Original Article

Binary Logistic Regression Model to Predict the Need of Intensive Care Unit (ICU) Support of Sepsis Patients during Hospital Stay

Aziz MZA[1], Islam MA[2], Islam MS[3], Ahasan HAMN[4]

Conflict of Interest: None
Received: 08.02.2021
Accepted: 04.11.2021
www.banglajol.info/index.php/JSSMC

Key Words:
Binary logistic regression model; Sepsis, Severe sepsis; Intensive care support; Hospital mortality

Abstract

Hospital mortality in ICU patients of Bangladesh suffering from severe sepsis, which is significantly higher than countries reported. Binary logistic regression model of important clinical variable will use for this study to predict the category of severe sepsis, fatal outcome and need of Intensive Care Support (ICU) during hospital stay. The aim of this study was to achieve accurate prediction of the category of severe sepsis and the need of ICU of sepsis and severe sepsis patients by using binary logistic regression model. This study was carried out in the Department of Medicine, Dhaka Medical College Hospital (DMCH) during January 2015 to December 2015.We select 100 patients from them 35 were sepsis and 65 were severe sepsis. Data was collected in a pre-designed proforma. All data compiled together and statistical analyses was carried out by using IBM SPSS Statistics 22.0 & MS-Excel 2016. Total 100 patients from both the groups (sepsis 35 and severe sepsis 65) completed the study. The aim of the logistic regression analysis models was to predict outcome variables like improvement during hospital stay, need of ICU support, fatal outcome and fall in the category of severe sepsis. In our study, we found 55 of the 65 cases (84.6 %) are classified correctly as severe sepsis, 22 of the 35 cases (62.9 %) were not categorized as severe, 4 of the 14 cases (28.6 %) who had fatal outcome during hospital stay are classified correctly. Overall, 77% of the cases are classified correctly 83 of the 86 cases (96.5 %) who did not have fatal outcome during hospital stay. Overall, 87 % of the cases are classified correctly. 74 of the 79 cases (93.7 %) who required Intensive Care Unit (ICU) support during hospital stay are classified correctly. 5 of the 21 cases (23.8 %) who did not require ICU support during hospital stay are classified correctly. Overall, 79 % of the cases are classified correctly. From this study, it is concluded that sepsis & severe sepsis is very common in a hospital of Dhaka at a tertiary level. We found by applying binary logistic regression model there 77% severe sepsis patients, 87% fatal outcome and 93.7% patients need intensive care unit (ICU) support. These results suggest that binary logistic regression model can help to predict need for ICU support and eventually help to measure the outcome during hospital stay.

[J Shaheed Suhrawardy Med Coll 2021; 13(2): 94-99]
DOI: https://doi.org/10.3329/jssmc.v13i2.65168

Introduction

In statistical modeling, regression analysis is a set of statistical processes for estimating the relationships between a dependent variable (often called the 'outcome variable') and one or more independent variables (often called 'predictors', 'covariates', or 'features') and a binary regression estimates a relationship between one or more explanatory variables and a single output binary variable. In a binary logistic regression model, the dependent variable has two levels (categorical). Outputs with more than two values are modeled by multinomial logistic regression and, if the multiple categories are ordered, by ordinal logistic regression (for example the proportional odds ordinal logistic model).[1,2]

Sepsis is one of the oldest and most elusive syndromes in Medicine. Sepsis is defined as the presence (probable or documented) of infection together with systemic manifestations of infection. Severe sepsis is defined as sepsis plus sepsis-induced organ dysfunction or tissue

1. Dr. Mohammad Zakaria Al- Aziz, Department of Medicine, Sheikh Hasina Medical College, Tangail, Bangladesh
2. Dr. Md. Atiqul Islam, Department of Medicine, Pabna Medical College, Pabna, Bangladesh
3. Dr. Md. Shamiul Islam, Department of Cardiology, Sheikh Hasina Medical College, Tangail, Bangladesh
4. Dr. H A M. Nazmul Ahasan, Department of Medicine, Popular Medical College, Dhaka Bangladesh

Correspondence: Dr. Mohammad Zakaria Al- Aziz. Assistant professor, Department of Medicine, Sheikh Hasina Medical College, Tangail, Bangladesh. Mobile: +8801715176244, Email: drazizdmch2@gmail.com

hypo perfusion (any of the following thought to be due to the infection). Hippocrates claimed that sepsis was the process by which flesh rots, swamps generate foul airs, and wounds fester.[3] Sepsis is a systemic, deleterious host response to infection leading to severe sepsis and septic shock. Severe sepsis and septic shock are major healthcare problems, affecting millions of people around the world each year, killing one in four (and often more), and increasing in incidence.[4] Similar to polytrauma, acute myocardial infarction, or stroke, the speed and appropriateness of therapy administered in the initial hours after severe sepsis develops are likely to influence outcome.

The clinical manifestations of sepsis are highly variable, depending on the initial site of infection, the causative organism, the pattern of acute organ dysfunction, the underlying health status of the patient, and the interval before initiation of treatment. The signs of both infection and organ dysfunction may be subtle, and thus the most recent international consensus guidelines provide a long list of warning signs of incipient sepsis.[5] Acute organ dysfunction most commonly affects the respiratory and cardiovascular systems. Respiratory compromise is classically manifested as the acute respiratory distress syndrome (ARDS), which is defined as hypoxemia with bilateral infiltrates of no cardiac origin.[6] Cardiovascular compromise is manifested primarily as hypotension or an elevated serum lactate level. After adequate volume expansion, hypotension frequently persists; requiring the use of vasopressors, and myocardial dysfunction may occur.[7] Hospital mortality in ICU patients of Bangladesh suffering from severe sepsis was 49·2%. It was significantly higher than countries reported. Compliance to entire components of both resuscitation& management bundles were reported to be zero in ICUs of Bangladesh.[8] The overall mortality from bacteremia was 18%. Bacteremia associated mortality notable after the age of 45. The mortality rate in polymicrobial septicemia was 3 out of 5 (60%), which was higher than monomicrobial septicemia (15.78%).[9] Hospital mortality was 44.5% (572/1285) in Asia. While mortality from severe sepsis is high, compliance with resuscitation and management bundles is generally poor in much of Asia.[10] Binary logistic regression model of important clinical variable will use for this study to predict the category of severe sepsis, fetal outcome and need of Intensive Care Support (ICU) during hospital stay so that we can measure the way to reduce mortality of sepsis or severe sepsis patients. Therefore, this study was undertaken to achieve accurate prediction of the category of severe sepsis and the need of ICU of sepsis and severe sepsis patients by using binary logistic regression model.

Materials and methods

It was hospital- based analytical observational study. This study was carried out in the Department of Medicine, Dhaka Medical College Hospital (DMCH). The Patients admitted in department of Medicine were the study population**.** Sepsis patients admitted in intensive care unit (ICU) of DMCH referred from the department of Medicine were included in the study. The study was carried out between the period of January 2015 to December 2015. The sampling method was non-random, and purposive. The sample size was determined using the following formula as below:

$$\frac{z^2 pq}{d^2}$$

n= the desired sample size

z= Standard normal deviate usually set at 1.96 in 95% confidence level

p= Proportion in the population 14.9 % (0.149 % proportion of sepsis, DMCH year Book 2013)

q= 1-p=0.851

d= Degree of accuracy which is considered as 5 %(0.05) margin of error for sample size determination

According to formula, the estimated sample size= 194.7=195

The patients who fulfilled the criteria of sepsis and age more than 14 Years were enrolled in the study. Finally, we recruited 100. Out of them 35 were sepsis and 65 were severe sepsis patients for our study**.** Data was collected in a pre-designed proforma. Patients' information was obtained using information sheet which includes questionnaire, clinical findings and investigation findings. Severity of sepsis was categorized based on clinical and laboratory parameters recorded during the study. Attempt was made to find association of different outcome variables (i.e. need of ICU support and severity of sepsis) with different clinical and laboratory parameters. Binary logistic regression is a type of probabilistic statistical classification model. It is used for predicting the outcome of a categorical dependent variable (i.e., a class label of mortality, severity of sepsis and need of ICU support) based on one or more qualitative or quantitative predictor variables. Exclusion criteria were age: <14years, decompensated liver cirrhosis**,** Nephrotic syndrome**,** Hematological malignancy**,** Pregnancy**,** Acute coronary syndrome**,** the patients who did not give consent. Finally, all data compiled together and statistical analyses was carried out by using IBM SPSS Statistics 22.0 (IBM Inc, Chicago, Illinois, USA) & MS-Excel 2016. Significance of relationship between important categorical variables was demonstrated using cross-tables with Pearson's Chi-squared test Statistical significance was deemed while $P < 0.05$ at 95% confidence interval.

Results

It was observed that male was 66 (66%) and female was 34 (34%). The male: female ratio was approximately 1.9:1. Among the study population, more male 24 (36.4%) belonged to 14-40 years' age group while more female 10 (29.4%) were in 51-60 years' age group [Figure 1]. we found graphical presentation of percentage of sepsis 35 % and severe sepsis 65% [Figure 2].

A binary logistic regression model was constructed to ascertain the effects of different clinical parameters like. age, sex, fever duration, oliguria, hypotension fluid imbalance [significant edema or positive fluid balance (>20ml/kg over 24 hr)] and capillary refill time that patient may fall into the category of severe sepsis even before complete initial evaluation. The ratio of the coefficient (B) to its standard error (S.E.), squared, equals the Wald statistic (Table I).

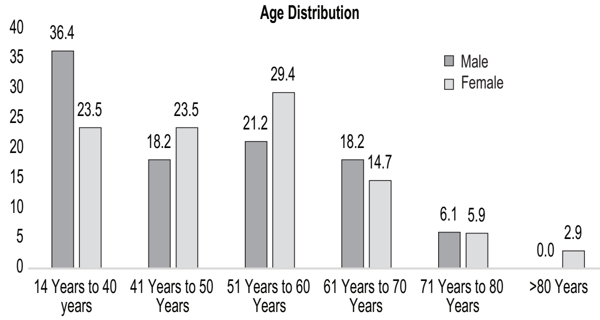

Figure 1. *Demonstrate and distribution of the study population according to age (n =100)*

Table 1a

Binary logistic regression analysis of important clinical variables that may predict whether patients may belong to the category of severe sepsis even before completing the initial evaluation (N=100)*

	B	S.E.	Wald	Df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Age group	0.24	0.20	1.53	1	0.216	1.28	0.87	1.88
Sex	-0.68	0.56	1.51	1	0.219	0.51	0.17	1.50
Fever duration	0.10	0.08	1.59	1	0.207	1.10	0.95	1.28
Initial GCS	-1.20	0.40	9.14	1	0.003	0.30	0.14	0.66
Tachycardia	0.51	0.69	0.55	1	0.46	1.67	0.43	6.46
Tachypnea	-0.72	0.55	1.72	1	0.189	0.49	0.17	1.42
Fluid imbalance	1.31	0.98	1.78	1	0.182	3.70	0.54	25.29
Capillary refill time	0.58	1.20	0.23	1	0.63	1.78	0.17	18.57
Constant	0.92	2.43	0.14	1	0.704	2.52		

* $\chi^2(9)$ [from Omnibus Tests of Model Coefficients] = 26.508, P = 0.002; Nagelkerke R Square statistic = 0.363

Table 1b

Classification table from Binary logistic regression model of important clinical variables that may predict whether patients may belong to the category of severe sepsis even before complete initial evaluation

Observed		Predicted		
		Severe sepsis		Percentage Correct
		No	Yes	
Severe sepsis category	No	22	13	62.9
	Yes	10	55	84.6
Overall Percentage				77.0

The cut value is 0.50

If the significance level of the Wald statistic is small (less than 0.05) then the parameter is useful to the model. Exp(B) represents the ratio-change in the odds of the event of interest (i.e. severe sepsis category) for a one-unit change in the predictor**.** The classification table shows the practical results of using the binary logistic regression model. For each case, the predicted response is 'Yes' if that case's model-predicted probability is greater than the cutoff value (0.50). Cells on the diagonal are correct predictions and cells off the diagonal are incorrect predictions. Of the cases used to create the model, 55 of the 65 cases (84.6%) who eventually fell in the category of severe sepsis are classified correctly. 22 of the 35 cases (62.9%) who were not categorized as having severe Sepsis are classified correctly. Over all 77% of the cases are classified correctly.

Table 2a

Binary logistic regression analysis of important clinical variables that may predict requirement of Intensive Care Unit (ICU) support during hospital stay (N=100)*

	B	S.E.	Wald	Df	Sig.	Exp (B)	95% C.I. for EXP (B)	
							Lower	Upper
Age group	-0.46	0.26	3.07	1	0.08	0.635	0.383	1.053
Sex	-0.39	0.71	0.30	1	0.58	0.678	0.17	2.713
Fever duration	-0.20	0.09	4.80	1	0.03	0.816	0.681	0.979
Oliguria	-0.87	1.40	0.39	1	0.54	0.418	0.027	6.556
Initial GCS	-2.08	0.67	9.54	1	0.00	0.125	0.034	0.468
Hypotension	0.02	0.82	0.00	1	1.00	1.022	0.205	5.109
Tachycardia	-0.73	0.91	0.64	1	0.42	0.482	0.081	2.88
Tachypnea	0.06	0.63	0.01	1	0.92	1.064	0.312	3.635
Fluid imbalance	1.02	1.38	0.55	1	5.00	2.767	0.187	40.95
Constant	11.00	4.36	6.34	1	0.01	58649.16		

*χ^2(9) [from Omnibus Tests of Model Coefficients] = 26.508, P = 0.002; Nagelkerke R Square statistic = 0.363

Table 2b

Classification table from Binary logistic regression model of important clinical variables that may predict requirement of Intensive Care Unit (ICU) support during hospital stay

Observed		Predicted		
		Intensive Care Unit (ICU) support needed		Percentage Correct
		No	Yes	
Intensive Care Unit (ICU) support needed	No	5	16	23.8
	Yes	5	74	93.7
Overall Percentage			79.0	

The cut value is 0.50

Same clinical variables are also used to predict whether the patients need intensive care unit (ICU) support or not (Table 2). If the significance level of the Wald statistic is small (less than 0.05) then the parameter is useful to the model. Exp (B) represents the ratio-change in the odds of the event of interest (i.e. Intensive Care Unit (ICU) support needed) for a one-unit change in the predictor. The classification table shows the practical results of using the binary logistic regression model. For each case, the predicted response is 'Yes' if that case's model-predicted probability is greater than the cutoff value (0.50). Cells on the diagonal are correct predictions and cells off the diagonal are incorrect predictions. Of the cases used to create the model, 74 of the 79 cases (93.7%) who required Intensive Care Unit (ICU) support during hospital stay are classified correctly. 5 of the 21 cases (23.8%) who did not require ICU support during hospital stay are classified correctly. Overall, 79% of the cases are classified correctly.

Discussion

This Hospital based cross sectional, analytical observational study was carried out with an aim to predict the severity of sepsis and need of intensive care unit (ICU) support of sepsis patient by using binary logistic regression model and also the hospital mortality rate at the end of first week of enrollment in the study. Sepsis can occur in all age groups and sex, even though various previous studies found that the elderly were more susceptible and suffered from more severe manifestations of sepsis.[11] Our study as well as other study done by many investigators show incidence of severe sepsis increasing day by day with increased mortality, probably due to late presentation, unable to early recognition and delay of management. With advancement of medical management this scenario is unexpected. An emergency mass awareness programmed is important to combat the situation. This study utilized binary logistic regression analysis to develop models based on some clinical variables. The aim of the models was to predict outcome variables like improvement during hospital stay, need of ICU support, fatal outcome and fall in the category of severe sepsis. These models would in turn help to develop criteria depending on clinical variables only so that in resource-poor primary health care setting, answers to important questions regarding outcome can be determined without laboratory support that can contribute to appropriate priority-based referral system. It was observed that male was 66 (66%) and female were 34 (34%). The male: female ratio was approximately 1.9:1. This indicates that sex distribution revealed male predominance among the study population. More male 12 (70%) belonged to 61-70 years' age group while more female 24 (41%) were in 51-60 years' age group. Overall, 24 (75%) of study population were below 40 years of age. Thirty-six percent (36%) patient were smoker. Similarly, an Indian study by Prashanth showed among 100 sepsis patients studied, 60 were male (60%) and 40 were female (40%). The patient's age ranged from 18 to 88 years (mean 41.85). An Indonesian study showed out of forty-two 11(28.6) were more than 60 years and male were 52.4%, female was 47.65%. which support our study result. Phua J observed mean age 59.2 years, male was 61.7%. Another study done by Faruq in Bangladesh obtained that Age (years) 52·3 ± 19·7 were in Survivors and 55·6 ± 15·6 non-survivors, male was 44% and female were 55% which differ with the current study. This difference result may be due to they included surgical, gynecological and medical cases. There sample were only severe sepsis. The female patient developed more severe sepsis assume due to hormonal and genetical causes. In this study 35 (35%) were classified as sepsis and 65 (65%) as severe sepsis based on Surviving Sepsis Campaign (SSC) criteria for the respective categories (Figure 2).

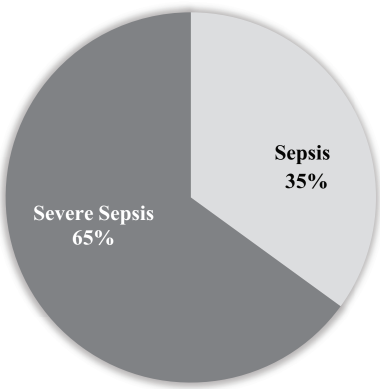

Figure 2. *Graphical Presentation of Sepsis and Severe Sepsis (N=100)*

It was observed that severe sepsis was more prevalent probably because of late presentation of the patients, delay in diagnosis, subsequent delay in initiation of treatment and lack of adherence to recommended early treatment protocols as well as making decision by patient or attended whether transfer to ICU or not. In a study from New Delhi by Nasa[12] showed 132 of 387 (34%) patients were sepsis that was similar to our study. Widodo. (2004) showed, 42 subjects who participated in the study, eleven subjects fulfilled the criteria for sepsis (26.2 %), 20 subjects for severe sepsis (47.6%), and 11 subjects for septic shock (26.2%). B. Khwannimit and R.Bhurayanontachai[13] showed that the incidence of severe sepsis and septic shock increased significantly from 16.6 to 21.6/100 ICU admissions in Thailand hospital. Severe sepsis and septic shock were identified in 87(22.3%) and 303 (77.7%) patients respectively. Martin[14] founded that the number of sepsis cases increased from 164,072 in 1979 to 659,935 in 2000. This was an increase of 13.7 percent per year. In this study, 55 of the 65 cases (84.6%) who eventually fell in the category of severe sepsis are classified correctly. 22 of the 35 cases (62.9%) who were not categorized as having severe sepsis are classified correctly. Overall, 77% of the cases are classified correctly. A binary logistic regression analysis was performed to ascertain the effects of different clinical parameters namely age group, sex, fever duration, oliguria, hypotension, fluid imbalance [significant edema or positive fluid balance (> 20 mL/kg over 24 hr)] and capillary refill time on the likelihood that patients may fall into the category of severe sepsis even before complete initial evaluation. The logistic regression model was statistically significant [$c^2(8) = 25.216$, $P = 0.001$]. The model explained 30.70% (Nagelkerke R^2) of the variance in severe sepsis category and correctly classified 77% of cases. Patients having higher initial GCS were only 0.302 times as likely to fall into the category of severe sepsis after completion of initial evaluation including clinical and laboratory tests ($P = 0.003$) as compared to those having poor initial GCS, while assuming all other variables being equal. Increasing GCS was, therefore, associated with a reduction in the likelihood of having severe sepsis in the study cases. We carefully noticed Four **(**4) of the 14 cases (28.6%) who had fatal outcome during hospital stay are classified correctly. 83 of the 86 cases (96.5%) who did not have fatal outcome during hospital stay are classified correctly. Overall, 87% of the cases are classified correctly. A binary logistic regression analysis was performed to ascertain the effects of different clinical parameters namely age group, sex, fever duration, oliguria, hypotension, fluid imbalance [significant edema or positive fluid balance (> 20 mL/kg over 24 hr) and capillary refill time on the likelihood that patients may have a fatal outcome Intensive during hospital stay. The logistic regression model was statistically significant $c^2(7) = 19.508$, $P = 0.007$. The model explained 31.90% (Nagelkerke R^2) of the variance in fatal outcome and correctly classified 87% of cases. None of the variables included in the model individually significantly altered likelihood of having a fatal outcome for the patients. This study found**,** 74 of the 79 cases (93.7%) who required ICU support during hospital stay are classified correctly. Five of the 21 cases (23.8%) who did not require ICU support during hospital stay are classified correctly (Figure 3).

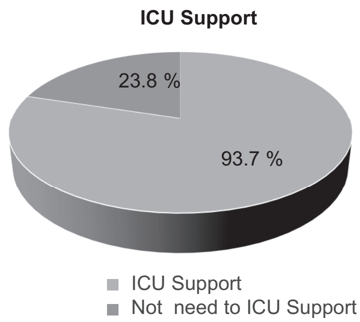

Figure 3. *Graphical Presentation of intensive care unit (ICU) support or not (N=100)*

Overall, 79% of the cases are classified correctly. A binary logistic regression analysis was performed to ascertain the effects of different clinical parameters namely age group, sex, fever duration, oliguria, hypotension, tachycardia, tachypnea and fluid imbalance significant edema or positive fluid balance (> 20 mL/kg over 24 hr) on the likelihood that patients may require Intensive Care Unit (ICU) support during hospital stay. The logistic regression model was statistically significant $\chi^2(9)$ = 26.508, P = 0.002. The model explained 36.30% (Nagelkerke R^2) of the variance in cases requiring ICU support and correctly classified 79% of cases. Cases with longer duration of fever were only 0.816 times as likely to require ICU support during the course of hospital stay (P = 0.028) as compared to cases without hypotension, while assuming all other variables being equal. Cases with initial higher GCS were only 0.125 times as likely to require Intensive Care Unit (ICU) support during the course of hospital stay (P = 0.002) while assuming all other variables being equal. Therefore, longer duration of fever and higher initial GCS were associated with a decreased likelihood of requiring Intensive Care Unit (ICU) support.

There were a number of limitations of the present study. First, the studied population was selected from Medicine department and Intensive Care Unit of a single tertiary level center in Dhaka city. Hence, the results of the study may not reflect the exact picture of the country. In addition, the present study was conducted within a very short period of time. Small sample size was also a limitation of the present study. Patients involved in the present study were followed up only once at the end of first week after enrolment in the study. It was too small to get an idea about sepsis and severe sepsis patient population of Bangladesh. An accurate epidemiology, clinical features and hospital outcome of sepsis patient was difficult to obtain from this study.

Conclusion

From this study, it is concluded that sepsis & severe sepsis is very common at a tertiary level hospital in Dhaka. We found by applying binary logistic regression model there77% severe sepsis patients, 87% fatal outcome and 93.7% patients need intensive care unit support. Severe sepsis kills many of our patient silently. Elderly patients are suffering more in both sepsis and severe sepsis in with many comorbid conditions. Clinical symptom, sign and laboratory profile are varying with individual patients. Mortality is higher among female sepsis patients. It is prism that the significant reason for the higher mortality may be due to late presentation in the health care center, to delay in diagnosis and subsequent delay in initiation of treatment. So binary logistic regression model can help to predict need for ICU support and eventually help to measure the outcome during hospital stay.

References

1. Tolles, Juliana; Meurer, William J (2016). “Logistic Regression Relating Patient Characteristics to Outcomes”. JAMA. 316 (5): 533–4. doi:10.1001/jama.2016.7653. ISSN 0098-7484. OCLC 6823603312. PMID 27483067.
2. Walker, SH; Duncan, DB (1967). “Estimation of the probability of an event as a function of several independent variables”. Biometrika. 54 (1/2): 167–178. doi:10.2307/2333860. JSTOR 2333860.
3. Majno, G 1991, ‘The ancient riddle of sigma eta psi iota sigma (sepsis)’, J Infect Dis, vol. 163, pp. 937-45.
4. Dombrovskiy VY, Martin AA, Sunderram J, Paz HL. Rapid increase in hospitalization and mortality rates for severe sepsis in the United States: a trend analysis from 1993 to 2003. Critical care medicine. 2007 May 1;35(5):1244-50.
5. Levy, MM, Fink, MP, Marshall, JC, Abraham, E, Angus, D, Cook, D et al. 2001, ‘SCCM/ESICM/ACCP/ATS/SIS International Sepsis Definitions Conference’, Crit Care Med, vol. 31, pp. 1250-6.
6. Ranieri, VM, Rubenfeld, GD & Thompson, BT 2012, ‘Acute respiratory distress syndrome: the Berlin Definition’, JAMA, vol. 307, pp. 2526-33.
7. Dellinger, RP, Levy, MM, Rhodes, A,Annane, D, Gerlach, H, Opal, SM et al. 2013, ‘Surviving Sepsis Campaign: international guidelines for management of severe sepsis and septic shock’, Crit Care Med, vol. 41, pp. 580-637.
8. Faruq, M.O. Ahsan, A.S.M.A. Uddin, M.N. U H. Khatun, S. Mannan, M.A. Tamanna, R.J. et al. (2013), ‘Implementation of Sepsis Bundles in Intensive Care Units of Bangladesh: A Prospective Observational Study’, Bangladesh Crit Care J; 1: pp. 8-17.
9. Prashanth, HV, Saldanha, RMD, Shenoy, S, Baliga,S 2011, ‘Predictors of mortality in adult sepsis’, Int J Biol Med Res. Vol.2(4), pp.856 – 861.
10. Phua,J ,Koh, Y,Du, B, Tang, YQ, V Divatia, JV, Tan,CC et.al 2011,’ Management of severe sepsis in patients admitted to Asian intensive care units: prospective cohort study’, ONLINE FIRST | bmj.com.
11. Widodo, D, 2004,’ The clinical, laboratory, and microbiological profile of patients with sepsis at the Internal Medicine Inpatient Unit of Dr. Cipto Mangunkusumo National General Hospital, Jakarta’, Med J Indones, Vol 13, pp.90-95.
12. Nasa P, Juneja D, Singh O 2012 ‘Severe sepsis and its impact on outcome in elderly and very elderly patients admitted in intensive care unit’, J Intensive Care Med. Vol.27, pp.179-83.
13. Khwannimit,B, Bhurayanontachai,R 2009,’ The epidemiology of, and risk factors for, mortality from severe sepsis and septic shock in a tertiary-care university hospital setting’, Epidemiol. Infect. , vol.137, pp.1333–1341.
14. Martin, G.S., D.M. Mannino, S. Eaton and M. Moss. 2003. The Epidemiology of Sepsis in the United States from 1979 through 2000. New England Journal of Medicine 348: 1546–54.