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Does the healthcare system know what to cut under the pandemic emergency pressure? An observational study on geographic variation of surgical procedures in Italy

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ABSTRACT

Objectives During 2020 many countries reduced the number of elective surgeries to free up beds and cope with the COVID-19 outbreak. This situation led healthcare systems to prioritise elective interventions and reduce the overall volumes of treatments.
The aim of this paper is to analyse whether the pandemic and the prioritisation policies on elective surgery were done considering the potential inappropriateness highlighted by the measurement of geographic variation.

Setting The setting of the study is acute care with a focus on elective surgical procedures. Data were analysed at the Italian regional level.

Participants The study is observational and relies on national hospitalisation records from 2019 to 2020. The analyses refer to the 21 Italian regional health systems, using 48917 records for 2019 and 33821 for 2020. The surgical procedures analysed are those considered at high risk of unwarranted variation: coronary angioplasty, cholecystectomy, colectomy, knee replacement, hysterectomy, tonsillectomy, hip replacement and vein stripping.

Primary and secondary outcome measures Primary measures were the hospitalisation rate and its reduction per procedure, to understand the level of potential inappropriateness. Secondary measures were the SD and high/low ratio, to map the level of geographic variation.

Results For some procedures, there is a linear negative relationship (eg, tonsillectomy: $\rho = -0.92$, $p<0.01$; vein stripping: $\rho = -0.93$, $p<0.01$) between the reduction in hospitalisation and its starting point. The only two procedures for which no significant differences were registered are cholecystectomy ($\rho = -0.22$, $p=0.31$) and hysterectomy ($\rho = -0.22$, $p=0.33$). In particular, in all cases, data show that regions with higher 2019 hospitalisation rates registered a larger reduction.

Conclusions The Italian data show that the pandemic seems to have led hospital managers and health professionals to cut surgical interventions more likely to be inappropriate. Hence, these findings can inform and guide the healthcare system to manage unwarranted variation when coming back to the new normal. This new starting point (lower volumes in some selected elective surgical procedures) should be used to plan elective surgical treatments that can be cancelled because of their high risk of inappropriateness.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study is based on observational routinely collected hospital discharge records of a national single-payer healthcare system.
⇒ This study can be easily replicated in other healthcare systems.
⇒ The analysis is limited to a selection of eight elective surgical procedures.
⇒ The analysis is limited to administrative health data.

INTRODUCTION

The COVID-19 outbreak has led many countries to reduce the number of elective surgeries, to free up beds (both in ICU and acute care wards) and healthcare professionals (mainly anaesthesiologists) to cope with the acute care treatments for patients with COVID-19.[1–4] This situation led countries, regions, and counties (in the case of decentralised healthcare systems), as well as providers, to prioritise treatments and reduce overall volumes. The policies adopted aimed to (1) ensure urgent treatments and time-dependent diseases such as stroke and Acute Myocardial Infarction (AMI); (2) identify the elective treatments to be protected and ensured because they are not deferrable or are life saving, like surgical cancer interventions and (3) postpone deferrable elective surgery.

In particular, elective surgery has been investigated for almost a century because of its variation. For instance, in the first decades of the 20th century, Sir James Allison Glover in his speech at the English epidemiology and state of medicine on the 27 May 1938 cited studies of geographic variation in tonsillectomy; in the last decades of the 20th century, Wenneberg re-launched studies on the geographic variation in use-rates, promoting

the Dartmouth Atlas of Variation[5 6] for several services; yet, in the first decades of this century, scholars have reported wide variation in tonsillectomy hospitalisation rates among different geographic areas in different countries.[7 8] Nowadays, the pandemic has boosted the importance of geographic variation studies in the rebound stage of elective surgery, supporting health systems to plan a more appropriate new start.

Significant geographic variations have been revealed for several very common elective surgical interventions.[6 9–13] In some cases, like a tonsillectomy, there is consensus on the opportunity to reduce the rate, especially in geographic areas presenting high hospitalisation rates. Instead, in other cases, the right rate and the determinants of variation are still discussed. Following revision of Wenneberg's categories by Nuti and Seghieri,[8] variation in elective surgery may occur in the following situations: (1) when there are clinically proven effective services (eg, volumes of specific surgical procedures such as hip fracture operated within 2 days)—in this case, differences in quality should be avoided; (2) when services are delivered according to care settings determined by organisational choices (eg, in-patient admissions for interventions which could instead be performed on a day surgery basis)—in this case, differences may not have an impact on outcomes; (3) when variation reflects patients' different needs or preferences or when it often reflects physicians' discretionary choices and (4) when variation depends on supply (supply-sensitive services), which occurs when the number of services available increases (ie, number of beds, number of specialists, etc.).

Based on this stream of literature, when geographic variation does not depend on patients' preferences or needs,[14] it can be classified as unwarranted.[5 6 15] Several studies[9 10] have reported that patient characteristics and preferences do not completely account for geographic variation in the provision of elective surgery; rather, greater influence is exerted by clinicians' behaviour and judgement. This classification and consideration have to be taken into account when planning the volumes of (appropriate) elective surgery to be ensured, especially in Beveridge-like systems where unwarranted variation can be seen as a signal of horizontal equity (because of the same level of patient need, variation may highlight disparities in resource allocation, the quality of care or access to the services across its territories)[16] also known as 'postcode lottery'.[17]

This seems particularly relevant in this period related to the planning of rebound activities. While some scholars have reported how to deal with the growing backlog of healthcare procedures related to non-communicable diseases during the pandemic crisis[18–21] (such as the delay in cancer procedures and especially in the time-dependent intervention[22]), there has still been poor debate stimulated on the relationship between the reduction of elective surgeries and unwarranted geographic variation.

Indeed, this unprecedented situation can be considered as an opportunity to revise the intervention priority list with the aim to reduce (or at least freeze) potential inappropriate interventions, thus freeing up resources (operating rooms and professionals) that can be employed in bouncing back the (appropriate) interventions that had been postponed.

The paper discusses the opportunity of managing unwarranted variation of elective surgeries in this emergency period using empirical evidence from Italy. Relying on primary data from Italian hospital discharge records from 2019 and 2020, this paper analyses whether the pandemic and the prioritisation policies for elective surgery have had an impact on regional geographic variation. In particular, considering the extant Italian regional differences in providing elective surgery, the issue investigated is whether the healthcare system grabbed the opportunity to prioritise beds to reduce potential inappropriate elective surgery. Closing remarks have been formulated for the rebound stage.

Elective surgery in the Italian context

The Italian healthcare system is a Beveridge-like model that provides universal coverage through general taxation; it is characterised by a high degree of decentralisation.[23] The decentralisation process, following the market-oriented reforms of the early 1990s, culminated in the 2001 constitutional reform, with the introduction of an essential healthcare benefits package (defined as Livelli Essenziali di Assistenza, LEA) guaranteed to all citizens. This reform granted more power to the regions.[24] The current institutional arrangement implies that the central government is responsible for channelling general tax revenues, defining benefit packages, exercising overall management and governance and, more recently, monitoring regional budgets. Meanwhile, regional governments are responsible for the organisation and delivery of health services through the local health authorities and public and accredited private hospitals, and can also raise local taxes and fund additional health services.

Because of the joint responsibility for healthcare, both the national and regional health systems monitor performance using tools; mainly three have been identified by the 2016 European Report[25] with specific characteristics: LEA grid; National Outcome Programme (known by the acronym PNE) and Inter-Regional Performance Evaluation System (IRPES).

All three systems highlight that geographic variation occurs across and within regions on different dimensions: access, quality, appropriateness and efficiency. While the LEA grid does not have specific indicators to monitor elective surgery variation, PNE and IRPES monitor some common elective surgery procedures known to have a high degree of variability, often because of the lack of standards. Figure 1 shows, as an example, that the hospitalisation rates for tonsillectomy can be as much as four times higher in one region compared with another.

In 2020, overall elective surgery at the national level was reduced by up to 28% with respect to 2019 volumes. Mild differences were registered across regions. Larger

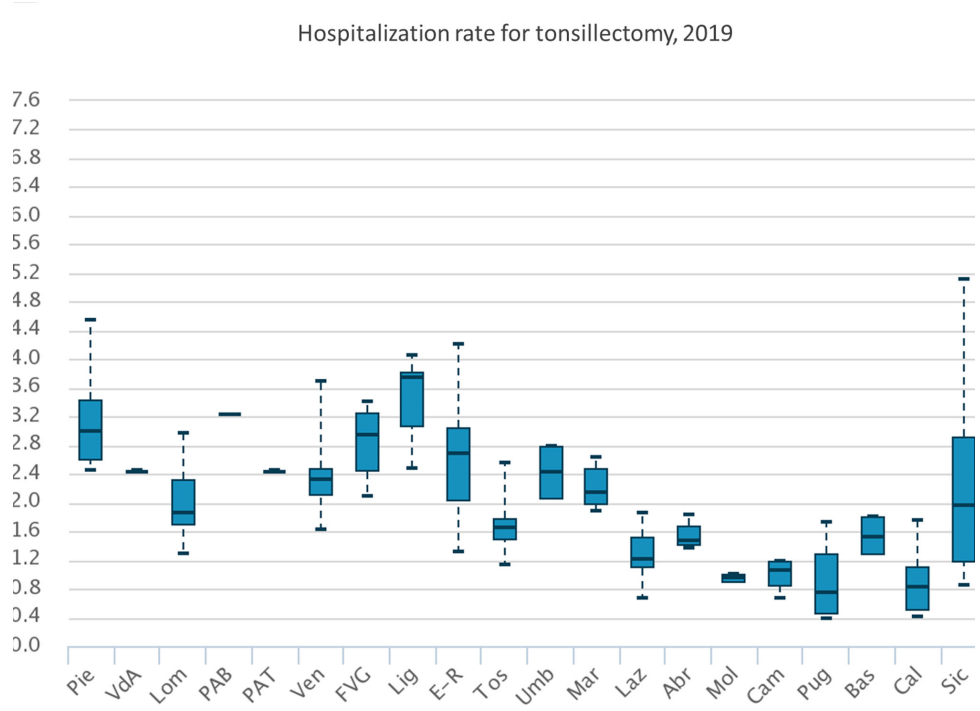

Figure 1 Hospitalisation rates for tonsillectomy across and within Italian regions in 2019. Source: PNE, 2019. Pie (Piemonte); VdA (Valle d'Aosta); Lom (Lombardia); PAB (Provincia Autonoma di Bolzano); PAT (Provincia Autonoma di Trento); FVG (Friuli Venezia Giulia); Lig (Liguria); E-R (Emilia Romagna); Tos (Toscana); Umb (Umbria); Mar (Marche); Laz (Lazio); Abr (Abruzzo); Mol (Molise); Cam (Campania); Pug (Puglia); Bas (Basilicata); Cal (Calabria) and Sic (Sicilia).

differences show up when comparing single surgical procedures such as oncological interventions.[26]

METHODS

The RECORD guidelines[27] were applied to conduct the study. This study did not involve human participants and ethics committee approval was not required. The RECORD checklist has been included in the supplementary materials (see online supplemental material 1).

Starting from the hospitalisation records of the Italian National Health Service provided by Agenas, the paper analyses geographic variation for the procedures selected by Nuti and Seghieri,[8] which usually present wide unwarranted geographic variation across and within countries: coronary angioplasty, cholecystectomy, prostatectomy, knee replacement, hysterectomy, tonsillectomy, hip replacement and vein stripping (details about ICD9CM (International Classification of Diseases, 9th revision - Clinical Modification) and DRGs (Diagnosis Related Group) are reported in the Appendix, in online supplemental material 2. Additional information can be requested from the authors). These procedures have also been used by other authors, both separately and combined.[28–30]

These crude rates (number of procedures per 100 000 inhabitants) were indirectly standardised by age and sex using SAS 9.4 software and then put into a relationship with the reduction of surgical hospitalisation rates for the two consecutive years 2019 and 2020.

Overall, the analyses refer to 48 917 records for 2019 and 33 821 for 2020 that represent the entire database population for the selected 8 elective surgery procedures. The variables used in the study were those considered mandatory at the national level so the record can be accepted as a valid one. These data were put in relation to the population information gathered from the National Institute of Statistics (Istat). Data matching was carried out at the regional level. No record linkage at the person level was executed.

Following the Expert Panel on Effective Ways of Investing in Health definition of resilience,[31] the percentage reduction of non-COVID-19 services can be used to assess the capacity of healthcare systems to be resilient. In fact, one specific characteristic of resilience is the capacity to adapt to shocks and structural changes, to sustain required operations and to resume optimal performance as quickly as possible.[31] In this perspective, the reduction of volumes of surgical procedures can be seen as the potential for interventions to rebound after the emergency.

The matrix combining the 2019 hospitalisation rates with the percentage reduction of volumes in 2020 compared with 2019 has been used to graphically understand whether the pandemic has had any effect on the unwarranted regional variation of the selected elective surgery procedures.

The Pearson correlation has been also executed, showing the p value at 1%, 5% and 10%.

A cut-off was introduced to the absolute volumes per procedure. The cut-off was set at 10 volumes for the year 2019 to reduce the variability linked to the occurrence of a low number of cases.

Table 1 Descriptive statistics for selected elective surgery hospitalisation rates in 2019

Hospitalisation rate	Mean	SD	Minimum	Maximum	High/low ratio
Coronary angioplasty	76.27	24.86	27.22	114.44	4.20
Cholecystectomy	158.47	18.85	120.37	209.29	1.74
Hysterectomy	3.11	2.77	1.00	11.42	11.42
Prostatectomy	145.22	31.94	90.24	238.07	2.64
Knee replacement	155.87	27.49	102.33	212.95	2.08
Hip replacement	342.90	106.27	176.63	598.78	3.39
Vein stripping	46.62	34.22	7.19	135.31	18.82
Tonsillectomy	197.63	74.72	81.63	350.37	4.29

Elaboration of authors on 2019 data.

Patient and public involvement

Patients and the public were not involved in the design, conduct, reporting or dissemination plans of our research. The analysis is based on aggregated administrative data; at this stage of the analysis, the authors did not involve patient and public lay actors.

RESULTS

Starting from the hospitalisation records of the Italian National Health Service provided by Agenas, we display in table 1 the descriptive statistics for the selected procedures in 2019.

Table 1 shows wide variations across geographic areas (Italian regions). Moreover, regions with high (low) rates in one procedure have not been found to be associated with high (low) rates in another, most likely reflecting autonomous practices and failures in adhering to shared guidelines and protocols among professionals.

Considering the overall reduction in elective surgery of 28%,[26] table 2 reports that the mean reduction for the selected elective surgeries sometimes is lower but registers a wide variation across Italian regions. In some cases, regions enhanced their volumes concerning 2019. Specifically, in 2020, Valle d'Aosta increased the interventions in coronary angioplasty by 3% while Piemonte increased hysterectomy by 24%.

Concerning the selected elective procedures, figure 2 reports a chart of hospitalisation rates and their difference between 2019 and 2020.

The charts exhibit that for some procedures, there is a linear negative relationship between the reduction in hospitalisation and its starting point. In particular, the scatter plots of hospitalisation for vein stripping and tonsillectomy present a clear negative relation: regions with higher 2019 hospitalisation rates registered a larger reduction.

The Pearson correlation confirms that there is a statistically significant negative correlation between the hospitalisation rates and the reduction in 2020 in all the charts analysed.

In particular, table 3 reports the correlation coefficient and the p value. Tonsillectomy, hip replacement and prostatectomy are the procedures where the correlation is statistically significant at $p < 0.01$, knee replacement is statistically significant at $p < 0.05$, while a lower correlation and a lower significant p value were found for coronary angioplasty ($p<0.10$). No significant correlation was found for cholecystectomy and hysterectomy.

DISCUSSION

Considering the selected elective surgery indicators, we found that regions with higher potential inappropriate

Table 2 Volume reduction for selected elective surgery in 2020 compared with 2019

Procedures	Mean reduction	Minimum reduction	Maximum reduction
Coronary angioplasty	25%	–3%	57%
Cholecystectomy	34%	20%	50%
Hysterectomy	30%	–24%	100%
Prostatectomy	31%	20%	43%
Knee replacement	26%	8%	42%
Hip replacement	25%	20%	36%
Vein stripping	51%	38%	74%
Tonsillectomy	54%	27%	68%

Elaboration of authors on 2020 and 2019 data.

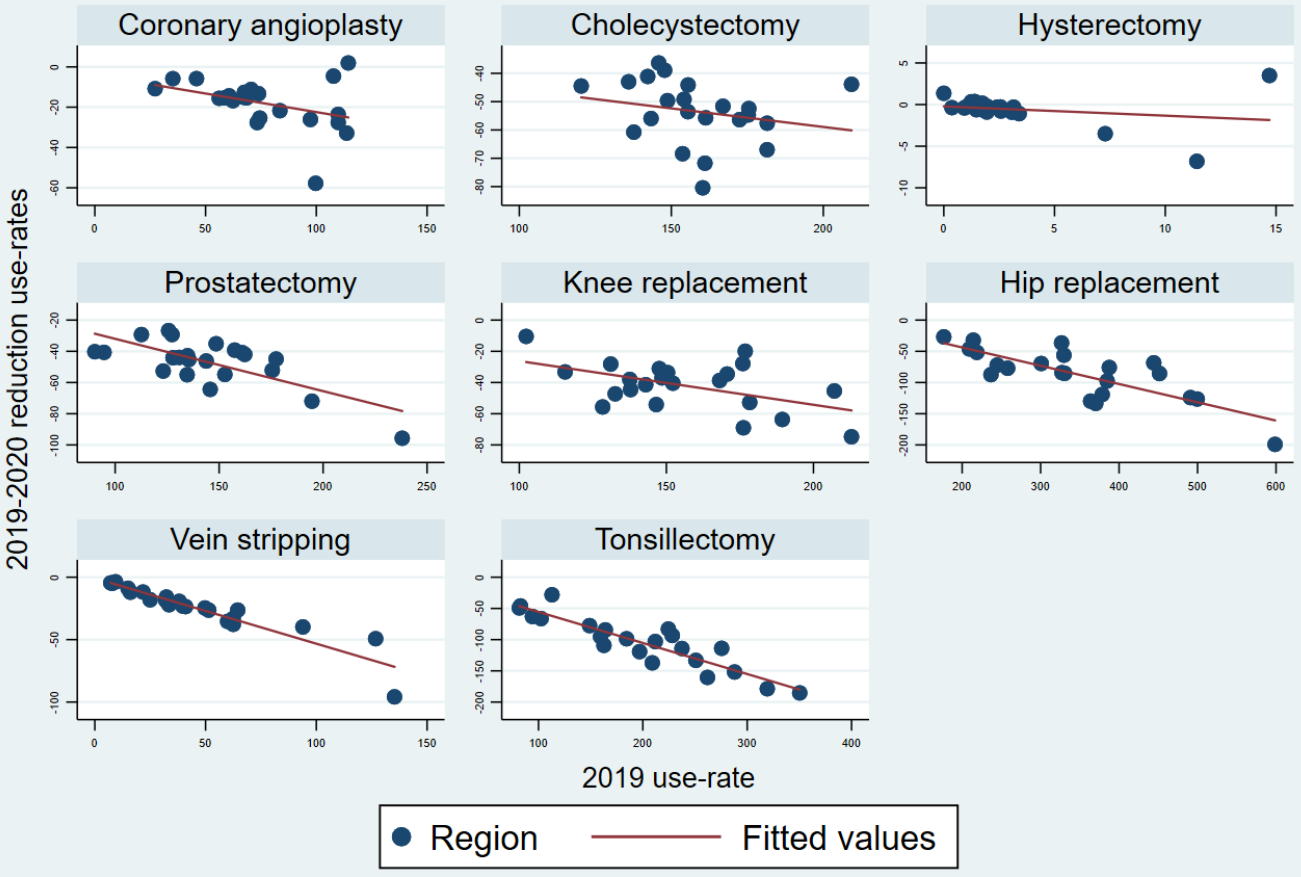

Figure 2 Matrix of 2019 hospitalisation rate and difference in hospitalisation rate between 2019 and 2020 for selected elective surgery procedures. Source: elaboration of authors on 2020 and 2019 data. Y-axis represents the difference in hospitalisation rate between 2019 and 2020. X-axis represents the 2019 hospitalisation rate. Lines represent the linear fit of the values.

elective surgery hospitalisation rates are those that reduced their volumes more.

In particular, tonsillectomy and vein stripping, which have been shown to be among the procedures with wider variation across geographic areas, are also those with a larger reduction (in both cases, the correlation coefficient is around −0.9 with a p value of <0.01). These straightforward results seem to support the idea that under emergency pressure, the healthcare system is more likely to provide stricter directions to allocate healthcare resources, preserving them for elective surgical interventions which have stronger clinical evidence. Yet, there is no standard for a number of surgical treatments; in those cases, the 2019 national median can be considered as a reference for all the regional health systems that overcame it in 2019 and the reduction that occurred in 2020 could not be taken into account when planning rebound and new activities. This evidence seems to confirm, at least for the potentially inappropriate hospitalisation rate, the rule of thumb known as Romer's law.

The drop-offs occurred to different degrees. These differences are not strictly linked to the level of variation or the level of use-rates. For instance, in the case of hysterectomy, for which a very high level of geographic variation was registered (as shown in table 1), no significant correlation was found between use-rates and their reduction (as shown in table 3); similarly, relatively lower

Table 3 Correlation between 2019 hospitalisation rates and hospitalisation rate reduction

Procedures	ρ	P value
Tonsillectomy	−0.92	0.00
Hip replacement	−0.79	0.00
Prostatectomy	−0.72	0.00
Coronary angioplasty	−0.38	0.08
Cholecystectomy	−0.22	0.31
Hysterectomy	−0.22	0.33
Vein stripping	−0.93	0.00
Knee replacement	−0.51	0.01

Elaboration of authors on 2020 and 2019 data.
Overall, the lower the 2019 hospitalisation rate, the larger the reduction of hospitalisation rates.

use-rates of vein stripping (as shown in table 1) were linked to a higher correlation with their drop-offs (as shown in table 3).

Tonsillectomy is the procedure that registered the second highest negative correlation coefficient between use-rates and their drop-offs ($\rho = -0.92$, $p<0.01$). After the introduction of Italian national guidelines, there was a decrease in the total number of tonsillectomies and their geographical variation.[32] However, in 2019, a 4-fold geographic variation was registered (as shown in table 1) and the uneven reduction that occurred across the Italian regions during 2020 seems to confirm that the doubts of the scientific community[33] related to the trade-offs of benefits against risks, discomfort and costs[7] are not solved yet.

Under the same national recommendation to protect those interventions with the highest degree of clinical relevance, the drop-offs among the procedures were different across regions, and they were not necessarily linked to the level of variation or the level of use-rates. Different healthcare performance between northern and southern regions has already been reported by other authors.[24 34] Conversely, this study does not report a clear North–South pattern in the high(low) hospitalisation rates analysed (detailed data of the regional use-rates with the North–South area labels are provided in online supplemental material 3). This evidence is in line with that of a recent study on the impact of COVID-19 in Italy which found that the pandemic exacerbated some disparities related to socio-economic or gender issues but there was no clear-cut evidence from the pandemic of a North–South divide for variations either in the quality of service provided during the first year of the pandemic or in the overall hospitalisation rates.[35] Disparities instead were exacerbated, in both health and access to healthcare for some fragile population groups, such as the elderly and migrants.[35] It is possible that differences in performance between North and South mainly concern resource allocation and management, while variation in medical practice such as that presented in this analysis occurred everywhere. In the former case, regions using a performance measurement system may help to change professional behaviours, while in the latter case the sharing process and a second opinion may provide that help.[16 36]

Further research is needed to better understand the role played by the different stakeholders: regional managers or health authority managers, professionals and patients. At first evidence, although fear of the population has affected the surgical reduction, the impact seems to be rather limited; a 2021 survey of the population highlighted that 8% of Italians preferred to postpone or avoid surgical treatments because of the fear of COVID-19.[37]

As a preliminary study on this topic, this research presents some limitations. First, the study context focused on the Italian healthcare system and its organisational structure so that it cannot be generalised. Nevertheless, geographic variation is a topic investigated in several countries, although with different intensity (eg, the USA showed double the use-rate for hernia compared with the UK,[29] while France showed a lower level of use-rates for some procedures with respect to the USA or UK[38]). Hence, evidence coming from this study may be analysed and replicated in both high-income, and low-income and middle-income countries.[29 38 39]

However, this study provides evidence to enlarge the debate on this relevant topic in Italy and also in those countries aiming to analyse what happened in 2020 to the unwarranted variation in elective surgery in their countries.

Second, there could be other indicators as valuable and informative as those included in the analysis. However, we considered the ones selected by a group of Italian regional healthcare managers and already included in two of the three performance evaluation systems used in Italy, IRPES and PNE, as indicators monitoring variation in surgical procedures.

Third, although we used standardised hospitalisation rates, further analyses can be done to better understand if patients' characteristics may have played any role in the reduction in volume. Other investigations could be also useful in understanding if some factors (such as the presence of private providers or patient outflow) may explain variation in the volume reduction.

Geographic variation may be a signal of inappropriateness related to overuse, for supply-sensitive care such as that related to the absence of clinical theories, or to misuse, for preference-sensitive care such as treatment that should be linked to patients' preferences, weak for prostatectomy.[40]

However, we cannot exclude the possibility that underuse may occur. Even if we selected procedures that are often considered as being overused, there is still the possibility that some of the patients who did not receive care ended up not getting the care they needed. Indeed, variation in use-rates is an indirect measure of inappropriateness.[41 42] To underline the uncertainty due to this indirect way of measuring inappropriateness, we added the adjective 'potential'. Indicators are relevant because they allow a further step of analysis and a sharing process and discussions among health professionals.

CONCLUSION

COVID-19 led healthcare systems to make hard choices in providing services. A large number of cuts, especially for acute care services, have been put in place. That has led healthcare systems to reflect on prioritising access to services, which is certainly an ethical issue but also an opportunity to reduce potentially inappropriate interventions.

This study aimed at providing preliminary evidence on the impact of the pandemic on the geographic variation of selected elective surgery procedures. In particular, the group of oncological surgical interventions belongs to the preference-sensitive categories of Wenneberg mostly influenced by the clinician's decision. Wide variation in

elective surgery rarely depends on patients' preferences or needs. In fact, a recent study demonstrated that often reservation of the operating room does not depend on demand or waiting times.[13] This variation category is also one requiring a deeper involvement of clinicians because it asks them to align their behaviour with clinical guidelines or practices.[8 16] The Italian data show that the pandemic seems to have led hospital managers and health professionals to cut the surgical interventions more likely to be inappropriate. Hence, these findings can inform and guide healthcare systems to manage unwarranted variation. In fact, when coming back to the new normal after this unpredictable situation given by the pandemic, it is important to use this new starting point (lower volumes in some selected elective surgical procedures) to plan elective surgical treatments that can be cancelled because of their high potential for inappropriateness.

Unfortunately, there are no gold standards for surgical use-rates. Under these circumstances, the public disclosure of information about use-rates among regions (and the risk of surgical intervention) can enable a discussion about appropriate care.[16 29 42 43]

In particular, once healthcare systems have achieved lower hospitalisation rates for potentially inappropriate treatments, as happened during the pandemic, it is important to reverse the burden of proof in the cases of surgical intervention, which are at high risk of inappropriateness. Hence, it could be useful to investigate if it is right that the region should come back to the past performance for interventions that have uncertain evidence instead of asking for a reduction of these cases.

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The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.

	Item No.	STROBE items	Location in manuscript where items are reported	RECORD items	Location in manuscript where items are reported
Title and abstract					
	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	In the abstract pg 2	RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract. RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	Included in the abstract pg 2 The title reports the geographic frame. Data analyzed are reported in the abstract pg 1 The study did not require record linkage pg 5
Introduction					
Background rationale	2	Explain the scientific background and rationale for the investigation being reported	In the introduction section pg 3		
Objectives	3	State specific objectives, including any prespecified hypotheses	In the abstract and in the introduction section pg 2,3		
Methods					
Study Design	4	Present key elements of study design early in the paper	In the method section pg 5		
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	In the method section 4,5		
Participants	6	*(a) Cohort study* - Give the		RECORD 6.1: The methods of study	

		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 *(b) Cohort study* - For matched studies, give matching criteria and number of exposed and unexposed *Case-control study* - For matched studies, give matching criteria and the number of controls per case	In the method section pg 5	population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided. RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided. RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	Included in the method section pg 5 Included in the method section pg 5 It is not the case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.	In the method section pg 5	RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	In the method section pg 5
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	In the appendix		
Bias	9	Describe any efforts to address potential sources of bias			

Study size	10	Explain how the study size was arrived at	In the method section		
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	pg 5 In the method section		
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (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 (e) Describe any sensitivity analyses	Method section includes only a) at pg 5		
Data access and cleaning methods		..		RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population. RECORD 12.2: Authors should provide information on the data cleaning methods used in the study.	In the method section pg 5
Linkage		..		RECORD 12.3: State whether the	

				study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	In the method section pg 5
Results					
Participants	13	(a) Report the numbers of individuals at each stage of the study (*e.g.*, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed) (b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram		RECORD 13.1: Describe in detail the selection of the persons included in the study (*i.e.,* study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.	In the results section, criteria in the method section pg 5 and pg 6
Descriptive data	14	(a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing data for each variable of interest (c) *Cohort study* - summarise follow-up time (*e.g.*, average and total amount)	In the results section pg 5, 6		
Outcome data	15	*Cohort study* - Report numbers of outcome events or summary measures over time *Case-control study* - Report numbers in each exposure category, or summary measures of exposure *Cross-sectional study* - Report numbers of outcome events or	In the results section pg 5,6		

		summary measures			
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	In the results section pg 5-7		
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	None		
Discussion					
Key results	18	Summarise key results with reference to study objectives	In the Discusions pg 7		
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	In the discussions section pg 7,8	RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	In the discussions section pg 7
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	In the discussions section		

Generalisability	21	Discuss the generalisability (external validity) of the study results	In the discussions section, pg7,8		
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	in the authors'profile pg 1		
Accessibility of protocol, raw data, and programming code		..		RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	In the method section pg 5

*Reference: Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press.

Supplementary material n. 2

Appendix- Codes of the ICD9CM and DRGs used for selecting cases, elective surgery.

Procedure	ICD9CM codes/DRG Grouper XXIV codes	Notes
Tonsillectomy	28.2x; 28.3x	Patients aged 0-18
Vein stripping	DRG 119	
Hysterectomy	68.3x-68.9x	All women aged 18 yrs and over with benign uterine conditions
Knee replacement	81.54	Total knee replacement
Hip replacement	81.51	All patients aged 65 and over, excludes diagnosis codes 820-821.39, 996.4x
Colectomy	45.71-45.76; 45.79; 45.8x	All patients with ICD-9-CM Diagnosis Code 153: malignant neoplasm of colon
Coronary Angioplasty	36.03; 36.04; 36.06; 36.07; 36.09; 00.66	
Cholecystectomy	DRG: 493;494	

Supplementary material n. 3
2019 and 2020 use rates by procedure and Region

Procedure	Region	Area	2019 use-rate	2020 use-rate	2019-2020 reduction use rates
Tonsillectomy	Piemonte	North	288	136	-152
Tonsillectomy	Valle d'Aosta	North	224	141	-83
Tonsillectomy	Lombardia	North	197	78	-119
Tonsillectomy	Bolzano	North	319	141	-179
Tonsillectomy	Trento	North	238	123	-114
Tonsillectomy	Veneto	North	228	135	-93
Tonsillectomy	Friuli Venezia Giulia	North	276	162	-114
Tonsillectomy	Liguria	North	350	165	-185
Tonsillectomy	Emilia Romagna	North	251	118	-133
Tonsillectomy	Toscana	Center	164	80	-84
Tonsillectomy	Umbria	Center	262	102	-160
Tonsillectomy	Marche	Center	212	109	-103
Tonsillectomy	Lazio	Center	113	85	-28
Tonsillectomy	Abruzzo	South	149	72	-77
Tonsillectomy	Molise	South	94	31	-63
Tonsillectomy	Campania	South	102	36	-66
Tonsillectomy	Puglia	South	82	32	-49
Tonsillectomy	Basilicata	South	163	54	-109
Tonsillectomy	Calabria	South	83	37	-46
Tonsillectomy	Sicilia	South	209	72	-137
Tonsillectomy	Sardegna	South	159	64	-95
Tonsillectomy	Italia	Italy	184	86	-99
Cholecystectomy	Piemonte	North	161	89	-72
Cholecystectomy	Valle d'Aosta	North	143	87	-56
Cholecystectomy	Lombardia	North	154	85	-68
Cholecystectomy	Bolzano	North	120	76	-44
Cholecystectomy	Trento	North	175	123	-52
Cholecystectomy	Veneto	North	156	111	-44
Cholecystectomy	Friuli Venezia Giulia	North	142	101	-41
Cholecystectomy	Liguria	North	160	80	-80
Cholecystectomy	Emilia Romagna	North	149	99	-50
Cholecystectomy	Toscana	Center	182	115	-67
Cholecystectomy	Umbria	Center	167	115	-52
Cholecystectomy	Marche	Center	148	109	-39
Cholecystectomy	Lazio	Center	146	110	-36
Cholecystectomy	Abruzzo	South	209	165	-44
Cholecystectomy	Molise	South	136	93	-43
Cholecystectomy	Campania	South	182	124	-58
Cholecystectomy	Puglia	South	155	102	-54
Cholecystectomy	Basilicata	South	138	77	-61
Cholecystectomy	Calabria	South	172	116	-56
Cholecystectomy	Sicilia	South	175	121	-55
Cholecystectomy	Sardegna	South	154	105	-49
Cholecystectomy	Italia	Italy	161	106	-56
Knee replacement	Piemonte	North	143	102	-41
Knee replacement	Valle d'Aosta	North	189	126	-64
Knee replacement	Lombardia	North	147	92	-54
Knee replacement	Bolzano	North	213	138	-75
Knee replacement	Trento	North	178	126	-53
Knee replacement	Veneto	North	177	157	-20
Knee replacement	Friuli Venezia Giulia	North	171	136	-35
Knee replacement	Liguria	North	176	107	-69
Knee replacement	Emilia Romagna	North	150	117	-34
Knee replacement	Toscana	Center	207	162	-45
Knee replacement	Umbria	Center	176	148	-28
Knee replacement	Marche	Center	168	129	-39
Knee replacement	Lazio	Center	149	111	-37

Knee replacement	Abruzzo	South	148	117	-31
Knee replacement	Molise	South	116	82	-33
Knee replacement	Campania	South	133	85	-47
Knee replacement	Puglia	South	131	103	-28
Knee replacement	Basilicata	South	128	73	-56
Knee replacement	Calabria	South	138	93	-45
Knee replacement	Sicilia	South	138	100	-38
Knee replacement	Sardegna	South	102	92	-10
Knee replacement	Italia	Italy	152	112	-40
Hip replacement	Piemonte	North	379	259	-119
Hip replacement	Valle d'Aosta	North	491	367	-124
Hip replacement	Lombardia	North	364	234	-130
Hip replacement	Bolzano	North	599	400	-199
Hip replacement	Trento	North	500	373	-126
Hip replacement	Veneto	North	452	366	-86
Hip replacement	Friuli Venezia Giulia	North	444	376	-68
Hip replacement	Liguria	North	370	237	-134
Hip replacement	Emilia Romagna	North	385	287	-97
Hip replacement	Toscana	Center	388	312	-76
Hip replacement	Umbria	Center	327	290	-37
Hip replacement	Marche	Center	330	274	-56
Hip replacement	Lazio	Center	301	231	-70
Hip replacement	Abruzzo	South	327	243	-84
Hip replacement	Molise	South	258	181	-77
Hip replacement	Campania	South	245	173	-72
Hip replacement	Puglia	South	214	182	-32
Hip replacement	Basilicata	South	237	149	-87
Hip replacement	Calabria	South	219	167	-52
Hip replacement	Sicilia	South	209	163	-46
Hip replacement	Sardegna	South	177	150	-27
Hip replacement	Italia	Italy	331	245	-85
Vein stripping	Piemonte	North	62	29	-33
Vein stripping	Valle d'Aosta	North	135	40	-96
Vein stripping	Lombardia	North	8	3	-5
Vein stripping	Bolzano	North	32	13	-19
Vein stripping	Trento	North	25	7	-18
Vein stripping	Veneto	North	9	6	-4
Vein stripping	Friuli Venezia Giulia	North	94	54	-40
Vein stripping	Liguria	North	16	4	-12
Vein stripping	Emilia Romagna	North	127	78	-49
Vein stripping	Toscana	Center	60	25	-35
Vein stripping	Umbria	Center	63	25	-38
Vein stripping	Marche	Center	51	25	-26
Vein stripping	Lazio	Center	32	16	-16
Vein stripping	Abruzzo	South	65	38	-26
Vein stripping	Molise	South	40	17	-23
Vein stripping	Campania	South	34	11	-22
Vein stripping	Puglia	South	15	6	-9
Vein stripping	Basilicata	South	41	17	-24
Vein stripping	Calabria	South	7	3	-4
Vein stripping	Sicilia	South	22	10	-12
Vein stripping	Sardegna	South	50	25	-25
Vein stripping	Italia	Italy	38	19	-19
Coronary angioplasty	Piemonte	North	110	86	-24
Coronary angioplasty	Valle d'Aosta	North	114	116	2
Coronary angioplasty	Lombardia	North	114	81	-33
Coronary angioplasty	Bolzano	North	46	40	-6

Coronary angioplasty	Trento	North	59	43	-15
Coronary angioplasty	Veneto	North	71	59	-11
Coronary angioplasty	Friuli Venezia Giulia	North	35	29	-6
Coronary angioplasty	Liguria	North	61	46	-14
Coronary angioplasty	Emilia Romagna	North	68	55	-13
Coronary angioplasty	Toscana	Center	56	41	-16
Coronary angioplasty	Umbria	Center	62	46	-17
Coronary angioplasty	Marche	Center	69	53	-15
Coronary angioplasty	Lazio	Center	74	61	-13
Coronary angioplasty	Abruzzo	South	67	52	-15
Coronary angioplasty	Molise	South	108	103	-5
Coronary angioplasty	Campania	South	110	82	-28
Coronary angioplasty	Puglia	South	97	71	-26
Coronary angioplasty	Basilicata	South	74	49	-25
Coronary angioplasty	Calabria	South	100	42	-58
Coronary angioplasty	Sicilia	South	73	46	-28
Coronary angioplasty	Sardegna	South	27	16	-11
Coronary angioplasty	Italia	Italy	84	62	-22
Prostatectomy	Piemonte	North	195	123	-72
Prostatectomy	Valle d'Aosta	North	238	142	-96
Prostatectomy	Lombardia	North	146	81	-64
Prostatectomy	Bolzano	North	176	123	-52
Prostatectomy	Trento	North	135	92	-43
Prostatectomy	Veneto	North	149	113	-35
Prostatectomy	Friuli Venezia Giulia	North	127	98	-29
Prostatectomy	Liguria	North	123	70	-53
Prostatectomy	Emilia Romagna	North	128	84	-44
Prostatectomy	Toscana	Center	126	99	-27
Prostatectomy	Umbria	Center	153	98	-55
Prostatectomy	Marche	Center	162	120	-42
Prostatectomy	Lazio	Center	161	120	-41
Prostatectomy	Abruzzo	South	177	132	-45
Prostatectomy	Molise	South	135	90	-45
Prostatectomy	Campania	South	113	83	-29
Prostatectomy	Puglia	South	131	87	-44
Prostatectomy	Basilicata	South	90	50	-40
Prostatectomy	Calabria	South	95	54	-41
Prostatectomy	Sicilia	South	157	118	-39
Prostatectomy	Sardegna	South	135	80	-55
Prostatectomy	Italia	Italy	144	98	-46
Hysterectomy	Piemonte	North	1	2	0
Hysterectomy	Valle d'Aosta	North	15	18	3
Hysterectomy	Lombardia	North	1	1	0
Hysterectomy	Bolzano	North	0	1	1
Hysterectomy	Trento	North	0	0	0
Hysterectomy	Veneto	North	2	1	-1
Hysterectomy	Friuli Venezia Giulia	North	2	1	-1
Hysterectomy	Liguria	North	2	2	0
Hysterectomy	Emilia Romagna	North	1	1	-1
Hysterectomy	Toscana	Center	1	1	0
Hysterectomy	Umbria	Center	1	2	0
Hysterectomy	Marche	Center	3	2	0
Hysterectomy	Lazio	Center	7	4	-3
Hysterectomy	Abruzzo	South	11	5	-7
Hysterectomy	Molise	South	3	2	-1
Hysterectomy	Campania	South	3	3	0
Hysterectomy	Puglia	South	3	2	-1
Hysterectomy	Basilicata	South	3	2	0
Hysterectomy	Calabria	South	2	2	0
Hysterectomy	Sicilia	South	2	2	0
Hysterectomy	Sardegna	South	1	1	0
Hysterectomy	Italia	Italy	3	2	-1