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Structural Modeling of Differential Diagnosis, Treatment, and Results for Allergic Rhinitis

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This paper analyzed the relationship among the differential diagnosis, treatment, and results for allergic rhinitis using the covariance structural model. The data were collected from 274 patients with suspected allergic rhinitis who visited the Otorlaryngology Department of the Paik Hospital during 1991-1993. After each patient's characteristics was categorized and combined into several common factors, covariance structure analysis was performed to analyze the structural relationships among the differential diagnosis, treatment, and results of treatment using the significant factors obtained from discriminant analysis. The significant characteristics influenced the diagnosis were the results of skin test from mite/animal, and from mugworts, the results from laboratory tests, rhinorrhea and sneezing, and nasal polyps. The significant characteristics that influenced the method of treatment were: nasal polyps, headache/general symptom, family history/medication, and septal deviation. Headache/general symptom was the only significantly influencing factor for the treatment results.

Key Words: Allergic rhinitis, covariance structure modeling, factor analysis, discriminant analysis

Allergic rhinitis has ranked as the sixth most prevalent chronic condition in the United States, outranking heart disease (Smith, 1988). In England, morbidity from allergic rhinitis had increased twofold from 1974 and 1982 (Fleming, 1987), and furthermore, its prevalence rate ranged from 10 to 15 percent in 1987 perhaps due to environmental changes (Trigg, 1991). According to the Japan National Health Insurance records, morbidity from allergic rhinitis had increased threefold during the 10 year period from 1981 to 1990 in Japan (Miyao *et al.* 1993). While the exact prevalence of allergic rhinitis is not known in Korea, there are many indications that its prevalence is also increasing in recent years as air-pollution becomes a more serious problem, and as foreign plants are imported.

Allergic rhinitis implies the existence of a hypersensitive response to foreign allergens mediated by IgE antibodies. The most common allergens include pollens of grasses, weeds, and trees; animal danders; house-dust mites; insects; mold spores; and foods. The hallmark of allergic rhinitis is the temporal correlation of nasal symptoms with exposure to allergens.

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A thorough clinical history, and physical examination are basic to the diagnosis of nasal allergy. There are several complementary tests which have proven to be useful. The most widely used are skin tests and specific IgE (mainly RAST) tests. However, no test is completely reliable, and often the diagnosis is based exclusively on clinical findings (Romero and Scadding, 1992).

The treatment of a patient with allergic rhinitis also largely depends on experience. The major obstacle in proposing a logical approach to therapy is the limited information available on the natural history of allergic rhinitis along with its prognosis without treatment. The symptoms of allergic rhinitis remit completely in 5 to 10 percent of patients. However, it is not known what percentage of patients with allergic rhinitis have persistent symptoms from nonallergic rhinitis or from complications such as chronic sinusitis. Therefore, recommendations towards therapy vary from the minimum amount required to the obtain symptomatic relief to the aggressive approach aimed at altering the natural history of the disease (Naclerio, 1991).

Many studies on allergic rhinitis have also been conducted in Korea. Most of these studies dealt with patient characteristics such as symptoms (Kim *et al.* 1980; Moon *et al.* 1983), aggravating factors (Song *et al.* 1982), past and family history (Song *et al.* 1982; Oh *et al.* 1989), skin tests (Kim *et al.* 1990; Yoo *et al.* 1991), and physical examinations (Min *et al.* 1983). However, most of such studies of allergic rhinitis have focused on describing the individual patient characteristics and risk factors separately using descriptive statistics (e.g. mean, percentage). Therefore, the relative importance of these factors could not be compared together and their statistical significance could not be established. In addition, no study has attempted to collectively analyze a structural relationship among patient characteristics, diagnosis, treatment method, and results within the same model.

In this study, the structural relationship among such variables for allergic rhinitis patients were analyzed using the covariance structure modeling (CSM) approach. During the last decade, CSM has emerged as a powerful technique to investigate structural relationships among variables and to test theories. In practicing science, it is desirable for an investigator to be able to control the variables of interest and thereby observe the effects of such variation on some external criteria, i.e. dependent variables. Most animal studies provide a better situation for controlling the variables in the experimental laboratory. However, in non-experimental studies based on patient data such as this study, comparable control is not accessible. The solution is observe the relationships among variables, which result is sampled from the population as a form of sample covariance (correlation) matrix. CSM is the most popular technique in specifying and testing a model's fit to covariance data set. While CSM has never been used in analyzing allergic data, it has been widely used in the fields such as education (Alwin and Arland, 1984), psychology (Lee, 1987), demography (Beckman *et al.* 1983), and epidemiology (Lee, 1993; Kim, 1993).

The purposes of this study were to examine the patient characteristics affecting the differential diagnosis, the treatment, and the results of allergic rhinitis, and then to determine a structural relationship among these factors using the CSM. This analysis can better help in understanding the structure of these relationships, and may provide additional therapeutic information for allergy patients.

MATERIALS AND METHOD

Subjects

The subjects of the study were 440 patients with allergic symptoms who visited the Otolaryngology Department of Inje University Paik Hospital from September 1 1991 to August 31 1993. The patient characteristics, physical examination, laboratory test, diagnosis, treatment methods, and results of 274 patients who had complete information about questionnaire were used in the data analysis.

Methods

The relationships among patient characteris-

Table 1. Category of allergic patient characteristics

Category	Content
1. Symptom	runny nose, itching eye, headache, general symptom
2. Severity	serverity of symptom, duration of symptom during a day/year frequency of sneezing
3. Time factor	time of manifestation, duration of symptom during a day, duration of symptom during a year
4. Aggravating factor	aggravating factor from house (dusting, smoking, etc.) aggravating factor from work place (cold air, etc.)
5. History Medication	past history, family history, medication (antibiotics)
6. Physical examination	mucosal color, anatomic defects, character of discharge
7. Laboratory test	prick test on 11 allergens, laboratory test(IgE, Eosinophilia)

tics, differential diagnosis, treatment methods, and results were analyzed according to the following steps.

Determination of common factors on patient characteristics: The patient characteristics were acquired through 42 questionnaire items, a physical examination, and a laboratory test. Since there were too many variables that could be possible for statistical analysis, these variables were incorporated into a smaller number of common factors using factor analysis (Chae *et al.* 1989). As seen in Table 1, the patient characteristics were first divided into 7 homogeneous categories, and then using factor analyis, common factors were derived from each category.

Determination of factors affecting the diagnosis and treatment results: The scores for the common factors, obtained from step 1, were used as independent variables to determine which factors were important in predicting the diagnosis and the treatment results in the discriminant analysis. Two types of dependent variables were used in the analysis: differential diagnosis (1=allergic rhinitis, 0=non-allergic rhinitis) and treatment result (1=improved, 0=not improved). The patients were classified as improved cases if they fell into one of the two categories after they were followed up for six months: ① the symptoms completely disappeared after the treatment; ② the symptoms disappeared for a few months after the treatment but the patient revisited the hospital with a recurred symptom. The latter cases were classified as improved cases because the effectiveness of the treatment could be defined for a certain period. Those cases which demonstrated otherwise were classified as not-improved. Non-allergic rhinitis was comprised of three diagnostic categories: probable allergic rhinitis, non-allergic rhinitis, and sinusitis.

Analysis of the relationship among the patient characteristics, diagnosis, treatment methods, and results:

Model specification; The significant factors on patient characteristics identified from step 2 were used as the independent variables for determining the structural relationship among the patient characteristics, diagnosis, and the treatment results based on the covariance structure model (CSM). The relationship between patient characteristics and treatment methods were determined by clinical judgement. The variables were recategorized for the analysis as follows: treatment (1=surgery, 0=drug therapy) and results (0.25=no change, 0.5=little improvement, 0.75=much improvement, 1.0=cured). Since the measurement of these variables was mixture of ratio variables, ordinary variables, and nominal variables, ordinary path analysis could not be used. The CSM used in this study not only can handle all these variables, but has the capability of handling the measurement error for each variable.

CSM is well known by other names, such as the simultaneous equation model, the linear structural relations (LISREL) model, or the causal model. All of these different names represent techniques concerned with hypothesizing, testing, modifying, and cross-validating models to analyze the empirical covariance data (Lee, 1987). Historically, the CSM is an outgrowth of path analysis in biometrics and factor anlysis used in psycometrics. Path

analysis is concerned with the network of measured variables that are explicitly observed. Factor analysis involves extracting factors which are latent in a set of measured variable (MV). The MV is a variable that is directly observed and measured, whereas a latent variable (LV) is a hypothetical construct that is not directly measurable, but rather is approximated by using valid and reliable MVs as indicators. In this study, the three latent variables (diagnosis, treatment method, and result) were determined from the three aforementioned measured variables by assuming 20 % measurement error based on clinical judgement. That is, λ_y was assumed to be the variance of MV×0.8, and $\varepsilon$was assumed to be the variance of MV×0.2.

A covariance structure model generally consists of two submodels: measurement model and structural model. CSM is a general method of modeling and testing the relationships among the MVs and LVs. Given the sample covariance data of MVs, one can estimate the unknown parameters and evaluate the goodness of fit of the model. A brief review of the mathematical framework of the CSM is presented here to define the equations (Fig. 1).

Structural Equation Model: $\eta = B\eta + \tau\xi + \zeta$

Measurement model: $Y = \lambda_y\eta + \varepsilon$, $X = \lambda_x\xi + \delta$

where

X: independent MV (patient characteristics)

Y: dependent MV (Y_1=diagnosis, Y_2=treatment method, Y_3=result)

ξ: independent LV, η: dependent LV

δ: error of independent MV, ε: error of dependent LV

ζ: equation error of residual

λ_x: factor loading of X on ξ, λ_y: factor loading of Y on η

τ: path coefficient matrix between independent LV and dependent LV

(γ: indivisual path coefficient)

B: path coefficient matrix between dependent LVs

(β :individual path coefficient)

Model evaluation; The proposed model was evaluated in terms of the overall fit. Multiple fit indexes were adopted due to the lack of an single best accepted index at present. They

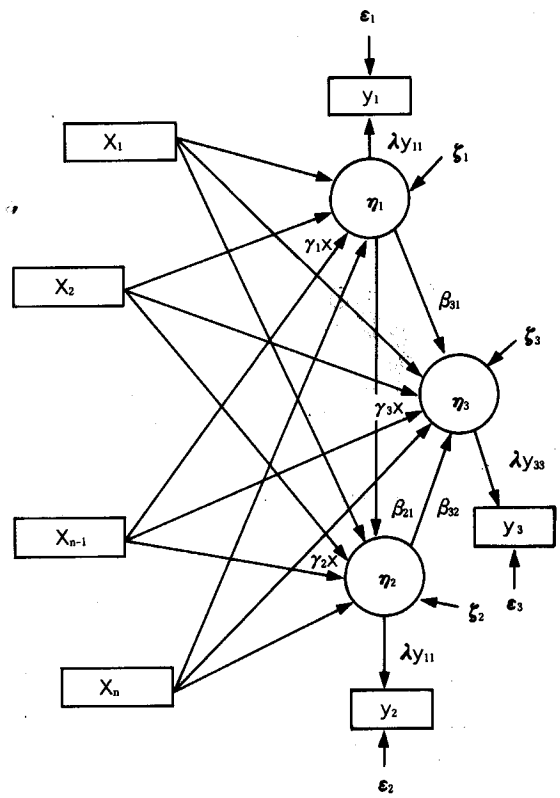

Fig. 1. Frame of covariance structure model for allergic rhinitis.

are: χ^2 (chi-square), χ^2/df (degrees of freedom), Goodness-of-fit Index (GFI), Adjusted Goodness-of-fit Index (AGFI), and Critical N (CN). χ^2 tests the null hypothesis stating that there is no difference between the model-implied covariance matrix (or the proposed model) and the observed covariance matrix. χ^2 test is known to be sensitive to large samples, and to depart from the multivariate normality of observed variables (Bollen, 1989; Joreskog and Sorbom, 1989). Both predicaments inflate an obtained χ^2 value and thereby may lead to the rejection of an acceptable model. Due to these problems of χ^2 test, χ^2/df was suggested instead as a measure of a goodness-of-fit whre small values of this ratio (less than 2) indicate a good fit (McIver, 1981). GFI measures "the relative amount of variances and covariances in the observed covariance matrix jointly ac-

counted for by the model" and AGFI adjusts for the degrees of freedom (Joreskog and Sorbom, 1984). Both indexes range between 0 and 1. Finally, CN is the number of samples that must be attained in order to accept the fit of a given model. Hoelter (1983) suggested that CN values exceeding 200 indicate an acceptable fit.

Analysis of characteristics affecting the results for the allergic rhinitis patients treated by antihistamine and steroid: While the above analysis provided overall information on the relationship between the common factors of patient characteristics and results, it did not specifically tell us when a certain treatment (e.g. antihistamine and steroid) would be effective for the patients diagnosed with allergic rhinitis. To obtain such information, categorical data analysis using λ (asymmetic lamda) statistic between the patient characteristics and the results was performed for allergic rhinitis patients treated by antihistamine and steroid. λ measures the association between two variables in a cause-effect relationship.

RESULTS

Determination of common factors from patient characteristics

As seen in Table 2, several common factors were derieved from each of 7 categories of patient charcteristics: 6 factors from the symptom category, 4 factors from the severity category, 3 factors from the time factor category, 2 factors from the aggravating factor category, 5 factors from the family and past history category, 6 factors from the physical examination category, and 4 factors from the test category. These common factors were selected based on the four statistics in factor analysis: factor loading used to represent the relationship between variables and factors, communality to represent the rate of the variation of variables explained by factors, the eigen value to represent the total variation explained by the factor, the total variance to represent the percentage of the eigen value, and its cummulative variance. Only the eigen values and the cummulative variances were given in Table 2.

Determination of factors affecting the diagnosis and the treatment results

Results of discriminant analysis for the diagnosis: The significant factors affecting the diagnosis were selected from the discriminant analysis using the factors obtained in the previous step. As seen in Table 2, the following factors were selected from each category of patient characteristics: itchy nose and sneezing from the symptom category, daily predominance from the time factor category, discharge and presence of polyps from the physical examination category, and all four factors from the laboratory test categories.

The predictive capability of the discriminant model was examined by the three measures seen in Table 3: the specificity was 71.3%, the sensitivity was 91.3%, and the correct prediction rate was 81.3%.

Results of discriminant analysis for the treatment results: The following factors affecting the treatment results were selected from each category of patient characteristics (Table 2): headache and general symptom from the symptom category, daily predominance from the time factor category, working condition (cold air, etc.) from the aggravating factor category, medication from the history category, skin test (mold, etc.) from the test category. Compared to the diagnosis model, predictive power for this model was lower than the model for the diagnosis. As seen in Table 4, the specificity for the model was 61.4 %, the sensitivity was 50.0%, and the correct prediction rate was 56.0%.

Covariance structure model

Relationship among diagnosis, treatment methods, and results: Before the CSM, the overall relationship among diagnoses, treatment methods, and results were analyzed as seen in Table 5. The success rate from drug therapy was greater for the allergic rhinitis patients than non-allergic rhinitis patients. Moreover, drug therapy was more effective than surgery for allergic rhinitis patients.

Table 2. Results of factor analysis on patient characteristics

Category of Patient char.	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Symptom	Runny nose Itching eye (2.3, 16.3)	Headache[a] general symptom (1.6, 281.1)	Itching nose[a] Sneezing (1.1, 36.2)	Rhinorrhea (1.1, 43.9)	Nasal obstruction (1.1, 51.5)	Hyposmia (1.0, 58.6)
Severity	Nasal obstruction (2.2, 21.7)	Duration of symptom during day (1.3, 34.3)	Frequency of sneezing (1.1, 45.6)	Duration of symptom during year (1.0, 56.0)		
Time factor	Seasonal predominance (1.6, 20.3)	Daily[a,b] predominance (1.4, 37.9)	Before sleep (1.1, 52.0)			
Aggravating factor	House (dusting, smoking) (1.9, 26.7)	Work place (cold air)[b] (1.2, 44.0)				
History	Past history (Asthma) (1.4, 14.3)	Past history (nasal surgery uritcaria, etc) (1.3, 27.2)	Family history (1.2, 27.2)	Atopy (1.1, 49.8)	Medication[b] (antibiotics) (1.0, 60.0)	
Physical examination	Mucosal color (Pink, Bluish) (2.4, 21.4)	Septal[a] deviation (1.6, 35.9)	Presence of[a] nasal polyps (1.3, 47.8)	Swelling (1.2, 58.3)	Middle meatal block (1.1, 67.9)	Mucosal color (Pale) (1.0, 77.2)
Test	Skin test[a] (Mite, animal) (3.5, 28.9)	Skin test[a,b] (mold, tree) (2.3, 48.4)	Laboratory[a] test(IgE, Eosinophilia) (1.3, 59.6)	Skin test[a] (Mugwor) (1.1, 68.4)		

Figures in parenthesis are eigen value and cummultive variance of each factor
a: Factors significantly affecting the diagnosis
b: Factors significantly affecting the treatment result

Table 3. Predictive power of the discriminant model for diagnosis

Actual	Predicted: Non allergy	Predicted: Allergy	No. of cases	Correct prediction rate
Non allergy	158(91.3)[a]	15(8.7)	173	81.3%
Allergy	29(28.7)	72(71.3)[b]	101	

a: Specificity
b: Sensitivity

Table 4. Predictive power of the discriminant model for treatment result

Actual	Predicted: Not improved	Predicted: Improved	No. of cases	Correct prediction rate
Not improved	49(50.0)[a]	49(50.0)	98	55.7%
Improved	68(38.6)	108(61.4)[b]	176	

a: Specificity
b: Sensitivity

Table 5. Relationship among diagnosis, treatment method, and result

Diagnosis	Treatment method	Result				Sub total
		No change	Little improvement	Much improvement	Cured	
Allergic rhinitis	Drug therapy	4(4.71)	21(24.71)	43(50.59)	17(20.00)	85(100.0)
	Surgery	1(6.25)	7(43.75)	8(50.00)	0(0.00)	16(100.0)
	Sub total	5(4.95)	28(27.72)	51(50.50)	17(16.83)	101(100.0)
Non-allergic rhinitis	Drug therapy	6(5.50)	35(32.11)	57(52.29)	11(10.09)	109(100.0)
	Surgery	6(9.38)	18(28.12)	35(54.69)	5(7.81)	64(100.0)
	Sub total	12(6.94)	53(30.64)	92(53.18)	16(9.25)	173(100.0)
	Total	17(6.20)	81(29.56)	143(52.19)	33(12.04)	274(100.0)

( ): percentage

Table 6. Goodness of fit test for the covariance structure model

Goodness of fit index	Value
Chi square (degree of freedom)	12.41(28)
p-value	0.005
Chi square/degree of freedom	0.44
Goodness of fit index	0.994
Adjusted goodness of fit index	0.973
Critical N	903

Model evaluation: Effects of the patient characteristics on these relationships were further analyzed by the CSM. Since there is a limitation on the number of variables which can be used in the CSM, 3 factors (daily predominance, pale mucosal color, skin test on mold) out of 16 significant factors obtained from the discriminant analysis were omitted from the model based on the clinical judgement.

As seen in Table 6, χ^2 value was 12.41 and

Table 7. Standardized variance/covariance among the patient characteristics

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
Runny nose/itching eye(X_1)	1.00												
Heedache/general symptom(X_2)	.0	1.00											
Rhinorrhea/sneezing(X_3)	.0	.0	1.00										
Nasal distruction(X_4)	.0	.0	.0	1.00									
Severity of nasal obstruction(X_5)	−.04	−.13*	0.7	−.12*	1.00								
Aggravating factor (cold air, X_6)	.21*	.23*	.14*	.06	−.12*	1.00							
Past history(Asthma)(X_7)	−.04	.17*	.13*	.14*	−.07	.10	1.00						
Family history, medication(X_8)	.8	−.00	.10	.02	−.02	.10	.0	1.00					
Septal deviation(X_9)	.14*	−.03	.24*	.00	.10	.09	−13*	0.7	1.00				
Nasal polyps(X_{10})	−.07	−.05	−.07	.01	−.06	0.3	−0.1	.02	.0	1.00			
Skin test(mite, animal)(X_{11})	.17*	−.01	.25*	−.01	.08	.05	.07	.11	.11	−.20*	1.00		
Laboratory test(IgE), (Eosinophilia)(X_{12})	.01	−18*	.07	−.02	−.00	−.13*	−.07	.02	.15*	−.01	.0	1.00	
Skin test(Mugwort)(X_{13})	.08	−.08	−.02	.10	.01	−.17*	−.04	.01	.00	.05	.0	.0	1.00

*$P<0.05$

its p-value was 0.995. This indicates that the model-implied variances and covariances were not significantly different from the observed covariance matrix. This result strengthens the fit of the model. The χ^2/df value was 0.44, which is within the range of an acceptable fit.

Table 8. Effects of the patient characteristics on diagnosis, treatment methods, and results

	Diagnoisis	Treatment method			Treatment result		
	Direct effect(γ_{1x})	Direct(γ_{2x})	Indirect	Total	Direct(γ_{3x})	Indirect	Total
Runny nose/itching eye	–	0.072	–	0.072	0.073	−0.005	0.068
Headache and general symptom	–	0.172*	–	0.172	−0.157*	−0.012	−0.169
Rhinorrhea/sneezing	0.178*	–	–	–	–	–	–
Nasal obstruction	–	−0.071	–	−0.071	–	–	–
Severity of nasal obstruction	–	−0.073	–	−0.073	0.054	0.005	0.059
Aggravating factor (cold air, etc)	0.060	–	–	–	−0.116	0.003	−0.113
Past history (asthma, etc.)	−0.033	–	–	–	−0.087	−0.002	−0.089
Family history, medication	–	−0.160*	–	−0.160	0.038	0.011	0.049
Septal deviation	0.085	−0.128*	−0.012	−0.14	–	–	–
Nasal polyps	−0.143*	0.434*	0.021	0.455	–	–	–
Skin test (mite, animal)	0.573*	–	–	–	–	–	–
Laboratory test (IgE, etc.)	0.167*	–	–	–	0.015	0.009	0.024
Skin test (Mugwort, etc.)	0.195*	–	–	–	–	–	–
	–	−0.146*(β_{21})	–	−0.146	0.056(β_{31})	0.01	0.066
Treatment method	–	–	–	–	−0.067(β_{32})	–	−0.067
Covariance of remaining var(ϕ)		0.435			0.665		0.908

Indirect effect of treatment method = (γ_{1x})×(β_{21})
Indirect effect of treatment result = (γ_{1x})×(β_{32}) or (γ_{2x})×(β_{32})
–: no relationship
*: $p<0.05$

GFI was 0.994 and AGFI was 0.973, indicating that the model accounted for 97.3% of the observed variances and covariances. CN value was 903, which are much higher than the suggested minimum value of 200. Overall, the results from this model indicate a very good fit of the model to the sample.

Relationship among the patient characteristics: Standardized variance/covariance among the patient characteristics were presented in Table 7. Of these, noticeable relationships (absolute values greater than 0.2) occured between aggravating factors and runny nose/itching eye and headache/general symptom, between septal deviation and rhinorrhea/sneezing, and between skin test (mite, animal) and rhinorrhea/sneezing and nasal polyps. Family history/medication was the only factor which did not have any significant relationship with other characteristics.

Relationship among the patient characteristics, diagnosis, treatment methods, and results: Three types of the effects of patient characteristics were presented in Table 8: direct effects on diagnosis (γ_{1x}), treatment methods (γ_{2x}), and results (γ_{3x}); indirect effects on treatment methods from the diagnosis ($\gamma_{1x}x\beta_{21}$), indirect effects on results from the diagnosis ($\gamma_{1x}x\beta_{31}$) and from the treatment method ($\gamma_{2x}x\beta_{32}$); and total effects on treatment methods and results which were a sum of the two effects.

The significant characteristics influencing the diagnosis were results from the skin test with mite and animal (γ=0.573), the skin test with mugwort (γ=0.195), rhinorrhea and sneezing (γ=0.178), laboratory test (γ=0.167), and nasal polyps (γ=−0.143). Surprisingly, aggravating factor (e.g. cold air) and past history (e. g. asthma), which have been traditionally well known to be important caual factors for allergic rhinitis, were not significant. Compared with the results of discriminant analysis, all significant factors from the discriminant analysis were also significant in the CSM except septal deviation (γ=0.085).

The significant characteristics influencing the treatment methods at the 5% level were: nasal polyps (γ=0.455, total effects), headache and general symptom (γ=0.172), family history and medication (γ=−0.160), septal deviation (γ=−0.14). The path coefficient γ indicated with a positive sign (+) refers to surgery, while a negative sign (−) refers to drug therapy (e.g. antihistamine, steroid, or both). For example, surgery was the likely treatment for the patients with nasal polyps.

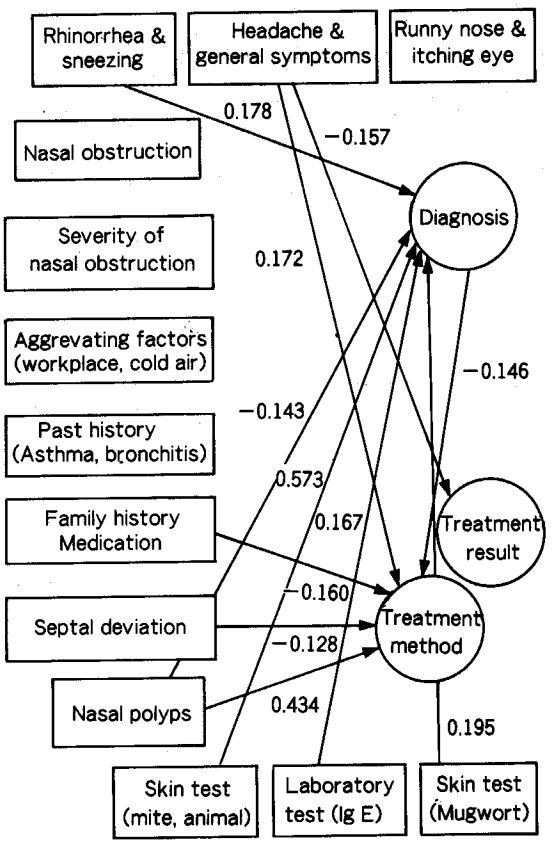

Fig. 2. *Structural relationship among patient characteristics, diagnosis, treatment methods, and results for allegic rhinitis.*

In case of treatment results, only headache/general symptom was a significant factor with the total effect of −0.169. That is, if a patient had a headache and any general symptom, he or she did not respond well to the treatment. Unlike the diagnosis model, this result was quite different from results for the discriminant model.

In contrast to the previous study, runny nose/itching eye, nasal obstruction, aggravat-

Table 9. Important characteristics affecting the results for the allergic rhinitis patients treated by antihistamine and steroid

Patient characteristics			Treatment result		Asymmetric lamda(λ)
			Not improved	Improved	
Symptom aggravates while reading?		No	14(22.2)	49(77.8)	0.21
		Yes	5(83.3)	1(16.7)	
Symptom aggravates in the afternoon?		No	15(23.4)	49(76.6)	0.16
		Yes	4(80.0)	1(20.0)	
Symptom begins after planting?		No	17(25.4)	50(73.5)	0.11
		Yes	2(100.0)	0(0.0)	
Skin test on house dust	Level	0	10(32.3)	21(67.7)	0.05
		1~3	0(0.0)	9(100.0)	
		4	3(16.7)	15(83.3)	
		5	6(54.6)	5(45.4)	
Allergic to cosmetics?		No	18(26.5)	50(73.5)	0.05
		Yes	1(100.0)	0(0.0)	
Allergic to aspirin?		No	18(26.5)	50(73.5)	0.05
		Yes	1(100.0)	0(0.0)	
Symptom begins after making beds?		No	17(25.8)	49(74.2)	0.05
		Yes	2(66.7)	1(33.3)	

ing factors, such as cold air, and one's past history, such as an occurance of asthma, did not have any significant effect on diagnosis, treatment methods, or results. The path diagram which represents these structural relationship was presented in Fig. 2.

The remaining covariance (ϕ) for the diagnosis was 0.435. This means that patient characteristics account for 56.5% of the variance in the diagnosis. The remaining covariance for the treatment method and results were 0.665 and 0.908, respectively. Therefore, the patient characteristics accounts for only 9.2% of the variance in the results, perhaps due to various confounding factors affecting the results.

Determination of relative measures of association between the patient charactristics and results for the allergic rhinitis patients treated by antihistamine and steroid

Results from the categorcial data analysis for the 69 allergic rhinitis patients treated with antihistamine and steroid were presented in Table 9. Aggravating factor related to reading was identified as the most important characteristic (λ=0.21). That is, 49 out of 63 patients (77.8%), whose symptoms were not aggravated while reading, displayed an improved condition by the treatment of antihistamine and steroid, whereas 5 out of 6 patients (83.3 %), whose symptoms were aggravated while reading, displayed no such improvement from drug therapy. Other important patient characteristics were: occurrence of symptom in the afternoon (λ=0.16), occurrence of symptom after planting (λ=0.11), skin irritation from house dust (λ=0.06), allergic to cosmetics (λ=0. 05), allergic to aspirin (λ=0.05), and occurrence of symptom after making beds (λ=0.05). While asymmetric lamda values could not be obtained from the other characteristics due to a lack in sample size, these findings provide

some clue into the use of a certain treatment.

DISCUSSION

Determination of the diagnosis and the treatment of allergic rhinitis is a multifactorial process involving the assessment of symptoms, severity, seasonal variation, past and family history, laboratory test, and specific diagnostic procedures. There has been many studies on the causes of allergic rhinitis. Kim *et al.* (1980) found that the symptoms for allergic rhinitis were sneezing (66.5%), fatigue (57.4%), rhinorrhea (52.3%), and headaches (50 %). Moreover, Song *et al.* (1982) also reported that 90% of allergic patients had rhinorrhea, septal deviation, and sneezing. Unlike this study, however, most of these findings were based on percentages or means, and therefore it was difficult to tell whether they were statistically significant or not. On the other hand, our study compared the relative effects for each cause of the diagnosis in the same multivariate analysis model. Nevertheless, this study selected rhinorrhea and sneezing as the significant factors ($p<0.05$) from both the discriminant model and the CSM.

Dold *et al.* (1992) found that environmental and hereditary factors were the most important causes of allergies. They reported that odds ratio was 3.6 for those who had one parent with allergic rhinitis. Naclerio (1991) also found that the incidence of allergic rhinitis is about 30 percent higher among those who have a parent with a history of atopic disease, and even higher among those with two parents who have such a history. In Korea, Oh *et al.* (1989) reported that 54.8% of patients with allergic symptoms had a positive family history. However, family history and environmental factors were not significant in neither the discriminant model nor the CSM.

In regard to past history, Dold *et al.* (1992) found that allergic rhinitis was highly related with asthma and atopic dermatitis. Similarly, Song *et al.* (1982) also reported that allergic rhinitis patients had also other diseases such as asthma and bronchitis. However, past history was also insignificant in this study.

In regard to allergens, Chung *et al.* (1987) and Kim *et al.* (1990) found that the following allergens demonstrated a strong positive reaction to the skin prick test in allergic rhinitis patients: D.F. (*Dermatophagoides farinae*), house dust, and D.P. (*Dermatophagoides pteronyssinus*), etc. Lee *et al.* (1987) found that house dust and mite caused the highest percentage of positive reaction (82.6%). These findings coincided with the results from both the discriminant model and the CSM.

While there are several tests which complement the clinical history and the physical examination, none of these are completely reliable in the diagnosis of allergic rhinitis (Romero and Scadding, 1992). They suggested the usefulness of eosinophilia measurements in nasal smears (ENS) for the diagnosis of allergic rhinitis. They also found that the correct correlation between the ENS and the skin prick test was 71.4%, whereas the correct correlation between the ENS and the nasal challenge test was 69%.

In this study, the discriminant model was developed to predict the diagnosis and to calculate the correlation between the model and actual diagnosis made by doctor. It was 81.3% (specificity=91.3%, sensitivity=71.3%), and this suggested that the discriminant model should be given more relevance, and be used as a reference in the diagnosis of allergic rhinitis.

This study also simultaneously analyzed the structural relationships among patient characteristics, diagnosis, treatment methods, and results within the CSM. The significant characteristics influencing the treatment methods at the 5% level were: nasal polyps ($\gamma=0.455$, total effects), headache and general symptom ($\gamma=0.172$), family history and medication ($\gamma=-0.160$), septal deviation ($\gamma=-0.14$). The path coefficient γ with a positive sign (+) refers to surgery, while a negative sign (−) refers to drug therapy (e.g. antihistamine, steroid, or both). On the other hand, headache/general symptom with the total effects of −0.169 was the only significant factor influencing the treatment results. That is, if patient had a headache or a general symptom, then he or she did not respond well to the treatment.

Unlike the model for diagnosis, this result is quite different from the results from the discriminant model. Since most of the previous studies did not analyze the effects of patient characteristics from neither treatment methods nor results, our findings cannot be compared with other studies.

There were several limitations in this study. First, three types of non-allergic rhinitis patients were combined into one non-allergy group: probable allergic rhinitis, non-allergic rhinitis, and sinusitis. Since there were wide variety of characteristics that might influence the treatment results among these non-allergic patients, some important characteristics may not have been selected as significant factors in the analysis. To more precisely identify the distinct patient characteristics influencing the treatment results, the non-allergic rhinitis category should be further divided into smaller and more homogeneous subcategories in future reports. Second, another reason for not selecting key characteristics may be due to the lack of cases in the sample. Joreskog and Sorbom (1989) suggested that the overall fit of the model improves as the sample size increases. Since this analysis required a complete data set for patients (i.e. characteristics, test, treatment methods, and results), the data collection period should be further increased considering the drop-out patients during the treatment.

The findings from this study may be used in developing a medical decision support system (MDSS). MDSS is defined as those systems which deal with clinical data or medical knowledge, and which perform one or more of the following tasks: serve as a tool for medical information management; help doctors to focus attention or give advice in the form of a patient-specific consultation (Shortliffe, 1987). Most of these systems use an artificial intelligent (AI) approach based on decision rules, statistical models, and symbols to acquire and represent medical knowledge.

The first such MDSS was MYCIN which was developed to assist doctors in prescribing antibiotics (Shortliffe, 1976). Since then, many MDSS have been applied to various medical fields such as: Digitalis therapy advisor (Gorry *et al.* 1978); ONCOCIN for Hodgkin's disease (Shortliffe *et al.* 1981); the INTERNIST for internal medicine (Miller *et al.* 1986); the QMR for general medical references (Miller *et al.* 1986) and the QMR with speech recognition capability (Shiffman *et al.* 1991).

In Korea, medical diagnosis systems were developed for hearing loss (Chae *et al.* 1989; Chung *et al.* 1989) and for allergic rhinitis (Jang, 1990; Chung *et al.* 1990; Chae *et al.* 1992). In previous studies on MDSS for allergic rhinitis, primary knowledge was acquired by neural network and case-based reasoning (Kang, 1993) with the focus on providing only diagnostic information. In the future, the findings from this study should also be integrated into the MDSS after a thorough validation of the model. Furthermore, the association between patient characteristics, and the results for the patient treated with antihistamine and steroid, which were measured by asymmetric lamda (λ) in Table 9, may be converted into scores which indicate important characteristics for influencing treatment results, after recalculating them using more data.

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APPENDIX

List of Input Data for the Statistical Analysis

1. Questionnaire Data (42 items)
   1) Demographic characteristics of patients
   2) Symptom
   3) Provoking factor
   4) Aggravating factor
   5) Seasonal factor
   6) Environmental factor
   7) Allergen specific factor
   8) Treatment history
   9) Family history
   10) Miscellaneous
2. Test results
   1) Discharge characteristics (e.g. watery, mucoid, purulent)
   2) Mucosa
   3) Structural anormaly (e.g. polyps, sinusitis)
   4) Paranasal X-ray
   5) Nasal smear (e.g. eosinophil)
   6) IgE
   7) Blood eosinophil count (e.g. 300−, 300~600, 600~1000, 1000+)
   8) Skin test (e.g. tree, grass, weed, mold, dust, dust mite, epithelials, food, mugwort)
   9) RAST
3. Treatment results
   1) Antihistamine
   2) Topical steroid
   3) Surgery (e.g. Sinus operation, S.M.R., Conchotomy)