



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

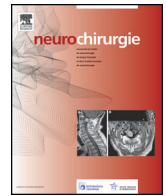


Disponible en ligne sur

ScienceDirect
www.sciencedirect.com

Elsevier Masson France

EM|consulte
www.em-consulte.com



Original article

Financial fallout from the COVID-19 pandemic: Report from a high-volume academic neurosurgery



G. Loganadane^{a,1}, S. Senova^{b,1}, P. Duportail^c, K. Debbi^a, M.A. Cherif^a, S. Ghith^a, S. Tazi^b, A. Marniche^b, G. Gouello^b, T. Idreceanu^b, P. Kauv^d, P. Varlet^e, Y. Belkacemi^a, S. Palfi^{b,*}

^a Department of Radiation Oncology, AP–HP, Inserm Unit 955 Team 21, University of Paris-Est Creteil (UPEC), Créteil, France

^b Department of Neurosurgery, DMU Care, FHU adapt, Mondor Institute of Biomedical Research, Translational psychiatry, AP–HP, Inserm Unit 955 Team 15, University of Paris-Est Creteil (UPEC), Créteil, France

^c Department of Medical Informatics, AP–HP, CHU Henri Mondor, University of Paris-Est Creteil (UPEC), Créteil, France

^d Department of Neuroradiology, AP–HP, CHU Henri Mondor, University of Paris-Est, Créteil (UPEC), Créteil, France

^e Department of Neuropathology, Sainte-Anne Hospital, Paris, France

ARTICLE INFO

Article history:

Received 14 April 2022

Received in revised form 21 April 2022

Accepted 27 April 2022

Available online 24 May 2022

Keywords:

Covid 19 pandemic

Neurosurgical procedures

Income

ABSTRACT

Background. – The global healthcare system has been overwhelmed by the Coronavirus disease-2019 (COVID-19). In order to mitigate the risk of spread of the virus, most elective surgical procedures have been cancelled especially during the lockdown periods. The purpose of this study was to assess the financial impact of the COVID outbreak due to the supposed reduced workload from our neurosurgery department in 2020.

Methods. – Number of neurosurgical procedures (NSP) within the Department of Neurosurgery and their associated estimated income were retrospectively reviewed globally and month wise from administrative records of billing in 2020 and 2019 based on the Diagnosis related group (DRG) and severity of illness (4 levels).

Results. – Overall, 824 and 818 inpatient surgical procedures were performed in 2019 and 2020 respectively. The total estimate revenue generated from inpatient surgeries was moderately decreased (3%): 9 498 226.41 euros in 2020 versus 9 817 361.65 euros in 2019 without significant difference across DRG ($P=0.96$) and severity of illness.

Conclusions. – Our data suggests a moderate negative impact of the COVID-19 pandemic had on neurosurgical and financial activity. However, a more in-depth medico-economic analysis need to be performed to assess the real financial impact.

© 2022 Elsevier Masson SAS. All rights reserved.

1. Introduction

The COVID-19 pandemic has disrupted global health, social welfare and the economy in a proportion unparalleled in modern history. Treatment for COVID-19 has created exceptional demand for certain medical equipment and supplies as the pandemic has disrupted supply chains, increasing the costs that hospitals face to treat COVID-19 patients. In addition to the effects of the disease itself on public health, a cancellation of so called nonessential surgical procedures has emerged with a shift towards more emergent interventions to protect and mitigate risk for all patients and caregivers [1–3]. A reorganization model was proposed from the

Lombardy neurosurgical model based on their initial experience with their experience with the Covid-19 pandemic [4].

The financial impact on the health system has been tremendous but has not been thoroughly investigated. The reduced income related to decreased outpatient activity and elective surgery may be mitigated by higher number of hospitalizations and occupancy of the intensive care unit during the COVID-19 outbreak associated with a potential rebound of the surgical activity afterwards. Yet, elective surgery is more lucrative compared to urgent surgery. We observed a negative impact of the COVID-19 outbreak on the number of inpatient neurosurgical procedures from our institution located in one of the hotspots during the first lockdown (17 march to 11 may 2020) (non-published data). However, annual analysis would be more interesting since many academic medical institutions developed efficient strategy (implementation of specific workshift) to compensate partially the loss of activity and income

* Corresponding author.

E-mail address: stephane.palfi@aphp.fr (S. Palfi).

¹ Contributed equally.

related to the outbreak during this specific period. The DRG and the severity of illness data was also missing in the previous analysis. Therefore, this report attempts to compare and quantify the number of neurosurgical procedures and the estimate of income month wise in terms of DRG and severity of illness in 2020 (affected by the COVID-19 pandemic) in comparison to 2019.

2. Material and methods

2.1. Patients' selection strategy during the lockdown

During the early phase of COVID-19 outbreak, life threatening emergencies such as head trauma, hydrocephalus, neurovascular injuries and brain tumors were dealt with urgently. For elective procedures, a decision-making surgical committee provided guidance on a daily basis and endorsed surgery if deemed necessary. Surgery for elective cases was justified in case of high risk of complication or significant impact on quality of life including the occurrence of a severe neurologic disability from degenerative spinal conditions or battery replacement for impulse generators (Parkinson's disease, severe tremors severe chronic pain or even severe and resistant Obsessive compulsive disorders) for highly dependent patients.

2.2. Period and data

This is an Institutional Review Board approved epidemiological study. Anonymized monthly Data on all inpatient operating room procedures within the Department of Neurosurgery were obtained from administrative records of billing (Programme National de Médicalisation des Systemes d'Information (PMSI)) from 2019 and 2020.

In cases of multiple surgeries, only the first intervention was taken into account. The PMSI is a standardized data set containing a certain number of parameters for each inpatient stay: gender, age, diagnosis-related groups (DRG), activity group, type of admission and discharge (home, referral), severity of the DRG (4 levels), month and year of discharge and type of surgical procedures. The cost of whole inpatient stay including the surgical procedure and the hospital room rate was estimated based on the root DRG.

2.3. Endpoints and Statistical analysis

The numbers of inpatient neurosurgical procedures and their associated income were stratified per DRG and severity of illness related to neurosurgery and were compared between 2019 and 2020 using t and exact Fisher tests. The *P* value for statistical significance was set at 0.05 for one-sided analyses. Statistical analyses were performed with the R Software version 3.5.1 (R project, Vienna, Austria).

3. Results

824 and 818 inpatient neurosurgical procedures were performed in 2019 and 2020 respectively without significant difference across DRG ($P=0.99$). The total estimate revenue generated from inpatient surgeries was moderately decreased (3%): 9 498 226.41 euros in 2020 versus 9 817 361.65 euros in 2019 without significant difference across DRG ($P=0.96$). These results are presented in [Table 1](#). Although lower number of surgical procedures and income was observed during the first lockdown (march to may 2020), the overall monthly comparison demonstrated no statistical significant difference in terms of number of inpatient surgical procedures ($P=0.92$) and income related to inpatient surgery between 2019 and 2020 ($P=0.74$) ([Fig. 1](#)). The number of neurosurgical interventions and revenues generated according to the severity of illness

(4 levels, level 1: the least severe, level 4: the most severe) within DRGs across months in 2020 were compared with those of 2019 ([Supplementary data, Fig. 1](#)).

No significant difference was found for level 1 ($P=0.46$), level 2 ($P=0.51$), level 3 ($P=0.39$), level 4 ($P=0.79$) in terms of numbers of intervention performed between 2019 and 2020 across months.

No significant differences were found for level 1 ($P=0.18$), level 2 ($P=0.27$), level 3 ($P=0.66$) and level 4 ($P=0.88$) in terms of revenues generated between 2019 and 2020 across months. A non-Significant drop of the activity related to level 1 severity of the DRG (least severe) was noted during the first lockdown (460 307.27 euros from 78 interventions from march-may 2019 vs 248 159.11 euros 51 interventions from march-may 2020). The monthly comparison of the revenue according to DRG across showed no significant difference between 2019 and 2020 ([Supplementary data, Fig. II](#)).

4. Discussion

To limit the spread of disease and create additional inpatient capacity and staffing, many medical institutions had to close outpatient departments and postpone or cancel elective visits and procedures. These changes, while needed to respond to the early phased of the COVID-19 outbreak, may have jeopardized the financial situation of hospitals, especially those with preexisting financial challenges and those heavily reliant on revenue from outpatient and elective services [1,5].

Hospitals in France are reimbursed for inpatient care based on diagnosis-related groups (DRG)[6]. Each inpatient admission is classified into a DRG that is based on diagnosis, complications, and comorbidities. Simple cases, with fewer services utilized, are more lucrative than complex cases that need more resources. Therefore, DRGs for many elective surgeries result in net profits for the hospitals. In the case of a pandemic in which there is high resource utilization with complex care and concomitant drop in elective and uncomplicated medical care, financial outcomes are not favorable. Surgery workloads and practice patterns were significantly affected by this pandemic with the greatest impact being the postponement of elective surgeries and availability of anesthesiologists and nurses. Indeed, they were relocated from the operating rooms to the intensity care units during the pandemic causing further rarefaction of operative slots and decrease of surgical activity. An epidemiological study estimated that cancellation of all elective procedures would result in loss of \$17.7 billion per month in revenue and \$5.4 billion per month in net income to US hospitals [7].

To ensure the financial sustainability of the department during the early phases of the pandemic, we had to reduce operating expenditures by reducing slots allocated to neurosurgery and reducing activity of the paramedical staff. The estimated net loss of income of was 319 135 euros in 2020 compared to 2019 which was probably less than expected in the context of the pandemic. Although no significant differences were observed in terms of DRG or severity of illness overall, surgery selection process were modified.

The number of craniotomies for trauma and non-traumatic injuries (mostly related to cancers) requiring emergent surgeries marginally increased (410 in 2020 vs. 376). On the contrary, the number of pituitary gland surgery which represents a typical elective intervention was only 11 in 2020 versus 29 to 2019.

We used a simple but robust method to estimate the financial fallout from COVID-19 which may be considered as challenging given the complex nature of the healthcare system. Comprehensive DRG data were also provided in this study. Important caveats should be noted in the interpretation of the findings though [7].

Table 1
Number of inpatient neurosurgical procedures (NSP) and estimated income (EI) in Euros generated per year according to each DRG (Diagnostic Related Groups).

Root DRG	Number of interventions 2019	Number of interventions 2020	Estimated income from each DRG 2019 (euros)	Estimated income from each DRG 2020 (euros)
01C03 Craniotomy for trauma (age > 17)	93	101	1365956.41	1384483.81
01C04 Craniotomy for non-traumatic injury (age > 17)	286	309	4823379.37	4844964.65
01C05 Intervention involving the spine for neurological condition	35	37	292949.05	408617.71
01C08 Intervention involving cranial or peripheral nerves	11	6	68230.63	34688.41
01C09 Implantation of brain stimulator	111	102	828642.94	763302.59
01C10 Implantation of medullary stimulator	43	33	109722.03	78153
01C11 Craniotomy for tumoral disease (age < 18)	1	0	12688.97	0
01C12 Craniotomy for non tumoral disease (age < 18)	1	1	13449.66	9400.84
01C15 Carpal tunnel surgery	4	4	6058.4	4019.48
01K03 Other treatment of the nervous system through vessel	0	1	0	15833.87
01M12 Other disease of the nervous system	2	0	5711.02	0
01M18 Severe intracranial traumatic lesions	0	1	0	8627.71
01M32 Exploration and surveillance for nervous system disease	1	4	804.51	3225.68
02C03 Intervention involving the orbit	2	2	10925.2	15201.75
02M08 Other eye disorders non related to diabetes (age > 17)	0	1	0	1307.11
03C07 Intervention involving sinus and mastoid process (age > 17)	3	2	17947.2	5628.3
03C26 Other interventions involving head and neck	0	3	0	43555.83
03C29 Other interventions involving ear, nose, throat for malignant tumor	1	2	3973.46	12606.24
03K03 ENT Endoscopy	0	1	0	715.83
03M14 Exploration and surveillance for Ear Nose Throat disease	0	3	0	2598.66
04C02 Major intervention involving the chest	0	1	0	35007.15
04M09 Tumor of the respiratory tract	1	0	15804.9	0
05C10 Major revascularization surgery	0	1	0	27222.79
06C04 Major intervention on small and great bowell	1	1	53351.84	10675
08C12 Osteoarticular biopsy	0	1	0	1530.37
08C21 Other interventions involving musculoskeletal apparatus and connective tissue	0	5	0	37476.9
08C27 Other intervention involving the spine	123	98	591188.06	480928.5
08C28 Maxillofacial intervention	1	3	7581.57	35409.93
08C51 Major spine intervention for fractures, kyphosis and scoliosis	2	2	19916.55	21938.78
08C52 Major intervention involving the spine	45	47	408033.33	427288.87
08C61 Major intervention for osteoarticular infection	1	2	17479.46	33172.34
08C62 Other interventions for osteoarticular infection	0	1	0	7991.93
09C03 skin graft and/or wound debridement	1	1	11480.38	14677.48
09C09 Non aesthetic plastic surgery	4	9	175715.49	31843.29
09C10 Other intervention involving the skin, subcutaneous tissue or breast	0	2	0	8881.82
09C15 Intervention involving the skin, subcutaneous tissue or breast Interventions related to trauma	0	2	0	10156.34
10C02 Pituitary gland surgery	29	11	289961.61	132649.64
10M13 Exploration and surveillance for endocrine or metabolic disease	0	2	0	3195.24
11C13 Intervention for non lithiasic disease	1	0	6061.39	0
17C06 Major intervention related to myeloproliferative disease or tumor of unknown site or diffuse	5	3	74661.72	48679.71
17C07 Intermediate intervention related to myeloproliferative disease or tumor of unknown site or diffuse	1	1	11115.38	6373.7
17C08 Major intervention related to myeloproliferative disease or tumor of unknown site or diffuse	0	1	0	1568.93
21C05 Intervention related to injury or complication of an act	2	1	11047.82	2347.68
25Z02 Disease related to HIV and death	0	1	0	22322.76
26C02 Intervention for severe polytrauma	12	8	471360.08	363252.01
27Z02 Blood stem cell allogenic transplant	1	1	92163.22	96703.78
Total	824	818	9817361.65	9498226.41
P value	0.99	0.96		

First, the PMSI database on which inpatient costs were estimated in this study was not designed to provide data required for clinical research but rather on the requirement of the billing process, which relies more on completeness of core information and basic consistency. Second, unlike our previous report (data not shown) which provided data categorized according to the surgery

pattern (elective vs emergent) and the subspeciality (trauma, oncology, neuromodulation), results are presented according to the DRG and the severity index.

Third, these data are incomplete as this study did not analyze the financial impact of postponement and cancellation of outpatient surgeries, consultations, implementation of telemedicine and

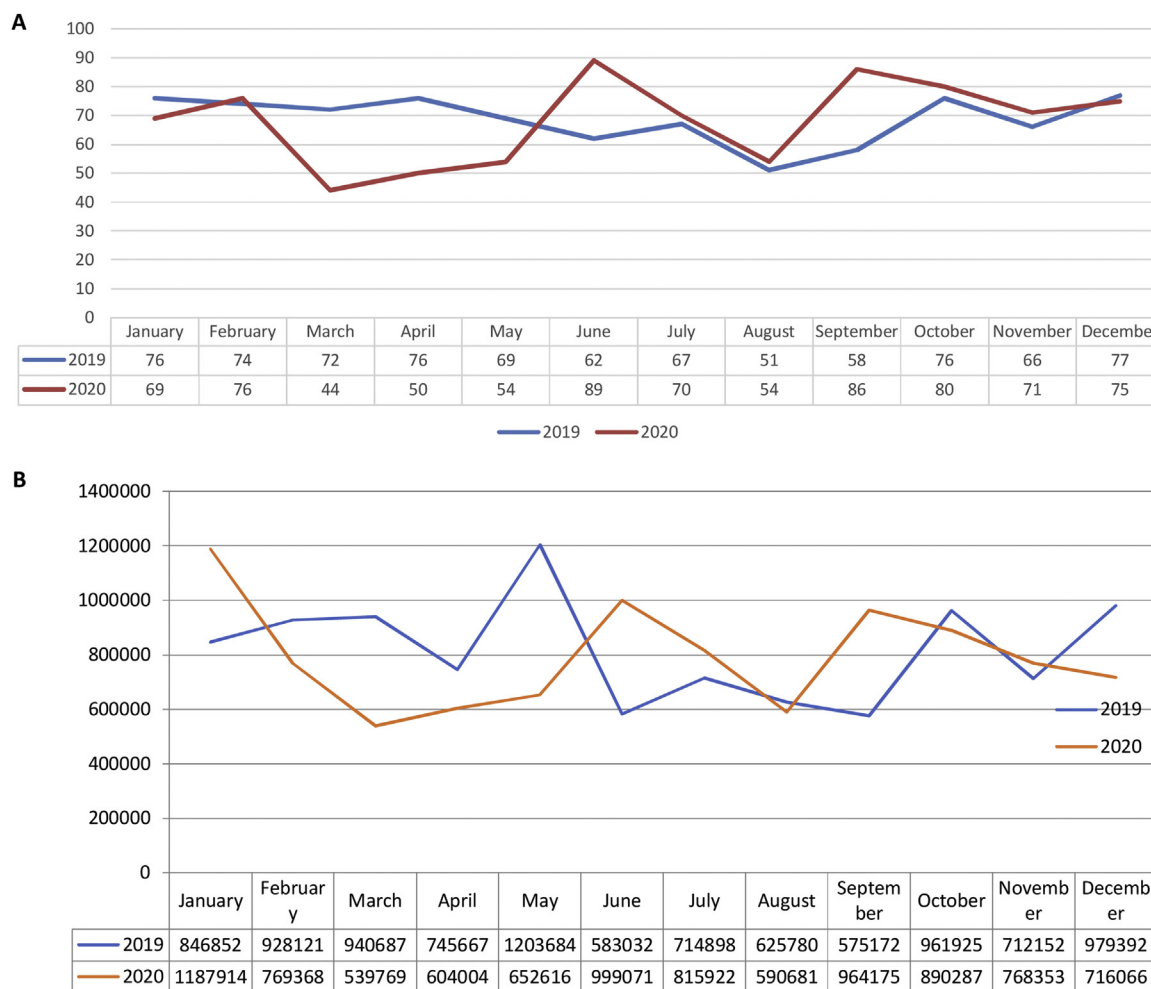


Fig. 1. Number of inpatient neurosurgical procedures (A) and estimated income (B) in Euros generated each month in 2019 and 2020.

revenues related to teaching, research publications and protocols were also missing. A previous study provided a comprehensive medico-economic analysis from a French neurosurgery department at a university hospital [8].

Our study did not take into account the additional costs associated with purchasing needed personal protective equipment (PPE) or additional COVID-19 screening tests such as computed tomography (CT) or RT-PCR. At the same time, some expenses were reduced due to the bed closures in neurosurgical departments and allocation of human and financial resources in favor of COVID units during the peak of the COVID-19 crisis. The impact of COVID-19 has not been well studied regarding other important nonclinical aspects and was also missing in this report: clinical and translational research, scientific productivity, availability of research grants, representation in national/international conferences, innovation and implementation of new techniques/technologies, residents' training, teaching activities and work-related stress (burnout rate).

Finally, data observed in our high-volume academic center may be not representative of numbers seen in smaller rural hospitals which are more vulnerable. Several programs have been developed as a comprehensive resource of the various financial assistance opportunities for hospitals impacted by COVID-19. For example, the Paycheck Protection Program and Health Care Enhancement Act (PPHCEA); and the Coronavirus Response and Relief Supplemental Appropriations (CRRSA) Act provided \$178 billion in relief funds to hospitals and other healthcare providers on the front lines of the coronavirus response in the United States [9]. Similarly in France,

hospitals were offered minimal guaranteed activity as financial assistance as per the ordinance of March 2020 [10]. Moreover, some budgetary easing programs was exceptionally adopted: National ceiling for health insurance expenditure (ONDAM) and the estimates of revenue and expenditures of hospitals (EPRD). Finally, a public healthcare reform consisting of modernization and investment will be implemented in coming years.

5. Conclusion

This study suggested that COVID-19 had a moderate financial impact on the neurosurgical activity in 2020. It would be important to know the consequences of the COVID-19 in terms of patterns of practice in neurosurgery with a longer follow up and using a more elaborate methodology.

Disclosure of interest

The authors declare that they have no competing interest.

Funding

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

Human and animal rights

The authors declare that the work described has not involved experimentation on humans or animals.

Informed consent and patient details

The authors declare that this report does not contain any personal information that could lead to the identification of the patient(s) and/or volunteers.

Author contributions

All authors attest that they meet the current International Committee of Medical Journal Editors (ICMJE) criteria for Authorship.

Individual author contributions are as follows:

GL, YS, PD: Conceptualization, Methodology.

GL, YS, PD: Data curation, Writing- Original draft preparation.

GL, YS, PD: Visualization, Investigation.

YB, SP: Supervision.: GL: Software, Validation.

All: Writing- Reviewing and Editing.

Acknowledgment

To our patients.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.neuchi.2022.04.006](https://doi.org/10.1016/j.neuchi.2022.04.006).

References

- [1] Khullar D, Bond AM, Schpero WL. COVID-19 and the financial health of US Hospitals. *JAMA* 2020;323:2127–8, <http://dx.doi.org/10.1001/jama.2020.6269>.
- [2] Belkacemi Y, Loganadane G, Grellier N, Fonteneau G, Zaoui G, Coraggio G, et al. Radiation Therapy Department Reorganization during the Coronavirus Disease 2019 (COVID-19) Outbreak: Keys to Securing Staff and Patients During the First Weeks of the Crisis and Impact on Radiation Therapy Practice from a Single Institution Experience. *Adv Radiat Oncol* 2020, <http://dx.doi.org/10.1016/j.adro.2020.04.039>.
- [3] Dannhoff G, Cebula H, Chibbaro S, Ganau M, Todeschi J, Mallereau C-H, et al. Investigating the real impact of COVID-19 pandemic on the daily neurosurgical practice? *Neurochirurgie* 2021;67:99–103, <http://dx.doi.org/10.1016/j.neuchi.2021.01.009>.
- [4] Zoia C, Bongetta D, Veiceschi P, Cenzato M, Di Meco F, Locatelli D, et al. Neurosurgery during the COVID-19 pandemic: update from Lombardy, northern Italy. *Acta Neurochir (Wien)* 2020;162:1221–2, <http://dx.doi.org/10.1007/s00701-020-04305-w>.
- [5] Sivakanthan S, Pan J, Kim L, Ellenbogen R, Saigal R. Economic Impact of COVID-19 on a High-Volume Academic Neurosurgical Practice. *World Neurosurg* 2020;028, <http://dx.doi.org/10.1016/j.wneu.2020.08.028>.
- [6] Or Z. Implementation of DRG Payment in France: issues and recent developments. *Health Policy Amst Neth* 2014;117:146–50, <http://dx.doi.org/10.1016/j.healthpol.2014.05.006>.
- [7] Best MJ, McFarland EG, Anderson GF, Srikumaran U. The likely economic impact of fewer elective surgical procedures on US hospitals during the COVID-19 pandemic. *Surgery* 2020, <http://dx.doi.org/10.1016/j.surg.2020.07.014>.
- [8] Lemaire J-J, Delom C, Coste A, Khalil T, Jourdy J-C, Pontier B, et al. Medico-economic analysis of a neurosurgery department at a university hospital. *Neurochirurgie* 2015;61:2–15, <http://dx.doi.org/10.1016/j.neuchi.2014.11.011>.
- [9] Affairs (ASPA) AS for P. CARES Act Provider Relief Fund: Data. HHSgov 2020. <https://www.hhs.gov/coronavirus/cares-act-provider-relief-fund/data/index.html> (accessed February 7, 2021).
- [10] Ordonnance du 25 mars 2020 relative à la garantie de financement des établissements de santé et aux régimes complémentaires obligatoires de sécurité sociale. *Vie Publiquefr* n.d. <https://www.vie-publique.fr/loi/273972-ordonnance-covid-19-garantie-de-financement-des-hopitaux> (accessed November 17, 2021).