Logistic Regression Analysis with Bootstrap on Determining Factors Affecting Patient Satisfaction Level on Health Services

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***Abstract* — This study aims to determine the factors that affect patient satisfaction level to the service of a private hospital outpatient unit in Padang, Indonesia. In this case, the level of patient satisfaction is the response variable with an ordinal scale consisting of four categories, they are dissatisfied, quite satisfied, satisfied, or very satisfied. On the other hand, the predictor variables consist of 3 socio-demographic factor variables, namely gender, education level, and type of insurance that use, and also 5 service quality (SERVQUAL) variables. To determine the predictor variables that are considered affecting response variables, an ordinal logistic regression with a bootstrap estimate of standard error is performed. The result of this research shows two predictor variables that affect the response variable signs, namely responsiveness and assurance with hit ratio 78.52%. Thus, it can be concluded that the model formed is feasible to determine patient satisfaction level of the hospital's services outpatient unit.**

Keywords* — *patient satisfaction level, service quality (SERVQUAL), ordinal logistic regression, bootstrap estimatian.

I. INTRODUCTION

Customers always want to get the best results from services and products that they are received, including in health field. They increase the attention on the health care they received. Health-service quality has been found to be associated with patient satisfaction as in [1]. The construction of consumer satisfaction refers to consumers' fulfillment responses or emotional feelings about a specific consumption experience [2]. Therefore, satisfaction or dissatisfaction is the conclusion of the interaction between expectation and experience after using the services that are provided.

The research on the level of customer satisfaction has actually started in the 1980s. Christian Gronroos proposed the concept of the customers' perceived service quality and created the perceived service quality model in 1982 [3]. In the mid-1980s, Parasuraman and Berry examined factors related to customer perceptions and decisions about service quality [4]. In 1985, they published an article about five service quality dimensions that initially consisted of 10 dimensions. The five service quality dimensions are:

1) *Tangibles*: physical facilities, equipment, and appearance of personnel.

2) *Reliability*: ability to perform the promised service dependably and accurately

3) *Responsiveness*: willingness to help customers and to provide prompt service

4) *Assurance (including competence, courtesy, credibility, and security)*: knowledge and courtesy of employees and their ability to inspire trust and confidence.

5) *Empathy (including access, communication and understanding the customer)*: caring and individualized attention to its customers.

In 1988, they developed an instrument to evaluate the quality of service called "SERVQUAL" [5]. Since then, SERVQUAL has been widely used in many fields of service, such as banking, education, tourism, enterprise, and including health and medical services. For example, satisfaction and service quality were highly correlated as in [6].

References [7] founded empirical evidence for the impact of three dimensions of service quality on patient satisfaction. From the five dimensions of service quality, there are three dimensions that affect patient satisfaction. Empathy dimension gives the greatest effect, followed by tangible and responsiveness dimension as in [8].

In this study, the predictor variables that used are not only derived from SERVQUAL that recieved by the patients but also from socio-demographic factors. The level of patient satisfaction in this study is based on the satisfaction felt by the patient itself and it is grouped into 4 categories, namely dissatisfied, quite satisfied, satisfied, or very satisfied. Since the level of patient satisfaction is classified into 4 categories and this study aims to determine the factors that affect patient satisfaction level, then the cross-sectional study as in [6] as well as the technique of data analysis in the form of multiple regression analysis as in [7] and [8] cannot be used. In this case, a suitable data analysis technique used to determine response variables with more than 2 categories that is affected by predictor variables is an ordinal regression.

II. LOGISTIC REGRESSION WITH THE ORDINAL RESPONS

The regression method is a data analysis used to find the relationship between response variable (Y) with one or more

predictor variables (X) as in [9]. The purpose of this method is to get a capable model to describe the relationship between response variables and set of predictor variables in a good and simple way. Logistic regression is a regression analysis used to describe the relationship between dichotomous (nominal or ordinal or two-dimensional) or polychotomus (nominal or ordinal scale with more than two categories) variables with a set of continuous or categorical predictor variables [10].

The response variables in logistic regression are not normally distributed, so its characterization may explain in characteristic function as Fourier-Stieltjes transform because the existance of characteristic function for every distribution. The properties of characteristic function for some special distributions have been explained in [11], [12], [13]. Then probability distribution of ordinal reponse of logistic regression could be characterize by using characteristic function. However, it also exists logit transform as mathematical transformation for characterize specific function, in regression logistic model, logit transformation is performed to give its model.

According to [9], basically logistic regression equation used from the approximate form of probability function $\pi(x) = E(Y|x)$ expressed in the following equation

$$\pi(x) = \frac{\exp(\alpha + \beta_1 x)}{1 + \exp(\alpha + \beta_1 x)}, \quad (1)$$

Then a logit transform is performed to simplify equation (1). In the logit form as:

$$g(x) = \ln\left(\frac{\pi(x)}{1-\pi(x)}\right) = \alpha + \beta_1 x \quad (2)$$

An ordinal logistic regression is one regression analysis used to analyze the relationship between response variables with predictor variables, where the response variable is polychotomus with an ordinal scale. The cumulative opportunity $P(Y \le r|x)$ is defined as:

$$P(y \le r|x) = \pi_r = \frac{\exp(\alpha_r + \sum_{k=1}^{p} \beta_k x_k)}{1 + \exp(\alpha_r + \sum_{k=1}^{p} \beta_k x_k)}, \quad (3)$$

where x is the vector value of predictor variable [10]. The estimation of the regression parameter is done by describing it using the logit transformation of $P(Y \le r|x)$.

$$\text{Logit } P(Y \le r|x) = \ln\left(\frac{P(Y \le r|x)}{1 - P(Y \le r|x)}\right) \quad (4)$$

By substituting equation (3) to equation (4), we obtain

$$\text{Logit } P(Y \le r|x) = \alpha_r + \sum_{k-1}^{p} \beta_k x_k \quad (5)$$

If there are r response categories, then the cumulative opportunities of the response are as in the equation below:

$$P(Y \le 1|x) = \pi_1(x) = \frac{\exp(\alpha_1 + \sum_{k=1}^{p} \beta_k x_k)}{1 + \exp(\alpha_1 + \sum_{k=1}^{p} \beta_k x_k)} \quad (6)$$

$$P(Y \le 1|x) = \pi_2(x) = \frac{\exp(\alpha_2 + \sum_{k=1}^{p} \beta_k x_k)}{1 + \exp(\alpha_2 + \sum_{k=1}^{p} \beta_k x_k)} \quad (7)$$

M

$$P(Y \le r|x) = \pi_r(x) = \frac{\exp(\alpha_r + \sum_{k\ 1}^{p} \beta_k x_k)}{1 + \exp(\alpha_r + \sum_{k\ 1}^{p} \beta_k x_k)} \quad (8)$$

Based on the cumulative opportunities in the above equation, we obtain the opportunity for each category of the response as follows

$$P(Y = 1|x) = \frac{\exp(\alpha_1 + \sum_{k=1}^{p} \beta_k x_k)}{1 + \exp(\alpha_1 + \sum_{k=1}^{p} \beta_k x_k)} \quad (9)$$

$$P(Y = 2|x) = \frac{\exp(\alpha_2 + \sum_{k-1}^{p} \beta_k x_k)}{1 + \exp(\alpha_2 + \sum_{k-1}^{p} \beta_k x_k)} - \frac{\exp(\alpha_1 + \sum_{k-1}^{p} \beta_k x_k)}{1 + \exp(\alpha_1 + \sum_{k-1}^{p} \beta_k x_k)} \quad (10)$$

M

$$P(Y = r|x) = \frac{\exp(\alpha_r + \sum_{k-1}^{p} \beta_k x_k)}{1 + \exp(\alpha_r + \sum_{k-1}^{p} \beta_k x_k)} - \frac{\exp(\alpha_{r-1} + \sum_{k-1}^{p} \beta_k x_k)}{1 + \exp(\alpha_{r-1} + \sum_{k-1}^{p} \beta_k x_k)} \quad (11)$$

The ordinal logistic regression model parameters are estimated by using the Maximum Likelihood Estimator (MLE). In the MLE method the estimation of the regression parameter is performed by maximizing a joint probability density function which is also called the likelihood function.

In ordinal logistic regression analysis, the response of each observation is assumed to be spread according to the multinomial distribution. If the response variable Y~Multinomial (y_1, y_2, ⋯, y_r; p_1, p_2, ⋯, p_r), then the function likelihood for the response y is

$$L(\alpha, \beta) = \prod_{i=1}^{n} [\pi_1(x_i)^{y_{1i}} \pi_2(x_i)^{y_{2i}} \Lambda\ \pi_r(x_i)^{y_{ni}}] \quad (12)$$

By doing natural logarithm of the equation (12), we obtain a log-likelihood function as follows

$$\ln(L(\alpha,\beta)) = \sum_{i-1}^{n} \{y_{1i} \ln[\pi_1(x_i)] + y_{2i} \ln[\pi_2(x_i)] + \Lambda + y_{ri} \ln[\pi_r(x_i)]\} \quad (13)$$

A maximum ln-likelihood can be obtained by differentiating L (α,β) against α and β and by equating to zero. The first derivative solution of the ln-likelihood function is a nonlinear function, so that a numerical method is needed to obtain the parameter estimation, one of them is Newton-Raphson method [10].

III. Data and Research Methods

In this study the data used come from the questionnaire that was distributed to 149 patients of a private hospital in Padang, Indonesia. The variables that are used consist of response variables (Y) and predictor variables (X). Patient satisfaction levels becomes the predictor variable divided into four categories, they are Y = 1 if the patient is dissatisfied, Y = 2 if the patient isquite satisfied, Y = 3 if the patient is satisfied, or Y = 4 if the patient is very satisfied. On the other hand, the predictor variables in this study consisted of 3 variables derived from socio-demographic factors, and 5 variables of service quality that is received by the patient.

The variables derived from socio-demographic factors are:

1) *Gender* (X_1): Patients' gender are divided into two categories, $X_1 = 1$ if the patient is male or $X_1 = 2$ if the patient is female

2) *Education Level* (X_2): patients' education level are divided into 3 categories, $X_2 = 1$ if the patient does not attend/primary education graduate, $X_2 = 2$ if the patient attends medium school graduate, or $X_2 = 3$ if the patient is a high school graduated.

3) *Type of Health Insurance* (X_3): Types of health insurance that are used by the patients are divided into 3 categories, namely $X_3 = 1$ if a patient uses insurance BPJS, $X_3 = 2$ if the patient is taking other insurance, or $X_3 = 3$ if the patient does not use any insurance (general patient).

Variables of service quality that are received by the patient are:

4) *Tangibles* (X_4): Physical evidence that includes physical facilities (e.g. buildings, office equipment), medical equipment that are used (technology), and the appearance of medical staff, hospital physical environment and surroundings.

5) *Empathy* (X_5): Terms to care, have an understanding and knowledge about patients, understand patient specific needs, and have a convenient operating time for patients.

6) *Reliability* (X_6): Performance must be in accordance with patient expectations which means punctuality, equal service for all patients, sympathetic attitude and high accuracy.

7) *Responsiveness* (X_7): Willingness to help and provide prompt and responsive service to patients with clear information.

8) *Assurance* (X_8): Knowledge, compassion and the ability of medical staff to grow patients' trust to the hospital.

The statistics data analysis is performed to obtain significantly expected parameters. The parameter consistency of structural model has been tested in [14], and the reliability index and heuristic strategies for assessing reliability has been explain in [15], while expected parameters on regression model of time series data has been modeled in [16]. In this study, we also perform the same thing to see the parameter consistency and its model.

The data analysis steps undertaken in this study are as follows:

1) Providing the statistics for the variable patient satisfaction level of hospital's services and predictor variables.

2) Determining the relationship between the factors that affect the patient satisfaction level on hospital's service using ordinal logistic regression analysis method with the following stages:

a) Establishing the best guessed model of ordinal logistic regression by involving all predictor variables

b) Testing the overall parameter significances of the ordinal logistic regression model simultaneously

This test is done to investigate the significance of the coefficient β of the response variable simultaneously by using the statistic test. The tested hypothesis are as follows:

H_0: $\beta_1 = \beta_2 = \cdots = \beta_r = 0$

H_1: there is $\beta_k \neq 0$; $k = 1, 2, ..., r$

The statistic test used is a G-test or likelihood Ratio Test.

$$G = -2\ln\left[\frac{L_0}{L_M}\right], \tag{14}$$

where L_0 is a likelihood of a model containing constants only and L_M is the likelihood of the model containing the variables. H_0 is rejected at a significant level of α if $G > \chi^2_{\alpha,df}$ with degrees of freedom is r or p-value < α [9]

c) Conducting a partial test between predictor variables and response variables

This test is done if the simultaneous test occurs rejection H_0 and aims to investigate the significance of the coefficient β partially by using the statistic tests or in other words, to determine predictor variables that have a significant effect on the response variable. The hypothesis tested is as follows:

H_0: $\beta_k = 0$

H_1: $\beta_k \neq 0$

This test is performed for each $k = 1, 2, ..., r$. The statistic test used is a Wald's test.

$$W_k = \frac{\hat{\beta}_k}{SE(\hat{\beta}_k)}, \tag{15}$$

where SE (β_k) is the standard error of the regression coefficient of k and β_k is the expected regression coefficient of k. H_0 is rejected at a significant level of α if $W_k > \chi^2_{\alpha,r}$ or p-value < α [9].

d) Creating the best ordinal logistic regression models that are significant variables in the partial test.

e) Finding and interpreting the odds ratio for each influencing predictor variable.

f) Conducting Test Accuracy Model

This test aims to determine the accuracy of data prediction measure that will measure how accurate the model that is formed. The accuracy of the model formed is determined by a measure called the hit ratio, which is defined as follows:

$$\text{hit ratio} = \frac{\text{many objects that are classified correctly}}{\text{total of observations}} \times 100\%$$

3) Perform bootstrap estimate of standart error

The algorithm of bootstrap estimate according to [17] is

a) Select B independent bootstrap samples x^{*1}, x^{*2}, ⋯, x^{*B}, each consisting of n data values drawn with replacement from x

b) Evaluate the bootstrap replication corresponding to each bootstrap sample,

$$\hat{\theta}^*(b) = s(x^{*b}), \quad (16)$$

where $b = 1, 2, \cdots, B$

c) Estimate the standart error $se_F(\theta)$ by the sample standard deviation of the B replications

$$\hat{se}_B = \{\frac{1}{B-1}\sum_{b=1}^{B}[\hat{\theta}^*(b) - \hat{\theta}^*(\cdot)]^2\}^{1/2}, \quad (17)$$

where $\hat{\theta}^*(\cdot) = B^{-1}\sum_{b\ 1}^{B}\hat{\theta}^*(b)$

IV. Results and Discussion

In this study we use the ordinal logistic regression analysis with some variable response of the patient satisfactions, namely dissatisfied, quite satisfied, satisfied or very satisfied, and also several predictor variables. The data used are 149 responses on questionnaires filled by patients or family of the patients.

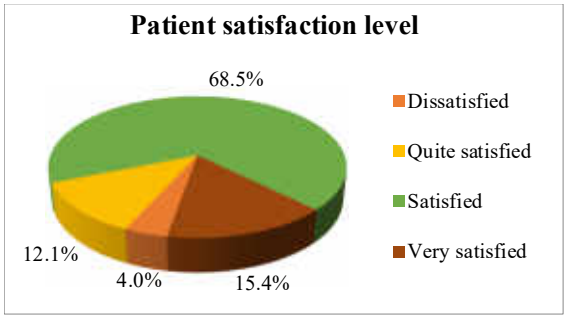

Fig. 1. Patient satisfaction level of hospital's service

Characteristics of patient satisfaction level can be known through descriptive statistics as follows. These analytics are used to find a simple picture of the data or the level of patient satisfaction from all sides. The graphic in Fig. 1 shows that patients who are satisfied with health services have the largest percentage, namely 68.5%. This means that most hospital's patients have been satisfied with hospital's services.

TABLE I. The characteristics of hospital's patients

Variable		Sum	%
Gender	male	54	36.2%
	female	95	63.8%
Education Level	not attend/primary school graduate	7	4.7%
	medium school graduate	74	49.7%
	high school graduate	68	45.6%
Type of Insurance	BPJS	63	42.3%
	other insurance	62	41.6%
	not use any insurance	24	16.1%

The characteristics of hospital's patients are shown by TABEL I. The proportion of female patients is almost twice as much as male patients with 36.2%. Meanwhile, patients with medium education have the highest percentage than other education levels, namely 49.7%. In contrast, patients who did not use any insurance have the lowest percentage by 16.1%.

After knowing the characteristic of the variable in this research, next we will determine the best logistic regression alleged model by entering all predictor variables and doing the model significance test. We obtain two predictor variables that significantly influence the level of patient satisfaction. Furthermore, by incorporating the two predictor variables, we obtain the model with the following conjecture.

$$\pi_1(x) = 17.002 + 0.321x_7 + 0.227x_8$$

$$\pi_2(x) = 19.111 + 0.321x_7 + 0.227x_8$$

$$\pi_3(x) = 23.946 + 0.321x_7 + 0.227x_8$$

To find out the presence or absence of predictor variables that affect the response variables significantly, the data are tested simultaneously using G statistic test or Likelihood Ratio Test.

TABLE II. Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	Df	Sig.
Intercept Only	232.930			
Final	155.323	77 607	2	0.000

From the above table, we obtain that the test value $G > \chi^2_{0.05,\,42}$ and p-value < 0.05. Because the G test is bigger than χ^2 table, the rejection of H_0 is happen. This means that at least one predictor variable significantly affects the response variable. Due to a repellent H_0, then the test is continued with the partial test by using the Wald test.

TABLE III. Parameter Estimates

Variable	Estimate	Wald	D_f	Sig.
Responsiveness (X_7)	0.321	15.700	1	0.000
Assurance (X_8)	0.227	6.307	1	0.012

Partial Significance Test By Stage 2 ($\alpha = 0{,}05$)

Based on TABEL III, it is known that the significance value of all predictor variables is less than the value α. Therefore, we can conclude that the variable responsiveness (X_7) and assurance (X_8) affect the response variable.

Furthermore, to interpret how big the above variables affect the patient satisfaction level, we use the value of odds ratio whose value can be seen in the following table:

TABLE IV. Value odds ratio Logistic Regression

Variable	Estimate	Exp (β)
Responsiveness (X_7)	0.320	1.379
Assurance (X_8)	0.227	1.255

From TABEL IV, we obtain that the odds ratio for responsiveness is 1.379. This means that each increasing of 1 unit responsiveness will increase the risk of 1.379 times, so that the patient will feel very satisfied with the hospital's service. On the other hand, the risk posed by an increasing of 1 unit variable assurance is 1.255 times and thus the patient will feel very satisfied with the hospital's service because the value of odds ratio is 1.255.

The next step is to calculate the exact value of the classification between the actual value and the predicted value obtained from the model that has been formed. The model predictions on response categorize 2 dissatisfied patients, 5 quite satisfied patients, 97 satisfied patients and

13 very satisfied patients. For more details, this classification mistake can be seen in the following table:

TABLE V. ACCURACY OF CLASSIFICATION

Observation	Prediction				Classification accuracy percentage
	Dissatisfied	Quite satisfied	Satisfied	Very satisfied	
Dissatisfied	2	1	3	0	33.33%
Quite satisfied	1	5	11	1	27.78%
Satisfied	0	2	97	3	95.1%
Very satisfied	0	0	10	13	56.52%
Overall percentage	1.34%	3.36%	65.1%	8.72%	78.52%

Based on the above table, we obtain that the accuracy of the classification of the model is 78.52%. Based on the value of hit ratio obtained above, the model can predict the data of 78.52%, which means that the resulting model is good and feasible used to predict the response variable

Using $B = 500$ bootstrap sample, each consists of $n = 100$ observations, the ordinal logistic bootstrap approach yield the following result:

TABLE VI. BOOTSTRAP APPROACH

Predictor	Estimate	Std. Deviation of estimate	Odds Ratio	95% confidence interval (CI)	
				Lower	Upper
Constant (1)	18.055	4.05			
Constant (1)	20.34	4.147			
Constant (1)	25.309	4.736			
Responsiveness (X_7)	0.34	0.116	1.40	1.12	1.76
Assurance (X_8)	0.242	0.124	1.27	1.00	1.62

And result model is

$$\pi_1(x) = 18.055 + 0.34x_7 + 0.242x_8$$

$$\pi_2(x) = 20.34 + 0.34x_7 + 0.242x_8$$

$$\pi_3(x) = 25.309 + 0.34x_7 + 0.242x_8$$

This model is slightly different from the model obtained by traditional ordinal logistic regression. Based on this model, it is concluded that the odds ratio for responsiveness is 1.40 (95% confidence interval is 1.12 to 1.76) and for assurance is 1.27 (95% confidence interval is 1.00 to 1.62). It means that an increasing of one-unit of responsiveness score will lead to 140% (95% confidence interval, 112 % to 176%) increase of odds of patient satisfaction to a higher level. Furthermore, an increasing of one-unit of assurance score associated will lead to 127% (95% confidence interval, 100% to 162%) increase of odds of patient satisfaction to a higher level. Because of any confidence interval is not equal to zero, so the variable responsiveness and assurance affect the response variable significantly.

A variable responsiveness give the highest effect to patient satisfaction level. A willingness helps and provides prompt and responsive service to patients with clear information needed by the patient to make them confident and satisfied with the services given by the hospital. Besides that, knowledge, compassion and the ability of doctors, nurses, and the other medical staff also give effect to patient satisfaction. Therefore, variable assurance also affect to patient satisfaction level. Higher variable responsiveness and assurance will lead to more satisfied patient with the hospital's services.

V. CONCLUSION

From the characteristics of the data of hospital's patient, it can be concluded that most hospital's patients are female (63.8%), only a small proportion of patients did not attend school/graduate from primary school (4.7%), and most of the patients used both BPJS insurances (42.3%) and other insurance (41.6%). The majority of hospital's patients (68.5%) have been satisfied with the services provided.

The results of this study proved that from 8 predictor variables, there are two responsiveness variables and assurance positively have a significant effect on the level of the patient's satisfaction with hospital's service of outpatient unit. On the other hand, the variables gender, level of education, types of insurance used, tangibles, empathy, and reliability do not significantly influence the patient satisfaction level of service of the private hospital outpatient unit.

Responsiveness variable has an odds ratio 1.379, and after bootstrapping the estimate of odds ratio become 1.40. This means that each increasing of 1 unit of competence and doctor's attitude will increase the risk 1.40 times and so the patient will feel very satisfied with the hospital's service. While the risk posed by an increasing of 1 unit variable assurance is 1.27 times which means that the patient will feel very satisfied with the hospital's service, because the value of the odds ratio is 1.27 after bootstrapping the previous estimate 1.255.

Based on the hit ratio, the model with the predictor variable above gives the model accuracy of 78.52%. Thus, it can be concluded that the model that is formed is feasible used to determine the factors that affect the patient satisfaction level to the service of a private hospital outpatient unit.

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