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The Effect of Applying Clinical Pathways on Medical Resource Utilization among Patients Undergoing a Thyroidectomy

臨床路徑對甲狀腺切除術之醫療資源利用的影響

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Abstract

Taiwan's National Health Insurance Administration (NHIA) began large-scale implementing the case payment method from 1997 with a view to reducing inpatient costs. Hospitals have adopted several management control systems such as Clinical Pathways (CPs) in response to the challenges of maintaining both fiscal soundness and the quality of medical care. The objective of this study is to assess the effects of CPs on the utilization of medical resources, particularly on the practice of thyroidectomy. We evaluate a total of 376 case payments for thyroidectomies operating in an academic medical center from 2001 to 2003 and compare differences between pre- and post-CPs implementation in terms of medical costs and Length of Stay (LOS). The empirical results show that after the implementation of the CPs, the reductions in LOS (31.90%) and in medical expenditure (14.98%) within the General Surgery (GS) department are statistically significant. In addition, the medical resource utilization in the GS division with CPs is significantly lower than that in the Ear, Nose, and Throat (ENT) division without implementing such a program. This study demonstrates that the CPs reduce hospital costs and improve the standard of medical care for patients. Further research is warranted to investigate the cost-effectiveness of CPs implementation and the potential risk of cost shifting from the inpatient to outpatient departments.

【Keywords】case payment, Clinical Pathways (CPs), thyroidectomy, Length of Stay (LOS), medical expenses

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摘 要

臺灣健保自 1997 年大規模實施論病例計酬制度以來，各醫院開始採取成本管控措施，如發展臨床路徑來降低醫療成本並維持醫療品質。本文採用回溯性及觀察性研究，以接受甲狀腺切除術的患者資料為例，探討實施臨床路徑對醫療資源耗用的影響。我們收集了 2001 至 2003 年某醫學中心 376 位接受甲狀腺切除術、論病例計酬的病患為研究對象，比較臨床路徑實施前後，其醫療費用和住院天數的差異。實證結果顯示，一般外科在實施臨床路徑後，平均住院天數及平均住院醫療費用均顯著下降（分別為 31.90% 及 14.98%）。此外，實施臨床路徑的一般外科之醫療資源耗用情形，也明顯低於未實施該項目的耳鼻喉科。本研究證實，臨床路徑可有效降低醫療費用並提高患者的醫療品質。未來可進一步研究實施臨床路徑的成本效益，以及其成本可能從住院部轉移到門診部的潛在風險。

【關鍵字】論病例計酬、臨床路徑、甲狀腺切除術、住院天數、醫療費用

1. Introduction

Population aging, extended life expectancy, changing health needs, and advances in medical technology have all contributed to medical costs on the increase as well as the potential abuse of medical resources (Partridge, Deelen, and Slagboom, 2018). These problems have brought about the greatest challenges faced by countries that have established National Health Insurance (NHI) systems (Cieza, Causey, Kamenov, Hanson, Chatterji, and Vos, 2020; Ou, Chao, Hung, and Lin, 2012). For instance, according to the 2020 annual report by the Ministry of Health and Welfare (MHW) in Taiwan, the National Health Expenditure (NHE) has reached NT$ 1,325 billion, accounting for 7.2% of gross domestic product, and involving spending an average of NT$ 56,199 per capita (Ministry of Health and Welfare, 2022). And to control for the substantial and rising medical care expenses, Taiwan's National Health Insurance Administration (NHIA) has established multiple payment methods for medical providers, such as fee for service, capitation, global budget, case payment and with a transition to the Diagnosis Related Groups (DRGs) payment system since 2010. Moreover, the reform of the NHIA payment systems and the economic competition among hospitals indeed require urgent attention from practitioners and scholars, not only with regard to large-scale adaptation in hospital management, but also in introducing appropriate tools to standardize the costs and procedures of medical care.

The NHIA began large-scale implementing the case payment method in 1997 with a view to reducing the continuously increasing medical expenses based on the fee-for-service payment method. However, the implementation has inevitably transferred the cost of patient care and financial pressure to medical service providers, especially for patients with multiple comorbidities and high disease severity. In response to such revision, hospitals have adopted several management control systems such as case management or Clinical Pathways (CPs) to effectively reduce medical costs.

Clinical pathways (CPs) are novel medical management plans designed to standardize medical activities, reduce cost, optimize resource usage, improve the quality of service and increase patient satisfaction (De Bleser, Depreitere, De Waele, Vanhaecht, Vlayen, and Sermeus, 2006). The CPs are intended to shorten the hospital stay and reduce healthcare costs, which has become an increasingly important issue in medical practice. The CPs are defined as structured multidisciplinary care plans which detail essential steps for the care of patients with a specific clinical problem or with a similar diagnosis, procedure, or symptom during a well-defined period of time (De Bleser et al., 2006; Rotter, Kinsman, James, Machotta, Willis, Snow, and Kugler, 2012). Previous research on the quality of cancer care, guidelines and CPs has demonstrated improvements in compliance with guidelines and evidence-based medicine, as well as reductions in the length of hospital stays, complication rates and financial costs (Kwon, Lee, Woo, Lim, Moon, and Paik, 2018; van Dam, Verheyden, Sugihara, Trinh, Van Der Mussele, Wuyts, Verkinderen, Hauspy, Vermeulen, and Dirix, 2013). To date, CPs have been implemented for a great variety of diseases to improve the effectiveness of treatment and lower costs.

The objective of this study is to assess the effect of CPs on medical resource utilization by comparing the costs and Length of Stay (LOS) for patients undergoing a thyroidectomy before and after the implementation of the CPs, and among the different divisions and surgeons performing the thyroidectomy. To the best of our knowledge, none of the recent efforts have evaluated the effect of CPs on medical resource utilization in thyroidectomy by different surgeons. The reasons for comparing patients undergoing a thyroidectomy involving different surgeons, i.e., General Surgeons (GS) and Ear, Nose, and Throat (ENT) doctors, are as follows.

Traditionally, thyroidectomy operations have been conducted by general surgeons. However, with the advances in the medical domain and medical specialties and subspecialties becoming exhaustive, it has become common for the ENT doctor to perform a thyroidectomy. At present, according to the case-payment items stipulated by the NHIA in Taiwan, a thyroidectomy comes under the GS category. However, if the principal procedural codes of the thyroidectomy correspond with the primary declaration, every division in the hospital can declare the expenditure. This may result in different procedures and different medical costs for different surgeons, which may in turn lead to potential disparities for patients in the allocation of healthcare resources.

Over the last few decades, the incidence of thyroid cancer has gradually increased in numerous countries and regions worldwide (Li, Dal Maso, and Vaccarella, 2020). In 2020, according to the Taiwan Cancer Registry, thyroid cancer was ranked 8th among the various cancers. The age-standardized incidence rate of thyroid cancer is 13.1 per 100,000 people, involving a total of 4,053 patients (Health Promotion Administration, Ministry of Health and Welfare, 2020). Although thyroidectomy is a common form of surgery, it can incur huge medical expenses owing to postoperative complications (Li et al., 2020). While it is well known that a higher latitude in terms of operative procedure results in better control of thyroid diseases, it can be accompanied by more complications. The diversification of intervention and surgical treatment methods for thyroid cancer thus have a distinct impact on the burden of medical resources. For example, a Total Thyroidectomy (TT) is the primary treatment method for thyroid cancer; however, this method can induce complications such as hypoparathyroidism, laryngeal nerve injuries, and hemorrhages (Famà, Linard, Patti, Berry, Gioffrè-Florio, Piquard, and Saint-Marc, 2013). On the other hand, although most of the surgeons argue that non-total operations result in less morbidity; nevertheless, patients diagnosed with differentiated thyroid cancer following non-total thyroidectomy will have greater complications due to repeated thyroid surgery (Erbil, Barbaros, Işsever, Borucu, Salmaslioğlu, Mete, Bozbora, and Ozarmağan, 2007). As such, different surgical procedures could result in large differences in costs and utilities among patients.

Thyroid diseases are common in middle-aged and older adults (Helfand and Redfern, 1998). Aside from factors related to nutrition aspects such as a lack of iodine intake, socioeconomic changes and a stressful life may also be the causes of thyroid diseases, which are some of the typical problems in modern society (Coscia, Taler-Verčič, Chang, Sinn, O'Reilly, Izoré, Renko, Berger, Rappsilber, Turk, and Löwe, 2020). Owing to the advances in diagnostic methods, the lifetime costs for patients with thyroid cancer have become relatively low compared to those for patients with other cancers (Aschebrook-Kilfoy, Schechter, Shih, Kaplan, Chiu, Angelos, and Grogan, 2013). However, because of the rapid increase in the incidence of thyroid cancer, the overall cost of treating this disease can be expected to rise substantially in Taiwan in the coming decade. According to the American Thyroid Association (ATA), health optimization and cost reduction are two major challenges in clinical settings. Given the limited availability of resources, reducing the burden of caring for patients with thyroid cancer has a critical impact on society and the economy (Aschebrook-Kilfoy et al., 2013; Kwon et al., 2018; Lubitz, Kong, McMahon, Daniels, Chen, Economopoulos, Gazelle, and Weinstein, 2014).

The remainder of this paper is organized as follows. Section 2 describes the data, study population and the model constructed for identifying the effects of CPs on medical care utilizations among patients undergoing a thyroidectomy. In Section 3, we present the results from statistical analyses. Also, we employ the Difference-in-differences (DID) approach to address the potential endogeneity issue for robustness check. Section 4 provides the interpretation of our findings within the context of the wider literature as well as the implications for health policy and clinical practice. Lastly, we draw conclusions in Section 5.

2. Methods

2.1 Study Population

This is a retrospective observational study where the research subjects are patients who received thyroidectomies in a specified medical center and whose disease manifestations met the requirements of the case payment system. We collect the data between January 2001 and December 2003 since the CPs have been implemented during this period. In total, we recruit 381 patients, all receiving surgical interventions corresponding to the procedural codes of the International Classification of Diseases, Ninth Revision (ICD-9), where unilateral thyroid lobectomy (ICD-9: 06.2), partial thyroidectomy (ICD-9: 06.39), or TT (ICD-9: 06.4) are the primary diagnoses. To avoid analytical bias, we exclude surgeons who performed fewer thyroidectomy surgeries, because the number of surgeons may have an effect on clinical and financial outcomes (Al-Qurayshi, Robins, Hauch, Randolph, and Kandil, 2016). Thus, we consider three GS surgeons to be outliers because each of them performed no more than two thyroidectomy surgeries in the three sample years (2001-2003). Accordingly, we exclude five patients who are operated on by these three GS surgeons. Among these five exclusions, four surgeries are performed before the implementation of the CPs by two GS surgeons (each surgeon performs the thyroidectomy surgery twice), while one GS surgeon performs the surgery after the implementation of CPs. The final sample thus consists of 376 patients. There are 143 patients having the thyroidectomy performed by GS doctors before the CPs' implementation from January 2001 to June 2002, and 149 patients getting the surgeries after the CPs' implementation from July 2002 to December 2003. There are a total of 84 thyroidectomies performed by ENT doctors without adopting the CPs, of which 45 take place from January 2001 to June 2002 and 39 from July 2002 to December 2003.

2.2 Data Sources

We collect data related to NHI reimbursements of hospital charges, the medical records of patients, and the basic characteristics of surgeons from the hospital being investigated. We select the research subjects according to aforementioned ICD procedural codes. We also identify comorbidities using ICD 9 codes in any primary or secondary diagnosis fields (Deyo, Cherkin, and Ciol, 1992). The Charlson Comorbidity Index (CCI) is then computed for each patient. Additionally, we obtain the basic information regarding each surgeon from the medical center's personnel information archive, including age, specialty, and years of service.

2.3 Clinical Pathways (CPs) Protocol

The CPs are operational tools for executing best practices based on local practice and clinical guidelines that are shaped by interdisciplinary teams (De Bleser et al., 2006). These pathways create a consistent workflow for care delivery. The main objectives of the CPs are to improve the quality of medical care, maximize the effectiveness of available medical resources, define consistent and standard medical care procedures, and control medical costs (Rotter et al., 2012). Following the four essential components of CPs, i.e., a timeline, the categories of care or activities and their interventions, intermediate- and long-term outcome criteria, and the variance record (De Bleser et al., 2006), we consider the transition from hospitalization to discharge a standard procedure; however, within the CPs' framework. First, we develop the treatment procedures and observe the connection between the variation in procedures and treatment results. Secondly, we continually modify the procedures to optimize medical quality and utilize medical resources more efficiently.

In the current study, the workflow of the CPs developed for a thyroidectomy is as follows. First of all, we identify major diagnostic categories, types of diagnosis, and treatment intervention before selecting the development procedure for the CPs. Secondly, we examine the current procedure and clarify the related factors to develop the CPs. Third, we assess whether the new CPs are applicable for the current study. Finally, we constantly monitor and review the workflows for the developed CPs.

2.4 Model and Statistical Analysis

Using the CPs developed above, this study compares the differences in medical resource consumption among the three groups as follows. The first one is the GS group before the CPs' implementation (GS-BCP group), the second one is the GS group after the CPs' implementation (GS-ACP group), and the third one is the ENT group without the CPs. The comparisons are conducted in two ways: one involves a comparison between the first and the second patient group within the GS department, i.e., GS-BCP vs. GS-ACP w/ and w/o CPs, respectively, and the other is that between the second and the third group of the GS-ACP and ENT departments, w/ and w/o implementing the CPs, respectively. The factors including comorbidities, and surgeon-related and disease-specific characteristics are also incorporated into the model to control for their possible effects on medical resource utilization.

Given the retrospective and observational nature of our study, there is a potential risk of selection bias and confounding variables such as the provider's behaviors that may influence the significance of our findings. To address this endogeneity issue, we thus estimate the impact of CPs on the LOS and medical care expenses of thyroidectomy patients using the Difference-in-differences (DID) method (Athey and Imbens, 2017; Wooldridge, 2012). To compare the mean outcomes for the treated and controlled variables before and after the CPs' implementation, the DID analysis requires data on the outcomes in the group that receives the CPs' implementation (GS patients) and the group (ENT patients) that does not, both before and after the implementation. For this purpose, in addition to the GS-BCP and GS-ACP referred to above, the ENT patients are also divided into two groups, ENT-BCP and ENT-ACP, before and after the CPs' implementation, respectively. The effect of the CPs on medical resource utilization, i.e., the DID, is estimated from a regression with terms for the group, period, group-by-period interaction and other control variables. A dummy variable, i.e., *Treatment*, is employed to distinguish GS patients (*Treatment* = 1) from the comparison group of ENT patients (*Treatment* = 0). The coefficient of the *Treatment* dummy represents the differences in medical resource utilization between the GS and ENT patients. Another dummy variable, i.e., the *CPs*, is introduced to denote the time period during which the CPs are in place (July

2002 to December 2003) and has a value of zero otherwise (January 2001 to June 2002). The coefficient of the *CPs* represents the changes in the utilization of thyroidectomy patients in the different time periods. The coefficient of the interaction term, i.e., *Treatment* * *CPs*, represents the changes in the utilization of GS patients relative to the changes for ENT patients in different time periods and reveals the impact of the CPs on the medical utilization. The DID approach allows us to account for any secular trend in utilization. By comparing changes, the observed and unobserved time-invariant, patient-related and surgeon-associated characteristics that may be correlated with medical expenses can be controlled. Any remaining significant differences in utilization can be attributed to the CPs.

In this study, patient covariates are presented as means with standard deviations and frequencies with percentages for continuous and categorical variables, respectively, unless otherwise stated. The *Chi*-square test is used to examine the differences in categorical variables among groups while the Analysis of Variance (ANOVA) is conducted for the same purpose for the continuous variables. Independent variables include *Age*, *Sex*, *Major diagnostic category*, *Major intervention*, *CCI scores* and surgeon-related characteristics. Multiple linear regression is used to investigate the effects of these variables on the hospital charges and LOS. A p-value of less than 0.05 is considered to be statistically significant.

3. Results

3.1 Descriptive Statistics

We divide the primary diagnoses of patients into the following three categories: malignant neoplasm of the thyroid gland (ICD-9-CM code 193), benign neoplasm of the thyroid gland (ICD-9-CM code 226), and other diagnoses of the thyroid gland. Table 1 shows that there are no significant differences among patients in terms of the proportion of each major diagnostic category ($p = 0.465$). *CCI scores* are used to denote the severity of the disease conditions. Notably, the average *CCI scores* range from 0.21 to 0.53. The reasons for the relatively low average *CCI scores* may be attributed to the fact that most patients in the current study are young adults and those middle-aged with the average age ranging from 40 to 55. The statistical tests reveal no significant differences in *CCI scores* among GS and ENT patients before and after the CPs' implementation ($p = 0.325$). This indicates that any observed differences in *CCI scores* among these groups are considered to be due to chance or random factors. It can be seen from Table 1 that not only the observed average *CCI scores* of GS patients decrease, but the average *CCI scores* of ENT patients also decrease after the CPs' implementation. However, the insignificant results do not permit the rejection of the null hypothesis of equal means. Similarly, despite the *CCI scores* of ENT thyroidectomy patients being higher than those of GS thyroidectomy patients both before and after CPs' implementation, the differences are not statistically significant. In other words, our sample does not provide sufficient evidence to infer that there are differences in *CCI scores* among patients in the different groups.

Conversely, there is a significant difference ($p < 0.001$) in three major clinical interventions, i.e., unilateral thyroid lobectomy (ICD-9-CM: 06.2), partial thyroidectomy (ICD-9-CM: 06.39), and TT (ICD-9-CM: 06.4). The ENT group has the highest percentage of partial thyroidectomy in the current medical center both before and after the CPs' implementation. The post hoc test results indicate that the ENT group differs significantly from the GS group both before and after the implementation of CPs ($p < 0.001$).

In regard to the results of the post hoc tests between the GS-BCP group and GS-ACP group, the average *LOS* falls from 3.73 to 2.54 days after the CPs' implementation, exhibiting a decrease of 1.19 days ($p < 0.01$). Similarly, the comparison between the GS-*ACP* group and the ENT group (where the CPs are not implemented) shows that the LOS for the GS-ACP group is 2.84 days shorter than that for the ENT group, exhibiting a significant difference of 52.79% ($p < 0.001$). Furthermore, the average total hospital charges are NT$38,232 and NT$32,505 for the GS-BCP group and GS-ACP group, respectively. This implies that after the CPs' implementation, each thyroidectomy results in a saving of NT$5,727 on average, representing a 14.98% decrease ($p < 0.01$). In addition, the hospital charges for the GS-ACP group are NT$5,123 less than those for the ENT group ($p < 0.001$).

Finally, the results of the post hoc tests indicate that there is no significant difference between the ENT-BCP and ENT-ACP groups except for the major clinical interventions, patient age and gender. The ENT-ACP group has a higher proportion of female patients ($p = 0.036$) and partial thyroidectomies ($p = 0.018$) than the ENT-BCP group. Patients in the ENT-ACP group are older than those in the ENT-BCP group ($p = 0.045$).

The details for hospital charges are further split into several fee items to examine which one has been reduced owing to the implementation of the CPs. The results indicate that in the GS division, nine fee items reveal a statistically significant drop ($p < 0.05$) after the CPs' implementation. These items consist of the diagnostic, ward, medicine service, laboratory, X-ray, therapeutic treatment, special medical supply, medicine and injection fees. Of these nine items, the ward fee exhibits the largest decrease in terms of the amount (NT$1,952), and the medicine fee experiences the greatest drop in percentage terms (54.81%). By contrast, the anesthesia and surgical fees do not exhibit statistically significant changes. Compared to their counterparts in the ENT division, the fee items in the GS division that drop significantly after the CPs' implementation are the diagnostic, ward, medicine service, laboratory, X-ray, anesthesia, medicine, and injection fees. Among these eight fee items, the ward fee still has the biggest reduction in terms of the amount (NT$2,934), and the medicine fee experiences the greatest drop in percentage terms (79.28%). The surgical, therapeutic treatment and special medical supply fees do not exhibit statistically significant changes between the GS-ACP and ENT groups (Table 2).

3.2 Multivariate Regression

The results regarding the effects of the CPs on LOS and hospital charges are presented in Tables 3 and 4, respectively. In Model 1 of Table 3 (with patient-related and disease-specific characteristics as the independent variables), partial thyroidectomy and *CCI scores* have significantly positive influences on LOS. The effect of patient age is significantly negative, together with the significantly positive effect of patient age squared, indicating that age exhibits a non-linear relationship with LOS, i.e., the younger or older a patient is, the longer that LOS will be. In Model 2 of Table 3, basic characteristics associated with surgeons are also included as independent variables. The results are similar to those in Model 1. However, we find that *surgeon age* and its squared term have a significant influence on LOS. Model 3 of Table 3 further compares the differences for LOS within each GS division and between the GS-ACP group and ENT group. In particular, in the GS division, the LOS is significantly longer before the CPs' implementation ($p < 0.01$). Further, LOS in the ENT group is significantly longer than in the GS-ACP group. These results demonstrate that implementing the CPs can effectively reduce LOS, which is critical for hospitals to remain financially sound. Additionally, the results of Model 3 regarding the rest of the control variables are consistent with those in Models 1 and

Table 1 Demographic Characteristics and Medical Resource Utilization of Subjects for Each Thyroidectomy Group

	GS-BCP (N = 143)	GS-ACP (N = 149)	ENT (N = 84)	ENT-BCP (N = 45)	ENT-ACP (N = 39)	*p-value*
Patient characteristics						
Sex						0.001[a]
Male	18 (12.6%)	20 (13.4%)	24 (28.6%)	17 (37.8%)	7 (17.9%)	
Female	125 (87.4%)	129 (86.6%)	60 (71.4%)	28 (62.2%)	32 (82.1%)	
Age	43.07 (14.71)	39.87 (12.59)	51.51 (15.29)	48.27 (14.41)	55.26 (15.59)	<0.001[b]
Disease characteristics						
Major diagnostic category						0.465[a]
Malignant neoplasm of the thyroid gland	29 (20.3%)	37 (24.8%)	15 (17.9%)	10 (22.2%)	5 (12.8%)	
Benign neoplasm of the thyroid gland	16 (11.2%)	12 (8.1%)	8 (9.5%)	6 (13.3%)	2 (5.1%)	
Other diseases of the thyroid gland	98 (68.5%)	100 (67.1%)	61 (72.6%)	29 (64.4%)	32 (82.1%)	
Major intervention						<0.001[a]
Thyroid lobectomy	59 (41.3%)	82 (55.0%)	9 (10.7%)	8 (17.8%)	1 (2.6%)	
Partial thyroidectomy	57 (39.9%)	47 (31.5%)	69 (82.1%)	32 (71.1%)	37 (94.9%)	
Total thyroidectomy	27 (18.9%)	20 (13.4%)	6 (7.1%)	5 (11.1%)	1 (2.6%)	
CCI scores	0.29 (1.05)	0.21 (0.83)	0.43 (1.19)	0.53 (1.29)	0.31 (1.06)	0.325[b]
0	125 (87.4%)	133 (89.3%)	66 (78.6%)	32 (71.1%)	34 (87.2%)	
1	10 (7.0%)	10 (6.7%)	12 (14.3%)	10 (22.2%)	2 (5.1%)	
2	4 (2.8%)	3 (2.0%)	3 (3.6%)	1 (2.2%)	2 (5.1%)	
4	0 (0.0%)	1 (0.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
6	4 (2.8%)	2 (1.3%)	3 (3.6%)	2 (4.4%)	1 (2.6%)	
Total	143 (100%)	149 (100%)	84 (100%)	45 (100%)	39 (100%)	
Surgeon characteristics						
Surgeon Age	44.19 (4.32)	44.10 (3.06)	48.71 (9.11)	48.13 (9.31)	49.38 (8.95)	<0.001[b]
Service years	11.92 (5.05)	12.01 (3.58)	16.88 (9.98)	16.31 (10.13)	17.54 (9.90)	<0.001[b]
Medical resource utilization characteristics						
Length of stay	3.73 (4.06)	2.54 (0.75)	5.38 (2.26)	4.98 (2.46)	5.85 (1.94)	<0.001[b]
Hospital charges	38,232.44 (25,839.65)	32,505.56 (5,837.13)	37,628.15 (11,516.41)	36485.40 (11890.25)	38948.87 (11074.29)	0.023[b]

Note: [a]*Chi-squared* test. [b]*ANOVA* test. Numbers in parentheses are percentages and standard deviations for categorical and continuous variables, respectively. *CCI scores* = Charlson comorbidity index scores; CPs = clinical pathways; GS-BCP = general surgery patients before clinical pathways' implementation; GS-ACP = general surgery patients after clinical pathways' implementation. ENT = ear, nose, and throat; ENT-BCP = ENT patients before clinical pathways' implementation; ENT-ACP = ENT patients after clinical pathways' implementation.

Table 2 Breakdown of Hospital Charges According to Thyroidectomy-type Operations

Hospital charges	GS-BCP group (N = 143) *Mean ± SD*	GS-ACP group (N = 149) *Mean ± SD*	ENT group (N = 84) *Mean ± SD*	Difference between 1st & 2nd groups	Difference between 2nd & 3rd groups
Diagnostic	1,383 ± 1,687	975 ± 250	1,750 ± 631	407 ***	774 ***
Ward	4,645 ± 11,658	2,693 ± 802	5,627 ± 2,365	1,952 **	2,934 ***
Medicine service	390 ± 335	294 ± 62	537 ± 200	95 ***	242 ***
Laboratory	3,732 ± 2,774	2,853 ± 888	3,055 ± 2301	878 ***	201 ***
X-ray	410 ± 1177	201 ± 39	374 ± 916	209 ***	172 ***
Therapeutic treatment	1,025 ± 4,267	421 ± 232	610 ± 624	603 **	188
Surgery	13,876 ± 3,525	13,582 ± 3,405	11,711 ± 4,536	294	-1,870
Anesthesia	10,798 ± 3,196	10,438 ± 2,669	10,713 ± 3,474	360	275 *
Special medical supply	785 ± 938	1,008 ± 1,574	825 ± 410	355 **	396
Medicine	1,008 ± 1,574	456 ± 227	2,201 ± 1,321	552 ***	1,745 ***
Injection	128 ± 394	78 ± 25	145 ± 62	50 *	67 **

Note: ENT = ear, nose, and throat; GS-BCP group = general surgery group before CPs' implementation; GS-ACP group = general surgery group after CPs' implementation. 1st group: GS-BCP group; 2nd group: GS-ACP group; 3rd group: ENT group. CPs = clinical pathways.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

2. Finally, Model 4, which includes all the independent variables, shows similar results to those of Model 3. However, it is slightly better in terms of explanatory power in that R-squared is equal to 0.272 (Table 3).

The results for the effects of the CPs on hospital charges are shown in Table 4. It is obvious from Model 7 that in the GS division hospital charges are significantly higher before the CPs implementation ($p < 0.01$). Compared to the GS-ACP group, although the hospital charges in the ENT group are higher, they are not significant. The effects of other control variables on hospital charges in Models 5 to 8 are similar to those on LOS in Models 1 to 4.

3.3 Difference-in-Differences (DID) Regression

The results for the DID regression are shown in Table 5. For LOS, the coefficient of the interaction term of the time period for CPs' implementation and the GS treatment group is negative and statistically significant, indicating that adopting CPs can effectively reduce LOS. On the other hand, the coefficient for the same interaction in the DID

Table 3 Results of Regression Analysis for the Length of Stay Using the Enter Method (N = 376)

Variables	Model 1	Model 2	Model 3	Model 4
Intercept	4.869***	101.122**	4.971**	70.415
Patient sex				
Male vs. Female	0.588	0.365	0.369	0.419
Patient age	-0.154**	-0.160**	-0.158**	-0.161**
Patient age squared	0.002***	0.002***	0.002***	0.002***
Major diagnostic category				
Malignant neoplasm of the thyroid gland vs. Other diagnoses	0.283	0.138	0.298	0.256
Benign neoplasm of the thyroid gland vs. Other diagnoses	-0.434	-0.447	-0.522	-0.492
Major intervention				
Thyroid lobectomy vs. Total thyroidectomy	0.261	0.201	0.442	0.405
Partial thyroidectomy vs. Total thyroidectomy	1.294*	0.801	0.867	0.834
CCI scores	0.804***	0.761***	0.760***	0.744***
Surgeon age	-	-4.391*	-0.008	-3.046
Surgeon age squared	-	0.048*	-	0.033
Surgeons' service years	-	0.593	-	0.682
Surgeons' service years squared	-	-0.025	-	-0.024
CPs and operation divisions	-	-		
GS-BCP group vs. GS-ACP group	-	-	1.017***	1.029**
ENT group vs. GS-ACP group	-	-	2.029***	1.648*
	R^2 = 0.216 $p < 0.000$	R^2 = 0.249 $p < 0.000$	R^2 = 0.267 $p < 0.000$	R^2 = 0.272 $p < 0.000$

Note: *CCI scores* = Charlson comorbidity index scores; *CPs* = clinical pathways; *ENT* = ear, nose, and throat; *GS-BCP group* = general surgery group before CPs' implementation; *GS-ACP group* = general surgery group after CPs' implementation.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

regression on hospital charges is also negative, but is not statistically significant. This is consistent with the results from Model 7 of Table 4 in that although hospital charges are significantly higher before the CPs' implementation within the GS division, the differences are not significant when comparing the GS-ACP group with the ENT group.

4. Discussion

This study explicitly controls for the factors of patient-related, disease-specific, and surgeon-associated characteristics to examine the effects of CPs on medical resource utilization in terms of Length of Stay (LOS) and medical expenses. To be specific, the length of stay for the GS division that adopted CPs decreases from 3.73 days to 2.54 days according to the descriptive statistics, which is also significantly lower than the corresponding figure of 5.383 days for the ENT division without implementing CPs. Moreover, the empirical results from the regression analysis that controls for other factors demonstrate that the implementation of CPs can effectively reduce LOS and hospital charges.

The findings of this study are consistent with previous research. For example, several studies have indicated that CPs have shortened the LOS by 1.9-3.3 days in Singapore and by 10.56-14 days in Japan (Kulkarni, Ituarte, Gunderson, and Yeh, 2011; Yang, Hu, Zhang, Cao, Li, Wang, Shao, and Xin, 2016). Furthermore, although one study conducted in the United States reports that thyroidectomy-related CPs did not reduce the LOS (Kwon et al., 2018), most other studies agree that implementing CPs can effectively lower the LOS (Kulkarni et al., 2011; Yang et al., 2016).

In addition, our results are in agreement with studies conducted in other countries that have found that implementing CPs reduces hospital charges for some surgical procedures such as those that are gastric- (Seo, Song, Jeon, and Park, 2012), colorectal- (Feroci, Lenzi, Baraghini, Garzi, Vannucchi, Cantafio, and Scatizzi, 2013), orthopedic- (Ayalon, Liu, Flics, Cahill, Juliano, and Cornell, 2011), and thoracoscopic-related (Schwarzbach, Rössner, Schattenberg, Post, Hohenberger, and Ronellenfitsch, 2010). Besides, further investigation on the fee items shows that the greatest reduction after implementation of the CPs is the medicine fee, which could primarily be explained by the NHIA definition of thyroidectomy as being a type of clean-wound surgery. More elaborately, in the GS

Table 4 Results of Regression Analysis for Total Hospital Charges Using the Entry Method (N = 376)

Variables	Model 5	Model 6	Model 7	Model 8
Intercept	47,771***	395,875	48,013***	365,627
Patient sex				
Male vs. Female	991	1,269	1,028	1,763
Patient age	-804*	-814*	-787*	-808*
Patient age squared	10**	10**	9**	10**
Major diagnostic category				
Malignant neoplasm of the thyroid gland vs. Other diagnoses	2,849	2,475	3,535	3,254
Benign neoplasm of the thyroid gland vs. Other diagnoses	-3,997	-3,805	-4,421	-4,126
Major intervention				
Thyroid lobectomy vs. Total thyroidectomy	651	187	1,978	1,525
Partial thyroidectomy vs. Total thyroidectomy	-1,019	-1,598	-480	-833
CCI scores	3,469***	3,366***	3,461***	3,304***
Surgeon age	-	-15,858	-86	-14,822
Surgeon age squared	-	163	-	148
Surgeons' service years	-	4,486	-	5,522
Surgeons' service years squared	-	-133	-	-156
CPs and operation divisions				
GS-BCP group vs. GS-ACP group	-	-	5,388**	6,209*
ENT group vs. GS-ACP group	-	-	3,911	5,616
	R^2 = 0.121 $p < 0.001$	R^2 = 0.128 $p < 0.000$	R^2 = 0.139 $p < 0.000$	R^2 = 0.150 $p < 0.000$

Note: *CCI scores* = Charlson comorbidity index scores; *CPs* = clinical pathways; *ENT* = ear, nose, and throat; *GS-BCP group* = general surgery group before CPs' implementation; *GS-ACP group* = general surgery group after CPs' implementation.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 5 Difference-in-Differences Regression for LOS and Hospital Charges (N = 376)

Variables	LOS	Hospital Charges
Intercept	6.721***	50,991***
Patient sex		
Male vs. Female	0.423	1,209
Patient age	-0.153**	-770*
Patient age squared	0.002***	9**
Major diagnostic category		
Malignant neoplasm of the thyroid gland vs. Other diagnoses	0.310	3,573
Benign neoplasm of the thyroid gland vs. Other diagnoses	-0.490	-4,313
Major intervention		
Thyroid lobectomy vs. Total thyroidectomy	0.450	2,006
Partial thyroidectomy vs. Total thyroidectomy	0.844	-556
CCI scores	0.770***	3,494***
Surgeon age	-0.010	-91
Treatment vs. Control group GS-division vs. ENT division	-0.752	2,348
Time for implementing CPs	0.614	2,058
Interaction term for the time when implementing the CPs and Treatment groups	-1.640**	-7,478
	R^2 = 0.270 p < 0.000	R^2= 0.140 p < 0.000

Note: *CCI scores* = Charlson comorbidity index scores; *CPs* = clinical pathways; *ENT* = ear, nose, and throat; *GS* = general surgery; *LOS* = length of stay.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

division, the CPs for this type of surgery usually require one dose of antibiotics only (some even require none), and no antibiotics are prescribed when patients are hospitalized and after they have been discharged. Further, the reasons for the reduction in other fee items such as laboratory, special medical supply, and X-ray fees may be attributed to the fact that the CPs or medical operation models have been jointly developed by multidisciplinary professionals, who have designed them to be the optimal, most cost-effective treatment models. The treatment procedures, which are laid out in a day-by-day agenda, have enabled the physicians involved to achieve a certain level of consistency and efficiency.

This in turn has minimized variations among patients during the treatment process and has effectively brought costs under control, thereby reducing hospital charges.

The results of the multivariate regression reveal that age and CCI have significant effects on LOS and hospital charges. In the current study, patient age has a non-linear effect on medical resource utilization, indicating that children or elder patients consume more medical resources, which is in agreement with previous studies (De Nardi, French, Jones, and McCauley, 2016). This may be due to the reason that elder patients are more likely to develop a more severe course and progression of the disease, which complicates medical conditions and increases the need for medical care resources. Another reason may be attributed to the fact that physicians tend to provide more preventive treatments when facing high-risk patients. Moreover, this study finds that LOS and hospital charges increase with comorbidities, which is in line with the findings of the previous literature. For example, a review on medical resource utilization suggests that granting patients the status of having developed a major illness significantly affects their LOS and hospital charges (Younossi, Otgonsuren, Henry, Arsalla, Stepnaova, Mishra, Venkatesan, and Hunt, 2015). In addition, related studies have also found that an increase in the number of secondary diagnoses results in increases in interventions, hospitalization days, and hospital charges (McPhail, 2016).

However, other control variables such as gender, the diagnosis factor, intervention methods and surgeon-related characteristics do not significantly influence the LOS and hospital charges. For instance, a study conducted in the United States on hospital charges for well-differentiated thyroid cancer treatment has found that hospital charges among female patients are higher than those among male patients (Lubitz et al., 2014). Conversely, the Statistics and Trends in Health and Welfare 2015 published in Taiwan by the MHW indicates that hospital charges for male patients are on average 1.4 times higher than those for female patients (Ministry of Health and Welfare, 2015). The discrepancies in these findings suggest that the relationship between gender and medical resource utilization may vary according to the disease.

Apart from gender, we also find that the intervention (surgical) types have no significant influence on medical resource utilization. Studies on thyroid-related diseases have pointed out that since surgical practices and equipment vary with each country, LOS and hospital charges may also vary accordingly (Kwon et al., 2018). The insignificant result in relation to surgical types in this study may also result from the method of classifying surgery codes adopted by the NHIA. The NHIA classifies thyroidectomy-related surgeries as DRG 290, which is defined only by the codes for major surgical interventions rather than by a major diagnostic category, without consideration of comorbidities or complications. Accordingly, all such surgeries are granted the same payment system.

This study demonstrates the beneficial effects of CPs on LOS and total hospital charges. The findings are expected to serve as a reference for the NHIA and medical institutions to manage thyroidectomy costs more effectively. In addition, the results of this study may also serve as a valuable benchmark for medical resource distribution and the quality control of healthcare under the current self-management project conducted by the NHIA, where the healthcare provider's performance such as the efficiency of healthcare resource utilization and the service items or quantities are evaluated to determine the total healthcare service points and the growth rate of yearly service quantity that the NHIA will offer to the individual hospital for the next contractual year.

However, there are several limitations that should be considered. First, this study uses claims data and is therefore associated with the limitations of the claims information. Some patients' characteristics such as socioeconomic status, and different stages of the disease that may also influence medical care utilization are not coded on the hospital's claim form. Nonetheless, this study provides some preliminary findings on the effect of CPs' implementation on healthcare utilization by patients receiving a thyroidectomy performed by different divisions and surgeons and should generate some insights regarding the effect of the CPs. Further research is necessary to elucidate the effect of CPs on healthcare utilization while controlling for the patient's socioeconomic status and different stages of the disease.

The second limitation is the extent to which the assumptions underlying the DID method have been met. The DID method relies on the assumption that the selection of treatment group is not correlated with the observed or unobserved factors (confounders), which are associated with the outcome (Jones and Rice, 2009). Wherever this assumption is untenable, the inference will be contaminated with selection bias due to a failure to control for unobserved or unobservable characteristics (Lin and Hsu, 2014; Song, Safran, and Chernew, 2019). In this study, although we have a strong belief that the changes in healthcare utilization are influenced by implementing the CPs, it is possible that other unmeasured factors also have an effect. For example, one concern is that surgeons may tend to select patients with lower disease severity and less complicated surgical procedures to enter the thyroidectomy CPs, thereby amplifying the advantages and effects of CPs. Nevertheless, there is no statistically significant difference between the GS and ENT groups according to the *CCI scores*. In addition, the major diagnostic categories that represent different disease severity and surgical procedures are also insignificant between the GS and ENT groups. Moreover, from the regression results, there is no significant impact of the age and years of service of the surgeons on the LOS and medical expenditure. Therefore, in the current retrospective study, it is highly unlikely that the surgeons will tend to select those patients with a lower severity of illness or who can be operated on with less complicated surgical procedures to enter the thyroidectomy CPs. Nevertheless, whether or not CPs have an impact on the provider's behavior and quality of care still needs further investigation.

5. Conclusion

This study demonstrates the importance of medical cost control on thyroid surgery under the case payment system. Overall, we show that the implementation of CPs improves the consistency of treatment among patients, enhances the quality of patient prognosis, reduces the costs of nursing care and LOS, and significantly lowers hospitalization expenditures. The CPs not only improve hospital finances but also further provide realistic benefits in terms of improved medical care quality, which is achieved through the joint efforts of physicians, nurses and other medical professionals who work together to develop clinical or care guidelines for the CPs. Facing the challenges from the case payment or the Taiwan Diagnosis Related Group System (Tw-DRGs), hospital managers should support the involvement and collaboration of medical staff in developing CPs for each specific case payment category to standardize intervention procedures as well as to reduce variability in medical care quality. Further research is warranted to investigate the cost-effectiveness of CPs' implementation and the potential risk of cost shifting from the inpatient to outpatient departments.

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Appendix. Correlation Coefficient

	Patient age	*Surgeon age*	*Service years*	*LOS*	*Hospital charges*	*CCI*
Patient age	1.000	0.147**	0.122*	0.263**	0.176**	0.199**
Surgeon age	0.121*	1.000	0.987**	0.104*	0.007	0.072
Service years	0.034	0.876**	1.000	0.096	0.010	0.065
LOS	0.155**	0.004	-0.016	1.000	0.840**	0.312**
Hospital charges	0.015	-0.049	-0.007	0.471**	1.000	0.267**
CCI	0.247**	0.071	0.002	0.137**	0.133**	1.000

Note: Upper-Right Triangle = Pearson; Lower-Left Triangle = Spearman. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

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