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Cross-Specialty Linkage and Extrapolation of Resource-Based Relative Value Scales

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This article describes methods used to produce a RBRVS (resource-based relative value scales), a common scale from two specialties (internal medicine and general surgery) and explains the newly developed extrapolation process within each specialty. To produce a common scale, we selected six 'same' services as linking services common to both specialties. Then we used the bi-weighted least squares method to locate all the same services on a single, common scale. By using the same method, we tried to extrapolate all the services within each specialty, not by the method of Kelly et al, dividing all the services within the specialty into families (small homogeneous groups of services) to apply charge-based ratios. To compare both methods, we extrapolated all the services of general surgery according to each method. With the correlation analysis to compare both results to American RVUs, we found that general surgery's RVUs from our own extrapolation method turned out to be more highly correlated with American RVUs than from Kelly's extrapolation method. Consequently, extrapolation with bi-weighted least squares method gave reasonable results.

Key Words: Cross linkage, Extrapolation, RBRVS (Resource-Based Relative Value Scales), bi-weighted least squares

To produce a RBRVS (resource-based relative value scales) for physicians' service, it is necessary to combine the relative work of different specialties on a common scale. However, separate specialty-specific work inputs cannot be related directly to each other. Since the reference standard in rating relative work within specialties was a service frequently performed in each specialty and therefore differed from specialty to specialty (Cho *et al.* 1995), it is essential to obtain a method of linking these different specialties for a common scale. In this sense, Braun *et al.* (1988) used the cross linkage method to produce a common scale from the different specialties with different standards for work rating. He defined pairs ("links") of services from different specialties that require approximately equal amounts of intra-service work but later Dr. Hsiao *et al.*(1988, 1990) modified this to develop his own methodology.

The next step to produce a RBRVS is the procedure of extrapolation for each specialty. For this step Kelly *et al.* (1988) used small, homogeneous families of services as the basic unit for the extrapolations and assumed that charges are reasonable indicators of relative work within such families. He then produced the extrapolated work values within each family by multiplying an estimate of work based on survey data by a benchmark procedure using charge-based ratios that represent

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the relationships between surveyed & non-surveyed services. However Levy *et al.* (1992) criticized Kelly's extrapolation method against some limits of using secondary data such as Medicare charge data. Here we adopted the cross specialty comparison method (Hsiao *et al.*, 1990; Kim *et al.*, 1995). But for the extrapolation, we changed and developed a new method in that we asked individual specialists in each subspecialty, formally divided by its own specialty society, to rate the work of all kinds, allocated exclusively and comprehensively to each subspecialty, while we asked individual specialist to rate the work of selected services sampled from each specialty linking services common to both specialties. We called the former set of services as an extrapolating set of services and the latter as a representing set of services.

The reasons we developed a new extrapolation process are as follows. First, there is no appropriate secondary data useful to extrapolation procedure in Korea. Secondly, there are few considerations for variation in existing method only by using mean values with simple ratios for small families of services.

In the light of this situation, we will describe our method of the cross linkage and extrapolation for our two research specialties-Internal Medicine & General Surgery. Furthermore, we will not only submit our results of cross-linkage and extrapolation using our own data, but will also compare the results of extrapolation between Kelly's method and our method for general surgery.

MATERIALS AND METHODS

Cross-specialty linking model

The cross linkage method was developed by Braun *et al.*(1988) and Hsiao *et al.*(1988) to make a common scale for each speciality's work input which cannot be related directly to each other since the reference standards in rating relative work within specialties are different from specialty to specialty. Prior to this linkage process, it is necessary to identify pairs of services from different specialties which require approximately equal amount of work. These services referred to cross-specialty linking services are judged to be the same services or the equivalent services.

The criteria for the same services were that when we consider the process of performing the service and the time spent by the physicians and the types of patients seen, these should be the same for more than one specialty, while equivalent services are not the same services even though specialists concerned may require essentially equal amounts of intra-service work. To apply the cross linking method with the cross-specialty linking services, three assumptions were required.

(1) The mean ratings for intra-service work obtained from our own survey are reasonable for services within a specialty.

(2) When services in different specialties are judged to be the same or equivalent, they involve nearly the same amount of intra-service work.

(3) The ratios of work of various services within a specialty are unchanged even after cross linking procedure.

With above assumptions, Fig. 1 shows the concept of the cross linking method for comparison and extrapolation.

The cross linking method can be explained mathematically as follows.

The data from a specialty provided for all services- i.e., for every service about which the physicians in the specialty were asked for ratings of work and also for the standard service-a value of the logarithm (to the base 10) of the work the service required. That value will be called d. Within a specialty, the sum of these ds was zero. To put it another way, d is a distance on the logarithmic scale for a specialty: the distance from the mean d over all services for the specialty to for the service. For each d, the data also provided a σ, which was an estimate of the standard error of that d.

The purpose of the cross-specialty linkage was to locate all the services from all specialties on a common scale of logarithm of work. Let b_i be the number that should be added to the ds from specialty i to convert them into locations on that common scale. The objective

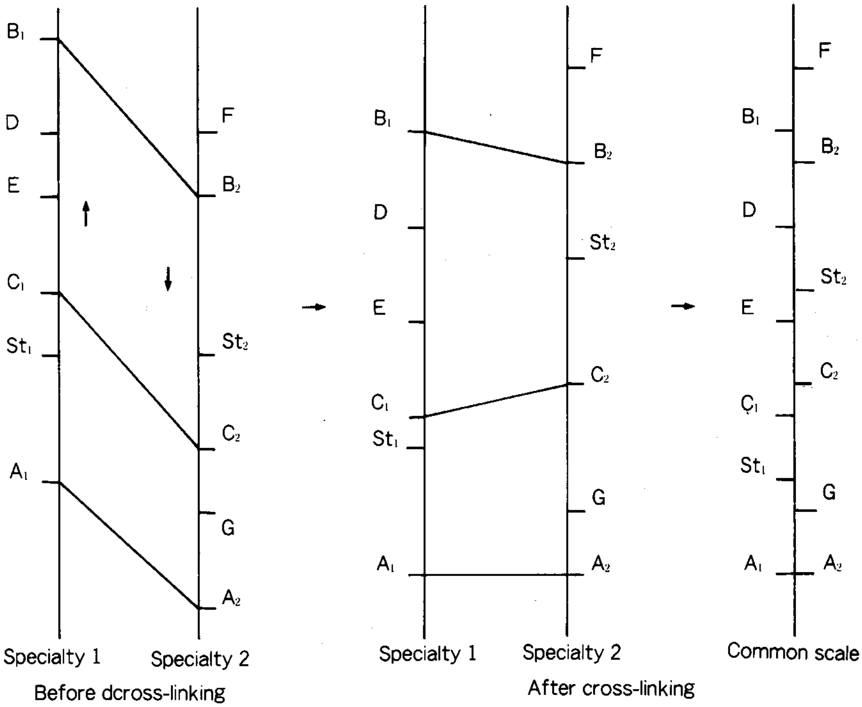

***Fig.1.** The concept of cross linkage.*

was to choose those bs. The bs were chosen with the help of cross-specialty links. Each link consisted of a service whose work was rated by one specialty and a service whose work was rated by another specialty.

Let i be an index that identifies links, and i an index that identifies specialties. Let d_{ij} be the d for one of the two services that form the ith link, specifically, the service from specialty i. Let σ_{ij} be the estimate of the standard deviation of that d. And finally, let a_i be a parameter peculiar to the ith link, where the as were constrained to be the same for the two services forming the link. So d_{ij} can be described as $(a_i - b_j + \varepsilon_{ij})$. In the first attempt to find suitable bs, the as and bs were chosen to minimize this sum of squares:

$$\sum_{ij} \varepsilon_{ij}^2/\sigma_{ij}^2 = \sum_{ij} (d_{ij} + b_i - a_i)^2/\sigma_{ij}^2$$

Then $d_{ij}+b_j$ is the location on the common scale of the service whose d is d_{ij}. The as are not of great interest in themselves; they are really by-products of the linkage procedure. However, a_i can be interpreted as a compromise location on the common scale-that is, a compromise between the locations of the two services that form the ith link. The difference

$$d_{ij} + b_j - a_i$$

is then the distance by which the position of the service whose d is d_{ij} deviates from the compromise position for the link. The relations between the as, bs, ds, and εs are shown in Fig. 2. The square of that deviation is divided by σ_{ij}^2 before the sum of the squares is computed. Weighing the square of the deviation by $1/\sigma_{ij}^2$ allows for the fact that some of the ds are estimated more precisely than others; that is, a d whose σ^2 is large is not allowed to influence the choice of the as and bs as much as a d whose σ^2 is small.

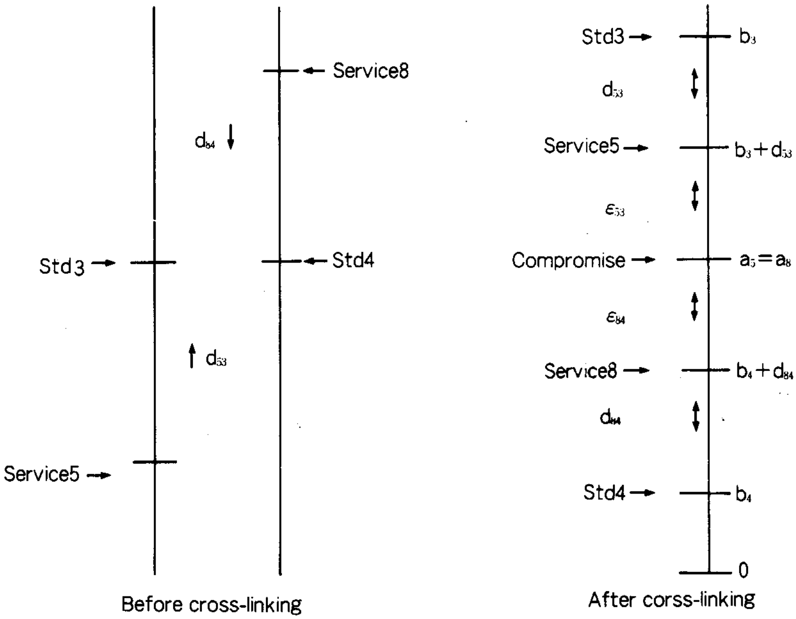

Fig. 2. *The process of cross linkage.*

Some of the deviations

$d_{ij}+b_i-a_i$

could be conspicuously larger in magnitude than most of the others; they are outliers. It would perhaps have been reasonable to conclude that links in which the deviations seemed abnormally large were poorly chosen, and therefore should be discarded. However, that would have required establishing a sharp, arbitrary cutoff beyond which a deviation would be considered large enough to warrant discarding of the link. It therefore seemed better to use a more subtle scheme that would give large deviations less weight in the sum of squares letting the weights get smaller as the deviations get larger in magnitude.

The scheme of "bi-squared weights", or "bi-weights" described by Mosteller and Tukey (1977) was used. The as and bs were chosen to minimize.

$$\sum_{ij} w_{ij}(d_{ij}+b_i-a_i)^2/\sigma_{ij}^2$$

The bi-weight w_{ij} is defined as follows: Let M be the median over all i and j of

$$\frac{|d_{ij}+b_i-a_i|}{\sigma_{ij}}$$

let $u_{ij}=(d_{ij}+b_i-a_i)/(6M\sigma_{ij})$,

and let

$$w_{ij}=(1-u_{ij}^2)^2, \quad \text{if } u_{ij}^2<1$$
$$=0 \quad , \text{if } u_{ij}^2\geq 1$$

The scheme required an iterative computation. The final step yielded the bs that will be used to locate all the services from all specialties on a common logarithmic scale of work. It also provided a standard error for each b and those standard errors will be used below to assess the success of the linkage process. We used the statistical package of GAUSS to estimate a_i and b_i.

Materials

As we mentioned at the end of the introduction, we have two sets of services used for a survey questionnaire given to two sets of survey subjects, the one 'representing set of services' for the sample of all internal physicians and the another 'extrapolating set' of services for the individual specialists within each formal subspecialties working at university hospitals. The sub-specialties in internal medicine were gastroenterology, pulmonary medicine, hemato-oncology, endocrinology, allergy, nephrology, and cardiology. In general surgery, they were formally subspecialized into stomach/hepatobillary surgery, small & large intestinal surgery, breast and endocrine organ surgery. We asked physicians to rate total work plus four dimensions of work which is the same as Dr. Hsiao's method for the 'representing set of services' and total work plus time for the 'extrapolating set of services'. All of them except time were asked to rate with the magnitude estimation. However, the scope of total work for our research was different with Hsiao's in that it included not only intra-service work but also pre & post-service

Table 1. Linking services of internal medicine and general surgery used for compansion between specialties

No	Services	Time(min.)	
		I.M	G.S
1	Hospital admit, 50 year old, LLQ pain & high fever without septic signs.	14.4	14.4
2*	Lymph node incisional biopsy	45.3	32.0
3*	Levin Tube insertion for Gastric Drainage	10.2	7.4
4*	Cut down	35.7	23.5
5*	Intubation Tube insertion	15.5	7.3
6	Foley Catheterization	8.3	7.4

*: Service with over 25% time difference

Table 2. Number of extrapolation(linking) services used for extrapolation process within specialties

	Specialty	No. at planning stage	No. at analysis	Rate of exclusion(%)
Internal medicine	I.M total	21	16	23.8
	Gastroenterology	9	6	33.3
	Pulmonary medicine	6	6	0.0
	Hemato-oncology	7	3	57.1
	Endocrinology	7	4	42.9
	Alleragy	6	4	33.3
	Nephrology	5	3	40.0
	Cardiology	7	4	42.9
	Sum	68	46	32.4
General surgery	G.S total	21	12	42.9
	Stomach/hepatobillary	8	1	87.5
	Intestinal	11	7	36.4
	Breast & endocrine	8	5	37.5
	Sum	48	25	47.9

work. The data were collected three times by mail (Kim *et al.*, 1995) and analyzed for the reliability by Cronbach alpha and Spearman-Brown predictor formula (Cho *et al.* 1995). We started with 6 cross linking services which were same services and not equivalent services in a strict sense at the planning stage for the comparison process between two specialties but we excluded 4 of 6 services which showed over 25% difference in rating time for linking service (Table 1).

For the extrapolation process, we decided to select 68 linking services in medicine and 48 services in general surgery and we named them 'extrapolating services'. However due to over 25% difference in rating time here again, 22 services in medicine and 23 services in G.S were excluded from analysis (Table 2).

RESULTS

Comparison between specialties

The remaining two linking services after exclusion of four from 6 services were used for cross linking method (Table 3). Table 3 shows the inputs to the linkage process and some of the results: the last three columns are results; the others specify the inputs. Each row represents a service that is involved in a link. The first column identifies the linking service. The next one identifies the specialty. Then there are the values of d_{ii} and σ_{ii} used in the linkage process.

The last three columns show some of the results of the linkage. The column headed $d_{ii}+b_i$ gives the location of the service on the combined scale of intra-service work. The column headed $d_{ii}+b_i-a_i$ shows the difference be-

Table 3. Inputs to and results from the cross-specialty alignment

Service	Specialty	d_{ii}	σ_{ii}	$d_{ii}+b_i$	$d_{ii}+b_i-a_i$	$\sqrt{w_{ii}}(d_{ii}+b_i-a_i)/\sigma_{ii}$
1	Internal medicine	0.2971	0.0290	1.8825	−0.0195	−0.6662
	General surgery	0.0804	0.0570	1.6691	0.0807	1.3549
6	Internal medicine	−0.4459	0.0511	1.9654	0.0634	1.2006
	General surgery	−0.8678	0.0433	1.5336	−0.0447	−1.0084

Table 4. Results from the quantitative linkage of specialties: Estimated regression parameters for d̲ and their standard errors

Specialty	Reference standard	b_i	Standard error	Percent standard error
Internal medicine	Initial office evaluation of groos hematuria, with no pain	1.5886	0.2234	67.3
General surgery	Appendectomy	2.4114	0.2234	67.3

Table 5. Results from the quantitative linkage of subspecialties for extrapolation: Estimated regression parameters for b and their standard errors

	Specialty	b_i	Standard error	Percent standard error	Reference standard
I.M	I.M total	1.7893	0.0352	8.4	Initial office evaluation of gross hematuria, no pain
	Gastroenterology	2.0575	0.1082	28.3	Gastroscopy
	Pulmonary medicine	1.7242	0.0877	22.4	Follow-up visit, 45 year old, chronic bronchitis treatment for 4years
	Hemato-oncology	1.9056	0.1713	48.3	Initial office visit 73 year old male, unknown weight loss 10 kg
	Endocrinology	1.6689	0.1425	38.8	Follow-Up office visit 70 year old, changed insuline dosage recently
	Allergy	1.7769	0.2750	88.4	Follow-Up consult 71 year old Pneumonia, Hosp. pt. skin lesion after antibiotic therapy
	Nephrology	2.1607	0.1580	46.9	re-admit 70 year old, female pyelonephritis discharged 1 wk. ago
	Cardiology	1.9420	0.0858	21.8	Follow-up visit 65 year endocarditis with anibiotic therapy, recent fever
G.S	G.S Total	2.2318	0.0360	8.6	appendectomy
	Stomach hepatobilliary	2.3183	0.1699	47.9	simple closure of perforated stomach or duodenum
	Intestinal	2.0375	0.1173	31.0	hemorrhoidectomy
	Endocrine	1.9001	0.1267	33.9	inguinal herniorrhaphy including intestinal resection

Table 6. RVU of general surgery after extrapolation with cross linking method

Services	RVUs after extrapolation	Services	RVUs after extrapolation
Simple closure of perforated stomach/duedenum	429.4	Inguinal herniorraphy with intestinal resection	412.4
Gastrotomy	300.6	Op. for umbilical hernia with intestinal resection	497.5
Gastrotomy with biopsy	347.1	Op. for umbilical hernia, others	296.8
Total gastrectomy	1090.1	Op. for incisional hernia with intestinal resection	432.6
Closure of gastroduodenal bleeding	429.7	Op. for incisional hernia, others	364.5
Truncal vagotomy	581.9	Inguinal herniorraphy, others	290.1
Vagotomy and pyloroplasty	630.6	Drainage of perirectal abscess	183.1
Vagotomy and gastroenterostomy	630.6	Rectal polypectomy	210.4
Fredet-Ramstedt operation	437.9	Resection of rectum	588.2
Gastrojejunostomy	533.9	High rectal fistulectomy	422.7
Gastrostomy	434.2	Op. for rectal malignancy	722.9
Excision of breast benign tumor	229.5	Repair or rectal prolapse, incomplete	460.5
Simple mastectomy	542.7	Repair or rectal prolapse, complete	562.7
Radical mastectomy	975.7		
Subcutaneous mastectomy	504.2		

Table 7. RVU of general surgery after the extrapolation with Kelly's method(small family concept)

Benchmark service	RVU after comparision	Services of family	Value within family	RVU after extrapolation
Simple colosure of perforated stomach or duodenum	543.7	Simple closure of perforated stomach/duedenum	100.0	543.7
		Gastrotomy	95.5	519.4
		Gastrotomy with biopsy	110.3	599.7
		Total gastrectomy	346.4	1883.6
		Closure of gastroduodenal bleeding	136.5	742.4
		Truncal vagotomy	184.9	1005.5
		Vagotomy and pyloroplasty	200.4	1089.7
		Vagotomy and gastroenterostomy	200.4	1089.7
		Fredet-Ramstedt operation	139.2	756.7
		Gastrojejunostomy	169.7	922.6
		Gastrostomy	138.0	750.2
Excision of breast benign tumor	216.7	Excision of breast benign tumor	201.8	216.7
		Simple mastectomy	451.8	485.1
		Radical mastectomy	812.3	872.2
		Subcutaneous mastectomy	419.8	450.7
Inguinal herniorraphy with intestinal resection	600.0	Inguinal herniorraphy with intestinal resection	250.2	600.0
		Op. for umbilical hernia with intestinal resection	239.7	574.8
		Op. for umbilical hernia, others	179.6	430.7
		Op. for incisional hernia with intestinal resection	262.5	629.4
		Op. for incisional hernia, others	221.1	530.3
		Manual reduction for incarcerated hernia	140.4	336.8
		Inguinal herniorraphy, others	176.0	422.0
Drainage of perirectal abscess	167.5	Drainage of perirectal abscess	120.6	167.5
		Rectal polypectomy	127.7	177.3
		Resection of rectum	356.9	495.6
		High rectal fistulectomy	256.5	356.2
		Op. for rectal malignancy	438.5	609.1
		Repair or rectal prolapse, incomplete	279.4	388.0
		Repair or rectal prolapse, complete	341.4	474.1

tween that location and the compromised location for the link. The column headed $\sqrt{w_{ij}}(d_{ij}+b_i-a_i)/\sigma_{ij}$ shows the weighted deviation: it is the sum of the squares of these weighted deviations that the as and bs were chosen to minimize.

Other results are shown in Table 4. It shows the b for each specialty. Those bs are perhaps the most important results. They determine how the work required by the services in one specialty is related to the work required by the services in another specialty.

With each b, the table shows an estimate of the standard error of each b. Those standard errors indicate the precision of the bs.

The standard errors in Table 4 are on the logarithmic scale of work. The final column converts them to the percentages on the original scale of work.

Extrapolation into each specialty

Using the cross linkage method: Consider-

Table 8. Results of correlation analysis

	1	2	3
1	1.0000	0.9052	0.8206
2		1.0000	0.7410
3			1.0000

1: Extrapolation with cross linking method
2: Extrapolation with Kelly's method
3: American RVU

ing our research model, if we use a cross linkage method again in the extrapolation process not the same as Dr. Hsiao's method based on charge-based extrapolation, we can produce other b_i shown at Table 5.

The standard errors in Table 5 are also on the logarithmic scale of work and show a broad range from 0.0352 to 0.2750. As in the case of comparison between specialities, the range of standard errors are directly related to the number of linking service used by the extrapolation process. In this context, 'Internal Medicine (I.M) total' and 'General Surgery (G. S) total' which have more linking services than other subspecialties as shown at Table 5 can get lower standard errors, while other subspecialties are *vice versa*.

We attempted to extrapolate for each specialty using estimated b_i shown at Table 5. Here we standardized b_i of each subspecialty not to be influenced from b_i estimated at the stage of comparison between specialties by converting both values of 'internal medicine total(1.7893) and general surgery total(2.2318)' to the value of '2'.

To compare this with the extrapolation method using the family group (Kelly's method), we submitted some RVUs of general surgery at Table 6.

Using the family group concept: We classified all the services of general surgery into 17 families to follow the method of Kelly *et al.* (1988). The benchmark services selected from each families were as follows; cut down, insertion of intubation tube, Foley catheterization, insertion of Levin tube for gastric drainage, nasogastric tube feeding, simple dressing, simple closure of perforated stomach or duodenum, subtotal gastrectomy with lymphatic dissection, excision of breast benign tumor, exploratory laparotomy, appendectomy, inguinal herniorrhaphy including intestinal resection, drainage of perirectal abscess, hemorrhoidectomy, cholecystectomy, and unilateral subtotal thyroidectomy.

We submitted a part of extrapolation results using small family concept after the comparison between specialties in Table 7.

Comparison of extrapolation methods by correlation analysis: We tried to compare both of the results in this study with the American physician RVU(AMA, 1992) by correlation analysis. Table 8 shows that the extrapolation process with 'cross linkage' has a higher correlation with the American RVU than using 'small family' adopted by Kelly *et al.* (1988).

DISCUSSION

In RBRVS which measures work input for physician's services in many specialties, the process such as a cross linking process is essential and very important because separate specialty-specific work input can not be compared directly to each other if it is not on a common scale. Braun *et al.*(1988) used both of the same services and the equivalent services as linking services to make a common scale by the cross linking method. It is not so easy to select such services done by all specialties simultaneously since the assumption is based on similarity of work input and its variation between and within specialties.

However as to equivalent services, it is difficult to make a consensus among compared physicians. As a result, it is necessary to keep the number of linking services over 8 kinds (Hsiao *et al.*1992). But at the beginning stage, we took 6 kinds of 'same service' of which four services were excluded and so just 2 services remained for the analysis because rating time differences of those 4 services were over 25% within each specialties. Moreover, those remaining 2 services also showed time difference between specialties, but not over 25%. These results may give such a negative effect on the validity of our results that it will limit interpreting our comparison between specialties.

The extrapolation process within specialties repeatedly adopted the same cross linkage method already used by the comparison process between specialties but asked individual sub-specialists working at university hospitals to rate total work and time not the same as comparison process. The reason why we used cross linkage method again for the extrapolation process instead of using Kelly's method is that there is no appropriate secondary data to make homogenous small families for the extrapolation in Korea so far and if any, extrapolation with the cross linkage method considering not only mean values but also its variation is thought to be better than the application of simple ratios considering only the mean values from the small families of services. Furthermore, RBRVS developed by Hsiao *et al.* (1990) was reviewed and modified by the Carrier Medical Director suspecting that Medicare charge data used for extrapolation process may affect the results as secondary data (HCFA, 1991) usually.

However, we are not sure that the extrapolation with the cross linkage method is better practically, even though its concept may be better than extrapolation with the small family concept. The reason is that the selection of the reference standard for extrapolation with the cross linkage method still has so many problem as we can see in the comparison between specialties that 47.6% of linking services in our study were excluded.

In light of this situation, we would like to suggest some changes in our survey method for future study and it will help our method of the extrapolation process be more refined; after we get the values of 'representing set of services', we are supposed to give these mean values to individual subspecialists in advance for 'extrapolating set of services' to rate work input relative to these mean values without the reference standard rather than ask them to rate relative values according to each reference standard separately as done by our study. This approach will make the analysis more simplified and the specialists' agreement process more easy.

The standard errors of b_is after comparison between specialties happened to be the very same 0.2234 (67.3%) but those after extrapolation ranged from 8.4% to 88.4%. This broad range of standard errors is thought to be very high when we consider the results (1.6%-9.3%) of Dr. Hsiao *et al.* (1990) and therefore must be influenced by the few number of linking services. In other words we can say that this high % of standard error had a negative effect on our results.

When we look at the results of correlation analysis more carefully, the fact that extrapolation with the cross linking method correlated to USA RVU higher than the extrapolation with small family concepts doesn't mean that the former is better than the latter. The reasons are that we are unable to compare the procedures between countries directly and ascertain the validity of the small families in both countries.

Nevertheless, the extrapolation with the cross linking method may be regarded as more reasonable since American RVU reflect physician work input properly and the procedures of general surgery usually need more sophisticated techniques not influenced by medical environmental change and we cannot deny absolutely the validity of small family classification so far.

After we implemented the comparison process between specialities and the extrapolation process based on our new method, we came to the following conclusions; First, if we have more linking services for both processes (comparison between specialties & extrapolation within each specialty), we could get more valid results. Secondly, we would rather take both the same service and equivalent service as a linking service for the future study.

Thirdly, though we have some limits in our study as above, the extrapolation with 'the biweighted least squares method of the cross-linkage method' showed more reasonable results than extrapolation with the charge-based ratios applying the small family concept (Kelly's method).

Yet, there may be still some limits of interpreting our results because many services selected at the beginning stage have been excluded through analysis.

REFERENCES

American Medical Association: Medical Physician Payment Reform: The Physician's Guide. *1992*

Braun P, Yntema DB, Dunn D, DeNicola M, Ketcham T, Verrilli D, Hsiao WC: Cross-specialty linkage of Resource-Based Relative Value Scales: Linking specialties by services and procedures of equal work. *JAMA 260(16): 2390-2396, 1988*

Cho WH, Sohn M, Park UC, Kim HJ, Hur YJ, Kang HG, Kim YK: Measurement and Analysis of Physician Work. *Korean J Health Policy Administration 5(2): 213-229, 1995*

Health Care Financing Administration: Medicare program: Fee schedule for physicians services; Proposed rule. *Federal Register 56(108): 25792-25798, 1991*

Hsiao WC, Braun P, Becker E, Causino N, Couh NP, DeNicola M, Dunn D, Kelly NL, Ketcham T, Sobol A, Verrilli D, Yntema DB: A National Study of Resource-Based Relative Value Scales for Physician Services: Final Report. *Massachusetts, Cambridge, Harvard School of Public Health, 1988, 355-451*

Hsiao WC, Braun P, Becker ER, Dunn DL, Kelly NL, Yntema DB: A National Study of Resource-Based Relative Value Scales for Physician Services: Phase II. Final Report. Massachusetts, Cambridge, Harvard School of Public Health, *1990, 300-381*

Hsiao WC, Braun P, Dunn DL, Becker ER, Yntema D, Verrilli DK, Stamenovic E, Chen SP: An Overview of the Development and Refinement of the Resource-Based Relative Value Scales: The Foundation for Reform of US Physician Payment. *Med Care 30(11): NS1-12, 1992*

Kelly NL, Hsiao WC, Braun P, Sobol A, DeNicola M: Extrapolation of measures of work for surveyed services to other services. *JAMA 260 (28): 2379-2384, 1988*

Kim HJ, Cho WH, Sohn M, Jun BY, Park UC, Lee SH, Kang HG, Hur YJ, Won JW, Kim YK: An overview of RBRVS in Korea. *Korean J Health Policy Administration 5(2): 202-212, 1995*

Levy JM, Bonowitz M, McNeill S, London WJ, Savord G: Understanding the Medicare Fee Schedule and its impact on physicians under final rule. *Med Care 30(11): NS80-94, 1992*

Mosteller F, Tukey JW: Data Analysis and Regression. Philippines, Addison-Wesley Publishing Company, Inc., *1977, 356-365*