Quest for Research Excellence On Computing, Mathematics and Statistics

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Faculty of Computer and Mathematical Sciences

Quest for Research Excellence on Computing, Mathematics and Statistics

Chapters in Book

The 2nd International Conference on Computing, Mathematics and Statistics (iCMS2015)

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CHAPTER 26
Risks of Divorce: Comparison between Cox and Parametric Models

Sanizah Ahmad, Norin Rahayu Shamsuddin, Nur Niswah Naslina Azid @ Maarof, and Hasfariza Farizad

Abstract. Divorce or also known as the dissolution of marriage occurs when the bond of matrimony between married couples is dissolved. Since the rate of divorce is on the rise all around the world, this study aims to identify potential risk factors contributing to divorce by making comparisons between Cox Proportional Hazards (PH) model (a semi-parametric method) with Weibull and Lognormal models (parametric methods) using survival data. We retrospectively studied 531 secondary data of the Muslim couples who filed for divorce in Selangor, Malaysia. The age at marriage of husband and wife, the presence of children, duration of marriage, couples' educational level and employment status, household income and counseling session were identified as potential risk factors. The AIC (Akaike Information Criterion) were used to compare the efficiency of models between the three methods. The Cox PH model gives the best fit with respect to the lower AIC value. The survival result from the Cox model showed that age at marriage of husband and attending counseling session significantly affect the decision to divorce.

Keywords: akaike information criterion (AIC); Cox proportional hazards; divorce; weibull; lognormal

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1 Introduction

Divorce or the dissolution of marriage is a legal ending to a marriage. Marriage is important as it gives the married couples happiness and prolongs their lives [1]. However, there are times when the marriage becomes almost impossible to continue. In the Islamic law, divorce or the dissolution of marriage is permissibl e when the relationship can no longer survive. Before proceeding with the divorce, couples are encouraged to go through counseling sessions organized by the Islamic Religious department in the hope for reconciliation. If it fails, they have the right to divorce as has been established in the Islamic Law. According to the court's procedures, those who applied for the divorce must have a follow up by the counseling report. If the husband fails to attend the counseling session for three times in a row, the wife has the right to request for the counseling report and she can proceed with the divorce to the Syariah court. However, there are cases where the husband or wife did not attend the counseling session because they managed to solve their marital problems themselves [2].

About 1.2 million Muslim marriages were registered in Malaysia between year 2008 and 2012. However, Malaysia is facing a high rate of divorce where 210,326 Muslim divorces were recorded over the same period, with Selangor topping the list with 28,570 cases [3]. News reports stated that statistics provided by the *Syariah* Judiciary Department Malaysia (JKSM) showed that the number of Muslim couples getting divorced rose by 2.3 times from 20,916 in 2004 to 47,740 in 2012 and to 49,311 in 2013. [4] stated that age at marriage is significantly correlated with divorce. This statement is supported by [5] and she reported that in Malaysia apparently, many divorce cases are among senior citizens where divorce happens among 5 out of 10 senior couples. It is also discovered that the presence of children help prevents couples from being separated [6]-[7]. A recent study also found that marriage is likely to be dissolved during the first 5 years of marriage [8]. JAKIM also reported in 2011 that 21% of 651,851 Muslim couples who got married between year 2005 and 2010 ended their marriages within 5 years. Study by [6] found that factors of being educated and employed also contribute to a higher risk of divorce. [9] also revealed that higher total family income, and those who did not attend counseling session were more likely to proceed with the divorce.

2 Methodology

This study obtained its secondary data from one of the Islamic Religious Department in Selangor, a state in Malaysia. The dataset consists of 531 cases reported by couples that filed for divorce for the year 2012. The determinants

are divided into three main categories; demographic variables, socioeconomic variables and treatment variable as suggested by [6].

Demographic variables consist of the age at marriage of the husband and wife,the presence of children and duration of marriage. The age at marriage of the husband and wife are divided into eight categories which is less than 29 years old, age 30-34 years, age 35-39 years, and age 40 year and above. The presence of children is presented by two categories which are yes and no, and the duration of marriage is presented through four categories, which are very short (less than one year), short (one to five years), medium (five to ten years), and long (longer than ten years).

On the other hand, socioeconomic variables consist of the educational level of the husband and educational level of wife (primary school, secondary school, diploma, bachelor, and master), employment status of the husband and wife (employed, unemployed) and household income (below RM5000 and RM5000 or more).

The treatment variable included in this study is the counseling session attended (yes, no) while the outcome variable is the survival time (in days). The survival time is calculated from the day the person or couple filed the case at the Islamic Religious Department until the day they made the decision on continuing with their divorcement or canceling it. R Programming was used to analyze the data.

A. Survival Analysis

Survival analysis is the study of durations between events. It deals with censored data in which the survival times are unknown. The censored data occurs when patients are still alive at the end of the study, withdraw before the end of the study or are lost to follow up. This is also known as right censoring. At times, analyses might also include left censoring due to its initial time at risk is unknown [10].

B. Univariate Analysis

It is highly recommended to look for Kaplan Meier curves for all categorical predictors, which will provide the shape of the survival function for each group and give some idea whether or not the groups are proportional (i.e. the survival functions are approximately parallel). Next, log-rank test will be carried out in order to determine whether the variables should be included in the Cox PH model, the most commonly used survival model [11]. It is also used to see the differences among the groups [12].

C. Cox Proportional Hazards(PH) Model

The Cox PH model is mainly used to assess the relationship of predictor variables such as age, gender, and the type of treatment to the survival time, T [13]. The proportional hazard relationship is:

$$\lambda(t;z) = \lambda_0(t) \cdot \exp(z \cdot \beta) \tag{1}$$

where $\lambda_0(t)$ is an arbitrary unspecified baseline hazard function for continuous time t and β is a vector of parameters. According to Fox [14], tests and graphical diagnostics for proportional hazards may be based on the scaled Schoenfeld residual.

D. Weibull Model

Weibull model is a very popular as a failure time distribution because constant hazard cannot be assumed. It is also one of the most frequently used parametric models in failure time data analysis [15]. The proportional hazards model is:

$$\lambda(t;z) = \gamma\lambda(z)t^{\gamma-1} \tag{2}$$

A graphical check on the Weibull assumption can be made by a plot of ln[-ln S(t)] versus ln t, where S(t) is a survival estimate obtained from the Kaplan-Meier method.

E. Lognormal Model

The lognormal distribution is used extensively in reliability applications to model failure times [16]. It provides a completely specified probability distribution for the observations and a sensible estimate of the variation explained by the model, a quantity that is controversial for the Cox model. The lognormal distribution is a flexible distribution that is closely related to the normal distribution. This distribution can be especially useful for modeling data that are roughly symmetric or skewed to the right. A random variable X is distributed as Log-Normal, denoted as $LN(\mu, \sigma^2)$, if $\ln(X)$ is normal, e.g. The probability density of X is given by

$$g(x \mid \mu, \sigma^2) = \frac{1}{\sqrt{2\pi}\sigma x} \exp\left(- \frac{(\ln(x) - \mu)^2}{2\sigma^2} \right) \tag{3}$$

where $x > 0, \mu > 0$ and $\sigma > 0$. The MLE of μ and σ^2 are given below, respectively:

$$\hat{\mu} = \frac{1}{n}\sum_{i=1}^{n}\ln(X_i) \text{ and } \hat{\sigma}^2 = \frac{1}{n}\sum_{i=1}^{n}(\ln(X_i) - \hat{\mu})^2 \quad (4)$$

F. Criterion Selection

One way to compare the parametric and semi-parametric performance between models is to base the decision on the minimum value of Akaike Information Criterion (AIC)[17]-[19]. It is a measure of the goodness of fit of the regression models that is based on the concept of entropy. The AIC can be viewed as the amount of information lost when a model is used to describe a set of observations. The formula for AIC is:

$$\text{AIC} = -2 \log L + 2k \quad (5)$$

where log L is the log likelihood of the proposed model and k is the number of parameters in the model.

3 Result

A. Descriptive Analysis

Table 1 represents the information of 531 couples that have filed for a divorce in a twelve month period, starting from January 2012 until the end of December 2012. The information retrieved from the records is the risk factors of marital dissolution. Based on Table 1, about 87.95 percent of the couples decided to save their marriage while only 12.05 percent of the couples proceeded with the divorce during the study and most of the couples who filed for a divorce were reported to have a child (77.59%), which is much higher compared to those couples without children (22.41%).

Table 2 explains the information of survival time with censoring data. The censored data are defined as 0 where the survival time is from the date the couple report the case until the case is close or the couple decides not to divorce or the couple delays the cases. Uncensored data are defined as status 1 indicating the survival time from the reported date until the date they decide to divorce. For example, 199+ means that the couple did not divorce within 199 days and was then unavailable for further study. This data are also classified as right censored.

On average, the survival time of marriage was 114.9 days. The minimum survival time was 1 day, which means the day the couples reported to file the case to the Islamic Religious Department was the same as the day they attended the counseling session and decided to file for divorce to the *Syariah* court. Meanwhile, the maximum survival time was 615 days. The standard

deviation is 93.99922 days, which indicates that the survival time varied a lot from one another.

Fig. 1 illustrates the Kaplan-Meier (KM) graph of the survival times for married couples ensuring for censored or uncensored data in the study. The vertical dashes represent the censored items. The curve shows higher survival rate within the first 83 days of the study and the survival curve decreases gradually as the number of days increase. The curve decreases even faster after 83 days reaching its minimum time on day one.

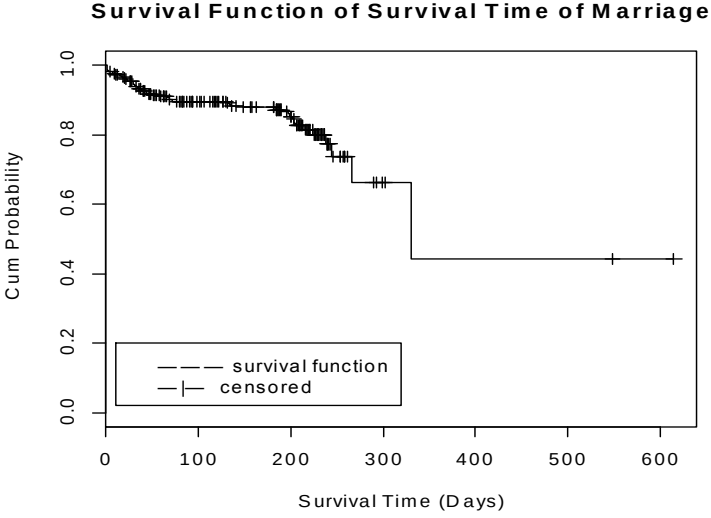

Fig. 1 Survival function of survival time of marriage

Table 1: Descriptive information on distribution of risk factors

Factor	Category	No. of couples	Percentage (%)
Age at marriage husband	< 30 years old	102	19.21
	30 - 34 years old	144	27.12
	35 - 39 years old	112	21.09
	> 39 years old	173	32.58
Age at marriage wife	< 30 years old	141	26.55
	30 - 34 years old	155	29.19
	35 - 39 years old	108	20.34
	> 39 years old	127	23.92
Presence of children	No	119	22.41
	Yes	412	77.59
Duration of marriage	Very short	54	10.17
	Short	167	31.45
	Medium	138	25.99
	Long	172	32.39
Education level of husband	Primary	63	11.86
	Secondary	226	42.56
	Diploma	109	20.53
	Degree	133	25.05
Education level of wife	Primary	46	8.66
	Secondary	201	37.85
	Diploma	106	19.96
	Degree	178	33.52
Employment status (husband)	Not employed	26	4.90
	Employed	505	95.10
Employment status (wife)	Not employed	109	20.53
	Employed	422	79.47
Household income	< RM5000	269	50.66
	RM 5000 and above	262	49.34
Divorce status	No	467	87.95
	Yes	64	12.05
Attend Counseling Session	No	241	45.39

Table 2: Table of survival time with censoring data

Survival Time	Censor (0=Delay/Did not divorce/Case close, 1=Divorce)
199+	0
197+	0
207+	0
22+	0
258+	0
16	1
548+	0
615+	0
204	1
257+	0
209+	0
259+	0
208+	0
243+	0
10+	0
.	.
.	.
.	.

B. Multivariate Analysis

Multivariate analysis of determinant factors were carried out using parametric and semi parametric models based. We compare the values obtain in the Cox regression, Weibull and Log-normal distribution based on AIC value. Based on Table 4, among variables that have been tested, all three models indicate that by attending the counseling session influence the survival of marriage. There are others factor that influences the survival rate differ in Cox, Log-normal and Weibull. For Cox regression model, other than attending the counselling sessions, the longest duration of marriage able to ensure the dissolution may not happened. We also indicate that as women who get married at age more than 40 years old, the risk of getting divorce is higher. However the result in Weibull indicates the other way round, where women who married at age 40 years and above, tend to save their marriage. The contradiction occur result from the grouping of age that does not have the same characteristics.

The result that we obtained from Log-normal showed that wife with higher education level (either degree or master) able to save the marriage. It may due to ability of the wife to seek for knowledge from outsource to ensure the marriage is still d in their life.From the AIC values, Cox regression gave a better result compared to parametric model. From Table 3, we can say that for the covariate age at marriage of wife, the risk of divorce increases about 0.43 times as the age increases. The 95% confidence interval (not include in the table) for the age at marriage of the wife (1.0323, 5.6311), suggesting that there is a difference in the survival of marriage between groups in this variable. On the other hand, the couples who attended the counseling session will reduce the risk of the divorcement by 0.3 times as the number of counselling session is increase. The 95% confidence interval for attending a counseling session (0.1141, 0.3692), suggests that there is a difference in the survival of marriage between those who attended and who did not attend any counseling session.

4 Conclusion

Overall, three models display the same result that by attending counseling session the couples able to sustained their marriage. Although the Weibull and Cox Regression showed the significant result on women who getting marriage at age 40 years and above, however the value obtained indicate vice versa in hazard ratio. While for Log-normal model, other risk factor that contributed significantly to marital dissolution is education level of the wife. The result of this study indicates that Cox PH model is the best model in describing the marital dissolution data and determined factors that influence the risk of divorce compared to parametric models as it gave the lowest AIC value.

Table 3. The comparison results between Cox, Log-normal and Weibull model for marital dissolution factors

Factors	Cox model		Lognormal model		Weibull model	
	β	SE	β	SE	β	SE
Age at marriage (husband)						
≤ 29 Years old	1.0000		1.0000		1.0000	
30-34 Years old	0.5431	0.5281	-0.6824	0.6437	-0.7676	0.6600
35-39 Years old	0.9444	0.6131	-1.2034	0.7458	-1.3317	0.7560
≥ 40Years old	0.8060	0.6357	-1.0487	0.7958	-1.0163	0.7890
Age at marriage (wife)						
35 – 39 years old	1.0000		1.0000		1.0000	
≤ 29 Years old	0.2612	0.5541	-0.5090	0.6894	-0.4205	0.6790
30-34 Years old	0.0380	0.4547	-0.1936	0.5917	-0.0962	0.5600
≥ 40 Years old	0.8800	0.4325*	-1.1236	0.5850	-1.1362	0.5540*
Presence of children						
No	1.0000		1.0000		1.0000	
Yes	-0.1293	0.3653	0.0894	0.4682	0.1320	0.4530
Duration of marriage						
Short	1.0000		1.0000		1.0000	
Very short	-0.8205	0.4834	0.6644	0.6438	0.9285	0.5950
Medium	-0.8729	0.5446	0.9779	0.7401	1.0582	0.6820
Long	-1.2085	0.4352*	1.1289	0.7848	1.3646	0.7470
Education level of husband						
Primary	1.000		1.0000		1.0000	
Secondary	0.2484	0.4352	-0.0729	0.5774	-0.2270	0.5300
Diploma	-0.4535	0.5308	0.8767	0.6758	0.7681	0.6500
Degree	0.0044	0.4841	0.0394	0.6397	0.1629	0.6000
Education level of wife						
Primary	1.0000		1.0000		1.0000	
Secondary	-0.4607	0.4366	0.7401	0.6129	0.5246	0.5460
Diploma	0.2699	0.4785	-0.4348	0.6675	-0.4597	0.5890
Degree	-1.0026	0.5206	-1.4122	0.7110*	1.0402	0.6570

Employment status (husband)						
Not employed	1.0000		1.0000		1.0000	
Employed	0.2851	0.5639	0.1204	0.7217	-0.2300	0.6870
Employment status (wife)						
Not employed	1.0000		1.0000		1.0000	
Employed	0.3154	0.3702	-0.5521	0.4736	-0.4504	0.4600
Household income						
≥ RM5000	1.0000		1.0000		1.0000	
< RM5000	-0.4168	0.3177	-0.5072	0.4392	0.4653	0.3940
Attend Counseling session						
No	1.0000		1.0000		1.0000	
Yes	-1.5840	0.2997***	2.0525	0.3486***	1.6706	0.3300***
AIC	**694.3374**		**979.2266**		**983.8292**	

*Significant at 5% level ***significant at 1% level

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