Mathematical Theory and Modeling
ISSN 2224-5804 (Paper) ISSN 2225-0522 (Online)
Vol.13, No.3, 2023

Modeling the Survival of Stomach Cancer Patients in Meru County using The Stratified Cox Model

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Abstract

Cancer is a disease that can affect anyone regardless of age, social-economic status, or sex. Research has shown there are over 28,000 new cancer cases in a year in Kenya, with a mortality of 22,000, implying a 78.5% chance that the victims do not survive. If not detected early, treated on time, and the right treatment chosen, cancer treatment is less likely to succeed, reducing the chances of survival. One of the most common types of cancer is stomach cancer. It is also the most prevalent cancer in Meru County. The purpose of the study was to find the relationship between the various treatment methods and the survivorship of stomach cancer patients. By doing so, patients and health workers can select the best treatment for cancer patients at different stages. The study modeled the survival of stomach cancer patients using the Stratified Cox model in the case of Meru County, Kenya. The study's general objective was to model the survival of stomach cancer patients in Meru County using the Stratified Cox model. The data was first fitted in a Stratified Cox model to do this. Then hazard functions were determined. From the hazard functions, hazard rates were calculated using R version 4.3.1. Chemotherapy was used as a reference category. The study used secondary data obtained from Meru General Hospital between 2017 and 2021. Different treatment methods: radiotherapy, chemotherapy, hormone therapy, and surgery are compared for each stage while considering several demographic characteristics such as age and sex. The research investigated the hazard rates that, in turn, helped find the survival of patients with stomach cancer based on the treatment method used. Hazard ratios were obtained from the collected data to determine and recommend the best treatment method at a particular stage of stomach cancer. After analysis, results showed that surgery is the best treatment for stage 1 and 2 cancer, while radiotherapy and chemotherapy are the best for stage 3 and 4, respectively. Notably, patients below 50 have higher survival rates than those above 50. It was also noted that women have higher survival rates than men. The three objectives were met, where the first objective involved fitting the data into the model. Hazard functions were formed, and the hazard rates were calculated using the coefficients from the hazard functions. Based on the objectives, it was recommended that modeling data after combining several treatments should be done. Also, the survivorship of patients after combining treatments should be found and compared with the survivorship after using one treatment at a time. Lastly, since herbal treatment is becoming a common treatment, enough data should be corrected and the treatment compared with other treatment methods.

Keywords*:* Stomach Cancer, Stratified Cox model, Hazard ratio/rates, chemotherapy, radiotherapy, hormone therapy, surgery

1. Introduction

Cancer cases have been on the rise, and it kills more people than a combination of AIDS, tuberculosis, and malaria but has received less attention (WHO, 2018). The International Agency for Research on Cancer (IARC) in 2020 concluded that 1 in 5 people develop cancer in their lifetime. Out of 8 men and 11 women who are diagnosed with cancer, one in each category dies from the disease. The most vulnerable group is the aging population (WHO,

2020). One of the most prevalent and deadliest cancers is stomach cancer, also called gastric cancer, which is most common among older males (Rawla 2019). Stomach cancer is an abnormal buildup of cells in part of the stomach. The most common type of cancer found in Meru County is stomach cancer, leading by over 13.5%. The most affected are those in the age group 60-69 years, with only 16% of the cancer cases reported for those under 50 years (Kobia *et al.*, 2019). Spiritual therapy, vitamins, and herbs are the most common cure, and when they do not work, patients rush for radiotherapy, chemotherapy, and chemo-radiotherapy. Nevertheless, the government has established different cancer centers in Kenya, all aimed at curing and preventing the spread of cancer cells.

1.1 Statement of the Problem

Scholars have been trying to find the best treatment method for each type of cancer in developed countries since cancer is one of the world's highest-killer diseases (Debela et al., 2021). However, there is inadequate research done in Kenya, particularly in Meru County, regarding stomach cancer treatment methods. According to Kobia et al. (2019), Stomach cancer has continued killing residents of Meru, which makes it essential to continue researching it to reduce its mortality rates.

One major challenge is the selection of treatment methods. The fact that a particular treatment works for a certain stage does not necessarily mean it can work for another stage. Likewise, a treatment may work on a given stage of a particular cancer, but that does not mean it can work for all cancers for that specific stage. The case is also the same for different regions. Research done by Ho et al. (2016) recommended that more research be done on various cancer treatments and the survivorship of the patients based on several regions since they found that one treatment may work well in a given region but not in another. If the right treatment based on a region and cancer stage is not done, there is a possibility of more deaths being experienced.

1.2 Objectives

i. To fit the stomach cancer data obtained from Meru General Hospital to the Stratified Cox model.
ii. To determine the hazard rate functions of patients at different stages from the fitted model.
iii. To determine the best treatment method at each cancer stage using the Stratified cox model

2. Summary of Literature

2.1 Use of Stratified Cox Model on cancer data

Hamashima et al. (2015) investigated the survival analysis for patients undergoing gastric cancer radiotherapy and endoscopy procedures. The Stratified Cox model was applied to examine the risk factors affecting stomach cancer patients undergoing endoscopic and radiographic screening. The results found that gastric-specific cancer survival rates were higher in endoscopic screening than in radiographic screening. A related study also found that the risk of gastric cancer death among patients undergoing endoscopic screening was lower than that of patients undergoing radiographic screening (Daouda et al., 2013)

Several other studies have used the Stratified Cox model to establish the determinants of survival among cancer patients. Notably, Pazvakawambwa and Embula (2017) published a study investigating risk factors for breast cancer survival in Namibia. The results depicted that demographic factors of age, region, and ethnicity influenced breast cancer. The study also showed that the Stratified Cox model has fewer assumptions compared to parametric techniques in determining the survival rates for breast cancer patients and hence more preferred in medical trials.

2.2 Use of hazard rates on cancer stages

The Stratified Cox model is employed to create hazard rate functions for patients at different stages of cancer using the fitted Stratified Cox model as provided in the study by Bellera et al. (2010). Abadi et al. (2014) conducted research on 15830 women diagnosed with breast cancer in British Columbia, Canada. Eight strata were formed based on age (2 strata) and stages (4 strata). A stratified model was then fitted according to the PH assumption. The results showed that chemotherapy had the highest hazard for those above 50 years and below 50 (HR= 3, CI: 2.29- 3.93), and radiotherapy (HR= 3.15, CI: 1.85-5.35) had the highest hazard for those below 50. For stages 3 and 4, surgery had the highest hazard for both groups.

2.3 Ethical consideration

Approval for this study was obtained from the Meru University of Science and Technology Directorate of Research. Since medical data was used, authority from Meru Institutional Research and Ethical Review Committee (MIRERC) for ethical binding was given. The data collected did not include the patient's identity and was stored in a locked computer.

3. Methodology

3.1 Study Design

The study adopted a quantitative method, where a retrospective cohort study was applied since the research used secondary data. A retrospective cohort study is carried out in the present time and uses historical data to examine medical events or outcomes (Song, 2010). In this study, the historical data used involves stomach cancer treatments, and the event of interest was the survival of patients who used the various treatment methods at different stages. The researcher used secondary data since the data was readily available at Meru General Hospital between 2017 and 2021.

3.2 General Stratified Cox Procedure

The general stratified Cox Model:

$$h_g(t,X) = h_{0g}(t)\exp\left[\beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p\right] \quad (1)$$

$g = 1,2,\ldots,k^*$, strata defined from Z^*

Z^*not included in the model

$h_g(t,X)$ Is the hazard rates at a given time t

$X_1, X_2, \ldots, X_p$ Included in the model

$h_{0g}(t)$ Is different baseline hazard functions:

$h_{0g}(t), g = 1,2,\ldots,k^*$

Coefficient is: $\beta_1, \beta_2 + \cdots + \beta_p$

To obtain the estimates of the regression coefficients$\beta_1, \beta_2 \ldots \beta_p$, the partial likelihood function L obtained by multiplying together the likelihood function of each stratum is maximized (David & Mitchel, 2012). Thus,

$$L = L_1 \times L_2 \times, \ldots \times L_{k^*}$$

Strata:	1	2 … k^*		
Likelihood:	L_1	L_2	...	L_{k^*}
Hazard:	$h_1(t,X)$	$h_2(t,X)$	...	$h_{k^*}(t,X)$

3.3 SC model with interaction

$$h_g(t,\boldsymbol{X}) = h_{0g}(t)\exp\left[\beta_{1g} X_1 + \beta_{2g} X_2 + \cdots + \beta_{pg} X_p\right] \quad (2)$$

$g = 1, 2, \ldots, k^*$, strata defined from Z^*

Notably, each regression coefficient in this model has a subscript g, denoting the g th stratum, which indicates that the regression coefficients differ for the different Z* strata (David & Mitchel, 2012).

Alternative SC interaction model:

- Use product terms involving Z^*
- Define k^* dummy variables $Z_1^*, Z_2^*, \cdots Z_{k^*}^*$, from Z^*
- Products of the form $Z_i^* \times X_j$ where $i = 1, \cdots, k^*$ and $j = 1, \cdots, p$

$$h_g(t, \boldsymbol{X}) = h_{0g}(t)\exp\left[\beta_1 X_1 + \cdots + \beta_p X_p + \beta_{11}(Z_1^* \times X_1) + \cdots + \beta_{p1}(Z_1^* \times X_p) + \beta_{12}(Z_2^* \times X_1) + \cdots + \beta_{p2}(Z_2^* \times X_p) + \cdots + \beta_{p,k^*}(Z_{k^*}^* \times X_p)\right] \quad (3)$$

g =1, 2 ...,k^*, strata defined from Z^*

The next thing is finding which model is most appropriate given the data. That is, which model is better between no-interaction and interaction models?

Testing the no-interaction assumption:

Wald statistic p was used at $\alpha = 0.05$

Where

$$H_0 = \begin{cases} \beta_{11} = \cdots = \beta_{p1} = 0 \\ \beta_{12} = \cdots = \beta_{p2} = 0 \\ \quad . \\ \quad . \\ \quad . \\ \beta_{1,k^*} = \cdots = \beta_{p,k^*} = 0 \end{cases} \quad (4)$$

Chemotherapy was used as a reference category. By reference category, it means that the hazard rate of chemotherapy was used as a comparison category. Due to this, the hazard rate of chemotherapy is equal to one. Hence, since the hazard ratio for chemotherapy is already known, the hazard function was not formulated

3.4 Specific Stratified Cox model

$$\begin{aligned} h_g(t, X) = h_g(t)\exp\big[&\beta_1 age + \beta_2 Gender + \beta_3 hormonal + \beta_4 radio + \beta_5 surgery \\ &+\beta_{11}(age \times Z_1) + \beta_{12}(age \times Z_2) + \beta_{13}(age \times Z_3) + \beta_{14}(age \times Z_4) \\ &+\beta_{21}(Gender \times Z_1) + \beta_{22}(Gender \times Z_2) + \beta_{23}(Gender \times Z_3) \\ &+\beta_{24}(Gender \times Z_4) \\ &+\beta_{31}(hormone \times Z_1) + \beta_{32}(hormone \times Z_2) + \beta_{33}(hormone \times Z_3) + \beta_{34}(hormone \times Z_4) \\ &+\beta_{41}(radio \times Z_1) + \beta_{42}(radio \times Z_2) + \beta_{43}(radio \times Z_3) + \beta_{44}(radio \times Z_4) \\ &+\beta_{51}(surgery \times Z_1) + \beta_{52}(surgery \times Z_2) + \beta_{53}(surgery \times Z_3) + \beta_{54}(surgery \times Z_4) \end{aligned} \quad (5)$$

Where g represents the strata, that is $g = 1,2,3\ and\ 4$

And: Z^* Represents the stage, that is $Z^* = 1,2,3,4$

Testing hypothesis using Wald statistic p:

H_0: No-interaction model acceptable, i.e.,

Treatment: $\beta_{i1} = \beta_{i2} = \cdots = \beta_{i4} = 0$

Age: $\beta_{11} = \beta_{12} = \cdots = \beta_{14} = 0$

Gender: $\beta_{21} = \beta_{22} = \cdots = \beta_{24} = 0$

This hypothesis is then measured at $\sigma = 0.05$ using the Wald statistic p of the interaction model.

Generating strata using Equation 5

When $\boldsymbol{stage\ 1 = 1,\ then\ stage\ 2 = stage\ 3 = stage\ 4 = 0}$.

In this case

$$h(t,X) = h_0(t)\exp[(\beta_1+\beta_{11})age + (\beta_2+\beta_{21})Gender + (\beta_3+\beta_{31})hormone + (\beta_4+\beta_{41})radio+(\beta_{51} + \beta_5)\,surgery \quad (6)$$

When $\boldsymbol{stage\ 2 = 1,\ then\ stage\ 1 = stage\ 3 = stage\ 4 = 0}$.

$$h(t,X) = h_2(t)\exp[(\beta_1+\beta_{11})age + (\beta_2+\beta_{22})Gender + (\beta_3+\beta_{32})hormone + (\beta_4+\beta_{42})radio+(\beta_{52} + \beta_5)\,surgery \quad (7)$$

When $\boldsymbol{stage\ 3 = 1,\ then\ stage\ 1 = stage\ 2 = stage\ 4 = 0}$

$$h(t,X) = h_3(t)\exp[(\beta_1+\beta_{13})age + (\beta_2+\beta_{23})Gender + (\beta_3+\beta_{33})hormone + (\beta_4+\beta_{43})radio+(\beta_{53} + \beta_5)\,surgery \quad (8)$$

When $\boldsymbol{stage\ 4 = 1,\ then\ stage\ 1 = stage\ 2 = stage\ 3 = 0}$

$$h(t,X) = h_4(t)\exp[(\beta_1+\beta_{14})age + (\beta_2+\beta_{24})Gender + (\beta_3+\beta_{34})hormone + (\beta_4+\beta_{44})radio+(\beta_{54} + \beta_5)\,surgery \quad (9)$$

4. Results and Discussion

4.1 Testing the PH Assumption

Table 4.1: PH assumptions

	Coeff	**P(PH)**
Cancer Stage 4	2.049	0.0099404
Treatment Type: Hormone Treatment	-1.148	0.82901
Treatment Type: Radiotherapy	0.5828	0.18557
Treatment Type: Surgery	1.035	0.0561
Treatment Type: Chemotherapy	2.036	0.071
Gender	-2.2711	0.43013
Age	1.79412	0.11364
Cancer Stage 1	2.711	0.012
Cancer Stage 2	1.819	0.009471
Cancer Stage 3	1.967	0.0099428

p = < 0.00026

A model of no interaction was created in R version 4.2.3 (Shortstop Beagle) to test this. The P (PH) value for cancer stages is below the 0.05 level. This shows that all treatments, gender, and age satisfy the PH assumption while cancer stages do not. Since there is a situation where one of the predictors does not satisfy the PH assumption, a stratified Cox (SC) procedure was carried out. Using SC, the stage variable was controlled since it does not satisfy the PH assumption through stratification while including the gender, age, and treatment variables in the model since they all satisfy the PH assumption. The general model is also significant at a 0.05 level of significance since the p-value is less than alpha.

4.2 Stratified Cox model

Table 4.2: Stratified Cox model coefficients

	Coeff	**Se(Coeff)**	**P**
Age	0.07719	0.02433	0.03667
Gender	-1.09995	0.0322	0.04494
Hormone Therapy	0.2298	0.05726	0.02012
Radiotherapy	-0.7672	0.7278	0.03593
Surgery	-0.09848	0.5263	0.03667
Age*Stage 1	0.61317	1.3421	0.00461
Age*Stage 2	0.2874	0.03732	0.00271
Age*Stage 3	0.97900	0.02781	0.04095
Age*Stage 4	1.22188	0.02451	0.0155
Gender*Stage 1	1.19036	0.3473	0.0043
Gender*Stage 2	1.49115	0.9334	0.04175
Gender*Stage 3	1.61737	0.7065	0.0186
Gender*Stage 4	1.99807	0.26745	0.0128
Hormone*Stage 1	0.24162	0.02673	0.0856
Hormone*Stage 2	-0.02815	0.01851	0.03483
Hormone*Stage 3	0.08230	0.06143	0.03975
Hormone*Stage 4	0.75166	0.2761	0.04381
Radiotherapy*Stage 1	1.19942	0.00473	0.00432
Radiotherapy*Stage 2	1.05603	0.01332	0.00692
Radiotherapy*Stage 3	-0.08471	0.08698	0.0102
Radiotherapy*Stage 4	1.26493	0.09627	0.0432
Surgery*Stage 1	-2.0336	0.03861	0.03561
Surgery*Stage 2	-0.09985	0.07471	0.05321
Surgery*Stage 3	0.38868	0.06381	0.04421
Surgery*Stage 4	0.39353	0.08367	0.0045

p=0.0115

Testing null hypothesis

H_0: No-interaction model acceptable, i.e.
Treatment: $\beta_{i1} = \beta_{i2} = \cdots = \beta_{i4} = 0$
Age: $\beta_{11} = \beta_{12} = \cdots = \beta_{14} = 0$
Gender: $\beta_{21} = \beta_{22} = \cdots = \beta_{24} = 0$
The Wald statistic p of the interaction model is used to test this hypothesis. At a 0.05 significance level, the p-value is 0.0115, which is less than 0.05. The null hypothesis is rejected; hence, the interaction model is acceptable

After inserting the coefficient, the following model was obtained

$$h(t,X) = h_0(t)\{0.07719(age) - 1.09995(Gender) + 0.2298(hormonal) - 0.7672(radio) - 0.09848(surgery)$$

$$+0.61317(Age * Z_1) + 0.28740(Age * Z_2) + 0.97900 * (\text{Age} * Z_3) + 1.22188 * (\text{Age} * Z_4)$$

$$+1.19036\,(Z_1 * Gender) + 1.49115 * (Z_2 * Gender) + 1.61737 * (Z_3 * Gender) + 1.99807 * (Z_4 * \text{Gender})$$

$$+0.24162(\text{hormone} * Z_1) - 0.02815 * (\text{hormone} * Z_2) + 0.08230\,(\text{hormone} * Z_3) + 0.75166 * \text{homornal} * Z_4\,)$$

$$+1.19942(\text{radio} * Z_1) + 1.05603 * (\text{radio} * Z_2) - 0.08471 * (\text{radio} * Z_3) + 1.26493 * (Radio * Z_4)$$

$$-2.0336(surgery * Z_1) - 0.09985 * (surgery * Z_2) + 0.38868 * (surgery * Z_3) + 0.39353 * (surgery * Z_4)\} \quad (10)$$

4.2.1 Hazard functions for treatment method in Stage 1

$$h_1(t,X) = h_1(t)\exp\,[0.69036age + 0.09041Gender + 0.47142hormonal + 0.4322radio - 2.132084surgery \quad (11)$$

4.2.2 Hazard function for treatment method in Stage 2

$$h_2(t,X) = h_2(t)\exp\,[0.36459age + 0.39120Gender + 0.20165hormonal + 0.28883radiotherapy - 0.19833surgery \quad (12)$$

4.2.3 Hazard function for treatment method in Stage 3

$$h_3(t,X) = h_3(t)\exp\,[1.05619age + 0.51742Gender + 0.32121hormonal - 0.85191radiotherapy + 0.2902surgery] \quad (13)$$

4.2.4 Hazard function for treatment method in Stage 4

$$h_4(t,X) = h_4(t)\exp\,[(1.29907)age + (0.89812)Gender + (0.98146)hormonal + 0.49773radio + 0.29505surgery] \quad (14)$$

Notably, a positive coefficient indicates an increasing risk, while a negative coefficient indicates a decreasing risk.

4.3 Association between patients' survival time, age, treatment method, gender, and cancer stage using the stratified Stratified-Cox model

The reference category is chemotherapy. Implies that the hazard rate can be defined as,

$$h(t,X) = h\left(\frac{x}{chemotherapy}\right) \quad (15)$$

Table 4.3: Hazard rates for the various treatment used.

	Stage 1	Stage 2	Stage 3	Stage 4
Hormone Therapy	1.602260	1.22342	1.37880	2.66834
Radiotherapy	1.540667	1.33487	0.42660	1.64498
Surgery	0.118590	0.82010	1.33670	1.34319
Chemotherapy	1.00000	1.00000	1.00000	1.00000
Age>50	1.994430	1.43992	2.87540	3.66589
Gender M	1.094625	1.47875	1.67769	2.45499

4.3.1 Stage 1 Analysis

In stage one, surgery has higher survival rates than chemotherapy. This is because it has a hazard ratio of 0.118590, which is less than one. This can also be interpreted as; a person using surgery to chemotherapy has an 88.14% chance of surviving. Radiotherapy has a hazard ratio of 1.540667. This implies that a person who uses radiotherapy instead of chemotherapy has a 1.540667 chance of dying. Hormone therapy, which has a hazard ratio of 1.602260, which is also greater than one, implying chemotherapy, has a higher survival rate than hormone therapy. The risk of death is 1.60226 times higher when using drug hormone therapy than when using chemotherapy. In the above results, the hazard rate is 1.994430, which is greater than 1, implying that the survival rate for those over 50 is lower than that for those below 50 in this category. Notably, those above 50 have a 1.994430 times higher chance of dying than those below 50 years.

Machlowska et al. (2020) assert surgery is the best treatment approach for stage 1 stomach cancer and involves removing the part of the stomach with cancer and nearby lymph nodes.

4.3.2 Stage 2 Analysis

Surgery, which has a hazard rate of 0.82010, has a hazard rate of less than 1, implying that surgery has a higher survival rate than chemotherapy. This can be interpreted as; there is a 0.82 chance of dying while using surgery over chemotherapy. Alternatively, the risk of death when surgery reduces by 17.99% compared to chemotherapy. The risk of death when using hormone therapy is 1.22342 times higher than when using chemotherapy. The chance of dying from using radiotherapy is 1.33487 higher than using chemotherapy. Surgery, chemotherapy, hormonotherapy, and radiotherapy are the treatment with the highest survival rates. A male has a 1.47875 chance of dying than a female from stomach cancer. Likewise, those above 50 have a low survival rate, as shown by the hazard ratio of 1.43992. This implies that a person above 50 has a 1.43992 chance of dying than a person below 50.

Surgery and chemotherapy at stage 2 are preferred as it helps down-stage the disease to reduce the local and distant recurrence rate, thus improving survival (Chen *et al*., 2021).

4.2.3 Stage 3 Analysis

A person using hormone therapy to chemotherapy has a 1.37880 higher chance of dying. This implies that a patient who chooses chemotherapy over hormone therapy has a high survival rate. A person using surgery to chemotherapy has a 1.33670 higher chance of dying. A person using radiotherapy to chemotherapy has a 0.42660 higher chance of dying, indicating that using radiotherapy increases the chances of survival by 57.34% than using chemotherapy. By ranking the treatment methods, radiotherapy and chemotherapy are the best treatments for stomach cancer stage three. Age has a hazard of 2.87540, meaning those above 50 have low survival rates, and since gender has a hazard rate of 1.67769, men have higher mortality rates.

At stage 3, stomach cancer grows into the stomach's inner supportive muscle or outer layer. At this stage, radiotherapy and chemotherapy is the best treatment method (Sexton et al., 2020). At stage 3, the cancer has not infected other organs or distant body parts, and radiation therapy helps regulate the cell growth rate. Radiotherapy creates small breaks in the DNA of a patient's cells to keep cancer cells from growing and dividing, causing them to die.

4.2.4 Stage 4 Analysis

A person using hormone therapy to chemotherapy has a 2.66834 chance of dying. Also, the hazard rate is greater than 1, implying that chemotherapy is preferred over hormone therapy. In addition, radiotherapy has a hazard rate of 1.64498, greater than one. This indicates that a person using radiotherapy to chemotherapy has a 1.64498 chance of dying, denoting that patients who use radiotherapy have a lower survival rate than those using chemotherapy. The same is found if a patient undergoes surgery with a high hazard rate of 1.34319. This indicates that a person using surgery to chemotherapy has a 1.34319 chance of dying. This implies that in this category, the most preferred treatment is chemotherapy, surgery, radiotherapy, and hormone therapy. Age has a hazard of 3.66589, meaning

those above 50 have low survival rates, and since gender has a hazard rate of 2.45499, men have higher mortality rates.

At stage 4, stomach cancer spreads to other organs in the body, and surgical removal is not possible. Chemotherapy is the only viable treatment option at this stage as it helps control the growth of the cancers (Sexton et al., 2020).

5. Conclusion

This research was done in order to determine the best treatment for stomach cancer patients in Meru County. The Stratified Cox model was suggested since, unlike other survival models, like the logistic model, it is used when survival time information is available, and there is censoring.

The first objective involved fitting the stomach cancer data obtained from Meru general hospital on the model. However, a PH assumption test was carried out to determine which variables would be used for stratification. It was found that the model of the stages did not meet the PH assumption, which suggests that all variables with a p-value of less than 0.05 will be used for stratification.

Hazard rate functions were obtained from the fitted stratified Cox model in the second objective. The model was formed based on the fact that a patient cannot experience two cancer stages at the same time. By doing this, a general model was obtained for each cancer stage. The model was then narrowed down because only patients who underwent one treatment per stage were used. By doing this, three models were obtained.

The third objective involves getting the treatment with the highest survival rates per stage by comparing the predictor variables used. The variables compared include treatment methods, cancer stages, age, gender, survival status, and treatment duration. It was found that surgery is the best treatment for stages one and two of stomach cancer. Patients who used surgery in these stages had the highest survival rates. The conclusion was based on the fact that the treatment method had the lowest hazard rates, implying that they had the lowest chance of dying. In stage three, radiotherapy was the best treatment method, while in stage 4, chemotherapy was the best. The analysis was based on the fact that the two treatments had the lowest hazard rates in their respective stages. In all stages, those above 50 had the lowest survival rates than those below 50. It was found that men had a lower survival rate than women. Notably, the results were also supported by respective literature.

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