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Productivity Costs Decrease After Endoscopic Sinus Surgery for Refractory Chronic Rhinosinusitis

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Abstract

Objective—The primary objective of this pilot study was to define the change in productivity costs following endoscopic sinus surgery (ESS) for chronic rhinosinusitis (CRS). Secondary objectives were to identify CRS-related characteristics that may influence the degree of productivity improvement after ESS.

Study Design—Prospective, multi-institutional, observational cohort study.

Methods—The human capital approach was used to define productivity costs. Annual absenteeism, presenteeism, and lost leisure time was quantified to define annual lost productive time (LPT). LPT was monetized using the annual daily wage rates obtained from the 2012 US National Census and the 2013 US Department of Labor statistics.

Results—27 patients with refractory CRS who underwent ESS were followed for a mean of 15 [SD 4.0] months (range: 8 – 25 months). Following ESS, there were improvements in annual absenteeism (22 days reduced to 3 days), annual presenteeism (41 days reduced to 19 days), and annual household days lost (12 days reduced to 6 days). Overall, the preoperative productivity costs were reduced after ESS, \$9,097 vs. \$3,301, respectively (p<0.001).

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Conclusion—Daily productivity is negatively impacted by the presence of CRS. The outcomes from this study provide the first insights into the reduced productivity costs associated with receiving ESS for refractory CRS. Future studies with larger sample sizes will need to validate the results from this pilot study.

Keywords

Chronic rhinosinusitis; Sinusitis; Productivity; Cost; Sinus Surgery; Economic; Indirect cost; Absenteeism; Presenteeism

I. Introduction

An important goal of health economics is to inform appropriate allocation of scarce health care resources in a manner that best benefits society. Since the societal perspective of an economic evaluation requires that both direct and indirect (i.e. productivity costs) costs to be included in the analysis¹, accurately defining productivity costs before and after an intervention are important outcomes. Furthermore, it is generally accepted that productivity costs are several times greater than direct medical costs and therefore should be considered when evaluating a clinical intervention².

In our earlier study, we reported the annual productivity cost associated with medically refractory CRS before receiving endoscopic sinus surgery (ESS)³. Outcomes from this prospective study demonstrated that the mean annual productivity cost was \$10,077 per patient, which equates to an estimated \$12.8 billion of lost productivity related to CRS per year in the United States (US).

Given that ESS is a therapeutic option for patients suffering from refractory CRS^{4–6}, the purpose of this study was to evaluate how productivity costs change following surgery for CRS. The primary outcome is the incremental change in productivity costs before and after ESS.

II. Methods

This study is the longitudinal follow-up of patients from our initial observational study³ who specifically elected to undergo ESS for the indication of refractory CRS. All patient-level data was collected prospectively in a multi-institutional, international (USA and Canada), observational study (Clinicaltrials# NCT00799097; NIH: R01 DC005805). Patients with CRS (based on AAO-HNS guidelines⁷) who failed initial medical therapy (as defined by a minimum 3 months of topical nasal steroid therapy, a minimum 7 days of systemic corticosteroid therapy, and 2 weeks of broad spectrum antibiotic) and elected ESS were included in this study. Patients who were apart of the original cohort³ but elected continued medical therapy were excluded. Patients with ciliary dysfunction, cystic fibrosis, or granulomatous diseases were excluded.

Measurement of Productivity Losses

Lost Productive Time (LPT) was defined as the per-person work days lost due to refractory CRS. We assumed the following average paid work time per patient: 8 hours per day, 5 days

per week with 4 weeks of vacation per year. This provided a total of 48 paid work weeks and a total of 240 paid work days per year.

Based on current recall recommendations, absenteeism was quantified by asking both the number of full work days missed and the number of work hours missed due to CRS in the last 3 months⁸⁻¹⁰. As defined above, a cumulative loss of 8 hours of work was equal to 1 full work day missed.

Presenteeism was measured based on the Quantity and Quality Questionnaire^{11,12}. Questionnaires were administered preoperatively at time of enrollment and at planned study visits every 6 months for 18 months after ESS. For patients with multiple postoperative follow-up questionnaires, the most recent was used to calculate productivity costs after ESS. Patients were asked on average the degree (%) of reduced daily work performance due to CRS in the last 3 months. Healthy baseline performance was assumed to be 100% productivity. It was assumed that the average productivity level within the last 3 months would remain stable over the next 12 months. The annual number of work days missed due to CRS-related presenteeism was calculated using the following formula: $P = (E - A) * p$; where P is the number of missed work days due to presenteeism, E is the expected number of annual work days (ie. 240), A is the work days missed due to absenteeism, and p is the % reduced performance at work¹⁰. Annual LPT was calculated by summing the work days lost from both presenteeism and absenteeism due to CRS.

Household productivity loss was calculated by asking patients how much time per day was consumed at home to care for their sinuses. It was assumed the potential household productivity/leisure time available for weekdays is 7 hours per day (5pm to 12am) and on weekends it is 15 hours per day (9am to 12am) for 52 weekends per year. Therefore, 7 household hours lost per weekday or 15 household hours lost per weekend would equal one household work day lost. Household productivity is reported separately from paid work days missed since it has a different monetary valuation.

Monetization of Productivity Losses

The human capital approach was used to monetize productivity losses. To accurately reflect the productivity cost to society, we used the median annual US societal wage rate of \$30,853 based on the 2012 US National Census¹³. Assuming 48 work weeks per year, at 40 hours per week and 8 hours per day, this produces a mean daily income of \$128.55 per patient¹³. This value was used to monetize the paid work LPT.

Household productivity was valued by assuming it was equal to the hourly wage of a housekeeper. Using the 2013 US Department of Labor statistics¹⁴, the mean hourly wage rate for a housekeeper was \$10.49 which at 8 hours per day produced a daily household monetized LPT of \$90.91.

Change in Productivity Costs after ESS

Productivity costs were calculated for each individual patient before and after ESS. Patient level data enabled us to statistically evaluate the association between productivity costs and several CRS-specific characteristics including patient demographics, disease subtypes,

comorbidities, degree of quality of life (QoL) reduction using the Sinonasal Outcomes Test-22 (SNOT-22)¹⁵ and endoscopy scores using Lund-Kennedy scoring system¹⁶.

Improvements in productivity costs after ESS between comorbid characteristics, as well as study participants with and without follow-up, were assessed using the Mann Whitney U test for nonparametric distributions. Wilcoxon signed rank tests were used to evaluate significant improvement over time between all pre-ESS and post-ESS measures where appropriate. Fisher's exact testing was also used to evaluate difference in frequency measures between participants with and without follow-up. All comparisons were reported with a type I error probability determined at the 0.050 level of significance.

III. Results

Subject characteristics

Baseline productivity data was collected on 39 patients with refractory CRS who received ESS. Twelve patients were lost to follow-up which provided a total of 27 patients in our final cohort with a minimum of 6 months follow-up¹⁷. Mean postoperative follow-up was 15.0 [SD 4.0] months (range: 8 – 25 months). The average subject age was 40.6 [SD 14.8] years old (range: 19 – 68) with a higher proportion of females (n=14; 52%) than males. Comorbid characteristics included: 3 subjects with nasal polyps (11%) and 8 subjects with asthma (30%). The mean baseline SNOT-22 score was 51.1 [SD 20.4] while the mean endoscopy score was 5.1 [SD 4.1].

No significant differences were found when comparing study participants with and without follow-up for mean years of age (40.6 [SD 14.8] vs. 44.1 [SD 15.5], respectively; $p=0.599$), the prevalence of nasal polyposis (11% vs. 33%, respectively; $p=0.172$), comorbid asthma (30% vs. 33%, respectively; $p=0.817$), mean preoperative SNOT-22 scores (51.1 [SD 20.4] vs. 50.3 [SD 23.1], respectively; $p=0.916$), mean endoscopy scores (5.1 [SD 4.1] vs. 5.5 [SD 3.2], respectively; $p=0.429$). Likewise, no significant differences between participants with and without follow-up were found for preoperative productivity costs associated with CRS \$9,097[SD \$6,040] vs. \$9,926 [\$6,179] respectively; $p=0.499$).

Productivity Costs Before and After ESS

Reported daily work productivity level increased from a mean of 81% to 92% before and after ESS, respectively. There was a reduction in both paid work absenteeism and presenteeism after ESS for CRS (Table 1). Overall, paid work productivity losses (absenteeism + presenteeism) were reduced from a mean of 63 days prior to ESS to 22 days per year after ESS, producing a net gain of 41 days of paid work per year.

Patients with refractory CRS reported a mean of 26 and 14 minutes per day caring for their sinus disease before and after ESS, respectively. The reduction in daily time required to perform maintenance therapy for CRS resulted in a savings of 6 household days per year (Table 1).

Overall there was a significant reduction in annual productivity cost after ESS, \$9,097 [SD \$6,040] reduced to \$3,301 [SD \$4,258]. This results in an annual mean savings to society of \$5,796 per patient with refractory CRS after ESS.

Effect of CRS Characteristics on Productivity Costs

The degree of change in productivity costs after ESS for various CRS subgroups were evaluated and outlined in Table 2. Although several subgroups contained small sample sizes and were underpowered to detect statistical differences, all subgroups received improved productivity after ESS.

IV. Discussion

This prospective observational study has provided the first insights into the change in productivity costs associated receiving ESS for the indication of medically refractory CRS. The mean annual preoperative productivity cost was \$9,097 per patient. After a mean of 15 months following ESS, the mean annual productivity cost was reduced to \$3,301 per patient. The improvement in productivity level after ESS produced an annual net societal benefit of \$5,796 per patient. With an estimated 250,000 ESS procedures performed per year in the US, this translates into over \$1.5 billion net benefit to society per year. Although the results from this study need to be validated with a larger prospective sample size that incorporates potentially more accurate data collection strategies to minimize productivity recall bias, it provides a first glimpse into the positive impact of ESS on productivity in patients with refractory CRS.

In the appropriately selected patient with medically refractory CRS^{18,19}, ESS has been associated with improvements in several health outcomes including QoL¹⁷, sleep²⁰, depression²¹, olfaction²², and asthma²³. Furthermore, several studies have demonstrated that ESS is associated with reductions in the consumption of health care resources such as medications, outpatient physician visits and emergency department visits^{24–26}. A recent economic evaluation studied the impact of these positive health gains relative to the upfront direct costs associated with ESS, and demonstrated that a surgical strategy has a higher probability of being the most cost-effective management decision in patients with refractory CRS compared to continued medical therapy.²⁷ However, one important limitation of this economic evaluation was that it did not include the indirect costs associated with productivity losses. Given that productivity costs are several times greater than direct medical costs², future economic evaluations on ESS need to take a broader societal perspective to improve policy making decisions. Furthermore, given that, on average, uncomplicated ESS in the US has a direct health care cost between \$8,200 to \$10,500 (2014 USD)²⁸, the reductions in productivity costs and direct health care costs after ESS need to be justified using refined economic models.

There have been four studies quantifying the productivity costs associated with CRS^{3,29–31}. In 2009, Bhattacharyya evaluated the National Health Interview Survey database and reported that the mean annual absenteeism related to CRS was 5.8 work days²⁹. In 2011, Stankiewicz et al. quantified the changes of work productivity after balloon dilation of the ethmoid infundibulum in patients with CRS limited to the maxillary alone or maxillary and

anterior ethmoid sinuses using the Work Limitation Questionnaire (WLQ) and Work Productivity and Activity Impairment (WPAI) questionnaire³¹. With a minimum of 1-year follow-up after balloon dilation (n=53), the results demonstrated a 73% (composite score 9.0 to 2.4; $p<0.0001$) and 76% (composite score 38.3 to 9.2; $p<0.0001$) improvement in productivity on the WLQ and WPAI, respectively. In 2012, Bhattacharyya evaluated the Medical Expenditure Panel Survey and reported that patients with CRS have an incremental increase of 1 work day missed per year and functional limitations at work compared to non-CRS matched patients³⁰. In 2014, Rudmik et al, prospectively evaluated 55 patients with medically refractory CRS who were considered candidates for ESS and reported the annual absenteeism and presenteeism related to CRS was 25 and 40 days per patient which produced an annual productivity cost of \$10,077 per patient³. It is important to note that the outcomes from the latter study included patients managed at a tertiary level Rhinology clinic, had failed extensive medical therapy, and included lost leisure time related to caring for chronic sinus disease which may explain the substantially higher productivity impairments. Furthermore, the study by Bhattacharyya, which reported an annual productivity loss of 5.8 days, used administrative data to quantify a population-based estimate of CRS productivity impairment²⁹. This suggests that on a population-wide scale, patients with CRS may have a less severe inflammatory phenotype with milder reductions in productivity as compared to a more select group of CRS patients who present to a tertiary level rhinology clinic and elect ESS who have a more severe phenotype with larger productivity impairment. All three studies demonstrated that patients with CRS suffer from substantial productivity losses making it an important outcome to investigate and improve.

The outcomes from this study highlight several important points. First, the results demonstrate that ESS not only reduces direct health care costs, as demonstrated in prior studies^{24,32}, but also provides beneficial cost savings to society by improving productivity. Second, it demonstrates the importance of continuing to develop improved medical therapy strategies after surgery since patients still have \$3,301 in productivity costs after ESS. Third, the largest preoperative productivity costs as well as the largest economic benefit after ESS appears be in patients between 18 and 39 years of age which demonstrates the importance of surgery in this age group. Lastly, based on the published literature, ESS provides comparable or larger improvements in productivity gains other surgical interventions for chronic diseases such as refractory epilepsy³³, knee osteoarthritis³⁴, cataracts³⁵, migraines³⁶, and low back pain³⁷ (Table 3).

This was the postoperative follow-up component of a pilot study whose purpose was to determine the feasibility of prospectively collecting productivity outcomes in patients with CRS. Therefore, the primary limitation of this study is the relatively small sample size of 27 patients. This limited our ability to provide meaningful statistical analysis of the CRS subgroups. To overcome this limitation, we are now collecting productivity outcomes on all patients enrolled in a multi-institutional observational study. A second limitation included the loss of 12 patients to follow-up after ESS. However, it is unlikely that the loss of these 12 patients would influence the overall outcomes since there were no statistical differences between baseline characteristics (see Results section). Third, to prevent an overestimation of the annual productivity cost associated with CRS patients after ESS, we did not include the lost time associated with recovering from the ESS procedure. The lost time associated the

ESS procedure is important but should be included in future economic evaluations specifically evaluating ESS as opposed to this cost analysis evaluating the productivity costs of living with CRS after ESS. Fourth, there is a risk of recall bias by using a 3-month recall period. Although a 3 month recall period has been shown to be as accurate as a 4-week recall period⁸, using other data collection methods such as a daily log book may improve the accuracy of our outcomes. Fifth, patients enrolled in this study had failed appropriate trials of medical therapy and thus the results may not be generalizable to all patients with CRS but rather those patients who would be considered candidates for ESS. Lastly, the stability of the improvements in productivity after ESS needs to be quantified with longer-term follow-up. However, given that productivity losses appear to be correlated with the level of QoL impairment³, we can hypothesize that on a patient-level productivity costs will begin to increase if a patient begins to develop recurrent or poorly controlled CRS.

V. Conclusions

Daily productivity is negatively impacted by the presence of CRS. The outcomes from this study have demonstrated an association between ESS and short-term productivity improvements in patients with refractory CRS. Future studies with larger sample sizes will need to validate the results from this pilot study.

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Table 1

Summary of Baseline and Post-ESS productivity losses

	Pre-ESS (Mean)	Post-ESS (Mean)	p-value
Annual <i>paid</i> work LPT from <i>Absenteeism</i>	22 days	3 days	----
Annual <i>paid</i> work LPT from <i>Presenteeism</i>	41 days	19 days	----
Monetized daily paid work LPT	\$128.55	\$128.55	----
<i>Annual paid work productivity cost</i>	\$8,099	\$2,828	----
Annual <i>household</i> LPT	12 days	6 days	----
Monetized daily <i>household</i> LPT	\$90.91	\$90.91	----
<i>Annual household work productivity cost</i>	\$1,091	\$545	----
Annual productivity cost per patient with refractory CRS	\$9,097	\$3,301	<0.001

LPT, lost productive time; CRS, chronic rhinosinusitis; ESS, endoscopic sinus surgery

Table 2

Summary of CRS-subgroup changes in productivity costs after ESS for patients with postoperative follow-up (n=27)

CRS subgroups	Pre-ESS Productivity Costs (mean[SD])	Post-ESS Productivity Costs (mean[SD])	p-value
CRS s/NP (n=24)	\$9,314 [\$6,307]	\$3,358 [\$4,299]	0.109
CRS w/NP (n=3)	\$7,360 [\$3,413]	\$2,852 [\$4,781]	<0.001
CRS w/ Asthma (n=8)	\$9,555 [\$6,456]	\$2,269 [\$3,547]	0.012
CRS s/ Asthma (n=19)	\$8,904 [\$6,029]	\$3,736 [\$4,542]	0.002
Preoperative SNOT-22 Scores:			
0–20 (n=1)	\$423	\$0	0.317
21–40 (n=5)	\$8,039 [\$6,004]	\$2,466 [\$1,736]	0.080
41–60 (n=16)	\$8,384 [\$4,863]	\$1,954 [\$2,874]	<0.001
61–80 (n=3)	\$15,322 [\$8,654]	\$6,327 [\$4,780]	0.109
81–110 (n=2)	\$13,442 [\$8,492]	\$13,277 [\$4,468]	0.655
Preoperative Endoscopy Scores:			
0–2 (n=7)	\$6,699 [\$3,601]	\$1,604 [\$1,884]	0.018
3–5 (n=10)	\$7,687 [\$5,735]	\$2,209 [\$3,055]	0.009
6 (n=9)	\$12,201 [\$7,237]	\$6,042 [\$5,733]	0.066
Age (years):			
18–29 (n=8)	\$10,621 [\$7,245]	\$4,230 [\$4,753]	0.012
30–39 (n=7)	\$11,494 [\$6,897]	\$2,317 [\$3,115]	0.018
40–49 (n=4)	\$9,962 [\$4,279]	\$6,952 [\$7,038]	0.715
50–59 (n=4)	\$5,127 [\$3,298]	\$1,516 [\$1,175]	0.068
60+ (n=4)	\$4,960 [\$2,218]	\$1,300 [\$1,481]	0.144

NP, nasal polyposis; CRS, chronic rhinosinusitis; SD, standard deviation; SNOT, sinonasal outcome test; n, number; SNOT-22, 22-item SinoNasal Outcome Test.

Table 3

Comparison of productivity cost outcomes after other surgical interventions.

Intervention	Chronic disease	Societal Gain After Surgery (\$ per patient per year)
ESS	Refractory CRS	\$5,796
Total Knee Replacement ³³	End-stage Knee OA	\$4,700
Surgical Deactivation of Migraine Trigger Points ³⁵	Chronic Migraine	\$3,949
Temporal lobectomy ³²	Refractory epilepsy	\$3,826
Single Eye Cataract Surgery ³⁴	Cataracts	\$2,240
Lumbar fusion ³⁶	Low back pain	\$758

* all costs were converted to 2015 USD using in

CRS, chronic rhinosinusitis; ESS, endoscopic sinus surgery; OA, osteoarthritis