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Rhinology

Determination of costs for the CSRwNP pathway. A time-driven activity-based costing experiment

La stima dei costi nel percorso della CRSwNP. L'approccio del time-driven activity-based costing

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SUMMARY

Objectives. The study aims to define the economic resources needed to manage chronic rhinosinusitis with nasal polyposis (CRSwNP), assuming the hospital perspective, based on different patient characteristics, within a 24-month time horizon.

Methods. Real-world data were collected in 3 Italian hospitals. A time-driven activity-based costing approach was implemented to map and assess the pathways for CRSwNP. The following drivers were considered: diagnostic services, drugs, consumables, human resources, equipment and overhead costs based on the length of stay. Costs related to management of comorbidities and adverse events were evaluated. Three main groups of patients were identified: ineligible for surgery; having 1 intervention; having more than 1 intervention. The economic absorption of patients who continued corticosteroid treatment was analysed.

Results. Patients experiencing 1 intervention had a cost of 3,453.31 € that increased to 4,705.03 € for those who required additional surgery. The cost of intranasal corticosteroids was 649.20 €, whereas the cost of oral corticosteroids was 37.60 € per patient.

Conclusions. The results demonstrate the strategic relevance of analytical cost definitions of the clinical pathway for CRSwNP, which can help to support decision makers in the review of internal procedures and in the definition of proper reimbursement tariffs.

KEY WORDS: chronic rhinosinusitis with nasal polyposis, CRSwNP, surgical pathway, process mapping, time-driven activity-based costing

RIASSUNTO

Obiettivi. *Lo studio mira a definire i costi per la gestione della rinosinusite cronica con poliposi nasale (CRSwNP), assumendo la prospettiva ospedaliera, in base alle caratteristiche dei pazienti, in un orizzonte temporale di 24 mesi.*

Metodi. *Dati reali sono stati raccolti in 3 ospedali italiani con il supporto di dati gestionali di contabilità analitica. L'approccio Time-driven Activity-Based Costing è stato adottato per valorizzare i costi di: servizi diagnostici, farmaci, materiali di consumo, risorse umane, attrezzature e costi generali, in base alla durata della degenza. Inoltre, sono stati valutati i costi per la gestione delle comorbilità e degli eventi avversi. Sono stati identificati tre gruppi di pazienti: non idonei all'intervento; sottoposti a 1 intervento; sottoposti a più di 1 intervento.*

Risultati. *Per i pazienti sottoposti a 1 intervento i costi sono 3.453,31 €, che aumentano a 4.705,03 € in caso si presentino recidive. Il costo per i corticosteroidi infranasali (INCS) è pari a 649,20 € a paziente, mentre quello relativo alla somministrazione dei corticosteroidi orali (OCS) è di 37,60 €.*

Conclusioni. *I risultati dimostrano la rilevanza strategica della definizione analitica dei costi del percorso clinico, che può aiutare a supportare i decisori nella revisione delle procedure interne e nella definizione di tariffe di rimborso adeguate.*

PAROLE CHIAVE: *rinosinusite cronica con poliposi nasale, CRSwNP, percorso chirurgico, mappatura dei processi, time-driven activity-based costing*

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Introduction

Chronic rhinosinusitis with nasal polyposis (CRSwNP) is a disease that is often associated with considerable impact on the quality of life of subjects who suffer from it, generating not only direct healthcare costs for management of patients, but also disability and high social costs related to both CRSwNP and associated comorbidities (indirect costs) [1]. Treating this disorder is not easy for clinicians; the available therapeutic strategies mainly consist of drugs or surgery, which in many cases may be ineffective due to the high risk of disease recurrence [1]. In addition, the currently-available medical treatments are limited, and focused mainly on decreasing inflammation in sinuses and nasal passages to reduce symptoms. The most used and widespread medical therapy is corticosteroid-based drugs, via spray application (intranasal corticosteroids, INCS) or in repeated cycles with oral assumption (oral corticosteroids, OCS). Antibiotics, antifungals, and antihistamines are also used to treat the various comorbidities associated with the disorder.

When these pharmacological approaches are not effective, surgery is required, in particular Functional Endoscopic Sinus Surgery (FESS), which is effective in the short-term, but it is associated with high recurrence rates after treatment [2]. In a healthcare context, innovation plays a key role. In fact, innovative healthcare technologies (such as novel drugs, medical devices, medical procedures, or organizational models) can positively impact the optimisation of the patient journey [3]. Focusing on the CRSwNP setting, one possible innovation is represented by biologic therapies, which have been introduced in recent years and act on the underlying type 2 inflammation that causes clinical symptoms [4]. Trials for biological therapies for the treatment of CRSwNP generate the opportunity to raise important issues for future cost-effectiveness analyses alongside clinical evidence to define the benefits that these drugs have for patients [5].

Considering the importance of CRSwNP from clinical, social and economic points of view, analysis of the economic aspects related to the diagnostic and therapeutic pathway of this disorder is acquiring strategic relevance to understand the consumption of economic resources, assuming the point of view of the healthcare facility that manages these patients.

Coverage of the above knowledge gap represents an urgent priority that is useful to support decision-making for allocation of healthcare resources devoted to treatment options offered to patients with CRSwNP. Herein, the present paper had the aim of defining the economic resources needed for management of CRSwNP patients with traditional methods (without considering treatment with biological drugs), focusing on the analysis of financial sustainability related to a routine use of surgical procedures in this population.

The achievement of the above objective would help to define what resources are needed for hospital management of a patient with CRSwNP on the basis of the different clinical conditions, considering the entire hospital stay, from diagnosis to surgical intervention, also defining discharge and follow-up monitoring procedures.

It is not the objective of the present study to compare surgical treatment with innovative pharmacological alternatives, paving only the way for future discussions based on quantitative information concerning the economic burden of surgical procedures. This comparison and related considerations will be dealt with, in prospective studies.

Methods

A micro-costing technique using time-driven activity-based costing (TDABC) analysis [6,7] was performed to quantify the resources related to hospital management of CRSwNP patients, assuming the hospital's point of view and considering a 24-month time horizon.

The economic assessment of the CRSwNP clinical pathway was conducted using real-life data collected in 3 Italian hospitals: two public and one private. Data were collected from October 2020 to February 2021 using a data collection form in which information was requested regarding the management pathway for CRSwNP, stratified as follows: *i)* patients who were not eligible for surgery; *ii)* patients who underwent a single intervention; *iii)* patients who underwent more than one intervention.

The clinical pathway of CRSwNP was divided into the following phases: 1) *Diagnosis* - consisting in the definition of procedures and related costs, concerning all diagnostic activities conducted for clinical confirmation of CRSwNP; 2) *Treatment* - considering both medical and surgical treatments offered to patients with CRSwNP. Concerning medical treatments, both out-of-pocket drug therapy and corticosteroid medications were analysed. Focusing on the surgical procedure, Functional Endoscopic Sinus Surgery (FESS) was based on different hospitalization regimens (ordinary, with one night hospitalisation, or day-hospital in case of no hospital stay); 3) *Management of comorbidities and adverse events* - in terms of costs related to the hospital resolution of complications or concomitant diseases, based on the occurrence rate derived from literature evidence [8]; 4) *Follow-up* - all activities and hospital procedures administered to CRSwNP patients after a surgical procedure or for drug monitoring.

The above phases were economically evaluated for each

group of patients, considering the following healthcare items of expenditure, representing the input data for the economic evaluation:

- *Human resources* - in terms of assistance minutes spent by clinicians, anaesthesiologist nurses, and socio-healthcare operators, were quantified in accordance with the Italian National Labour Contracts per professional class, as labour cost. To allocate a cost to each activity in terms of the work factor, it was necessary to calculate a cost per minute for each professional involved in each phase of CRSwNP clinical pathway. Thus, the labour factor cost per activity was calculated, multiplying the "cost per minute" and the number of minutes spent by each healthcare professional for clinical activities. This cost was considered for the diagnostic phase, surgical treatment, management of comorbidities and adverse events, and follow-up;
- *Drugs administered* - evaluated considering medication therapies administered to CRSwNP patients based on the specific dosage and duration. Drugs were stratified in those directly purchased by CRSwNP patients (representing an "out of pocket expenditure" item of cost), and drugs whose costs are directly sustained by hospitals and by National Healthcare Service (NHS). The total cost of drugs was calculated multiplying the related acquisition cost by the duration of administration, as prescribed by clinicians. In this view, INCS treatment, used to reduce nasal polyp size [2], represents an out-of-pocket expenditure, whose cost was determined according to the typology of INCS therapy, usually fluticasone furoate (27.5 mcg), mometasone furoate (50 mcg), or budesonide (50 mcg). The average therapy cost was calculated using a weighted average of cost estimates and prescription rates of the different active agents, as collected in real-life practice, in hospitals involved in the analysis. In contrast, the costs of OCS is directly sustained by the NHS. The following medications were considered: prednisone (40 mg), triamcinolone (25 mg), and deflazacort (30 mg). In addition to OCS, the costs for antibiotic and antimycotic therapy were evaluated considering infections and other complications and the cost of drugs needed to treat. Thus, this was considered for the treatment phase and for management of comorbidities and adverse events;
- *Equipment* - measured as the type of equipment or different types of equipment, useful for surgical procedures (fiberscopes, microdebrider, endoscopy and other surgical equipment) and during hospital stay for CRSwNP. The economic analysis considered acquisition costs of equipment (integrated with VAT), as well as the related life cycle costs and equipment maintenance. Equipment costs were included in both the surgical treatment and diagnostic phases;
- *Hospital consumables* - considered the different consumables, such as sterile gowns, canvas with/without adhesive border, and gloves used by healthcare professionals and patients. These costs were included only in the evaluation of surgical treatment phase;
- *Laboratory exams and diagnostic procedures* during hospitalisation follow-up, and management of adverse events and complications, in terms of quantity and type of procedures, multiplying the quantity of each procedure to determine the related hospital costs;
- *General and fixed costs* - all items of expenditure different from labour, consumables, and equipment, which are strictly required for management of CRSwNP given their role in logistic and infrastructure support. Specifically, energy, water, gas, general hospital maintenance services, sterilisation services, laundry, managerial and administrative support costs were considered. General costs are common in all phases of the management pathway.

All cost items derived from anonymous administrative and accounting flows related to hospitals cost centres, provided by the management controls of the hospitals involved, allowed for estimation of the overall costs of CRSwNP management.

After definition of CRSwNP management costs directly sustained by hospitals, an additional economic analysis was performed assuming the NHS perspective to understand the financial sustainability of the surgical procedure. According to the above, the Diagnosis Related Group (DRG) and associated charges (provided by the NHS) were considered, based on the different hospitalization regimens for surgical procedures, as well as for all activities required for management of adverse events and complications.

Bayesian statistics were used [9,10]. Gamma distributions were developed to verify the robustness of the results in the presence of uncertainty factors, concerning costs related to management of CRSwNP, considering the different patientis' subgroups.

Results

Patients' distribution

Table I shows that the majority of CRSwNP patients (90.82%) are eligible for surgical treatment. Only 9.18% of patients did not undergo intervention and were thus treated with specific drugs.

Focusing on the economic results, considering both the hospital and the NHS perspectives, Table II reports the costs related to the diagnosis phase for the three clinical

Table I. Distribution of patients according to treatments.

Pathway	Average distribution	Average number of patients in Hospital A in 24 months	Average number of patients in Hospital B in 24 months	Average number of patients in Hospital C in 24 months
Patients not eligible for surgery	9.18%	38	14	20
Patients with 1 intervention	67.46%	318	148	152
Patients with more than 1 intervention	23.37%	150	54	52

Table II. Diagnostic phase costs.

Diagnostic phase economic evaluation	Patients not eligible for surgery	Patients with 1 intervention	Patients with more than 1 intervention
Hospital perspective	239.48 €	311.36 €	583.60 €
NHS perspective	310.07 €	401.83 €	755.15 €
Difference	**70.58 €**	**90.47 €**	**171.55 €**

pathways, which differ based on the frequency of the procedures performed.

Concerning the pharmacological treatment phase, focusing on medical management of CRSwNP patients, the total costs related to INCS administration were € 649.20, whereas the total costs related to OCS administration were € 37.60. These costs are attributable to all three groups of patients, as drug therapy is taken to keep the condition under control, over the long term. It is important to specify that the entire cost of the CRSwNP treatment pathway is borne by the Italian NHS, but the purchase of INCS is an expense to be incurred by the patients. This last cited dimension of cost represents the social burden of the clinical condition.

Evaluating surgical procedures, Table III shows detailed information regarding FESS surgery, considering an ordinary or day-hospital regimen. The costs of the surgery performed in the inpatient setting are higher than in the day-hospital setting, since all costs related to the patient's bed occupancy are included, increasing the total cost of the CRSwNP management pathway. Patients who are admitted as ordinary inpatients show an average hospital stay of 2.5 days.

To calculate the costs attributable to the category of patients who underwent more than 1 operation in the 24-month time-horizon considered, the cost of a single operation was multiplied by the average number of operations per patient, obtained from administrative flows of the 3 reference centres, which is 2.11.

The economic assessment of both comorbidities and potential adverse events of patients undergoing a surgical procedure is detailed in Table IV.

Costs related to the management of type 2 comorbidities are attributable to all three categories of patients considered.

In contrast, costs related to adverse events are attributable only to patients who underwent at least one surgical procedure.

Considering the cost of treating each comorbidity and its probability of occurrence, the expected costs were calculated to be € 1,251.61 per patient with CRSwNP. Similarly, the cost related to the management of possible adverse events was calculated: € 65.19 represent the weighted adverse events economic burden, devoted to each patient undergoing surgery, considering the probability of experiencing all the possible adverse events. This value could appear very low, but is justified by the fact that the occurrence rates of adverse events have very small orders of magnitude, and in the calculation of the weighted cost they significantly affect the related value. These results demonstrate that, even if surgery has a high degree of safety, adverse events can occur, including subpalpebral haematoma and swelling (oedema) of the face; post-operative haemorrhage that may be provoked in the packing removal, usually in the first week after surgery, and could be solved by replacing or reinforcing the nasal tampon; neuralgia and altered sensation at the supraorbital and infraorbital nerves or at the upper teeth; haematoma of the orbit, caused by intraorbital haemorrhage, which can cause compression and ischaemia of the orbit with consequent impairment of vision and visual field; blindness due to traumatic sectioning of the optic nerve in its course along the lateral wall of the posterior ethmoid and/or sphenoid sinus; endocranial complications; injury to the internal carotid artery or cerebral cavernous sinuses, that can lead to permanent neurological injury (paralysis) or death; bacteriological infections, which occur rarely since antibiotics are usually administered.

The economic burden related to follow-up activities was investigated by considering the number of specialist visits

Table III. Cost items considered for surgery evaluation.

Cost items	FESS intervention cost in case of hospitalisation	FESS intervention cost in case of day hospital
Human resources	275.21 €	275.21 €
Equipment	299.08 €	299.08 €
Drugs and consumables	325.13 €	325.13 €
Pre- and post- intervention visits	162.45 €	162.45 €
Length of stay	774.74 €	178.24 €
General costs	363.71 €	246.77 €
Total	**2,200.32 €**	**1,486.88 €**
Cost for NHS (considering national reimbursement tariffs)	**2,798.00 €**	**1,790.00 €**
Difference	**597.68 €**	**303.12 €**

Table IV. Comorbidities and adverse events with economic evaluation.

Type 2 comorbidities	Prevalence of comorbidities among NP patients [9]	Cost for management of each case
Asthma	37.10%	1,583.00 €
Allergic rhinitis	32.20%	386.00 €
Eosinophilic oesophagitis	8.30%	629.43 €
Atopic dermatitis	12.60%	1,248.00 €
Food allergies	7.40%	2,065.40 €
Chronic obsructive pulmonary disease	8.60%	2,066.22 €
Adverse events	**Prevalence [8]**	**Cost related to adverse event management**
Haemorrhage	1.21%	715.66 €
Cerebrospinal fluid leakage	0.56%	1,428.00 €
Orbital haematoma	0.59%	20.66 €
Orbital subcutaneous emphysema	0.12%	20.66 €
Meningitis	0.06%	4,066.00 €
Pulmonary embolism	0.12%	4,466.00 €
Neuralgia	0.12%	81.96 €
Toxic shock	0.06%	1,440.00 €
Blindness	0.12%	16,803.00 €
Other complications related to the surgery	1.50%	1,334.00 €

performed and the different clinical conditions of patients, as reported in Table V.

Therefore, depending on the category of patients and the hospital in which they are treated, different costs are incurred, ranging from a minimum of € 1,653.22 (patients not eligible for surgery) to a maximum of € 8,098.34 (patients undergoing more than 1 surgery).

The robustness of the proposed economic results was strengthened by Bayesian statistics (Fig. 1).

With reference to patients who underwent a surgical procedure, patients with more than 1 intervention always had (probability equal to 100%) greater absorption of economic resources compared to those undergoing a single intervention in both hospitalisation regimens analysed. The same consideration could be proposed for patients undergoing a surgical procedure based on an ordinary hospitalisation regimen, whose economic resource consumption was always higher than patients treated with a day-hospital procedure. The management of patients experiencing more than one surgical procedure required more resources (+2%) if they are treated with ordinary hospitalisation. Patients experiencing an ordinary admission for surgical procedure had a probability of 0.6% in consuming more economic resources than patients requiring more than one surgical intervention, but in a day-hospital setting.

Table V. Follow-up evaluation.

Pathway	Patients not eligible for surgery	Patients with 1 intervention	Patients with more than 1 intervention
Number of visits	3.33	5.33	8.5
Cost for healthcare	211.42 €	338.27 €	539.12 €
Reimbursement tariff	270.93 €	433.49 €	690.88 €
Difference	**59.51 €**	**95.22 €**	**151.76 €**

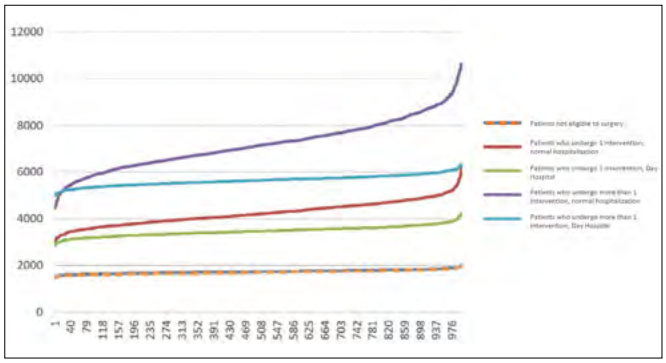

Figure 1. Bayesian statistic.

Discussion

In the present paper, the results regarding costs of the pathway for taking care of patients with CRSwNP were determined, with a particular focus on surgery and assuming that each patient receives the most appropriate treatment according to the clinical condition. CRSwNP is a very difficult condition to manage because of its high recurrence rate and the large number of comorbidities associated with it. In the hospital settings investigated, it was found that there are also some patients who receive corticosteroid treatment even if they are eligible for surgery (130 in hospital A, 54 in hospital B and 70 in hospital C). An economic analysis similar to the previous one highlighted that this specific subgroup of patients is characterised by an expense of € 290.70 borne by the hospital for diagnostic examinations and a follow-up cost of € 147.99 for the hospital. Considering the expenditure for INCS, OCS and the cost to manage comorbidities, the total cost for this category of patients is € 1,690.30 in 2 years.

The study attempts to outline the pathway of a patient suffering from CRSwNP considering consumption of direct costs and reimbursement tariffs, due to the development of complications that can significantly impact the sustainability of the entire pathway.

In particular, the costs related to CRSwNP management have been analysed in recent years in a specific stream of literature specifically devoted to the so-called "Out Of Pocket Expenditure (OOPE)", which represents the costs directly sustained by each patient for treatments aimed at treating their health condition. A study in the United Kingdom estimated the OOPE to be £ 304.84 per year, per patient. Comparing this value in euros, within a 24-month time-horizon the economic burden is € 712.66, thus being consistent with the results of the present study (i.e. € 649.20). The difference is related to the fact that this latter value only refers to direct patient expenditure for the purchase of INCS, without considering the costs required for transportation to the hospital for diagnosis and treatment [11], thus only partially exploring the actual social and indirect costs related to CRSwNP.

Other studies have analysed the impact of direct costs for treating CRSwNP on the hospital budget. Lourijsen and colleagues [12] estimated that direct facility costs (including those for the diagnostic pathway, surgery, and hospitalisation) in the Netherlands were € 1,501.20: this could be considered very similar to the € 1,777.58 found herein for the diagnostic pathway and for FESS (including hospitalisation).

The rates of occurrence of adverse events may seem high from a clinical point of view: this arises from a study that collected a 25-year experience and also considers several risk factors, such as age, revision surgery, anatomic variation, extensive disease, general health status and any drug treatments [2]. The CRSwNP pathway is therefore lengthy, prolonged over time, and subject to direct and indirect costs that are not always easy to estimate, as for other chronic conditions. Moreover, the treatments, quality of life and costs of the pathway differ substantially depending on the complexity of the disease, rate of recurrence, and number of associated comorbidities, as well as their related severity.

To map the process and analyse the consumption of resources, it is essential to identify possible areas for improvement, deciding to intervene by eliminating inefficiencies, focusing on core activities which are decisive for the success of patient management. This approach is also relevant to retrieve important information about the current situation, redesign the pathways, and stratify treatments according to different patient needs.

The current evaluation was carried out considering a time

horizon of 24 months, with the awareness that the management of a patient with severe nasal polyposis could require a longer period, with more recurrences and events related to comorbidities, with consequent persistence of symptoms in the long term that compromise the patients' quality of life.

In this context, it also becomes important to evaluate potential alternatives to current surgical and medical treatments, with the possibility to manage those who may be ineligible for corticosteroid-based drug therapies or surgery. Based on this consideration, an alternative is represented by biological drugs, such as an anti-IL-4Rα (blocking IL-4/13 activities) agent, which in recent years have been studied with particular attention to type 2 inflammation, the disorder underlying nasal polyposis[4]. Although structured long-term data are not yet available, it has been shown that in the short-term biological agents are able to significantly improve the quality of life of patients, by acting with precision on type 2 inflammation: in addition to effectively treating polyposis, they can also mitigate most comorbidities and reduce the need for surgery and OCS treatment [4]. The administration of targeted agents might thus reduce the management complexity associated with the disease, freeing-up organisational healthcare resources (in terms of beds, operating rooms, and staff), which could be used for other purposes and avoid the indirect costs of productivity losses.

The comparison between surgical and biological drugs was not an objective of the present paper. Nevertheless, the results obtained during this analysis could support the discussion concerning the definition of criteria and the population stratification to investigate potential treatment alternatives. According to the above, and since healthcare decision-making is moving towards a personalised approach to therapy, targeting treatments to patients who are most responsive and most beneficial is strictly required. Identifying the most responsive patients for a certain treatment would also optimise the costs of the treatment pathway, obtaining the most benefits by patients: this approach could be used to identify patients undergoing a surgical approach and treatment with biological drugs, as already proposed in a recent study in the United States [13].

It is thus important to define the criteria to stratify patients who might benefit most from each possible treatment. According to this, a potential topic for further research is the investigation of the criteria to choose patients for different treatments by extending the time horizon of analysis up to three years from the first recurrence after surgery, thus identifying patients who might be best suited for biologic drugs [14].

Conclusions

The present analysis has provided a snapshot of the direct costs for a patient suffering from CRSwNP (stratified for severity), with particular attention to surgical treatment and management of recurrences and adverse events. In this context, the analysis has shown that the cost of a single patient suffering from CRSwNP has a significant impact, not only on the Operative Unit that manages the patient, but also on the entire hospital and on patients and their families. CRSwNP is a pathology that has substantial social burden, especially in case of relapse and repeated re-interventions.

Conflict of interest statement

The authors declare no conflict of interest.

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Author contributions

MT, AV, PP, ST and LP retrieved anonymous data in their respective hospitals and described process activities, thanks to their clinical know-how. EF, FS and DB performed the time-driven activity-based costing, statistical and economical elaborations. All authors cooperated in validating results and in writing the Discussion chapter.

Ethical consideration

No Ethical Committee had to approve the study, since there are no patient data.

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