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APPLICATION OF COX PH MODEL ON BROILERS IN la NYEVU POULTRY FARM IN KALOLENI SUB-COUNTY; A SURVIVAL ANALYSIS CASE STUDY

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ABSTRACT

This research was about a survival analysis on broilers in la Nyevu poultry farm in Kaloleni sub-county. Chapter one gives an insight into the introduction of the paper, chapter two discusses the methodology used, chapter three gives the results, chapter four discusses the findings briefly and chapter five gives the conclusions arrived at and some recommendations.

Key words: Time to event, Cox proportional hazards, hazard rate

1.0 Introduction

Broilers are birds reared for meat. Survival analysis is a branch of statistics which deals with analyzing the expected time until one or more events (in this case, death of broilers) happen. Many different researchers have tried to study this scenario. Some of them include Awobajo et. al. (2007), Arikan et. al. (2017), and many more did a similar task however their studies were based on the hazard rates only which is inadequate to show the trend of the birds whereas this research used the Cox PH model to find the hazard rate of the broilers with regards to diseases and accidents.

2.0 Methodology

A sample of 698 broilers from la Nyevu poultry farm in Kaloleni sub-county respectively, was observed. These sampled broilers were observed for a period of 42 days then the observation stopped. Different survival estimates were determined using the R software for analysis.

2.1 The variables under study: The response variable: was the time (in days) until a broiler died, and the predictor variables were the number of broilers that died due to diseases and the number of broilers that died due to accidents.

2.2 The model development: This study used the Cox PH model which in general is of the form; h (t, x) = h_0(t) exp($\beta_1 X_1$+$\beta_2 X_2$+……$\beta_P X_P$), where X_1,X_2,…X_P are the explanatory variables and β_1,β_2,…..β_P are the regression coefficients, h(t) is the hazard function at time, t, and h_0(t) is the baseline hazard function at time, t. Therefore the specific form of the Cox PH model used was, h (t, x) = h_0(t)exp($\beta_1 X_1$+$\beta_2 X_2$) where X_1=number of broilers that died due to diseases and X_2= number of broilers that died due to accidents.

2.3 Assumptions of the Cox PH model: The Cox PH model has the following assumptions: the hazard rate normally can be expressed as a function of the predictor variables, the baseline hazard function is a time dependent function and is independent of the variables, there is a linear relationship between the hazard function and the predictor variables, the Cox PH model exhibits a constant hazard rate and is semi parametric.

2.4 Estimation of the regression coefficients in the model: In the estimation of β_is the likelihood of the Cox PH model was obtained. The Cox PH model uses the partial likelihood method to find the parameters. The illustration is as shown here below;

Denote, j= 1, 2,….m to stand for the number of broilers which died, out of n broilers.

Denote $t_{(i)} \le t_{(2)} \le \ldots \le t_{(m)}$ to stand for m failure times that are ordered at which the broilers died.

Denote R_i to stand for the number of broilers that were at risk of dying just before time t_i, considering one variable at a given time.

Then the probability that (broiler i had experienced the event of death at time, $t_{(i)}$ | one event at time, $t_{(i)}$

$$= \frac{h(t,x_i)}{\sum_{j=Rt(i)} h(t,x_j)} = \frac{ho(t)e^{\beta' xi}}{\sum ho(t)e^{\beta' xj}} = \frac{e^{\beta' x_i}}{\sum_{j=Rt(i)} e^{\beta' x_j}}$$

Where X_i = ($x_{i1} x_{i2}$ … … … … . x_{ip}), is the vector of predictor variables of the i^{th} broiler.

When there are ties in the times of failure, the Cox likelihood will be defined over all the times to the event which is the death of a broiler, i.e. $t_{(i)}$, i=1,2,…m, and were therefore determined as given below.

$$L(\beta) = \prod_{i=1}^{m} \frac{e^{\beta' x_i}}{\sum_{j=Rt(i)} e^{\beta' x_i}},$$

for the uncensored broilers alone.

For the broilers that are censored, censoring was done after the j[th] time, and was included in the risk set and was normally for computing the j[th] likelihood. The logarithm of the partial likelihood was expressed as;

$$\log l(\beta) = \sum_{i=1}^{m} (\beta x_i - \ln(\sum_{j=Rt(i)} e^{\beta' x_i}.)$$

Where the maximum partial likelihood estimates for the regression coefficients were found by working the solutions for the set of equations.

$\frac{\partial l(\beta)}{\partial \beta i} = 0$, where i = 1,2,…….p, where p is the number of parameters.

2.5 Comparison of the survival curves: To compare the number of broilers that died due to diseases, and accidents, the researcher did a graph the survival function of the broilers under study. This was done by showing the survival plots on the same axes. Generally, if the plot of a given survival curve is above other survival curves, it can be concluded that the variable whose curve is above all the rest has the best survival rate than all other variables. Nevertheless, a researcher might want to study whether or not the survival curves for different variables are statistically equal.

3.0 Results

The results were obtained using the R software for data analysis

The results in table 1 show the survival curve of the fraction of a cohort of 698 broilers alive from time of purchase for a period of 42 days. The table shows the number at risk number of events which describes the number events of interest and their survival probabilities and their associated standard error. The upper and lower confidence interval of the survival probability is also shown. The result shows that, 20 broilers, out of a total 698 broilers died in day one translating to 0.9713 probability of survival past one day. In the estimation, the survival probability keeps decreasing with time.

The survival estimates

	time	n.risk	No.event	surv	std.err	lower	upper
1	1	698	20	0.971347	0.006315	0.959049	0.983802
2	2	656	10	0.95654	0.007763	0.941445	0.971876
3	3	645	1	0.955057	0.007891	0.939715	0.970649
4	4	636	7	0.944545	0.008747	0.927555	0.961846
5	6	622	5	0.936952	0.009313	0.918876	0.955384
6	8	591	3	0.932196	0.009662	0.91345	0.951327
7	10	578	1	0.930583	0.009779	0.911613	0.949948
8	11	571	16	0.904507	0.011474	0.882296	0.927277
9	12	548	8	0.891303	0.012219	0.867673	0.915577
10	14	509	13	0.868539	0.01344	0.842593	0.895283
11	15	483	4	0.861346	0.013801	0.834716	0.888825
12	16	467	11	0.841057	0.01477	0.812602	0.870509
13	17	441	12	0.818171	0.015776	0.787827	0.849684
14	19	404	3	0.812096	0.016044	0.78125	0.844159
15	21	397	2	0.808005	0.016222	0.776827	0.840434
16	22	391	17	0.772874	0.017613	0.739113	0.808177
17	23	350	6	0.759625	0.018123	0.724923	0.795988
18	24	341	1	0.757397	0.018206	0.722542	0.793934
19	25	339	1	0.755163	0.018289	0.720155	0.791872
20	26	338	2	0.750694	0.018451	0.715388	0.787744
21	29	336	3	0.743992	0.018688	0.708251	0.781536
22	30	333	1	0.741758	0.018765	0.705876	0.779463
23	31	332	10	0.719416	0.019485	0.682222	0.758636
24	33	307	12	0.691295	0.020344	0.65255	0.73234
25	35	291	8	0.67229	0.020865	0.632615	0.714454
26	38	265	10	0.646921	0.021565	0.606006	0.690598
27	39	250	5	0.633982	0.021896	0.592488	0.678383
28	40	235	11	0.604307	0.022625	0.56155	0.650319
29	42	209	32	0.511781	0.024366	0.466185	0.561838

The survival probability was plotted against time to obtain the survival probability curve shown in figure 1 to visualize the trend. The results shows the survival probabilities are above the median survival time (the horizontal dotted line) during the entire period of the study. This is a good indicator of to the farm and the ideal case of low deaths rates are depicted by flatter survival curve.

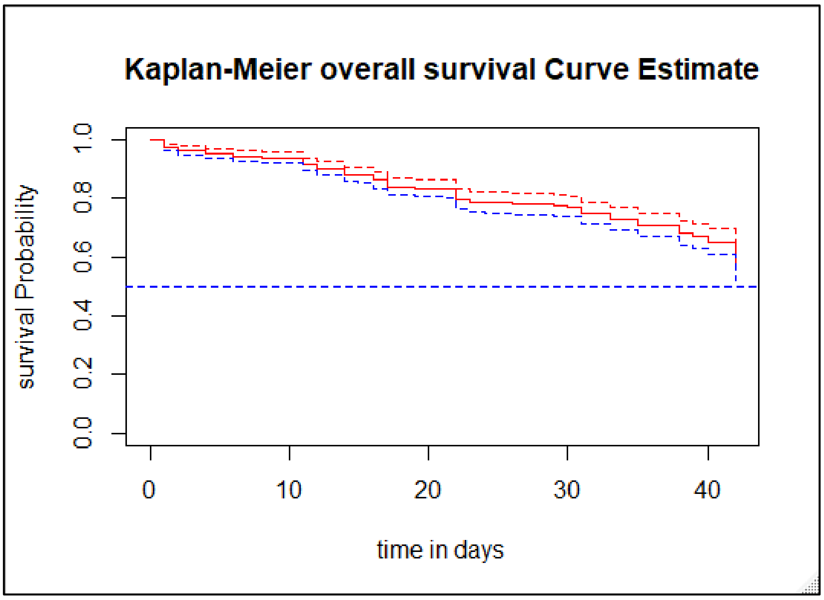


Figure 1: Plots of product limit estimates of survival of a group of broilers

3.1 The Cox PH results

The Cox (proportional hazards) regression analysis models the relationship between a set of one or more covariates and the hazard rate. The first feature of the cox model is the |z| value that gives the Wald statistic value which is to the ratio that evaluates whether the beta coefficient of a given variable is statistically significantly different from zero. Significant values means that the coefficient is significantly different from zero. From the output results in table2, the |Z| < .05 therefore the study concludes that the cause of death variable is statistically significant in the survivorship of the broilers

The R summary for the Cox model gives the hazard ratio (HR) for the second group (accidents) relative to the first group (disease). The beta coefficient for cause of death is 0.7906 indicates that broilers have higher risk of death from the disease than deaths from accidents. That sign indicates that individual broilers with higher scores in variable (accidents) are less likely to observe the event of interest, in this case, die than those with lower scores (disease).

The exponentiated coefficients (exp(coef) = exp(0.7906) = 0.4536) is the Hazard Ratios (HR) that describes the effect size of a covariates relative to the other. In this case it shows the effect of accident (=2) reduces the hazard by a factor of 45.36%

Table2

```
coxph(formula = (surv_object) ~ broilers333$var1, method = "breslow")

  n= 698, number of events= 204
   (1 observation deleted due to missingness)
```

	coef	exp(coef)	se(coef)	z	Pr(>|z|)
Cause	0.7906	0.4536	0.1403	-5.635	1.75e-08

Cause *** Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

	exp(coef)	exp(-coef)	lower .95	upper .95
Cause	0.4536	2.205	0.3445	0.5971

Concordance= 0.614 (se = 0.018)
Likelihood ratio test= 31.27 on 1 df, p=2e-08
Wald test = 31.75 on 1 df, p=2e-08
Score (logrank) test = 33.43 on 1 df, p=7e-09

The p-value for all three overall tests (likelihood, Wald, and score) are significant, indicating that the model is significant. These tests evaluate the omnibus null hypothesis that all of the betas coefficients are zero. In the results table2, the fit test statistics are in close agreement, and the omnibus null hypothesis is soundly rejected.

3.2 The log rank Test Results

The log rank test was run so as to establish if there is a significance difference in the two groups of deaths. The results presented in table 3 shows that the survival time between the two death causes is highly significant as indicated by a significant Chi-square value of 34.6 (p= 4e-09, 1 degree of freedom). The results means that broilers subjected to accidents had longer survival times than those subjected to disease.

Causes	Number	Observed deaths	Expected deaths	$(O-E)^2/E$	$(O-E)^2/V$
Disease	262	106	67.2	22.4	34.6
Accidents	436	98	136.8	11.0	34.6

Chisq= 34.6 on 1 degrees of freedom, p= 4e-09

3.3 Cox PH assumptions results

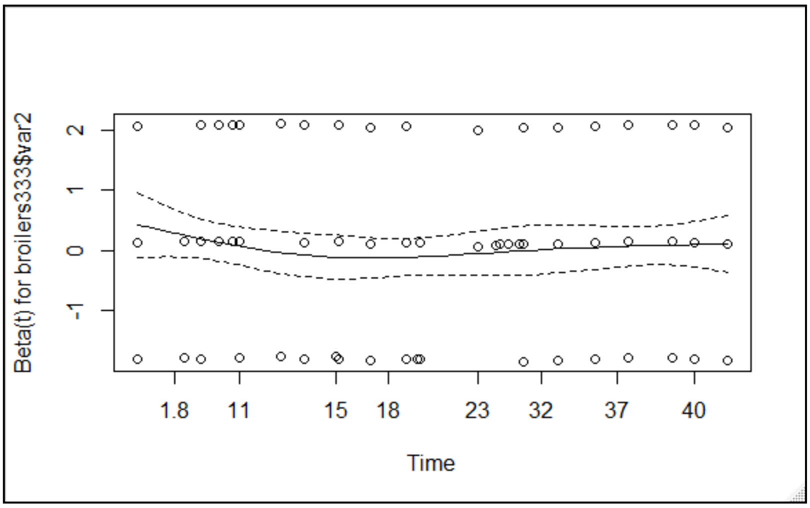
The proportional hazards (PH) assumption was checked using graphical method based on the scaled Schoenfeld residuals. These residuals are assumed to be independent of time and therefore, a plot that shows a random pattern against time is evidence of that the PH assumption is met.

The assumption is also tested statistically using the Chi square approach. In the R package, the function cox.zph() in the survival package provided the statistical test of the proportional hazards assumption for each covariate included in a Cox regression model fit. For each covariate, the function cox.zph() correlates the corresponding set of scaled Schoenfeld residuals with time, to test for independence between residuals and time. Additionally, it performs a global test for the model as a whole. The proportional hazard assumption is supported by a non-significant relationship between residuals and time, and refuted by a significant relationship. The output results in table 2 shows that the Chi square value is statistically insignificant (Chi Square=0.307, p=0.5797) at α=0.05 therefore the proportional hazards is assumed.

The results are provided in table2.

	rho	chisq	p
Cause	-0.0396	0.307	0.5797

The graphical below shows the schoefeld curves to test for



The interpretation of the graph in its simplest way is how curved it is; a flat curve suggests the assumption of proportionality is not violated. If it is decidedly different from flat, then the assumption is violated.

4.0 Discussion

It is therefore apparent that there is a significant difference between the survival rates of the broilers in the two groups of deaths in la Nyevu poultry farm. Therefore la Nyevu poultry farm should endeavor to sensitize the farmers on proper mechanisms that will guarantee any flock of birds to be free of diseases so as to increase revenue and reduce losses

5.0 Conclusion

The County Government of Kilifi can consider allocating more resources in terms of personnel and money at the grassroots level to enable farmers get information on the best poultry methods to undertake in order to realize profit as this can improve the economic status of the farmers and society in general.

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