary rise in readmissions during the implementation of the case-based payment system, this pricing reform does not appear to have had a significant long-lasting effect on readmissions at 30 days in the public sector. The increase in the readmission rate at 30 days after an admission for surgery appears to be related mainly to modifications in care practices, notably for cataract surgery and, secondly, to a structural modification associated with the aging patient population. To interpret these results, further studies are needed to examine the influence of the different changes in populations and clinical practices on readmissions for each group of diseases.

Disclosure Statement: The authors have nothing to disclose

Conflicts of Interest: The authors have no conflicts of interest relevant to this article to disclose.

Contribution to Authorship: AV and EY conceptualized and designed the study, interpreted the data and wrote the paper. AR contributed substantially to writing the manuscript. VR, MG, AB and CCG participated in the interpretation of the results reviewed and revised the manuscript drafts. CQ oversaw the data analysis and interpretation, and contributed substantially to writing the manuscript.

All authors accept responsibility for the paper as published.

Data sharing statement: No additional data available.

Ethics: This study was approved by the National Committee for data protection (registration number 1576793) and therefore was conducted in accordance with the Declaration of Helsinki. Written consent was not needed for this study. The PMSI database was transmitted by the national agency for the management of hospitalization data (ATIH number 2015-111111-47-33).

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Availability of data and materials: The PMSI database was transmitted by the national agency for the management of hospitalization data. The use of these data by our department was approved by the National Committee for data protection. We are not allowed to transmit these data.

References:

1. Fetter RB, Freeman JL. Diagnosis Related Groups: Product Line Management within Hospitals. Acad Manage Rev. 1986;11(1):41‑54.

2. Fetter RB. Diagnosis Related Groups: Understanding Hospital Performance. Interfaces. 1991;21(1):6-26.

3. McMahon LF Jr, Fetter RB, Freeman JL, Thompson JD. Hospital matrix management and DRG-based prospective payment. Hosp Health Serv Adm. 1986;31(1):62-74.

4. Roger FH. Case mix use in 25 countries: a migration success but international comparisons failure. Int J Med Inf. 2003;70(2-3):215‑9.

5. Dismuke CE, Sena V. Has DRG payment influenced the technical efficiency and productivity of diagnostic technologies in Portuguese public hospitals? An empirical analysis using parametric and non-parametric methods. Health Care Manag Sci. 1999;2(2):107‑16.

6. Dismuke CE, Guimaraes P. Has the caveat of case-mix based payment influenced the quality of inpatient hospital care in Portugal? Appl Econ. 2002;34(10):1301‑7.

7. Or Z. Implementation of DRG Payment in France: Issues and recent developments. Health Policy. 2014;117(2):146‑50.

8. van den Noord PTH a. TI. The Norwegian Health Care System [Internet]. OECD Publishing; 1998. http://dx.doi.org/10.1787/571585217086

9. Pirson M, Van den Bulcke J, Di Pierdomenico L, Martins D, Leclercq P. [Medical and economic evaluation of oncological inpatients in 14 Belgian hospitals]. Bull Cancer (Paris). nov 2015;102(11):923‑31.

10. Lilford RJ, Brown CA, Nicholl J. Use of process measures to monitor the quality of clinical practice. BMJ. 29 sept 2007;335(7621):648‑50.

11. Thomas JW, Guire KE, Horvat GG. Is patient length of stay related to quality of care? Hosp Health Serv Adm. 1997;42(4):489 ‑507.

12. Martin S, Street A, Han L, Hutton J. Have hospital readmissions increased in the face of reductions in length of stay? Evidence from England. Health Policy. 2016 ;120(1):89-99.

13. Kahn KL, Keeler EB, Sherwood MJ, Rogers WH, Draper D, Bentow SS, et al. Comparing outcomes of care before and after implementation of the DRG-based prospective payment system. JAMA. 17 oct 1990;264(15):1984-8.

14. Cutler DM. The Incidence of Adverse Medical Outcomes Under Prospective Payments [Internet]. National Bureau of Economic Research; 1993 mars [cité 1 févr 2017]. Report No.: 4300. http://www.nber.org/papers/w4300

15. Bahrami S, Holstein J, Chatellier G, Le Roux Y-E, Dormont B. [Using administrative data to assess the impact of length of stay on readmissions: study of two procedures in surgery and obstetrics]. Rev Epidemiol Sante Publique. apr 2008;56(2):79‑85.

16. Moghavem N, McDonald K, Ratliff JK, Hernandez-Boussard T. Performance Measures in Neurosurgical Patient Care: Differing Applications of Patient Safety Indicators. Med Care. apr 2016;54(4):359‑64.

17. Rosen AK, Chen Q, Shwartz M, Pilver C, Mull HJ, Itani KFM, et al. Does Use of a Hospital-wide Readmission Measure Versus Condition-specific Readmission Measures Make a Difference for Hospital Profiling and Payment Penalties? Med Care. feb 2016;54(2):155‑61.

18. SerdÃ©n L, Lindqvist R, RosÃ©n M n. Have DRG-based prospective payment systems influenced the number of secondary diagnoses in health care administrative data? Health Policy. 2003;65(2):101‑7.

19. Böcking W, Ahrens U, Kirch W, Milakovic M. First results of the introduction of DRGs in Germany and overview of experience from other DRG countries. J Public Health. 2005;13(3):128‑37.

20. Herwartz H, Strumann C. On the effect of prospective payment on local hospital competition in Germany. Health Care Manag Sci. 2012;15(1):48‑62.

21. Guccio C, Lisi D, Pignataro G. Readmission and Hospital Quality under Prospective Payment System [Internet]. 2014. https://mpra.ub.uni-muenchen.de/56490/

22. Abdul-Aziz AA, Hayward RA, Aaronson KD, Hummel SL. Association Between Medicare Hospital Readmission Penalties and 30-Day Combined Excess Readmission and Mortality. JAMA Cardiol. 26 oct 2016;2(2):200‑3.

23. Desai NR, Ross JS, Kwon JY, Herrin J, Dharmarajan K, Bernheim SM, et al. Association Between Hospital Penalty Status Under the Hospital Readmission Reduction Program and Readmission Rates for Target and Nontarget Conditions. JAMA. 27 2016;316(24):2647‑56.

24. Danino JF, Taylor T, Metcalfe CW, Muzaffar SJ, Sinha A. Readmission rates and financial penalties after ear, nose and throat surgery: how can we improve? Br J Hosp Med Lond Engl 2005. nov 2015;76(11):655‑7.

25. Gusmano M, Rodwin V, Weisz D, Cottenet J, Quantin C. Comparison of rehospitalization rates in France and the United States. J Health Serv Res Policy. jan 2015;20(1):18‑25.

26. Lainay C, Benzenine E, Durier J, Daubail B, Giroud M, Quantin C, et al. Hospitalization within the first year after stroke: the Dijon stroke registry. Stroke. jan 2015;46(1):190‑6.

27. Delmas M-C, Marguet C, Raherison C, Nicolau J, Fuhrman C. Readmissions for asthma in France in 2002-2005. Rev Mal Respir. nov 2011;28(9):e115‑22.

28. Abdulmalak C, Cottenet J, Beltramo G, Georges M, Camus P, Bonniaud P, et al. Haemoptysis in adults: a 5-year study using the French nationwide hospital administrative database. Eur Respir J. aug 2015;46(2):503‑11.

29. Creuzot-Garcher C, Benzenine E, Mariet A-S, de Lazzer A, Chiquet C, Bron AM, et al. Incidence of Acute Postoperative Endophthalmitis after Cataract Surgery: A Nationwide Study in France from 2005 to 2014. Ophthalmology. jul 2016;123(7):1414‑20.

30. Lorgis L, Cottenet J, Molins G, Benzenine E, Zeller M, Aube H, et al. Outcomes after acute myocardial infarction in HIV-infected patients: analysis of data from a French nationwide hospital medical information database. Circulation. 30 apr 2013;127(17):1767‑74.

31. Pagès P-B, Cottenet J, Mariet A-S, Bernard A, Quantin C. In-hospital mortality following lung cancer resection: nationwide administrative database. Eur Respir J. jun 2016;47(6):1809‑17.

32. Han S, Smith TS, Gunnar W. Descriptive analysis of 30-day readmission after inpatient surgery discharge in the Veterans Health Administration. JAMA Surg. nov 2014;149(11):1162‑8.

33. Davis C, Rhodes DJ. The impact of DRGs on the cost and quality of health care in the United States. Health Policy. 1988;9(2):117-31.

34. DesHarnais S, Kobrinski E, Chesney J, Long M, Ament R, Fleming S. The Early Effects of the Prospective Payment System on Inpatient Utilization and the Quality of Care. Inquiry. 1987;24(1):7‑16.

35. Sager MA, Easterling DV, Kindig DA, Anderson OW. Changes in the Location of Death after Passage of Medicare's Prospective Payment System. N Engl J Med. 1989;320(7):433‑9.

36. O'Reilly J, Busse R, HÃ¤kkinen U, Or Z, Street A, Wiley M. Paying for hospital care: the experience with implementing activity-based funding in five European countries. Health Econ Policy Law. 2012;7(1):73‑101.

37. Reuter PG, Kernéis S, Turbelin C, Souty C, Arena C, Gavazzi G, Sarazin M, Blanchon T, Hanslik T. Orientation of patients referred by their general practionner to the public or private hospital sector in France: A prospective epidemiologic study. Rev Med Interne. 2012 Dec;33(12):672-7.

38. DeVore AD, Hammill BG, Hardy NC, Eapen ZJ, Peterson ED, Hernandez AF. Has Public Reporting of Hospital Readmission Rates Affected Patient Outcomes?: Analysis of Medicare Claims Data. J Am Coll Cardiol. 1 mar 2016;67(8):963‑72.

39. McGarry BE, Blankley AA, Li Y. The Impact of the Medicare Hospital Readmission Reduction Program in New York State. Med Care. feb 2016;54(2):162‑71.

40. Stefanie N Hofstede, Leti van Bodegom-Vos, Dionne S Kringos, Ewout Steyerberg, Perla J Marang-van de Mheen. Mortality, readmission and length of stay have different relationships using hospital-level versus patient-level data: an example of the ecological fallacy affecting hospital performance indicators. BMJ Qual Saf. 2017 Oct 6.

41. Lu N, Huang K-C, Johnson JA. Reducing excess readmissions: promising effect of hospital readmissions reduction program in US hospitals. Int J Qual Health Care J Int Soc Qual Health Care. feb 2016;28(1):53‑8.

42. Barnett ML, Hsu J, McWilliams JM. Patient Characteristics and Differences in Hospital Readmission Rates. JAMA Intern Med. nov 2015;175(11):1803‑12.

43. Leape LL. Hospital readmissions following surgery: turning complications into « treasures ». JAMA. 3 feb 2015;313(5):467-8.

44. Morris MS, Deierhoi RJ, Richman JS, Altom LK, Hawn MT. The relationship between timing of surgical complications and hospital readmission. JAMA Surg. apr 2014;149(4):348-54.

45. McIntyre LK, Arbabi S, Robinson EF, Maier RV. Analysis of Risk Factors for Patient Readmission 30 Days Following Discharge From General Surgery. JAMA Surg. 1 sep 2016;151(9):855-61.

46. Burgess JF, Hockenberry JM. Can all cause readmission policy improve quality or lower expenditures? A historical perspective on current initiatives. Health Econ Policy Law. apr 2014;9(2):193-213.

47. Mehta HB, Dimou F, Adhikari D, Tamirisa NP, Sieloff E, Williams TP, et al. Comparison of Comorbidity Scores in Predicting Surgical Outcomes. Med Care. feb 2016;54(2):180‑7.

48. Metcalfe D, Olufajo OA, Zogg CK, Gates JD, Weaver MJ, Harris MB, et al. Are Older Adults With Hip Fractures Disadvantaged in Level 1 Trauma Centers? Med Care. jun 2016;54(6):616‑22.

49. Sedrakyan A, Kamel H, Mao J, Ting H, Paul S. Hospital Readmission and Length of Stay Over Time in Patients Undergoing Major Cardiovascular and Orthopedic Surgery: A Tale of 2 States. Med Care. jun 2016;54(6):592‑9.

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Legend:

Figure 1: 30-day all-cause readmission rates after surgery according to hospital sector, all surgical procedures (France, 2002-2012)

Figure 2: 30-day all-cause readmission rates after surgery according to the most frequent DRG groups, by hospital sector, all surgical procedures (France, 2002-2012)

Figure 3: Global trends in 30-day all-cause readmission rates per month after surgery (France, 2002-2012): interrupted time series analysis

Table 1: Characteristics of patients and admissions, all surgical procedures (France, 2002–2012)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Age, mean, y	48.6	49.2	49.5	49.8	49.7	49.8	50.3	50.6	51.0	51.0	51.3
Length of stay, mean, d	4.3	4.2	4.0	3.8	3.7	3.6	3.5	3.4	3.3	3.1	3.0
Gender, male, %	46.9	47.0	47.0	47.2	47.6	48.0	48.0	48.0	48.0	48.0	47.7
Type of hospital, admission %											
Private	60.2	61.3	60.1	60.5	59.9	59.1	58.2	58.1	58.2	58.2	58.6
Public	39.8	38.7	39.9	39.5	40.1	40.9	41.8	41.9	41.8	41.8	41.4
Admission through emergency department, %	-	-	-	-	-	-	9.0	10.1	10.6	11.1	11.4
Groups of surgical diagnosis-related groups, %											
Orthopedics, rheumatology	26.4	26.2	26.5	27.0	27.3	27.4	27.6	27.8	27.7	27.6	27.4
Ophthalmology	11.4	12.2	12.5	12.7	12.9	13.0	13.2	13.7	14.0	14.2	14.5
Ear nose throat, stomatology	12.8	12.7	12.3	12.4	13.2	13.2	12.9	12.7	12.7	12.8	12.8
Abdominal	13.0	12.9	12.4	12.1	11.8	11.7	11.7	11.5	11.6	11.4	11.2
Gynecology	9.3	9.3	8.7	8.4	8.5	8.3	8.2	8.1	7.8	7.8	8.0
Urology	6.8	6.8	6.8	6.9	7.1	7.3	7.3	7.5	7.6	7.7	7.7
Skin	5.9	5.8	6.6	6.8	6.1	5.9	5.9	6.1	6.2	6.4	6.4
Vascular peripheral	5.4	5.3	5.2	5.1	5.2	5.1	5.1	5.0	4.8	4.7	4.7
Nervous system	2.9	2.8	3.0	2.8	2.4	2.5	2.5	2.6	2.6	2.5	2.4
Cardiology	2.0	2.0	1.9	1.9	1.9	1.9	2.0	2.0	2.0	1.9	1.9
Endocrinology	1.2	1.1	1.2	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0
Other	1.0	1.1	1.0	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.6
Pneumology	0.6	0.6	0.5	0.5	0.5	0.5	0.6	0.6	0.5	0.5	0.5
Hematology	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.5
Burns	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Severe trauma	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Infectious diseases (HIV excluded)	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0
Psychiatry, suicide attempts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Patients with HIV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Number of admissions	4,058,201	4,143,632	4,322,156	4,529,058	4,639,829	4,722,789	4,806,150	4,921,823	5,017,772	5,186,634	5,270,938

Table 2: Multiple logistic regression of 30-day all-cause readmission rates according to characteristics of patients and admissions, all surgical procedures (France, 2002–2012)

	Public hospitals (odds ratios)		Private hospitals (odds ratios)	
	Model 0	**Model 1**	**Model 0**	**Model 1**
Year of surgery				
2002	*ref.*	*ref.*	*ref.*	*ref.*
2003	0.994	0.984**	1.023**	1.000
2004	1.043**	1.039**	1.074**	1.036**
2005	1.033**	1.018**	1.152**	1.096**
2006	1.084**	1.070**	1.212**	1.147**
2007	1.093**	1.075**	1.223**	1.121**
2008	1.105**	1.077**	1.246**	1.127**
2009	1.091**	1.059**	1.305**	1.151**
2010	1.090**	1.040**	1.351**	1.155**
2011	1.103**	1.045**	1.395**	1.166**
2012	1.103**	1.033**	1.448**	1.191**
Comorbidity				
Charlson index (> 0 vs. =0)	1.943**	2.061**	1.529**	1.812**
Admission				
Home vs transfer from hospital	0.899**	0.850**	0.640**	0.613**
Gender				
Male versus female	1.096**	1.106**	1.024**	1.049**
Age				
less than 10 y	*réf.*	*réf.*	*réf.*	*réf.*
10–19 y	0.918*	1.010*	1.438**	1.404**
20–29 y	1.112**	1.274**	2.636**	2.592**
30–39 y	1.400**	1.624**	3.692**	3.650**
40–49 y	1.398**	1.599**	3.544**	3.401**
50–59 y	1.615**	1.850**	4.150**	3.869**
60–69 y	1.712**	1.962**	4.567**	4.142**
70–79 y	1.777**	2.009**	5.028**	4.577**
80 y and over	1.954**	2.263**	5.304**	5.433**
Place of residence				
City center	1.004*	0.998	1.025**	1.032**
Suburbs	1.018**	1.008**	1.017**	1.019**
Small town	1.021**	1.011**	1.025**	1.002
Fixed effects for each DRG group[1]	Included	Included	Included	Included
Interaction term: DRG group * year	No	No	No	No
Number of observations	20,893,246	18,036,369	30,459,905	24,736,141
Concordance statistic				
concordant pairs, %	66.7	66.2	71.4	69.9

* : $p<0.10$, ** $p<0.01$
[1:] French Classification of Diagnosis-Related Groups

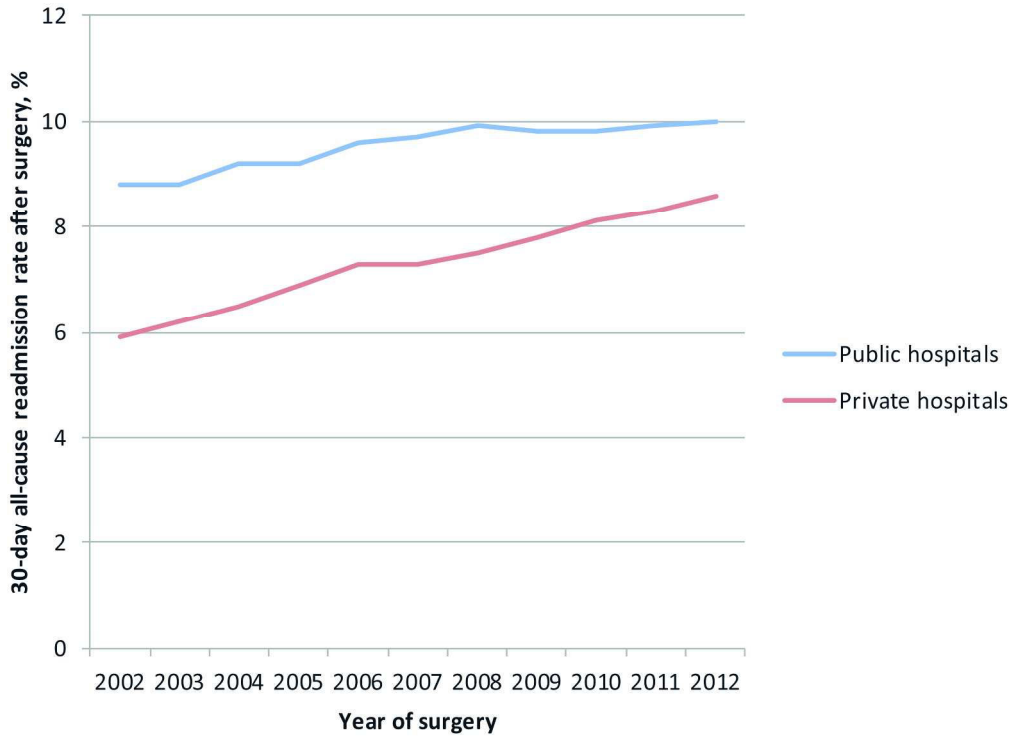

Figure 1: 30-day all-cause readmission rates after surgery according to hospital sector, all surgical procedures (France, 2002-2012)

222x162mm (300 x 300 DPI)

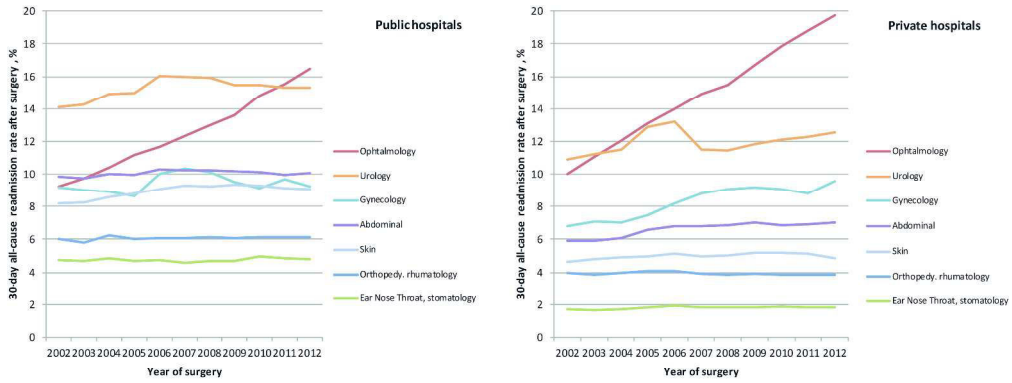

Figure 2: 30-day all-cause readmission rates after surgery according to the most frequent DRG groups, by hospital sector, all surgical procedures (France, 2002-2012)

294x109mm (300 x 300 DPI)

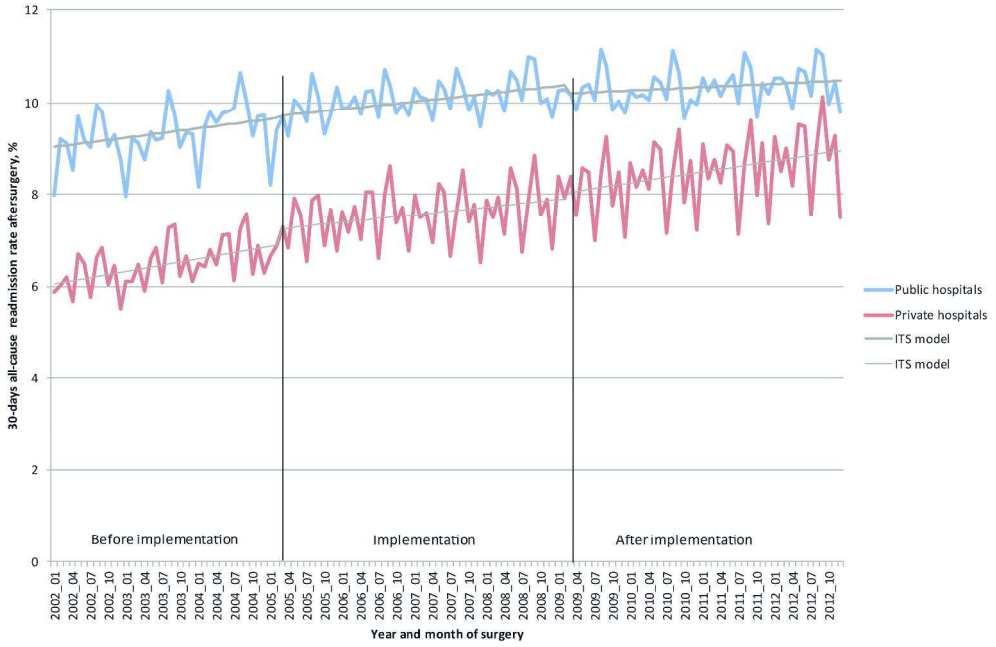

Figure 3: Global trends in 30-day all-cause readmission rates per month after surgery (France, 2002-2012): interrupted time series analysis

288x184mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2	This study was a retrospective multicenter study
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	This study aimed to describe trends in the hospital readmissions before, during and after the implementation of the case-based payment system in France from 2002 to 2012, using the national administrative database (PMSI). We found that the overall 30-day all-cause readmission rate following surgery discharge significantly increased, without deleterious effect of implementing the case-based payment system for hospital funding.
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4	
Objectives	3	State specific objectives, including any prespecified hypotheses	5	This study aimed to describe trends in the hospital readmissions before, during and after the implementation of the case-based payment system in France from 2002 to 2012, using the national administrative database (PMSI).
Methods				
Study design	4	Present key elements of study design early in the paper	5-6	This study was a retrospective multicenter study
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6	This study was a retrospective multicenter study based on nationwide PMSI data

				collected between January 2002 and December 2012.
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6	We included all patients admitted to hospital for a surgical procedure (as defined by the French DRG classification) during an 11-year period (2002–2012) in nearly all hospitals (740 hospitals). Hospitals with fewer than 300 stays per year were not included, because many of them closed during the study period
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6	For each selected surgery stay, the time from patient discharge to a new admission was calculated according to the linked information. Initial hospitalizations and stays ending in death or transfer, iterative treatments and neonatology were excluded.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6	Readmission was defined as "a new hospitalization in the 30 days following discharge after a stay for surgery, whatever the reason for this second stay" as done before.
Bias	9	Describe any efforts to address potential sources of bias	6	The fact that these national data are used for the allocation of hospital budgets encourages improvement in data quality in terms of coherence, accuracy and exhaustiveness.
Study size	10	Explain how the study size was arrived at	5	All patients admitted to hospital for a surgical procedure were included.

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why		No quantitative variables
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6	Two logistic regression models were created to measure the changes in the readmission rate over time. To determine the evolution of readmissions, all other things being equal, the probability of readmission at 30 days was analysed separately for the two types of hospital sector (i.e., public and private).
		(*b*) Describe any methods used to examine subgroups and interactions		No subgroups or interactions
		(*c*) Explain how missing data were addressed		No missing data
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy		Not applicable
		(*e*) Describe any sensitivity analyses		No sensitivity analyses
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7	About 52 million hospital stays were identified over the period January 2002 to December 2012 and registered in the national administrative database.
		(b) Give reasons for non-participation at each stage		Not applicable
		(c) Consider use of a flow diagram		Not necessary
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders		
		(b) Indicate number of participants with missing data for each variable of interest		No missing data
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	7	

Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	7	The number of stays with surgery selected in the database increased from 4.1 million in 2002 to 5.3 million in 2012, for a total of 51.6 million stays over the 11 years.
		Case-control study—Report numbers in each exposure category, or summary measures of exposure		
		Cross-sectional study—Report numbers of outcome events or summary measures		
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8	Between 2002 and 2012, the readmission rate following stays for surgery increased in both the public and private sector: from 8.8% to 10.0% and 5.9% to 8.6%, respectively. This increase appeared to be relatively steady in both sectors and was not affected by the implementation of a case-based payment system. This increase was significantly greater in the private than in the public sector ($p<0.001$). After adjustment for the DRG groups and morbidity, the probability of readmission at 30 days significantly increased with age, and the effect was linear. The effect of the risk of readmission according to age was greater in the private than in the public sector.
		(*b*) Report category boundaries when continuous variables were categorized		No continuous variables
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		

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Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8	We observed a considerable variability in level of readmission between the different studied DRG groups.
Discussion				
Key results	18	Summarise key results with reference to study objectives	9	In this study, we showed that the probability of readmission within 30 days increased significantly with age, even after adjustment for the DRG group and comorbidity. The introduction of a case-based payment system in France in the middle of this period did not seem to influence the readmission rate after adjustment for age, gender and comorbidities.
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12	It was not possible to distinguish between scheduled and unscheduled readmissions, because this information was not recorded. We could not compute a combined comorbidity score from the information available in discharge abstracts.
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9-11	As the rise in readmissions did not seem to be related to pricing reform, we wondered whether it may have been related to changes in care practices and developed some examples in ophthalmology and HIV-related surgery.

Generalisability	21	Discuss the generalisability (external validity) of the study results	10	Regarding to our results, we studied in the international literature the impact of readmissions in quality of care in different countries. We also studied the impact of the implementation of several policies to limit them.
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	2	This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.