DOI: 10.5137/1019-5149.JTN.8492-13.0
Received: 01.05.2013 / Accepted: 03.07.2013

Original Investigation

Prediction of Lumbar Disc Herniation Patients' Satisfaction with the Aid of an Artificial Neural Network

Georgios K. MATIS[1,2], Olga I. CHRYSOU[1], Danilo SILVA[3], Michail A. KARANIKAS[4], Gerasimos BALTSAVIAS[2], Nikolaos LYRATZOPOULOS[4], Spyridon BAROUTAS[5], Theodossios A. BIRBILIS[1]

[1]*Democritus University of Thrace Medical School, Department of Neurosurgery, Alexandroupolis, Greece*
[2]*University Hospital of Zurich, Department of Neuroradiology, Zurich, Switzerland*
[3]*Weill Cornell Medical College, NewYork-Presbyterian Hospital, Department of Neurosurgery, New York, USA*
[4]*Democritus University of Thrace Medical School, 1st University Surgery Department, Alexandroupolis, Greece*
[5]*General Hospital "G. Papanikolaou", Department of Neurosurgery, Thessaloniki, Greece*

ABSTRACT

AIM: To identify key determinants of lumbar disc herniation (LDH) patients' satisfaction and to evaluate the efficiency of an artificial neural network (ANN) model to prognosticate satisfaction derived from the hospital stay in this specific patient group.

MATERIAL and METHODS: A single item question was used to assess patient satisfaction. Principal component analysis evaluated several aspects of care (15 items). An ANN encompassed all variables and its prediction ability was tested. The ANN performance was correlated to a binary logistic regression (BLR) model.

RESULTS: Higher levels of satisfaction were reported by females, older patients, Greeks, and patients with elementary education staying in not rural areas. A history of a single previous hospitalisation was correlated with more satisfaction. The accuracy of ANN was 96% for satisfaction prediction outperforming the BLR model.

CONCLUSION: Satisfactory health services are influenced by sex, age, nationality, and number of prior admissions. The self-perceived health state plays also a crucial role. The current study is the first one reporting on the capability of an ANN to accurately predict the satisfaction levels of LDH patients.

KEYWORDS: Artificial neural network, Health services research, Lumbar disc herniation, Patient, Prediction, Regression, Satisfaction

INTRODUCTION

The quality of health care services is considerably improved by evaluating patients' satisfaction. Structured questionnaires constitute a valuable assessment tool of quality (1), if this is considered as a dynamic process of effectiveness, efficacy, and efficiency (5, 9, 10). Of note, quality is not the same as satisfaction (8). The first notion is related to the customers' perception over longer periods, while the second refers to the actual moment of service (29). The expectations of patients are also of vital significance (2, 4).

Lumbar disc herniation (LDH) exhibits a high prevalence and a tremendous social impact (26). Several reports have been previously published on very limited aspects of the hospitalisation period (23) or on the operated (due to LDH) patients' quality of life (25). However, there is hardly any research on how these patients appreciate the overall hospital stay. The aim of the current study was to evaluate inpatients' satisfaction for several care services, and to construct an artificial neural network (ANN) for prediction of LDH patients' satisfaction. This is the first study performed addressing specific issues that influence LDH patients' satisfaction.

Corresponding author: Georgios K. MATIS
E-mail: gkmatis@yahoo.gr

■ MATERIAL and METHODS

The Questionnaire

A satisfaction questionnaire approved and validated by the Greek Ministry of Health and Social Solidarity was used (17, 18, 20). It incorporated thirty-six questions, thirteen sociodemographic variables and five domains (admission, medical, nursing, accommodation, and administration services) (11). All patients reported on their perceived health status and on their total satisfaction (admission and discharge day). The satisfaction related questions are presented in Table I. A 5-grade Likert scale was employed, since such scales present a comprehensible structure both for researchers and patients (16).

Study Target

The analysis took place among LDH patients admitted to the "G. Papanikolaou" General Hospital, Thessaloniki, Greece. Eligible participants were hospitalised patients for at least 24 hours. Exclusion criteria: depression, psychosis, and dementia. A signed consent form was obtained. The study was in agreement with the Helsinki Declaration.

Compilation of Data

One hundred ninety-four patients was contacted at the day of discharge (August 2009-July 2010) and were asked to complete the questionnaire guaranteeing data confidentiality. The obtained response rate was 74.7% (145 patients). The option of a telephone or mail survey was not considered due to the lack of experience in the Greek territory and the low expected response rate (17, 18, 20).

Principal Component Analysis (PCA)

The scoring scales for all relative questions (Q21, Q22, Q33) were standardized (0-100), with 100 representing the best satisfaction (14). The Kaiser measure of sampling adequacy value was 0.889. Data were rotated with the Varimax system (13, 14). A correlation limit greater than 0.5 was chosen for the summated scales (31). The factor loadings were chosen to be greater than 0.20 (15). Values of Cronbach's alpha coefficient greater than 0.70 demonstrated homogeneity of the construct (7, 14). The Spearman coefficient, the Student's t-test, the analysis of variance, the Kruskal–Wallis test, and the χ^2 test (or Fisher's test) were appropriately utilised. The two-sided threshold p value was 0.05. Statistical analysis was performed by IBM SPSS Statistics v. 20 (IBM Corp., New York, USA).

Artificial Neural Network (ANN)

Neural networks represent a technique of learning complex correlations between input and output patterns. After training, a neural network can extrapolate to give solutions to new input patterns, as long as the training data were sufficient (3). NeuralWorks Predict® v. 3.24 (NeuralWare, Carnegie, PA, USA) was used to construct such an ANN based on 13 input (age, sex, Q17-20, Q25-28, Q30-32) and 1 outcome (satisfaction: Q33) variables. Satisfaction scores of 4 and 5 suggested 'patients' satisfaction', while scores 0-3 'lack of satisfaction'.

Logistic Regression

A binary response variable (satisfaction/no satisfaction) can be modeled by logistic regression. Like in ANN, binary logistic regression (BLR) was applied based on the same 14 variables (IBM SPSS Statistics v. 20). Dependent variable: the global satisfaction score dichotomized into 'very satisfied / satisfied' versus 'neither satisfied nor dissatisfied / dissatisfied / very dissatisfied'. For both ANN and logistic regression models, the areas under the receiver operating characteristic curves (AUCs) were calculated.

Table I: Satisfaction Related Questions

Question	Description of question
Q17	Emergency department services (physicians)
Q18	Professional efficiency – diagnosis, therapy (physicians)
Q19	Information and instructions provision (physicians)
Q20	Behavior, human relationships (physicians)
Q21	Professional efficiency, responsiveness, care (nurses)
Q22	Behavior, human relationships (nurses)
Q24	Professional efficiency (nurses paid by patients)
Q25	Cleanliness of wards, hospital
Q26	Toilet cleanliness
Q27	Organization – noise, visiting hours
Q28	Food – breakfast, lunch, dinner
Q29	Behavior (food distributing personnel)
Q30	Ability to communicate – television, telephone, salon
Q31	Processing of medical needs – schedule, further examinations
Q32	Administration – admission, payments, secretary
Q33	Global satisfaction

RESULTS

Patient Characteristics

The patients' demographics are shown in Table II. The mean age of participants was 43.8 years; the majority was men (56.6%), 71% were married, 55.2% lived in Thessaloniki, 37.24% had a university education, and for 42.8% this was their first hospitalisation. 90 respondents (62.1%) at admission and 11 participants (7.6%) at discharge rated the self-perceived level of health with ≤5 points.

Principal Component Analysis

Two summated scales were constructed. The first component (C1) explained 64.31% of total variance. The second (C2) explained 14.62% of total variance (78.93% in total). Q21, Q22 and Q29 were excluded from further analysis. Q25–28 and Q30–32 related to C1 (Cronbach's: 0.982). Q17–20 and Q24 related to C2 (Cronbach's: 0.855). The removal of Q24 improved the internal consistency (0.932). Two new summated scales were constructed: satisfaction from accommodation/administration and medical services (Table III). The satisfaction from medical services (4.5741±0.6481–89.3534±1.15433) is larger as compared to the satisfaction computed for accommodation/administration (3.9586±0.8489–73.9660±1.5119).The first one exhibits greater minimum values (3–50% versus 1.71–17.9%). The mean nursing services' satisfaction is lower in comparison with the medical satisfaction (4.3785±0.75211–84.4618±1.33958). Lower is the global/total satisfaction (3.9310±0.88662–73.2759±1.57915). The four scales' mean values with respect to several demographic variables are provided in Table IV. The largest satisfaction was observed in older Greeks, females, and patients with an elementary school degree. The mean general satisfaction was higher for responders from smaller cities (the other three scales showed better scores in patients from semi-urban areas). Satisfaction (all scales) was bigger for participants having one previous admission.

Correlating Sociodemographic Data with the Summated Scales

Q33 was not related to any variables. Age was linked to the medical (r_s=0.371, p=0.000), accommodation/administration (r_s=0.278, p=0.004) and nursing (r_s=0.348, p=0.000) satisfaction. Younger patients were less satisfied. Gender correlated with the medical (r_s= 0.392, p=0.000) and nursing (r_s=0.139, p=0.013) satisfaction. Men were less satisfied. The number of previous hospitalisations were linked to the medical (r_s=0.224, p=0.011) and nursing (r_s=0.218, p=0.026) satisfaction. The lower the number of admissions, the lower the reported satisfaction. Citizenship was found to be connected with the accommodation/administration satisfaction (r_s=0.258, p=0.049). Non-Greeks were less satisfied. The self-perceived health condition was linked to the medical (r_s=-0.245, p=0.005 [admission] – r_s=-0.236, p=0.010 [discharge]), accommodation/ administration (r_s=-0.223, p=0.019 [admission] – r_s=-0.189, p=0.034 [discharge]) and nursing (r_s=-0.125, p=0.004 [admission] – r_s=-0.122, p=0.012 [discharge]) satisfaction. Patients with worse self-perceived health were more satisfied.

Artificial Neural Network

Variables from 69 patients were analyzed during the training phase and 31 patients were included in the testing phase. Data were considered moderate noisy and they were moderately transformed. An exhaustive variable selection and an exhaustive network search were opted. The best ANN was chosen. The architecture used was a back-propagation

Table II: Demographics

Variables	Mean±SD	N (%)
Age	43.8±4.6	145 (100)
0-18		4 (2.8)
19-35		22 (15.2)
36-50		80 (55.2)
51-65		35 (25.0)
66+		4 (2.8)
Gender		
Male		82 (56.6)
Female		63 (43.4)
Location		
Thessaloniki		80 (55.2)
Other urban		10 (6.9)
Semi-urban		12 (8.3)
Rural		43 (29.6)
Insurance		
Public sector employees		39 (26.95)
Private sector employees		48 (33.1)
Farmers		46 (31.7)
Uninsured		8 (5.5)
Other		4 (2.75)
Education		
Uneducated		17 (11.7)
Elementary (6 years)		25 (17.2)
Secondary School (3 years)		23 (16.0)
High School (3 years)		26 (17.9)
University		54 (37.2)
Marital status		
Married		103 (71.0)
Unmarried		26 (17.9)
Widowed		12 (8.3)
Divorced		4 (2.8)
Citizenship		
Other		35 (24.1)
Greek		110 (75.9)
Prior admissions		
0		62 (42.8)
1		46 (31.7)
2		26 (17.9)
3		7 (4.8)
4+		4 (2.8)

Table III: Descriptives of the Four Satisfaction Domains (range: 0-100)

	N	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Global	145	0.00	100.00	73.2759	1.57915	19.01552	361.590
Medical	145	50.00	100.00	89.3534	1.15433	13.89999	193.210
Accommodation-Administrative	145	17.9	100.00	73.9660	1.51190	18.20550	331.441
Nursing	145	37.50	100.00	84.4618	1.33958	19.01552	258.406

Table IV: Demographic Variables and Satisfaction Scales

	Medical		Accommodation – Administration		Nursing		Global	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (years)								
0-18	76.5	11.4	70.2	11.8	74.2	12.7	73.5	8.0
19-35	88.0	10.1	72.9	18.7	82.8	12.2	72.3	18.2
36-50	91.1	9.2	76.8	17.5	89.9	10.9	76.8	16.6
51-65	86.4	12.5	78.6	19.0	86.1	17.1	71.9	17.7
66+	98.2	2.5	88.9	10.4	94.2	8.8	83.2	9.7
p value	**0.000***		**0.004**		**0.000**		0.289	
Gender								
Male	84.1	12.8	73.5	17.2	84.6	16.2	72.9	17.0
Female	94.2	9.6	76.2	15.2	87.4	14.1	76.2	11.1
p value	**0.000**		0.153		**0.013**		0.299	
Location								
Thessaloniki	88.3	12.7	76.4	16.1	87.2	14.6	73.1	18.2
Other urban	90.2	9.7	81.3	14.7	86.1	13.6	78.2	16.8
Semi-urban	95.6	10.5	82.4	13.2	92.2	9.7	75.9	16.2
Rural	82.0	13.3	72.3	14.4	79.6	16.2	71.2	13.8
p value	0.062		0.301		**0.017**		0.221	
Insurance								
Public sector employees	88.4	11.2	76.9	17.2	89.1	13.2	75.2	16.3
Private sector employees	89.5	13.1	78.1	15.8	85.7	12.2	78.4	17.2
Farmers	84.9	13.2	72.3	17.5	81.9	16.2	67.3	21.2
Uninsured	95.2	11.5	81.2	14.9	85.2	16.8	77.8	13.5
Other	95.1	7.7	81.9	14.2	86.6	15.1	79.1	12.6
p value	**0.034**		0.332		0.401		0.365	
Education								
Uneducated	91.1	13.1	72.7	11.1	86.6	12.1	74.3	2.1
Elementary (6 years)	94.1	12.3	80.9	12.9	90.4	12.5	76.2	11.6
Secondary School (3 years)	87.4	13.3	76.4	15.8	83.8	14.9	72.8	21.7
High School (3 years)	90.1	11.2	75.7	16.1	87.7	13.7	76.9	16.2
University	89.3	11.4	74.7	17.9	85.4	12.6	74.3	18.3
p value	0.712		0.467		0.299		0.812	
Marital status								
Married	91.2	11.3	77.1	16.1	86.2	14.5	73.7	17.3
Unmarried	85.2	12.4	76.2	13.6	82.4	13.4	76.2	12.2
Widowed	96.6	5.6	84.9	13.2	92.6	8.2	85.5	13.1
Divorced	88.4	16.2	72.1	24.9	86.4	17.8	69.6	23.8
p value	**0.013**		0.456		0.182		0.356	

Table IV: Cont.

	Medical		Accommodation – Administration		Nursing		Global	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Citizenship								
Other	84.3	15.0	67.6	13.8	83.2	17.4	74.2	12.8
Greek	91.3	13.2	76.1	16.3	85.6	16.5	76.8	14.6
p value	0.145		**0.049**		0.589		0.488	
Prior admissions								
0	86.1	13.7	74.1	14.4	82.2	16.8	74.4	14.5
1	94.1	9.2	82.5	18.7	90.3	7.8	81.0	20.4
2	92.8	8.7	76.8	14.3	86.4	11.2	74.4	15.9
3	91.2	12.2	77.6	21.0	88.1	12.4	74.3	20.7
4+	90.1	12.4	75.2	18.1	86.2	15.1	74.5	23.1
p value	**0.011**		0.391		**0.026**		0.461	

p values according to Analysis of Variance (ANOVA). Student's t test. and Kruskal-Wallis test.
**** the bold values indicate statistical significance.***

Table V: Performance Metrics for the Prediction Model

Groups	R	Avg. Abs.	Max. Abs.	RMS	Accuracy	Records
Training	0.9724	0.0196	0.5045	0.0855	0.9710	69
Testing	0.9383	0.0373	0.5045	0.1272	0.9355	31
Validating	0.9619	0.0251	0.5045	0.1003	0.9600	45

***R:** Pearson R, **Avg. Abs.:** Average absolute error, **Max. Abs.:** Maximum absolute error, **RMS:** Root mean square error (the square root of the average squared error between the target values and corresponding predicted outputs).*

Table VI: Performance Indices of the Binary Logistic Regression (BLR) Model and the Artificial Neural Network (ANN) Model Based on Forty-Five New Records

	Se	Sp	Accuracy	PPV	NPV	AUC (95% CI) (p)
ANN	0.98	0.94	0.96	0.98	0.94	0.985 (0.953-1.000) (0.000)
BLR	0.96	0.92	0.94	0.97	0.89	0.970 (0.911-1.000) (0.000)

***ANN:** Artificial neural network, **BR:** Binary logistic regression, **Se:** Sensitivity, **Sp:** Specificity, **PPV:** Positive predictive value, **NPV:** Negative predictive value, **AUC:** Area under the curve, **CI:** Confidence interval.*

network with seven hidden units and one output. Finally, the variables derived from another 45 patients were used as a validation group. The basic performance metrics are presented in Table V. The AAN outperformed the BLR model as it is shown in Table VI. The corresponding AUCs are illustrated in Figure 1.

■ DISCUSSION

The scope of the current study was to assess if patients undergoing surgery of LDH are really satisfied with the provided care. Other Greek satisfaction surveys have already studied most of the variables presented here (17, 18, 20). Nonetheless, to the best of the authors' knowledge, no published study exists implementing all these variables in LDH patients, so no direct comparison with other researchers' results could be attempted. Moreover, this is the only study evaluating and proving the feasibility of an ANN to predict the reported satisfaction of LDH patients.

The questionnaire was filled in (in order to limit the positive bias) after the hospitalisation (1, 10) and it has been used in previous surveys (17, 18). The results confirm that gender, age, citizenship, number of previous admissions and self-perceived level of health (at admission and at discharge) are all factors that exert a strong influence on satisfaction. The patients provided a global satisfaction of 73.2759%, a score found in other Greek surveys which evaluated brain tumor patients (17) and the general population (18, 21). No variable was found to relate to this dimension. However, older age and

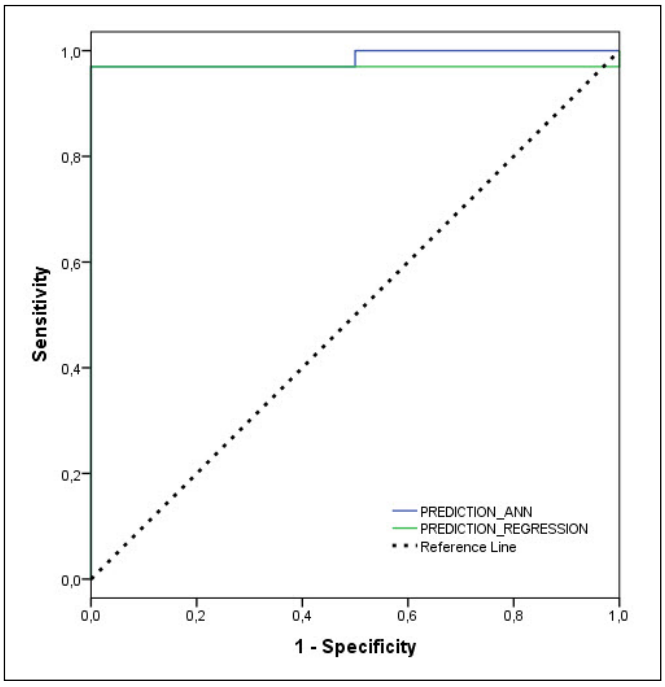

Figure 1: Receiver operating characteristic curves (ROCs) for both prediction models. **ANN:** artificial neural network.

lower education are associated with high global satisfaction in many studies (19, 20, 27). Interestingly, general satisfaction in older patients (>65 years) is reduced (19, 24). In contradiction to the present results, it has been argued that non-married patients and males are less satisfied with the hospital care (as seen by the global satisfaction) (12). Yet, Quintana et al. (22) reported lower levels of satisfaction in women and in the married patients.

In other Greek hospitals, the medical services' satisfaction ranged from 80.4% to 92.8% (current study: 89.3534%), and the nursing services' satisfaction ranged from 52.4% to 90.0% (current study: 84.4618%) (17, 18, 20, 21). These two domains were correlated with Greek nationality, gender (females), older age, more previous admissions, and poor self-perceived health condition (at admission). As in several published studies (6, 23, 24, 27) the physicians' and nurses' behaviour proved to be a more significant determinant than professional efficiency. Information provision was also reported to be of crucial importance in line with the findings of others (23, 24). However, gender was not associated with reported satisfaction (24, 27). Previous studies found that patients with previous admissions are more demanding (19, 22, 24). In fact, the larger the number of prior admissions, the larger the satisfaction scores, a finding not confirmed neither by other researchers (24), nor by the authors of this study. It was also suggested that a better score is linked to a better self-perceived health status at admission (29). Of note, responders tend to give higher rates to physicians, probably because they can not fully evaluate their services. Moreover, the nursing personnel shortage contributes substantially to the acquired responses (18).

The accommodation/administration domain's score was 73.966%. Other Greek surveys reported a satisfaction rate for administrative services reaching 96.2% (17). Niakas et al. measured an accommodation services' score of 75.9% (20). Even though an association between the number of previous admissions and the length of stay and satisfaction on areas such as cleanliness was found in many published studies (22), this could not be confirmed here.

Several predicting models have been constructed with traditional statistical methods, but their individualised application is limited by the variables involved, which may potentially interact with each other with possible reciprocal effects (32). Consequently, these approaches present intrinsic limitations in manipulating heterogeneous nonlinear data (28). The ANNs are models which employ a dynamic concept for interpreting outcomes. At the same time, they are capable of adjusting their indigenous framework with respect to a functional target (32). Although standard statistics reveal significant parameters in the whole population, ANNs incorporate criteria that are of importance individually (28, 32). The ANN model, when compared with the BLR model, was more accurate (96% versus 94%) in predicting satisfaction and exhibited better indices. Supplementary processing is expected to lead to further improvements in decision-making analysis. The current study contributes to evaluation of the capabilities of neural networks in comparison to the efficiency of logistic models, especially in the context of information shortage about the use of ANN for predicting satisfaction outcomes.

This report has some constraints. To start with, dissatisfied patients tend to answer less often (17, 18). It is also well known that the satisfaction assessment is a dynamic process demanding large samples from various care units at different moments in time, so that researchers can detect changes in satisfaction (2, 20). Besides, in this study, all questions were acknowledged as ratio scales. Yet, they could be considered as ordinal and/or interval scales (8, 29). An important drawback is that the used questionnaire does not seem to recognise the gravity of the nursing services as the PCA revealed (18). The comprehension of the findings could be simplified by the breakdown of Q21 in more questions or by introducing additional nurse-focused questions. Finally, Q18 and Q21 could be puzzling in consideration of patients' lack of expert knowledge to hold an opinion on this field (17).

In conclusion, the findings are in agreement with other studies from Greece, elucidating a uniformity in patients' ratings throughout the country (17, 18, 20). Key elements seem to be identical in LDH and tumor patients. Similar international reports underline the value of health providers' attendance of diversified educational activities (9, 10). A patient-centered communication is a substantial prerequisite (30). To end with, ANNs seem successful in LDH patients' satisfaction prediction. In the light of these data, the implementation of this method in our research tools seems to be justified.

REFERENCES

1. Andrzejewski N, Lagua RT: Use of a customer satisfaction survey by health care regulators: A tool for total quality management. Public Health Rep 112:206-210, 1997
2. Bateson JEG: Managing services marketing. Text and readings. Fortworth: Dryden Press, 1995
3. Bishop JB, Szpalski M, Ananthraman SK, McIntyre DR, Pope MH: Classification of low back pain from dynamic motion characteristics using an artificial neural network. Spine (Phila Pa 1976) 22:2991-2998, 1997
4. Bittner MJ, Booms BH, Tetreault MS: The service encounter: Diagnosing favorable and unfavorable incidents. J Mark 54:69-82, 1990
5. Cafferky ME: Managed Care & You. Los Angeles: Health Information Press, 1997
6. Cheng SH, Yang MC, Chiang TL: Patient satisfaction with and recommendation of a hospital: Effects of interpersonal and technical aspects of hospital care. Int J Qual Health Care 15:345-355, 2003
7. Cronbach LJ: Coefficient alpha and the internal structure of tests. Psychometrika 16:297–334, 1951
8. Cunningham L: The Quality Connection in Health Care. Integrating Patient Satisfaction and Risk Management. San Francisco: Jossey-Bass Inc Publishers, 1991
9. Donabedian A: An introduction to quality assurance in health care. New York: Oxford University Press, 2003
10. Enthoven AC, Vorhaus CB: A vision of quality in health care delivery. Health Affairs 16:44-57, 1997
11. Gonzalez N, Quintana JM, Bilbao A, Escobar A, Aizpuru F, Thompson A, Esteban C, Sebastián JA, de la Sierra E: Development and validation of an in-patient satisfaction questionnaire. Int J Qual Health Care 17:465–472, 2005
12. Hargraves JL, Wilson IB, Zaslavsky A, James C, Walker JD, Rogers G, Cleary PD: Adjusting for patient characteristics when analyzing reports from patients about hospital care. Med Care 39:635–641, 2001
13. Kaiser HF: A second-generation Little Jiffy. Psychometrika 35:401–415, 1970
14. Kline P: An Easy Guide to Factor Analysis. London: Routledge, 1994
15. Labarere J, Francois P, Bertrand D, Peyrin JC, Robert C, Fourny M: Outpatient satisfaction: validation of a French-language questionnaire: Data quality and identification of associated factors. Clin Perform Qual Health Care 7:63–69, 1999
16. Likert R: A technique for the measurement of attitudes. Arch Psychol 140:1–55, 1932
17. Matis GK, Birbilis TA, Chrysou OI, Zissimopoulos A: Satisfaction survey of Greek inpatients with brain cancer. J BUON 15:157-163, 2010
18. Matis GK, Birbilis TA, Chrysou OI: Patient satisfaction questionnaire and quality achievement in hospital care: The case of a Greek public university hospital. Health Serv Manage Res 22:191-196, 2009
19. Moret L, Nguyen JM, Volteau C, Falissard B, Lombrail P, Gasquet I: Evidence of a non-linear influence of patient age on satisfaction with hospital care. Int J Qual Health Care 19:382-389, 2007
20. Niakas D, Gnardellis C, Theodorou M: Is there a problem with quality in the Greek hospital sector? Preliminary results from a patient satisfaction survey. Health Serv Manage Res 17:62–69, 2004
21. Polysos N, Bartsokas D, Pierrakos G, Asimakopoulou J, Yfantopoulos J: Comparative surveys for patient satisfaction between hospitals in Athens. Arch Hell Med 22:284–295, 2005
22. Quintana JM, González N, Bilbao A, Aizpuru F, Escobar A, Esteban C, San-Sebastián JA, de-la-Sierra E, Thompson A: Predictors of patient satisfaction with hospital health care. BMC Health Serv Res 6:102-110, 2006
23. Rönnberg K, Lind B, Zoëga B, Halldin K, Gellerstedt M, Brisby H: Patients' satisfaction with provided care/information and expectations on clinical outcome after lumbar disc herniation surgery. Spine (Phila Pa 1976) 32:256-261, 2007
24. Schoenfelder T, Klewer J, Joachim Kugler: Determinants of patient satisfaction: A study among 39 hospitals in an in-patient setting in Germany. Int J Qual Health Care 23:503-509, 2011
25. Silverplats K, Lind B, Zoega B, Halldin K, Gellerstedt M, Rutberg L, Brisby H: Health-related quality of life in patients with surgically treated lumbar disc herniation: 2- and 7-year follow-up of 117 patients. Acta Orthop 82:198-203, 2011
26. Stienen MN, Cadosch D, Hildebrandt G, Gautschi OP: The lumbar disc herniation - management, clinical aspects and current recommendations. Praxis (Bern 1994) 100:1475-1485, 2011
27. Tokunaga J, Imanaka Y, Nobutomo K: Effects of patient demands on satisfaction with Japanese hospital care. Int J Qual Health Care 12:395-401, 2000
28. Tu JV: Advantages and disadvantages of using artificial neural networks versus logistic regression for predicting medical outcomes. J Clin Epidemiol 49:1225–1231, 1996
29. Urden LD: Patient satisfaction measurement. Current issues and implications. Outcomes Manage 6:125-131, 2002
30. Weiner JS, Cole SA: Three principles to improve clinician communication for advance care planning: Overcoming emotional, cognitive, and skill barriers. J Palliat Med 7:817–829, 2004
31. Westaway MS, Rheeder P, Van Zyl DG, Seager JR: Interpersonal and organizational dimensions of patient satisfaction: The moderating effects of health status. Int J Qual Health Care 15:337–344, 2003
32. Zou J, Han Y, So SS: Overview of artificial neural networks. Methods Mol Biol 458:15–23, 2008