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# Modeling the Risk of Divorce in the Age Range of Marriage 1 – 10 Years using Weibull and Exponential Distributions

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**Abstract**

Divorce is an act that is permitted in Islam but is hated by Allah. The rise in divorce over the last decade has become a serious concern for those involved in maintaining the resilience of household relationships. So, it is necessary to analyze at what age marriage becomes critical for maintaining it. This research uses divorce data from 2015 to 2020, with a variable measuring the maximum length of marriage at 10 years. The data used is secondary data obtained from the Pekanbaru Religious Court for 298 divorce cases. The analysis was carried out by determining the most appropriate distribution for modeling divorce data in Pekanbaru City: the Weibull or the Exponential distribution. This determination was carried out by a goodness-of-fit test using Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC). The results show that the Weibull distribution is the most appropriate for modeling divorce data in Pekanbaru, with the highest divorce risk at a marriage age of around 42 months (3.5 years), with a probability of divorce of 14%.

**Keywords:** Divorce Data, Exponential Distribution, Goodness of Fit, Maximum Likelihood Method, Weibull Distribution.

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## 1. Introduction

Marriage is a very important event in human life. Marriage unites two different people and changes their status [1]. According to article 1 of Law Number 1 of 1974 concerning marriage, it explains that marriage is a spiritual and physical bond between a man and a woman as husband and wife with the aim of forming a happy and eternal family based on the belief in the Almighty God. Divorce has emerged as a significant social phenomenon affecting family stability and societal well-being in many countries, including Indonesia. Recent statistics from religious courts and national demographic reports indicate a persistent increase in divorce cases over the past decade, with a substantial proportion occurring within the early years of marriage. Previous studies have consistently reported that marital dissolution is more likely to take place during the initial phase of marriage, reflecting heightened vulnerability among newly married couples [2][3]. This trend underscores the importance of understanding not only the determinants of divorce but also the timing at which divorce risk is most pronounced.

The early duration of marriage, commonly defined as the first ten years, represents a critical period in which couples face significant social, economic, and psychological adjustments. Several empirical studies have highlighted that divorce risk is not constant over time, but instead varies across different stages of marital duration [4][5][6]. However, many existing studies approach divorce as a static binary outcome, overlooking the dynamic nature of marital dissolution as a time-to-event process. As a result, the identification of specific periods with elevated divorce risk remains limited, particularly in developing country contexts

Most prior research on divorce has focused on identifying associated socio-demographic factors—such as age at marriage, education level, and economic conditions—using regression-based or clustering techniques [7][8][9]. While these approaches are valuable for uncovering correlational patterns, they are less effective in capturing the temporal structure of divorce events. In particular, methods such as cluster analysis group observations based on similarity but do not explicitly model the evolution of divorce risk over marriage duration. Consequently, the temporal dynamics and critical timing of divorce events are often insufficiently explored in the existing literature.

Survival analysis offers a natural and theoretically grounded framework for modeling time-to-divorce data, as it explicitly accounts for both the occurrence and timing of events. Parametric survival models are especially useful when the underlying hazard structure is of substantive interest. The Exponential distribution assumes a constant hazard rate over time, providing a simple baseline for event-time modeling. In contrast, the Weibull distribution allows for a time-varying hazard function, enabling the modeling of increasing or decreasing divorce risk as marriage duration progresses [10][11][12]. These properties make Weibull and Exponential distributions particularly suitable for examining whether divorce risk intensifies or diminishes during early marriage [13].

In research [14] comparing the best methods of maximum likelihood and Bayesian SELF methods with censored lung disease data with an exponential distribution, it was found that the Bayesian method was better. However, in research [15] a comparison was made of exponentially distributed parameter estimates with earthquake data using the maximum likelihood method and the Bayesian method, stating that the maximum likelihood method is more appropriate to use than the Bayesian method.

Research [16] conducted research on children in New Zealand who studied the period from birth to five years old using Cox proportional hazards, with cases of factors causing child destruction caused by divorced parents. Research [17] using survival analysis with a Cox proportional hazard model examines the influence of the type of marriage on household resilience, but with the Kaplan-Meier estimator the cause of divorce is not the type of marriage but the length of the marriage, because in the first 5 years couples are vulnerable to divorce.

Based on research [18] the results of the Cox proportional hazard model show that the husband's age at marriage and attending counseling have a significant effect on the final decision in a divorce case, whether to continue the marriage or not. By carrying out the same modeling on divorce cases [19] with the Cox proportional hazards model, it was found that infidelity was the cause of divorce in Pelaihari sub-district, South Sumatra in 2017.

This study provides a time-specific risk modeling of divorce by focusing on the early duration of marriage (1–10 years) using parametric survival distributions. Unlike previous studies that primarily rely on Cox proportional hazards models or qualitative categorizations, this research quantitatively identifies a critical divorce risk point at approximately 3.5 years of marriage using hazard and probability density functions.

In addition, this study presents an empirical comparison between Weibull and Exponential distributions based on Akaike's and Bayesian Information Criteria, providing statistical evidence that the Weibull distribution better captures the divorce risk pattern in the Indonesian context. The findings offer localized and data-driven insights that can support early marital intervention policies and counseling programs.

Therefore, this study aims to model the duration until divorce among early marriages using parametric survival analysis. Specifically, the objectives of this research are to (i) quantify the time-dependent risk of divorce within the first ten years of marriage, (ii) identify the critical period with the highest probability of divorce occurrence, and (iii) compare the performance of Weibull and Exponential distributions using information-based criteria. By focusing on the temporal pattern of divorce risk and providing empirical evidence from Indonesian religious court data, this study contributes localized and data-driven insights that may support early marital intervention and counseling strategies.

## 2. Research Methods

The data used in this research was not taken directly from the field. The data used is divorce data recorded at the Pekanbaru City Religious Court from 2015-2020 who experienced divorce with a marriage length of $x<10$ years. The research steps are:

### 2.1 Data Source and Study Population

This study utilizes secondary data obtained from religious court records in Indonesia, which document legally registered divorce cases. The dataset includes information on marriage duration, measured as the time (in years) from the date of marriage to the date of divorce. The analysis focuses on early marriages, defined as marriages with a duration of ten years or less, in order to capture the period most vulnerable to marital dissolution.

Observations for which divorce had not occurred within the study period were treated as right-censored. This structure naturally motivates the use of survival analysis techniques, which are designed to handle censored time-to-event data.

### 2.2 Parametric Survival Analysis Framework

Survival analysis models the time until the occurrence of a specific event, in this case divorce. Let $T$ denote the non-negative random variable representing marriage duration until divorce. The survival function $S(t) = P(T > t)$ describes the probability that a marriage survives beyond time $t$, while the hazard function $h(t)$ represents the instantaneous risk of divorce at time $t$, given survival up to that time.

Parametric survival models assume a specific functional form for the distribution of $T$, allowing explicit characterization of the hazard structure over time. In this study, the Exponential and Weibull distributions are considered due to their interpretability and widespread use in time-to-event modeling.

### 2.3 Exponential and Weibull Models

The Exponential distribution assumes a constant hazard rate over time, expressed as:

$$h(t) = \lambda,$$

where $\lambda > 0$ is the rate parameter. This model serves as a baseline specification, implying that the risk of divorce does not vary with marriage duration.

In contrast, the Weibull distribution allows for a time-varying hazard function of the form:

$$h(t) = \lambda k t^{k-1},$$

where $\lambda > 0$ is the scale parameter and $k > 0$ is the shape parameter. When $k > 1$, the hazard increases over time; when $k < 1$, the hazard decreases; and when $k = 1$, the Weibull model reduces to the Exponential case. This flexibility enables the Weibull model to capture changing divorce risk patterns across early marriage duration.

Model parameters were estimated using the maximum likelihood method.

### 2.4 Model Evaluation and Comparison

To assess model performance, the Exponential and Weibull models were compared using Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC). Lower values of these criteria indicate a better balance between model fit and complexity. This comparison allows for an objective evaluation of whether allowing for time-varying hazard rates provides a superior representation of divorce risk during early marriage.

## 3. Results and Discussion

Descriptive statistics is a method used in collecting data and presenting data so that it provides useful information. Descriptive statistics are used to see a general description of the research variable data. The following are descriptive statistics that show the characteristics of the length of marriage variable. This research involves several stages in the process of obtaining probability modeling that fits divorce data. The next discussion is as follows:

*Table 1. Divorce Data Life Table*

| *Survival Time* | *Surviving Pairs Based on Intervals* | **Couples Who Divorce Based on Intervals** | $\hat{S}(t)$ | $\hat{f}(t)$ | $\hat{h}(t)$ |
|---|---|---|---|---|---|
| 0 – 1 | 298 | 20 | 0.993 | 0.067 | 0.006 |
| 1. – 2 | 278 | 42 | 0.927 | 0.140 | 0.014 |
| 2. – 3 | 236 | 42 | 0.787 | 0.140 | 0.016 |
| 3. – 4 | 194 | 28 | 0.647 | 0.093 | 0.013 |
| 4. – 5 | 166 | 24 | 0.553 | 0.080 | 0.013 |
| 5. – 6 | 142 | 27 | 0.473 | 0.090 | 0.018 |
| 6. – 7 | 115 | 28 | 0.383 | 0.093 | 0.023 |
| 7. – 8 | 87 | 40 | 0.290 | 0.133 | 0.050 |
| 8. – 9 | 47 | 24 | 0.157 | 0.080 | 0.057 |

### A. Description of Divorce Data Statistics.

Descriptive statistics is a method used in collecting data and presenting data so that it provides useful information. Descriptive statistics are used to see a general description of the research variable data. The following are descriptive statistics that show the characteristics of the length of marriage variable.

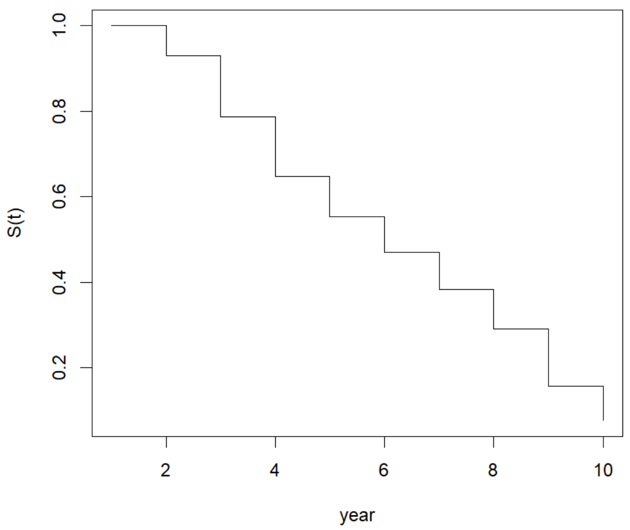


**Figure 1. Divorce data survival function curve**

From Table 1, there are 298 divorce data taken from 2015-2020 with a marriage duration of 10 years in Pekanbaru. It is known that the length of the marriage studied was 10 years. Of the 10 years of marriage, it can be seen that the 2nd and 3rd years of marriage are the years of marriage with the most divorces. However, in the first year of marriage, the minimum number of divorces that occur. Figure 1 shows the survival curve for divorce data for ten years of marriage, while Figure 2 is the probability density function curve.

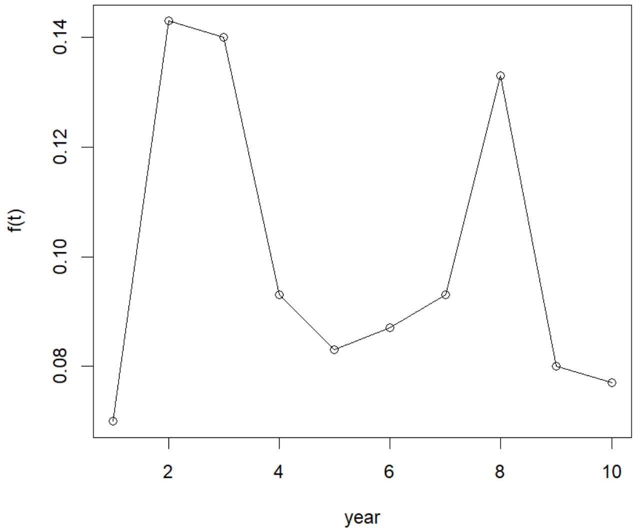


**Figure 2. Divorce Data Survival Density Function curve**

In Figure 1 it can be seen that the length of marriage in the first year up to the length of marriage in the second year is still at 100% - 80% of marriages that have a risk of divorce. However, the longer the marriage, such as the 10th year of marriage, the smaller the percentage of divorce. Figure 1shows that divorce often occurs in the 2nd to 3rd year of marriage. Because around 14% of the 298 divorce data occurred in the 2nd to 3rd year.

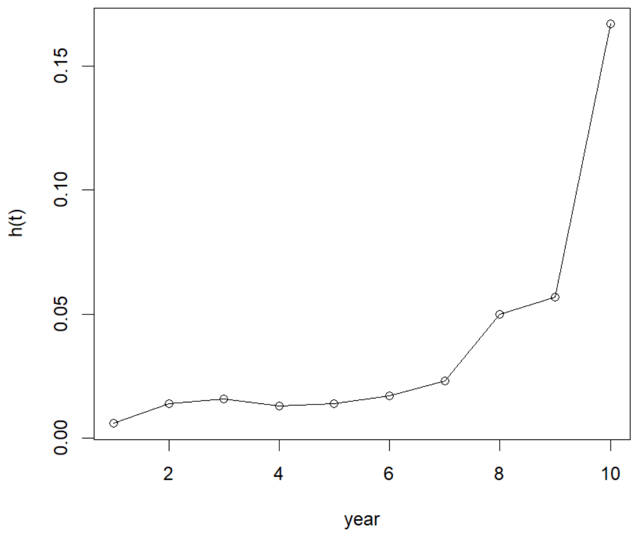


**Figure 3. Hazard Function Graph for Divorce Data**

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Figure 3 shows the hazard function, which means that if you enter the 9th and 10th year of marriage, the length of marriage is higher and the risk of divorce is lower.

## B. Estimating and Determining Parameter Values using the Maximum Likelihood Method

The maximum likelihood method is one of the methods used to determine the parameters of a distribution. In this research, this method will be used to determine the parameters of the Weibull and Exponential distributions. With numeric numbers it will be easier to solve with this method, especially using the Newton Raphson method.

**Exponential Distribution**

The parameters of the Exponential probability density function with one parameter (θ) can be shown as follows:

$$f(y,\theta) = \theta e^{-y\theta}, \qquad y \geq 0,\ \theta > 0 \tag{1}$$

then the likelihood function:

$$L(\theta;Y) = f(y_1;\theta)f(y_2;\theta)\dots f(y_n;\theta) = \theta e^{-y_1\theta}.\theta e^{-y_2\theta}\dots\theta e^{-y_n\theta}$$
$$= \theta^n e^{-\theta}\textstyle\sum_{i=1}^{n} y_i \tag{2}$$

After getting the likelihood function, we will then determine the maximum likelihood from Equation (1) by making the likelihood function into the natural logarithm of likelihood, namely:

$$l = lnL = ln\left(\theta^n e^{-\theta}\sum_{i=1}^{n} y_i\right)$$
$$= n\ln\theta - \theta\textstyle\sum_{i=1}^{n} y_i \tag{3}$$

Next, look for the maximum likelihood by reducing the log-likelihood of the parameters, namely:

$$\frac{\partial l}{\partial\theta} = \frac{\partial(n\ln\theta - \theta\sum_{i=1}^{n} y_i)}{\partial(\theta)}$$
$$0 = \frac{n}{\theta} - \textstyle\sum_{i=1}^{n} y_i \tag{4}$$

So the MLE of θ is:

$$\hat{\theta} = \frac{n}{\sum_{i=1}^{n} y_i} \tag{5}$$

after carrying out calculations, we obtain:

$$\theta = 0{,}2043868$$

Therefore, a divorce data model in Pekanbaru can be formed by substituting each parameter value into Equation (1) to obtain the following:

$$f(y) = 0{,}2043868e^{-y0{,}2043868}$$

The function above is a probability function from the exponential distribution of divorce data in Pekanbaru.

**Weibull distribution**

The parameters of the Weibull probability density function with two parameters $(t, d)$ can be shown as follows:

$$f(y,t,d) = \frac{t}{d}\left(\frac{y}{d}\right)^{t-1} e^{-\left(\frac{y}{d}\right)^t} \tag{6}$$

then the likelihood function:

$$L(\theta;Y) = f(y_1;\theta)f(y_2;\theta)\dots f(y_n;\theta)$$

$$= \frac{t}{d}\left(\frac{y_1}{d}\right)^{t-1} e^{-\left(\frac{y_1}{d}\right)^t} \cdot \frac{t}{d}\left(\frac{y_2}{d}\right)^{t-1} e^{-\left(\frac{y_2}{d}\right)^t} \ldots \frac{t}{d}\left(\frac{y_n}{d}\right)^{t-1} e^{-\left(\frac{y_n}{d}\right)^t}$$

$$= \left(\frac{t}{d}\right)^n \prod_{i=1}^{n} \left(\frac{y_i}{d}\right)^{t-1} e^{-\sum_{i=1}^{n}\left(\frac{y_i}{d}\right)^t} \quad (7)$$

After getting the likelihood function, we will then determine the maximum likelihood from Equation (7) by making the likelihood function into the natural logarithm of the likelihood, namely:

$$l = \ln L$$

$$= \ln\left(\left(\frac{t}{d}\right)^n \prod_{i=1}^{n} \left(\frac{y_i}{d}\right)^{t-1} e^{-\sum_{i=1}^{n}\left(\frac{y_i}{d}\right)^t}\right)$$

$$= n\ln(t) - nt\ln(d) + (t-1)\sum_{i=1}^{n}\ln(y_i) - \sum_{i=1}^{n}\left(\frac{y_i}{d}\right)^t \quad (8)$$

Next, look for the maximum likelihood by reducing the log likelihood of the parameters, namely:

$$\frac{\partial l(\theta)}{\partial d} = -\frac{nt}{d} + \frac{t}{d}\sum_{i=1}^{n}\left(\frac{y_i}{d}\right)^t \quad (9)$$

$$\frac{\partial l(\theta)}{\partial t} = \frac{n}{t} - n\ln d + \sum_{i=1}^{n}\ln(y_i) - \sum_{i=1}^{n}\left(\frac{y_i}{d}\right)^t \ln\left(\frac{y_i}{d}\right) \quad (10)$$

After obtaining the parameter equations from the Weibull distribution, the next step is to obtain the parameter values from the Weibull distribution. To approach the parameter values of the Weibull distribution using the Newton-Raphson method. Initial values are required in the Newton-Raphson method. To get the initial value by approaching the cumulative function, namely:

$$F(y) = 1 - e^{-\left(\frac{y}{d}\right)^t}$$

so that,

$$F(y) = 1 - e^{-(\lambda y)^t}$$

$$\ln(y) = \ln\frac{1}{\lambda} + \frac{1}{t}\ln\left(\ln\left(\frac{1}{1-F(y)}\right)\right) \quad (11)$$

through calculations involving divorce data, it is obtained:

$$b = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sum_{i=1}^{n}(x_i-\bar{x})^2} = 0{,}01878728$$

and,

$$a = \bar{y} - b\bar{x} = 1{,}3279998$$

So the initial parameter value is:

$$d^0 = e^a = 3{,}773481$$

and,

$$t^0 = \frac{1}{b} = 53{,}22751$$

After getting the initial values, the next step is to find the parameter values $d$ dan $t$ using the Newton Raphson method with iteration, namely:

$$\boldsymbol{\theta}^{(s+1)} = \overline{\boldsymbol{\theta}} - \left[l''\left(\boldsymbol{\theta}^{(s)}\right)\right]^{-1} l'\left(\boldsymbol{\theta}^{(s)}\right) \quad (12)$$

Next, form a Jacobian matrix, namely:

$$J_{1,1} = \frac{\partial^2}{\partial d^2} l(\theta) = \frac{\partial\left(-\frac{nt}{d} + \frac{t}{d}\sum_{i=1}^{n}\left(\frac{y_i}{d}\right)^t\right)}{\partial d} = \frac{nt}{d^2} - \left(\frac{t(1+t)}{d^2}\sum_{i=1}^{n}\left(\frac{y_i}{d}\right)^t\right)$$

$$J_{1,2} = \frac{\partial^2}{\partial d \partial t} l(\theta) = \frac{\partial \left(-\frac{nt}{d} + \frac{t}{d}\sum_{i=1}^{n}\left(\frac{y_i}{d}\right)^t\right)}{\partial t} = -\frac{n}{d} + \frac{1}{d}\sum_{i=1}^{n}\left(\frac{y_i}{d}\right)^t + \frac{t}{d}\sum_{i=1}^{n}\left(\frac{y_i}{d}\right)^t \ln\left(\frac{y_i}{d}\right)$$

$$J_{2,1} = \frac{\partial^2}{\partial t \partial d} l(\theta) = -\frac{n}{d} + \frac{1}{d}\sum_{i=1}^{n}\left(\frac{y_i}{d}\right)^t + \frac{t}{d}\sum_{i=1}^{n}\left(\frac{y_i}{d}\right)^t \ln\left(\frac{y_i}{d}\right)$$

$$J_{2,2} = \frac{\partial^2}{\partial t^2} l(\theta) = -\frac{n}{t^2} - \sum_{i=1}^{n}\left(\frac{y_i}{d}\right)^t \left[\ln\left(\frac{y_i}{d}\right)\right]$$

Jacobian matrix is obtained:

$$J = \begin{bmatrix} 1.4304 & -9.5370 \\ -9.5370 & 6.2367 \end{bmatrix}$$

then:

$$J^{-1} = \begin{bmatrix} -0.0760 & -0.1162 \\ -0.1162 & -0.017 \end{bmatrix}$$

After getting the parameter values with initial values: $d^0 = 3{,}773481$ dan $t^0 = 54{,}4413$. Calculations were carried out with the R software program. Based on the calculations in the program, we obtained:

$$d = 1{,}772839$$

and,

$$t = 5.485272$$

The parameter values *d* and *t* were obtained with 15 iterations to achieve convergence. So, the divorce data model in Pekanbaru can be formed by substituting each parameter value into Equation (6), therefore we get:

$$f(y) = \frac{5{,}485272}{1{,}772839}\left(\frac{y}{1{,}772839}\right)^{5{,}485272-1} e^{-\left(\frac{y}{1{,}772839}\right)^{5{,}485272}}$$

The function above is the probability function of the Weibull distribution on divorce data in Pekanbaru.

## C. Goodness Of Fit

The goodness-of-fit test was carried out to obtain an appropriate distribution model based on divorce data in the city of Pekanbaru for 2015-2020. In the goodness-of-fit test, the Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) tests will be used.

$$AIC = -2l + 2k$$

$$BIC = -2l + k\ln(n)$$

Calculation of goodness of fit tests for Weibull and Exponential distributions based on calculations in the program, obtained:

**Tabel 2. Goodness of Fit**

| | Weibull Distribution | Exponential Distribution |
|---|---|---|
| **AIC** | 1432,808 | 1544,294 |
| **BIC** | 1440,202 | 1547,991 |

After carrying out a goodness-of-fit test using the Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) tests, the results obtained in table 2 show that the AIC and BIC values of the Weibull distribution are minimum when compared to the Exponential distribution. Therefore, the Weibull distribution is a suitable distribution model for divorce data in the city of Pekanbaru.

The chances of couples divorcing in the city of Pekanbaru when viewed from the length of marriage can be seen in table 3.

**Tabel 3 Peluang Perceraian**

| **Length of Marriage (Years)** | **possibility of divorce** | **Length of Marriage (Years)** | **possibility of divorce** | **Length of Marriage (Years)** | **possibility of divorce** |
|---|---|---|---|---|---|
| 0,5 | 0,0439 | 4 | 0,1433 | 7,5 | 0,0726 |
| 1 | 0,0782 | 4,5 | 0.1374 | 8 | 0,0618 |
| 1,5 | 0,1042 | 5 | 0.1295 | 8,5 | 0,0518 |
| 2 | 0,1233 | 5,5 | 0,1193 | 9 | 0,0429 |
| 2,5 | 0,1361 | 6 | 0,1080 | 9,5 | 0.0351 |
| 3 | 0,1433 | 6,5 | 0,0961 | 10 | 0.0283 |
| 3,5 | 0,1455 | 7 | 0,0842 | | |

Based on Table 3, the highest chance of divorce occurs in the 3rd to 4th year of marriage. namely 14%. This is also supported by research [24] which states that the age of marriage in the first 5 years is vulnerable to divorce. This is triggered by several factors, such as the economy, disagreements, quarrels, etc.

The results of the parametric survival analysis indicate clear differences between the Exponential and Weibull models in describing divorce risk during early marriage. The Exponential model assumes a constant hazard rate, implying that the risk of divorce remains unchanged over marriage duration. While this assumption provides a useful baseline, it may oversimplify the complex dynamics of marital dissolution.

In contrast, the Weibull model allows the hazard rate to vary over time through its shape parameter. The estimated Weibull shape parameter greater than one suggests that divorce risk increases as marriage duration progresses within the early marriage period. Substantively, this finding indicates that couples may face accumulating pressures and adjustment challenges over time, leading to a higher likelihood of divorce rather than an immediate risk following marriage. This pattern is consistent with previous studies highlighting the early years of marriage as a period of gradual escalation in marital strain rather than a constant level of risk.

The superior fit of the Weibull model, as indicated by lower information criterion values, suggests that allowing for time-varying divorce risk provides a more realistic representation of marital dissolution dynamics. From a practical perspective, this result implies that intervention strategies should not only target newly married couples but also focus on specific durations where divorce risk intensifies. Identifying such critical periods can support more timely and effective marital counseling and family support programs.

## 4. Conclusion

After carrying out analysis and discussion, it can be concluded that, the parameter values of each distribution are obtained, the Weibull distribution parameter values are: $d$ = 1.772839 and $t$ = 5.485272. Meanwhile, the Exponential parameter value is $\theta$ = 0.2043868. After carrying out a goodness of fit test, it can be concluded that the Weibull distribution is the most suitable distribution to use to predict the chance of divorce in the city of Pekanbaru. This is evident from the AIC (1432.808) and BIC (1440.202) values of the

Weibull distribution which are smaller than the AIC (1544.294) and BIC (1547.991) values of the Exponential distribution.

Based on the length of marriage in divorce data in Pekanbaru, it can be concluded that a marriage age of 3.5 years has a high risk of divorce, namely 14%. Suggestions for this research are: This research has limitations, so it is used as a suggestion to future researchers to increase the amount of more concrete data in the future. In this study, there were only 298 divorce data from 2015-2020 with a marriage length of <10 years. Of course, if future researchers examine the same thing, it would be best to use more data from the author. The distribution used should be more varied than the one the author includes, so that there is more scientific development of which distribution is best.

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