Overview of extremity replantation in Taiwan by the National Health Insurance database from 1996 to 2000

由健保資料庫研究台灣 1996 至 2000 年之斷指再植概況

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中文摘要

本報告是第一篇關於台灣全部人口斷肢再植手術的流行病學報告。研究材料來自 1996 至 2000 年的健保局臨床研究資料庫 (NHIRD)。在 1:20 抽樣的住院資料中，根據 ICD 術式碼與詳細醫令碼 (CPT codes) 各得到 368 與 236 病例。

77.1% 及 14.0% 的病例各接受單指與二指的再植手術。一至四指手術的平均時間各是 3.9, 5.5, 7.9, 及 10.2 小時。醫學中心的平均住院日數，手術及全部醫療費用各為 12.5 天, $48,585, 與 $125,660；其他醫院則為 9.9 天, $36,786 至 $38,962, 以及 $60,845 至 $71,838 (新臺幣).

報告中強調醫療費用的變異性大，無法單由病人或醫院的基本資料，或是斷指的肢數解釋。這些資料對於將來的臨床研究或政策制定者都有參考價值。

關鍵字：斷指，再植手術，顯微手術，保險申報資料庫，預後分析，涵蓋人口的研究，流行病學，資料探勘

Abstract

This study is the first epidemiological report of limb replantation surgery concerning the whole population of Taiwan. The materials are based on the 1:20-sampled National Healthcare Insurance (NHI) Research Database from 1996 to 2000. 368 and 236 patients were extracted from the hospitalization datasets, based on the ICD procedure codes and the detailed medical orders respectively.

77.1% and 14.0% of cases received one- and two-digital replantation. The average operating times are 3.9, 5.5, 7.9, and 10.2 hours from one- to four- digit replantations. Average length of hospital stay, surgical and total fees were 12.5 days, $48,585, and $125,660 in medical centers, in comparison with 9.9 days, $36,786 - $38,962, and $60,845 to $71,838 (all in NT dollars) in other hospitals.

The wide variations of fees could not be explained simply by the demographic characteristics of patients and hospitals, or by the number of digits involved. These data provided reference for further clinical researchers and policy makers.

Keywords: digital amputation, digital replantation, microsurgery, claims database, outcome analysis, population-based study, epidemiology, data mining

Background

The history of finger replantation in Taiwan is more than 20 years. [1,2] Our plastic surgeons contributed much to the development of replantation surgery. [3,4] Today, microsurgical technique has become an integral part of the training of plastic surgeons, and limb replantations are widely available. Replantation is always an important topic in our meetings and conferences, but the focus is mainly on the special technical considerations. There is no report of the overall epidemiology of this important procedure in Taiwan.

Taiwan National Health Insurance (NHI) Bureau selectively released its claim database for clinical research since 2000. [5] NHI covered 96% of the 24 million populations. The characteristics of regional coverage of nearly all hospitals, and inclusion of all age groups and non-selective diseases and injuries, are promising for epidemiological studies.

We studied the 1:20-sampled inpatient datasets of the NHI research database (NHIRD) from 1996 to 2000. [6] The initial focus was on the epidemiology of various amputation injuries, and on the yearly trend in different hospital types and geographical areas, based on information of ICD-9-CM (international classification of disease, 9th edition with clinical modification) diagnoses and procedures (the S_DD datasets in NHIRD). During the exploration, we further linked the database of detailed medical orders with CPT (current procedural terminology) codes (the S_DO datasets), to enrich the clinical information, and also for comparison and correction of the accuracy of data based solely on ICD.

The three major questions we try to answer are:

1) The current status of digital replantation in Taiwan, and how the case numbers and

clinical characteristics changed in these 5 years;

2) Are outcome measurements in insurance claim database, eg. LOS (length of hospital stays), and surgical fees or total medical expenses, related to different hospital types or severity of injury (number of digits replanted).
3) Is outcome statistic based on ICD coding compatible with those on CPT coding.

The overall picture of replantation would serve as reference data for studies of trauma and other surgical procedures. The data is especially valuable recently in Taiwan, on the advent of global budget reform of NHI. The multi-institutional results across 5 years will provide concrete evidence for decision-making. The discrepancy between ICD and CPT information is especially addressed, because most of the reports of public health or of hospital administration are based solely on ICD codes, which are questionable from the point of views of clinicians, facing the highly variable real world, especially in the trauma settings.

Materials and Methods:

The 1/20-sampled inpatient NHI research databases (NHIRD) (S_DD and S_DO) [6] from 1996 to 2000 were pooled into Microsoft SQL-2000 data warehouse. Corresponding tables of ICD diagnosis and procedure hierarchies, CPT descriptions, and the types and geography of hospitals were added. Local, regional hospitals, and medical centers were **地區**, **區域醫院**, and **醫學中心**, respectively.

Data presentation, visualization, and exploration were greatly helped by the interactive on-line analytical processing (OLAP) function of the data warehouse programs. Multidimensional expression (MDX) facilitated complex queries beyond ordinary SQL language. The data could be studied and cross stratified by plain medical terms, rather than in the meaningless ICD and CPT codes.

The use of this database allowed us to examine digit replantation procedures based on the fallowing variables:

1. Demographics of the amputation injuries and the patients.
2. Clinical characteristics of related procedures.
3. Distribution between hospitals and departments
4. Outcome measurements including length of stay (LOS), surgical fees, and total hospitalization expenses.

In the S_DD datasets, 368 cases of digit reattachments were queried by ICD-9-CM procedure codes starting with 842 (extremity reattachments), from 842.1 (thumb

reattachment), 842.2 (finger reattachment), 842.3 (forearm reattachment), to 842.9 (non-specified reattachment).

To more concentrate on digital replantation, the detailed medical orders of S_DO datasets were studied. Only 236 patients received CPT order of digital or limb replantations (64153A to 64157A for one- to five-digits, and 64158A for limbs). The other 132 patients received other reconstruction operations, including revascularization, grafting, or other repairs, but were still coded with ICD-9-CM codes of reattachments.

All medical orders of these 236 patients were extracted from the S_DO datasets. The 14274 CPT order details, including procedures, treatments, and anesthesia, provide the basis of inference on the clinical information.

The number of operations was estimated by the charge of anesthesia, so the minor revision operations under local anesthesia were excluded. The operation time was indirectly collected from the anesthesia charges of first 2 and 4 hours, designated of 1 and 3 hours by average respectively, then the 30 minutes anesthesia charges beyond 4 hours were added cumulatively.

Results:

Demographics of amputation injury and distribution between hospitals were mainly collected from S_DD datasets. Clinical characteristics of replantation operations and outcome measurements utilized both S_DD and S_DO datasets.

Demographics of the amputation injuries and of the patients

The case numbers of ICD-9-CM reattachment procedures are listed in Table 1. 94% of cases received finger and thumb replantations, with ratio of about 5:1.

Average age was 34.3 year-old, with standard deviation of 14.3. The oldest patient was 75 years old, while the youngest was 8 month-old. The distribution is shown in Figure 1. Age distribution of Cathay General Hospital (CGH), mainly between 1980 and 1996, is plotted in shaded area for comparison. The peak age group in the earlier series is 20-30 year-old, with skewness to the younger. The normal distribution of the recent series implies that the age factor no longer limits the decision of replantation.

269 patients were males, 75, females, and 24, unknown in gender, compatible with the working pattern in Taiwan.

Clinical characteristics of related procedures

The clinical characteristics of the six CPT replantation procedures are listed in Table 2 and Table 3. One- and two- digital replantations include 91% of cases.

The need of other operations is not significantly associated with the number of digits replanted, implying the existence of other confounding factors. Operation time increases from 3.9 to 7.9 hours according to 1 to 3 digits replanted, but the variations are large. (Table 2) Operating hours are estimated by the longest operation received by each patient, and not

necessarily the first management of acute trauma.

Surgical fees and total fees also doubled according to 1 to 3 digits replanted. LOS did not differ. (Table 3)

LOS of the 236 patients, 220 associated operations were performed. There were 82 musculotendinous procedures, 56 wound managements, 29 amputations, 22 flap surgeries, 18 nerve surgeries, and 13 vascular procedures.

Considering microsurgery, there were 2 toe-to-hand transfers , both in the acute trauma setting, with emergency claims of 1.5 times the surgical fees. 4 free flaps were performed, all in emergency operation.

73.7% of patients were admitted in plastic surgical or surgical departments. In many hospitals, the plastic surgical divisions were included in the surgical departments. Orthopedic departments managed only 2.2%. (Figure 2) The distribution was stable across 5 years. (Table 4)

Distribution between hospitals and yearly trends

Figure 3 and Table 5 demonstrate the yearly trend and the case number of different hospital types. The case number of replantation did not drop in these 5 years. Figure 4 lists ratios of different hospital types. Regional hospital served 55.7% of cases.

Table 6 lists the number of hospitals involved in this sampled data as reference. But the distribution between hospitals was very imbalanced, both in the ICD and CPT analysis. Half of replantation procedures in Taiwan were performed in 5 or 6 hospitals. In ICD analysis, 65, 44, 20, 19, 17 and 16 cases were from a regional hospital in **台中縣**, a medical center in **桃園縣**, a regional hospital in **台北縣**, a regional hospital in **台南縣**, a medical center in **高**

雄縣, and a regional hospital in 桃園縣, respectively, accounting for 181 (49.2%) of the total 376 sampled cases. Similar trends of location was shown in CPT analysis, 51, 28, 15, 15, and 10 cases were performed in the same 5 hospital in same order, except the 3rd hospital in 台北縣. These 5 hospitals served 119 (50.4%) of the total 236 samples. By the CPT analysis of actual replantation, the remaining 117 cases were dispersed in 35 hospitals. 9 hospitals performed 5-9 replantations, and 26 hospitals performed less than 5 replantations in these 5 years.

Replantation operation was widely available in medical centers and regional hospitals, in comparison to the total number of hospital types in Taiwan, provided by China Medical Association. [7] In 1998, there were 14 medical centers, 51 regional hospitals, and 465 local hospitals. In 1999, the numbers were 19, 60, 456, and in 2000, 22, 69, and 432. The data should be interpreted cautiously because the source was derived from only 1:20-sampling.

By geographic analysis of the hospitals, the cases concentrated in north Taiwan in 1996, then shifted outward significantly. (Figure 5) The cases in middle Taiwan nearly doubled in 2000, reflecting the spread of trained plastic surgeons.

Outcome measurements

Outcome measurements in insurance claim database include length of hospital stay (LOS), surgical fees, and total fees. (Table 3 and Table 7 -11) Table 8 and Table 10 are based on only ICD codes derived from S_DD database; Table 9 and Table 11 are the real replantation cases confirmed by CPT procedures in S_DO database. Table 8 and Table 10 should be retained for comparison with other trauma registries, which are always reported on the basis of ICD coding. Our result reveals over-estimation of case number nearly 50%, but

only slight discrepancy between averaged outcome measurements. One of the possible explanations is the wide variation due to confounding factors other than the amputation injuries.

Average fees between different hospital types are listed yearly in Figure 6. Surgical fee reflects the complexity of surgical procedures, and does not differ significantly. LOS and total expense are higher in medical centers. (Figure 7) Difference between departments is insignificant. (Table 10, Table 11)

The distribution of total expenses deserves more attention. (Figure 8) The histogram highly skews to the left, with very wide variation. Application of discriminate statistic tests should be cautious. Figure 9 compared the different histogram of total fees. The expense of two-digit replantation spanned over a relatively normal distribution, but the shape was masked due to smaller case population.

LOS in medical centers was slightly longer in medical centers. (Table 7) The histogram of Figure 10 clearly demonstrates the overlap between one- and two-digit replantations.

The higher expenses could not be explained well by the hospital or department factors or simple indicators of severity of injuries, like number of digits replanted or the operation time of initial operations. Further examination of the order details of those patients was mandatory to disclose more clinical causes.

Discussion:

The foci of literature about limb replantation shifted from general survival and functional results to clinically difficult condition. [1,2,8-10] Most of recent reports came from large series in medical centers, [2,8] and multi-digital [3,8,10] or distal replantation [4,11], or techniques in children [12] were more often discussed. Our population-based study, in accordance with three previous reports, [13,14,15] confirms those conditions are very exceptional.

Population-based national studies gave an overall picture of this wide available procedure. The clinical characteristics, operation times or LOS for example, provides the practitioners, the learners, and even the patients, the ideas of expected performance and the wide variation of clinical problems in real world. Policy makers and hospital administrators could think more cautiously about case payments based solely on ICD diagnosis or on number of digits.

The first two epidemiological reports came from Denmark and Sweden, [13,14] in early days of microsurgery in 1982 and 1984. The discussions of underused replantation attempts and availability of microsurgeons are not an issue today in Taiwan. The third reports utilized claim datasets from 1996 Healthcare Cost and Utilization Projects (HCUP) in United States. [15,16] Related statistics and the impact of national surveys were also available to publics. [17]

In US, 60% of hospitals performed only 1 replantation one year in 1/20 sampled data, while 2% of hospitals performed 10 or more cases. [15] Our data is compatible in the same phenomenon of case concentration in some hospitals. We also agree the judgment of low utilization by the annual case number of 1153 replantations in US.

The ratio of thumb reattachment was 16.8% in NHIRD, only slightly increasing from the CGH thumb ratio of 12.7% before 1996. Both ratios are lower than in US (32%). [15] The main reasons for higher finger replantation rate are Chinese traditional wishes of keeping a whole body, and no limitation in indications by NHI.

In comparison to the average total charges of US$20,330 in 1996, our medical expense is surprisingly low. [15] In addition to the low payment for surgical sections in Taiwan, the data also provide strong evidence for the status of relative neglect of highly resource-demanding surgeries in the current NHI payment system.

Observation studies of insurance claim database like ours carry some limitations, including:

1. No detailed description of the level of injury, or outcome.
2. Inconsistent indication of operation and inclusion of patients.
3. No control, and undifferentiating of no action intentionally or simply by neglect.
4. No linkage to real patients or hospitals due to privacy policy of NHI.

The stability of case numbers and fees in our series did not suggest the epidemiology of amputation is stable. More availability of surgical or rehabitation resources, and more loose indication, which implied better service from the point of view of patients, also contribute to the maintenance across years. Further studies on real patients, with detailed medical orders and clinical results, under consistent indication of surgery, would help the evaluation of accuracy and prognosis, under the overall picture of our report.

Conclusions:

The cases of limb replantation did not drop in Taiwan, but the distribution dispersed rapidly, more significantly in middle Taiwan. Most of the replantations were cared by plastic surgeons. Regional hospital managed 60% of cases. About half of operations were performed in five or six hospitals.

77.1% and 14.0% of patients received one- and two-digit replantation. The operating time increased from 3.9, 5.5, 7.9, to 10.2 hours from one- to four-digit replantations. The operating time, surgical fees, and total fees, nearly double from one- to three-digit operation. LOS varied little between different number of digits. It should always be reminded that the variations were all wide.

Average LOS, surgical and total fees were 12.5 days, $48,585, and $125,660 in medical centers, in comparison with 9.9 days, $36,786 - $38,962, and $60,845 to $71,838 (all in NT dollars) in other hospitals. The causes of higher fee – for example, severity of injuries, or availability of better services --- needed further studies. Our medical expense for this high technical-demanding surgery is low, especially in comparison to the NHI payment of other operations, according to the recent report of average charges of US$20,330 in United States.[15]

Data based on only ICD information would overestimate nearly 50% of cases, but underestimated the resources only slightly, despite the mixture of non-replantation cases.

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Part of the materials has been presented in the Annual Meeting of Plastic Surgical Association, Republic of China, Tainan, Dec. 2001.

Table 1. Case numbers of related ICD-9-CM procedures in different hospital types.

	Other	Local Hospital	Regional Hospital	Medical Center	*Total*	
					Case No	*& Ratio*
Finger reattachment	14	29	163	83	*289*	*77.1%*
Foot reattachment			3		*3*	*0.8%*
Forearm/wrist/hand reattachment	1	2	2	6	*11*	*2.9%*
Thumb reattachment	8	6	37	12	*63*	*16.8%*
Toe reattachment			4		*4*	*1.1%*
Upper arm reattachment	2			3	*5*	*1.3%*

Table 2. Clinical information of those patients with CPT codes of various numbers of digital and limb replantations.

DigiNo	*Case No & Ratio*		No of Op Mean and StdDev		Max No of Op	OpHour Mean and StdDev		OpHour Min and Max	
1 Digit	182	77.1%	1.17	0.45	3	3.9	2.4	1	14
2 Digits	33	14.0%	1.29	0.53	3	5.5	3.1	1	14
3 Digits	9	3.8%	1.50	0.76	3	7.9	3.6	2.5	13.5
4 Digits	3	1.3%	1.33	0.58	2	10.2	3.5	6.5	13.5
5 Digits	1	0.4%	1.00		1	4.0		4	4
Limb Repl	8	3.4%	1.63	1.06	4	8.6	4.2	2.5	16
	236	100.0%							

Table 3. Outcomes of those hospitalizations with CPT codes of various numbers of digital and limb replantations.

DigiNo	HospStay Mean and StdDev		SurgicalFee Mean and StdDev		TotalFee Mean and StdDev	
1 Digit	10.1	4.9	$32,569	$10,973	$71,392	$36,250
2 Digits	12.2	6.0	$60,143	$16,683	$111,940	$47,579
3 Digits	11.6	3.4	$84,225	$12,707	$153,282	$65,837
4 Digits	12.7	2.1	$109,117	$8,357	$177,920	$31,537
5 Digits	9.0		$124,074		$163,184	
Limb Repl	15.3	9.0	$84,273	$25,293	$198,109	$90,671

Table 4. Case number of different hospitalization departments versus years.

Year	Plastic Surgery	Surgical Dept	Orthopedics	Other Dept
1995	1	2		
1996	33	33	5	
1997	43			26
1998	33	20	3	1
1999	45			33
2000	60			29
Total:	*215*	*55*	*8*	*89*

Table 5. Case number of different hospital types versus years.

Year	Other	Local Hospital	Regional Hospital	Medical Center	*Subtotal:*
1995		1	2		*3*
1996		4	42	25	*71*
1997	7	5	39	18	*69*
1998		5	30	22	*57*
1999	6	12	41	19	*78*
2000	11	8	50	20	*89*
Subtotal:	*24*	*35*	*204*	*104*	*367*

Estimated total number: 7340 cases

Table 6. Numbers of hospitals involved in this sampled database*.

	Other	Local Hospital	Regional Hospital	Medical Center	*Subtotal:*
1995		1	2		*3*
1996		2	14	8	*24*
1997	5	3	12	6	*26*
1998		3	13	7	*23*
1999	4	7	19	7	*37*
2000	7	3	11	7	*28*
Subtotal:	*16*	*19*	*71*	*35*	*141*

* See text for number of all (non-sampled) hospitals of different types.

Table 7. Days of hospital stays versus different hospital types.

Year	Other	Local Hospital	Regional Hospital	Medical Center	Average:
1996		8.8	10.9	15.4	12.4
1997	8.7	13.8	8.1	9.0	8.8
1998		4.8	7.9	10.6	8.7
1999	14.8	8.8	8.8	15.2	10.8
2000	13.4	7.9	8.2	10.9	9.4

Table 8. Outcomes of hospitalizations of different hospital types, derived from SDD database with ICD procedural information only. (Replantation and Revascularization cases.)

Type of Hospital	Case No and Ratio		Hospital Stay Mean and StdDev		Surgical Fee Mean and StdDev		Total Fee Mean and StdDev	
Other	24	6.5%	12.4	8.0	$47,940	$26,623	$125,019	$86,734
Local Hospital	35	9.5%	8.7	5.3	$35,594	$15,775	$58,192	$29,225
Regional Hospital	205	55.7%	8.9	7.4	$37,251	$22,906	$71,432	$51,945
Medical Center	104	28.3%	12.9	9.8	$45,649	$28,987	$126,810	$84,651
	368	100.0%						

Table 9. Outcomes of hospitalizations of different hospital types, derived from SDD and SDO database with ICD procedural and CPT order information. (Replantation cases only.)

Type of Hospital	Case No and Ratio		Hospital Stay Mean and StdDev		Surgical Fee Mean and StdDev		Total Fee Mean and StdDev	
Local Hospital	29	12.3%	9.8	5.5	$36,786	$15,858	$60,845	$30,282
Regional Hospital	138	58.5%	9.9	4.4	$38,962	$19,310	$71,838	$35,095
Medical Center	69	29.2%	12.5	6.3	$48,585	$27,406	$125,660	$65,211
	236	100.0%						

Table 10. Outcomes of hospitalizations of different departments, derived from SDD database with ICD procedural information only. (Replantation and Revascularization cases.)

Department	Case No and Ratio		Hospital Stay Mean and StdDev		Surgical Fee Mean and StdDev		Total Fee Mean and StdDev	
Plastic Surgery	215	58.4%	9.4	6.7	$38,939	$23,835	$84,304	$66,446
Surgical Dept	55	14.9%	12.2	11.8	$45,505	$26,112	$111,056	$85,774
Orthopedics	8	2.2%	11.9	8.9	$36,908	$10,778	$82,508	$37,637
Other Dept	90	24.5%	11.0	8.7	$40,244	$26,984	$88,888	$65,924
	368	100.0%						

Table 11. Outcomes of hospitalizations of different departments, derived from SDD and SDO database with ICD procedural and CPT order information. (Replantation cases only.)

Department	Case No and Ratio		Hospital Stay Mean and StdDev		Surgical Fee Mean and StdDev		Total Fee Mean and StdDev	
Plastic Surgery	138	58.5%	9.9	4.4	$40,643	$20,205	$80,188	$41,863
Surgical Dept	20	8.5%	11.0	4.6	$38,003	$17,662	$94,765	$48,238
Orthopedics	3	1.3%	11.0	6.6	$32,162	$6,100	$60,481	$19,573
Other Dept	75	31.8%	11.9	6.6	$44,621	$26,372	$96,508	$67,871
	236	100.0%						

Figure 1. Age distribution of NHI database, in comparison with CGH datasets.

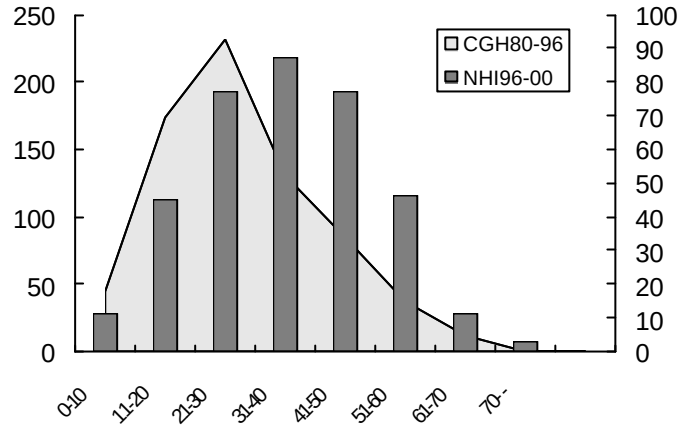

Figure 2. Ratio of hospitalization departments.

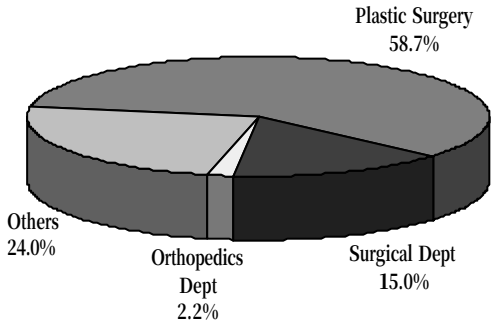

Figure 3. Case numbers of different hospital types across five years

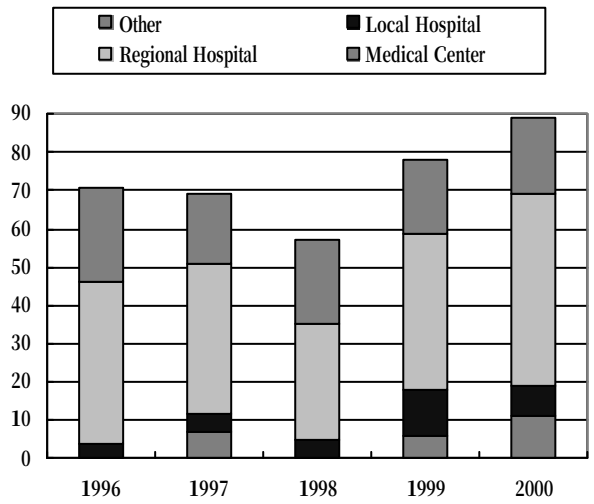

Figure 4. Ratio of cases managed in different hospital types across five years.

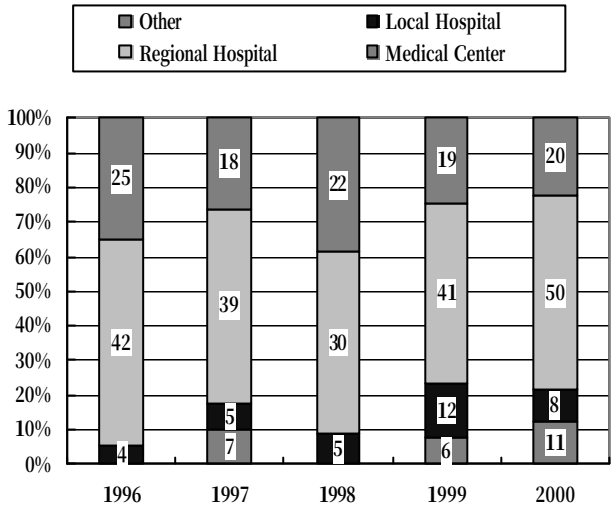

Figure 5. Ratio of geographical locations in Taiwan across five years.

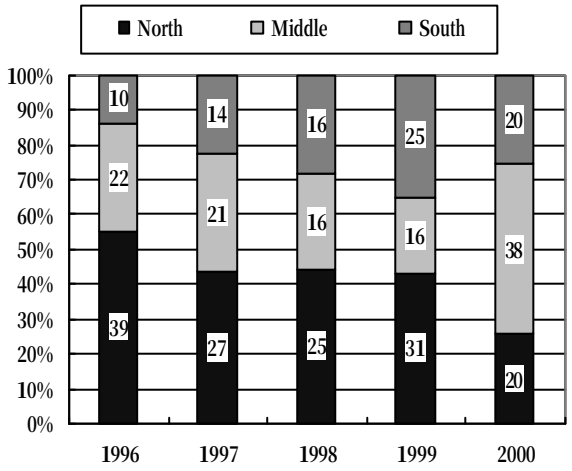

Figure 6. Average surgical fees of different hospital types.

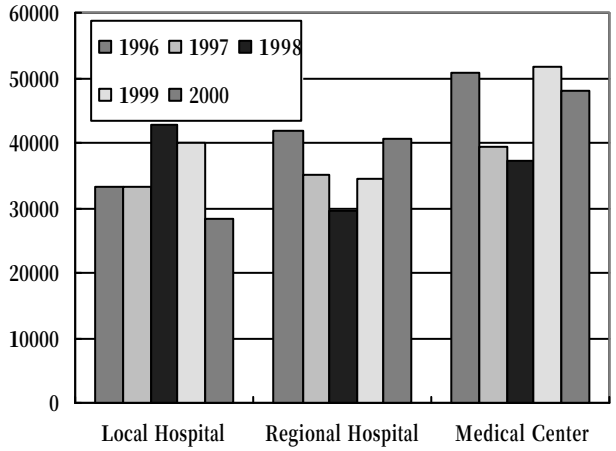

Figure 7. Average total hospitalization fees of different hospital types.

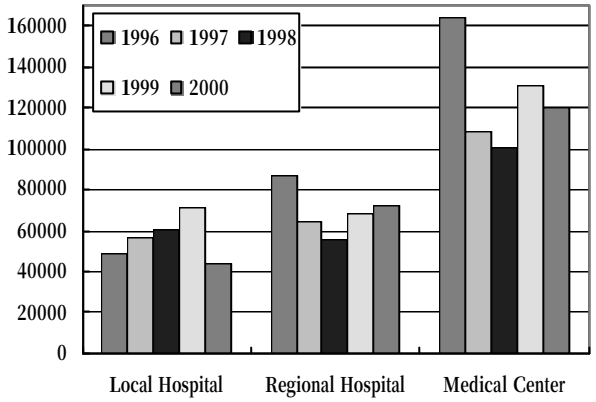

Figure 8. Histogram of total medical fees of overall cases.

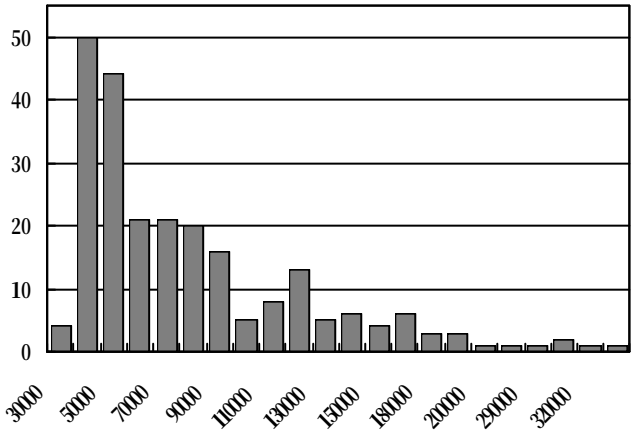

Figure 9. Histogram of total medical fees of one-digit and two-digit cases.

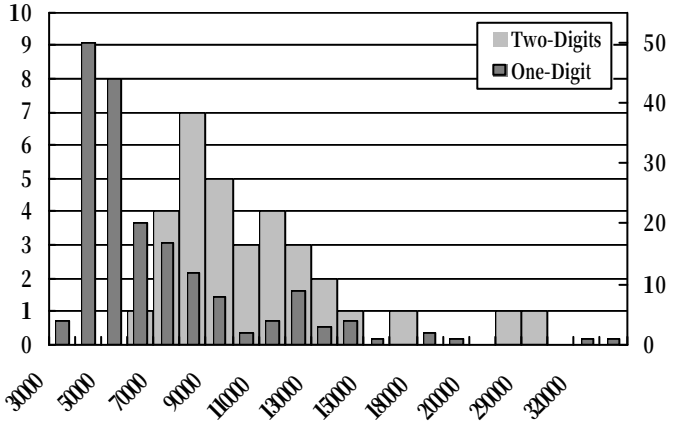

Figure 10. Histogram of hospital stay (days) of one-digit and two-digit cases.