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Survival Analysis of Patients with Kidney Failure at Arifin Achmad Hospital, Riau Province using the Kaplan-Meier Method

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Abstract

Kidney failure is a serious medical condition with a significant impact on the patient's health and quality of life. The survival test analyzes the time until recovery which can affect the survival of patients with kidney failure. This research aims to carry out survival analysis on patients with kidney failure at Arifin Achmad Hospital, Riau Province during the period January 2020 to November 2023. This research uses the Kaplan-Meier method to estimate the survival function by considering the time until healing occurs. Apart from that, a Log Rank test was also carried out to compare the survival function between two groups based on age, gender, comorbidities, pain, diabetes mellitus and hemodialysis. The results of the study show that the probability of survival on day 1 is 0.9130 according to the addition of time and is 0 on day 32. Based on the results of the Log Rank test there is a significant difference between the probability of survival based on comorbidities and history of diabetes mellitus. and carrying out hemodylysis therapy.

Keywords: Kidney disease, survival, kaplan-meier, log rank.

1. Introduction

Kidneys have shapes similar to a bean and measuring about 10-12 cm in length, 5-7 cm in width and also 2-3 cm in thickness. The kidneys are located second side of the spine, close to the bottom of the rib cage. They are located in the cavity stomach, One on the side left And One Again on the side right bone behind. Kidney functions to regulate the amount of water inside the body by regulating the volume and composition of urine produced. Kidney arrange pressure blood with control volume blood and stimulate production of hormones such as renin (Brenner and Rector, 2012). Kidney filters the blood to remove waste, metabolic products that are not desired, excretion excessive like urea, creatinine and sour tendon.

According to the World Health Organization (WHO, 2018) Kidney failure is a medical condition that affects the vital function of the human body's organs, namely the kidneys. This condition is characterized by a gradual and progressive decline in kidney function, so that the kidneys are unable to do their job properly in filtering waste and dangerous substances from the blood. This disease can be caused by various factors, including diabetes, high blood pressure, infections, autoimmune diseases, and use of certain medications. In Indonesia, kidney failure is an increasingly worrying health problem. The prevalence of this condition continues to increase from year to year, with the number of patients requiring intensive medical treatment and intervention. Riau Province, as one of the regions in Indonesia, is also not free from the impact of increasing cases of kidney failure, states that kidney failure is a dangerous disease. Kidney failure reaches more than 1.42 million people in Indonesia. In Riau Province, kidney failure reached 17,258 people (Kemenkes RI, 2019).

In Riau Province, RSUD Arifin Achmad is the main referral center for patients experiencing various health problems, including kidney failure. As the number of patients experiencing this disease increases, it is important to perform in-depth analysis to understand the factors that influence patient prognosis and survival.

Habibah et al., (2018), using the Kaplan-Meier method on medical record data of patients suffering from kidney failure for the period 1 January 2014 to 30 November 2017 at Soedjati Soemodiarjo Hospital, Purwodadi, Grobogan Regency. The results of this study show that the longer hemodialysis is carried out, the estimated survival value is an average of 776 days.

Rahmadani et al., (2023) Kaplan-Meier approach to determine the probability of survival of individuals diagnosed with kidney failure. From January 2018 to November 2020 at Hasanuddin University Hospital, South Sulawesi Province. The results showed that the variables chronic-acute disease, gender, and age were independent of each other in kidney failure patients. Additionally, the survival probability for individuals is 0.540.

Darmawan et al., (2023) used the Kaplan Meier method and log rank test to test differences in survival function in the treatment time for ODGJ patients. The conclusion is that the survival function curve in ODGJ patients has an estimated survival function from a recovery time of 2 days with a value of 0.99759 to 92 days with a value of 0.00000. The test results obtained for gender were 4.40 > 3.84, so the null hypothesis was rejected. The results of the survival estimate on the first day of survival for men were 0.9931 (99.31%) greater than for women, namely 0.9919 (99.19%), then the results of the Log-Rank test based on age were 2.44 < 3.84, so the null hypothesis is not rejected, so there is no significant difference, and the results of the survival estimate on the first day of survival for older age patients are greater than for older age patients, so that younger patients recover more quickly than older patients; and finally, the Log-Rank test result for comorbid and non-comorbid is 27.21 > 3.84, so the null hypothesis is rejected, so there is a significant difference, and the estimated survival results on the first day of survival for comorbid patients are 0, 9961 (99.61%) is greater than non-comorbid patients, namely 0.9937 (99.37%), so non-comorbid patients recover faster than comorbid patients.

Kurniawan et al., (2023) used the Kaplan-Meier Method or Limit Product Method. The data used is the Northern California Oncology Group Head and Neck Cancer Data. The group of head and neck cancer patients treated with radiation therapy plus chemotherapy (RCT) consisted of 45 patients. The results of the study showed that head and neck cancer patients who underwent RCT treatment had increasingly smaller chances of survival as time went on.

Widyasari et al., (2022) used Kaplan-Meier and Log-Rank tests. The data used is data on COVID-19 patients at RSI Malahayati from January to May 31 2021. The results obtained are the survival function curve or length of time for the recovery rate of COVID-19 patients based on gender, age, and positive patients and suspected COVID-19 with comorbidities and without comorbidities. However, based on the LogRank test, it was concluded that there was no significant difference in the length of recovery time for COVID-19 patients based on gender, age and positive patients as well as suspected COVID-19 patients with and without comorbidities.

Iqbal et al., (2022) used the kaplan-meier method on medical record data of Covid-19 patients at Surabaya A. Yani Islamic Hospital in January-July 2021. The research results showed that the survival time based on age was 12,423 days, the survival time based on gender was 12,078 days, survival time based on Initial Symptoms was 11,461 days and survival time based on SpO2 Capacity was 16,787 days. The conclusion of this study shows that, age has an effect on the respondent's survival time, where the 27-36 year interval has a better survival time than other respondents' age intervals. Females have a better survival time than males. Early symptoms determine the severity and duration of death for respondents. SpO2 capacity is directly proportional to the degree of patient safety, the higher the percentage of SpO2 capacity, the greater the chance of survival and the lower the percent of SpO2 capacity, the lower the hope.

Farifa et al., (2021) used the Kaplan-Meier method and Cox Proportional Hazard regression. The data used consisted of 394 medical records of breast cancer patients at Dr. Soetomo Surabaya in the period January 2018 – December 2019, with variables used including initial age of infection, clinical stage, tumor size, metastases to other organs, type of treatment, and patient status (alive or dead). The results show that the probability of survival for breast cancer patients (with sample data) is 0.737 or 73.7%. Variables that significantly influence the survival of breast cancer patients are age at initial infection, clinical stage, and tumor size.

Muhajir and Palupi, (2018) used medical record data for diarrhea disease using indicators of patient recovery time, age and gender in pediatric patients at the Jakarta Islamic Hospital in January 2017. The method used to determine the chance of disease resistance The ones that dominate pediatric patients at this hospital are the Kaplan-Meier and Log Rank methods. The results of the Kaplan Meier method analysis showed that male patients had a longer chance of recovery than female patients and patients aged 6-11 years had a longer chance of recovery than those aged ≤ 5 years. Furthermore, the Log Rank test showed that there was no significant difference between the cumulative survival chances based on gender or patient age.

Kurniawan and Mahara, (2021) using the Kaplan-Meier Method and Log-Rank Test, the data was categorized into three categories: 'Low', 'Medium', and 'High'. This classification aims to determine whether the survival function of each category has the same or different functions and to investigate whether there are differences in the responses given or not. Survival analysis using the Kaplan-Meier method revealed that the three categories had different survival functions. The final Log-Rank test shows that there is no difference in the responses given by the three categories when a maritime accident occurs.

Research conducted by Etika (2017) applied the Kaplan-Meier method using time to death in kidney transplant patients, time to infection in burn patients, and time to death for kidney failure trials. The study showed that there was no significant difference between the survival chances in the two categories for Drug A and placebo.

In this context, this study aims to carry out survival analysis in patients suffering from kidney failure at Arifin Achmad Hospital, Riau Province. The Kaplan-Meier method was chosen as the main analysis tool because of its ability to estimate survival functions on censored data, where the time of critical events is not always known for each subject. Meanwhile, the Log Rank test is used to compare the chances of patient survival based on each variable. In the next chapter, we will explain in detail the research methodology used, including the data collection process, statistical analysis, and interpretation of results.

2. Survival Analysis , Kaplan–Meier and Log Rank Test

Survival analysis is a set of statistical procedures used to analyze time data related to certain events. The data analyzed includes the time interval between events as well as data related to time, starting from the initial time (time origin) until the specific event occurs. The specific event may be failure, death, disease recurrence, trial response, or another event selected based on the researcher's interests. In addition, specific events can also include positive events such as birth, school graduation, recovery from illness, or other positive experiences (Kleinbaum and Klein, 2005).

There are three types of models or forms in survival analysis modeling , namely parametric, semiparametric and nonparametric. Parametric survival models are models that assume that survival time data follow certain distributions, such as Exponential, Weibull, and Log-logistic distributions (Kleinbaum and Klein, 2005).

survival model is a type of model that does not depend on assumptions about the distribution of survival time data. Nonparametric estimation is a type of estimation that does not depend on assumptions about data distribution (Abdullah and Ahmad, 2022).

Survival analysis uses data that records the time between certain events. Survival time is defined as the period between the initial point of observation until the occurrence of a failure event, and can be measured in days, months, or years. The starting point, also called the time origin or start-point, marks the time when the initial event that is the focus of the analysis occurs, such as a cancer diagnosis or the administration of a particular treatment. On the other hand, failure time, which is also known as failure time or end-point, is the time when a final event such as death, recovery, or other event occurs (Collet, 2003).

In survival analysis, there are three important aspects that must be considered regarding survival time (Abdullah and Ahmad, 2022):

1. Initial time of recording (time origin or start point): This is the time when observations begin or when the initial event that is the focus of the analysis occurs.
2. End time of recording (failure event or end point): This is the time when a failure event occurs or the end of observation, such as death or another event that is the focus of the analysis.
3. Measurement scale: The time measurement scale must be clearly defined, in units of days, months, or years, in order to limit the observed observation period.

Let T be random variable for survival time , then t as value of the random variable *T*. Because *T* is time, the value of the random variable *T* is number Which is at intervals 0 until ∞. variable random Q has probability density and probability distribution functions f(t). Distribution function Cumulative (F(t)) states the probability of someone experiencing an event up to time *t* . according to states that the survival function $S\ (t)$ is a probability an individual can survive with a survival time of up to time t (t , 0) (lawless, 2003).

$$\begin{aligned} S\ (\ t\ ) &= P\ (\ T > t\ ) \\ &= 1 - (\ T \leq t\ ) \\ \mathrm{S}(\ t\ ) &= 1 - F\ (\ t\ ), \end{aligned} \tag{1}$$

Function characteristics survival S (t) among them :

1. Not increasing means that the survival function S (t) decreases as the value of t increases
2. On moment t = 0, S (0) = 1 , namely on beginning case moment Not yet there is a subject Which experience failure or P(T > 0)=1 .
3. On moment $t \rightarrow \infty$, S (t) = S (∞) = 0, If extended period without limit in a way theoretical, time No There is subject Which can survive (Harlan 2017).

The Kaplan-Meier method is named after two scientists, Edward L. Kaplan and Paul Meier, who independently developed it in 1958. Kaplan-Meier is a nonparametric method that is useful for evaluating survival functions , especially in situations where the data has censored features and measures. small sample. The main advantage of this method is its ability to handle censored data well. Kaplan-Meier is often used to analyze survival data in various contexts, such as medical and epidemiological research (Kaplan and Meier, 1958).

$$S(t) = \frac{ni-di}{ni}. \tag{2}$$

$S(t)$states the probability that an object survives until time t

nistates that there are many motorbike taxis that are at risk but still survive at time i

in states the number of objects that experienced an event at time i

After estimating using the Kaplan-Meier method, the results can be represented in curve form. Survival odds curve displays the cumulative proportion of individuals who are still surviving at each time point t after experiencing an event. The symbol used to indicate the value of the survival probability curve at time t is $S\ (\ t\ )$, and this value can be calculated using the following equation (Kurnianda, 2020):

$$S(t) = S(t-1) \times \left(1 - \frac{d_i}{n_i}\right), \tag{3}$$

n_i states the number of people who still survive until time to time $i$and d_i states that someone experiences an event at time to time i.

Log Rank test is often used in the analysis of survival data to produce valuable insight into differences in the risk of experiencing an event over time between different groups. The Log Rank test uses the Chi-Square test to compare observed and anticipated cell frequencies in all time interval categories. The next stage outlines the Log Rank test procedure , as quoted from (Kurnianda, 2020):

Identify the number of events that occurred.

Calculates the cumulative absolute sum of n_{1i}andn_{2i}

Calculating the value of e_{1i}ande_{2i}

$$e_{1i} = \frac{n_{1i}}{n_{1i} + n_{2i}} \times d_i \; ; \; e_{2i} = \frac{n_{2i}}{n_{1i} + n_{2i}} \times d_i \tag{4}$$

n_{1i} states the number of times a person survives up to time i and e_{2i} states the expected failure at time to i Calculating value E_i

$$E_1 = \sum_{i=1}^{n} e_{1i} \; ; \; E_2 = \sum_{i=1}^{n} e_{2i} \tag{5}$$

Next, test the hypothesis as follows:

1. Hypothesis
   a. Productive and non-productive age (X_1)
      $H_0 : S_P(t) = S_N(t)$
      $H_1 : S_P(t) \neq S_N(t)$
   b. Male and female gender (X_2)
      $H_0 : S_L(t) = S_P(t)$
      $H_1 : S_L(t) \neq S_P(t)$
   c. There are comorbidities and no comorbidities (X_3)
      $H_0 : S_{AP}(t) = S_{TP}(t)$
      $H_1 : S_{AP}(t) \neq S_{TP}(t)$
   d. There is pain and there is no pain (X_4)
      $H_0 : S_{AR}(t) = S_{TR}(t)$
      $H_1 : S_{AR}(t) \neq S_{TR}(t)$
   e. There is diabetes mellitus and there is no diabetes mellitus (X_5)
      $H_0 : S_{AD}(t) = S_{TD}(t)$
      $H_0 : S_{AD}(t) \neq S_{TD}(t)$
   f. There is hemodilysis and there is no hemodilysis (X_6)
      $H_0 \; S_{AH}(t) = S_{TH}(t)$
      $H_1 : S_{AH}(t) \neq S_{TH}(t)$
2. Test statistics
   In this research, the test statistics used are as follows:

$$\chi^2 = \sum_{i=1}^{G} \left(\frac{O_i - E_i}{E_i}\right)^2, \tag{6}$$

   $O_i$states the observation value on the object of the group to i, $E_i$states the value of expectations on the object of the group to $i$and Gstates the number of rejections
3. Rejection area
   Reject H_0 if $\chi^2 > \chi^2{}_{\propto, G-1}$, $or\ p - value < \propto$.

3. Methodology Study

This research uses descriptive observational research methodology. Using cross-sectional methodology. The cross-sectional approach refers to an observational research method where data on the independent variable and dependent variable are collected simultaneously at one time. The author uses secondary data to refer to data that has been collected by other parties for different purposes and then reused by researchers for analysis. The data used by

researchers was obtained from medical records of individuals suffering from kidney failure at Arifin Achmad Hospital, Riau Province from January 2020 to November 2023. These medical records provide complete information about the patient, including medical history, laboratory test results, diagnosis, type of treatment. received, and other important information relevant to the patient's health condition.

As for steps in study This is as following:

a. Collect and input medical record data for patients diagnosed with kidney failure at Arifin Achmad Hospital, Riau Province using the Excel application.
b. Sort medical record data from shortest to longest
c. Carrying out descriptive analysis of medical record data for patients diagnosed with kidney failure at Arifin Achmad Regional Hospital, Riau Province.
d. survival opportunities to obtain a survival probability curve using the R Studio application.
e. Calculation of survival probability curves in each variable with the Log Rank test for each variable used to compare survival curves between different groups or categories.
f. Interpret the results of the analysis and draw conclusions from the differences in survival curves between the groups tested and identify factors that influence survival.

4. Results and Discussion

This study applies a survival analysis method using an initial time determined as when the patient developed kidney disease, and the end time of the study is marked by the patient's recovery. The data sensor applied in this research is left censoring, which means the recovery time from the start of the patient's kidney disease until the research time limit. In this study, there were six variables identified as potential factors that influence the length of time a patient is hospitalized, such as age, gender, pain, previous illnesses, diabetes mellitus and hemodialysis therapy. The amount of data used in this research reached 115 data. The visualization that can be used to illustrate this information is a bar chart. By using this visualization, information regarding the amount of data in each category can be more easily understood.

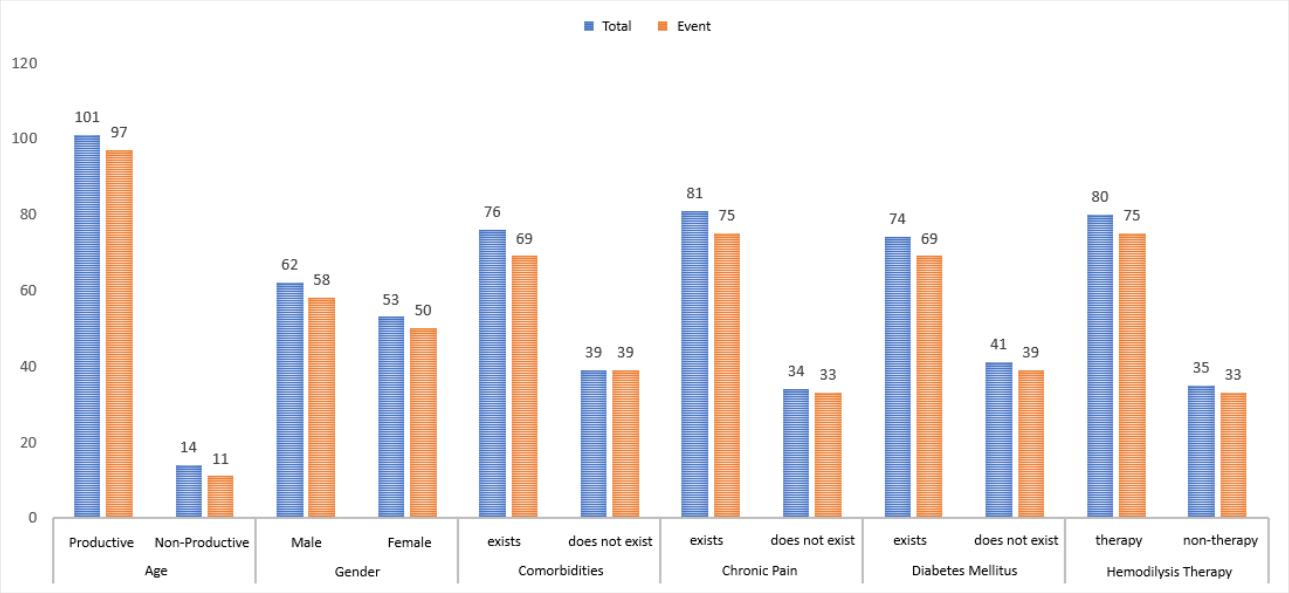

Figure 1:Visualization of the amount of data based on events

Based on Figure 1, several conclusions that can be drawn regarding the age variable are that the majority of patients are in the productive age group, with the number of patients who experience an event (recovery) higher than those who do not experience an event, both in the productive and non-productive age groups. Gender variable There was no significant difference in the number of patients experiencing an event between men and women. Comorbidity variables Patients who have comorbidities tend to have a slightly higher number of events compared to those who do not have comorbidities. Chronic pain variable, the majority of patients experience pain, and the number of events is higher in patients who experience pain. Diabetes mellitus variable: Patients who suffer from diabetes mellitus have a slightly higher number of events compared to those who do not suffer from diabetes mellitus. Hemodialysis therapy variable: There was no significant difference in the number of events between patients who underwent hemodialysis therapy and those who did not.

survival probability curve used estimates the survival function from survival time data , assuming that the data is censored . This curve is often used in survival analysis to visualize survival rates over time. The survival probability curve will provide an overview of the probability of survival of kidney failure patients at Arifin Achmad Hospital,

Riau Province after experiencing recovery. The process of creating this curve begins by collecting data on the survival time of patients who experience recovery, which is the time interval between the initial point of observation until recovery.

Table 1: Probability of survival for inpatients with kidney failure

Time	Lots of risks	Many recovered	Chance of Survival
1	115	10	0.9130
2	104	14	0.7901
3	89	16	0.6481
4	71	6	0.5933
5	65	6	0.5386
6	59	4	0.5020
7	55	8	0.4290
8	46	12	0.3171
9	34	4	0.2798
10	29	2	0.2605
11	26	2	0.2405
12	24	2	0.2204
13	22	2	0.2004
14	20	4	0.1603
15	16	3	0.1302
16	13	4	0.0902
17	9	2	0.0701
18	7	2	0.0501
20	5	1	0.0401
22	4	1	0.0301
23	3	1	0.0200
31	2	1	0.0100
32	1	1	0.0000

Then, the survival probability curve based on Kaplan-Meier can be seen in Figure 2 below:

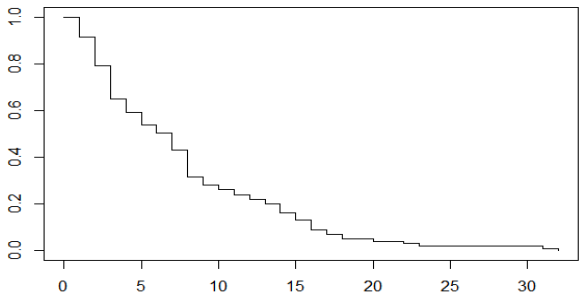

Figure 2: Survival probability curve for kidney failure patients

In Figure 2 , it can be seen that the curve on the first day of survival probability is around 0.9130. At the beginning of the period, the number of recoveries was relatively high, but decreased as time went by. It can be seen that the curve on the first day to the 3rd day of patients who recovered was relatively still very high. Then on the 4th day, patients who went home began to decline until the 7th day. Then on the 8th to the 32nd day the number of patients returning home decreased and became fewer and fewer. The survival probability shows the proportion of subjects who are still alive (recovered) at each time interval. The longer time goes by, the chances of survival tend to decrease. This shows that there is a decreasing risk of healing as time goes by. The chances of survival at the end of the period can be very low, especially over longer periods. This shows that patients with kidney failure have a high chance of survival, the higher the patient's survival.

a. Kaplan-Meier analysis will be carried out for each variable.
   Kaplain-Meier analysis based on age factor

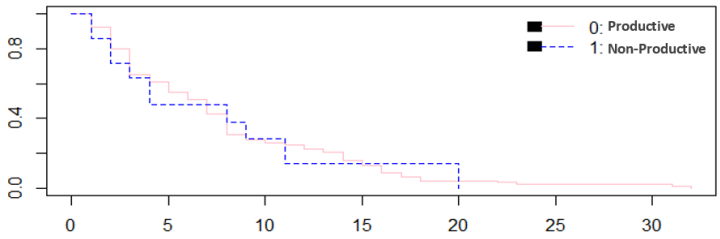

Figure 3: Survival probability curve based on age factors

Figure 3 shows that the curve at time 2 to 4 of the survival probability curve is higher compared to non-productive. However, at time 8 to 11, the chance of survival is higher for non-productive factors.

b. Kaplain-Meier analysis based on gender factors

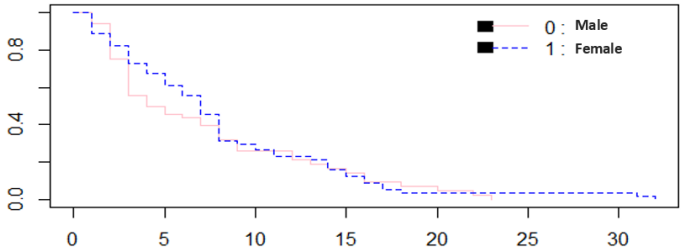

Figure 4: Survival probability curve based on gender factors

Figure 4 shows that the gender curve at time 3 to 8 has a higher chance of survival for men. However, on days 9 to 32 the curves tend to be close together.

c. Kaplain-Meier Analysis for Comorbidity Factors

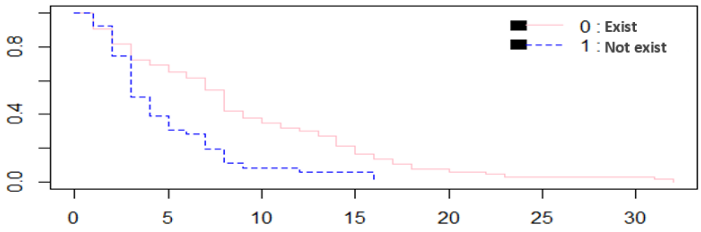

Figure 5: Survival probability curve based on comorbidities

Figure 5 shows that the curve at time 4 of the survival curve is still close. However, at the next time until day 32 the curves are far apart, which means there is a significant difference between the categories of patients with previous disease and those without previous disease.

d. Kaplain-Meier analysis for Pain factors

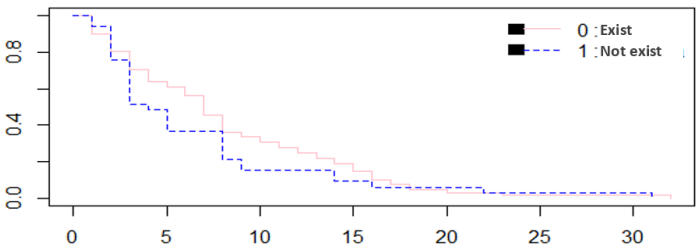

Figure 6: Survival probability curve pain category

Figure 6 shows that the survival probability curve from day 2 to day 3 of the survival function has decreased drastically. Then, on days 3 to 8, the survival function for the pain factor is higher compared to the survival function for patients who do not feel pain.

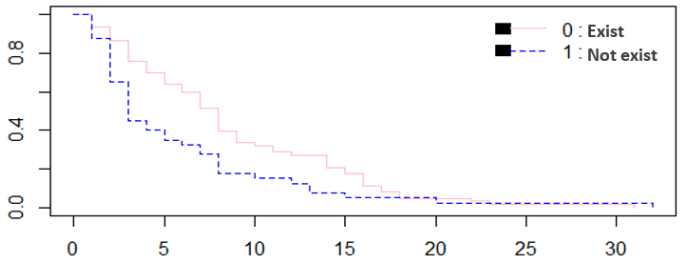

Figure 7: Survival probability curve diabetes mellitus category

Figure 7 shows that the curve at time 2 to day 18 of the survival probability curve for those who have diabetes mellitus is higher compared to the survival probability curve for those who do not have diabetes mellitus.

e. Kaplain-Meier Analysis for Hemolydisa Factors

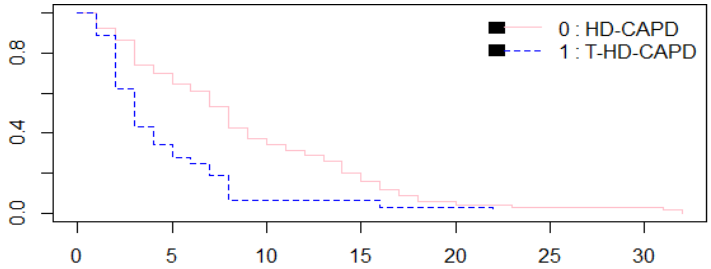

Figure 8: Survival probability curve hemodialysis category

Figure 8 shows that the curve at time 2 to day 19 is curve

The chance of survival is higher for those who undergo hemodilysis therapy compared to the survival probability curve for those who do not undergo hemodilysis therapy.

Log Rank test will be carried out to see whether there is a statistically significant difference between the two groups for each variable.

Table 2: Log Rank test results

Variable	Category	χ^2_{Count}	p-value	Decision
Age	productive non-productive	0.009	0.9	Failed to reject H_0
Type Sex	man Woman	0.3	0.6	Failed to reject H_0
Disease accompanying	There is No	11.2	2×10^{-4}	Reject H_0
Flavor Painful	There is No	1.25	0.2	Failed to reject H_0
Diabetes Mellitus	There is No	4.92	0.01	Reject H_0
Hemodylysis	There is No	11.62	2×10^{-4}	Reject H_0

5. Conclusion

Based on the research, it can be concluded that based on the survival probability curve , the highest probability of survival is on day 1, with a probability value of 0.9130, the lowest is on day 32, where the higher the chance of survival , the higher the patient's survival. Then the probability that the patient will be sent home continues to decrease until the 32nd day and has a probability value of 0.

The next results are based on the Log Rank test and the survival probability curve for kidney failure patients at Arifin Achmad Hospital in 2020-2023. There is no difference in the results between the Log Rank test and the survival probability curve . The variables age, gender and pain did not have a significant effect on the results. the

variables of comorbidities, patients who have diabetes mellitus and patients who receive hemodialysis treatment have a significant effect. These variables influence the length of stay for patients with kidney disease.

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