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Survival analysis of broilers in two poultry farms in Kaloleni Sub County

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Abstract
This research is about a survival analysis on broilers in two poultry farms 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.

Keywords: Time to event, cox proportional hazards, exponential distribution

1. 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 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 did a survival analysis of the broilers.

2. Methodology
Two samples of 20 and 30 broilers from la Nyevu and Det'eni poultry farms in Kaloleni sub-county respectively, were tagged. These sampled broilers were observed for a period of 28 days then the observation stopped. Different survival functions were determined using the R software for analysis.

2.1 The Survivor function, s (t)
This is a function that gives the probability that a broiler will survive beyond any given specified time. Let T, be the time to failure. The survivor function at a time t is defined as, s (t) = pr (T>t), which is the probability that a broiler doesn't die within the interval (0, t). s (t) = pr (T>t) = 1-pr (T≤t), But pr (T≤t) = 1- F(t). F (t) = 1- s (t). F' (t) = -s' (t). f (t) = - s' (t)

2.2 The product limit (Kaplan-Meier) estimator of the survivor function
It is a non-parametric statistic used to estimate the survival function from life time data. This research assumed a discrete failure time distribution with probability f_j, at the many points, $u_0 \leq u_1 \leq u_2 \leq u_3 \leq u_4 \leq u_5 \leq \ldots$ The K-M estimate is a table called 'life-table'.
Let N = sample size. t_j = the time at death for j = 1, 2, 3,….k such that $t<_1 t_{2<} t_3 \ldots\ldots < t_k$. d_j = number of deaths at time t_j, $d_1+d_2+\ldots d_k$ = m. c_j = the total number of birds censored = N-m. n_j = the number of birds at risk just before time t_j. The K-M estimator is given by, S (t) = Π [1-(d_j/n_j)]. In tabular form it is as given below.

Table 1: Survival curve based on the Kaplan-Meier Estimation technique

j	t_j	d_j	c_j	n_j	d_j/n_j	$1-d_j/n_j$	S(t)
0	t_0	$d_0=0$	$c_0=0$	$n_o=N$	d_0/n_o	1	1
1	t_1	d_1	c_1	n_1	d_1/n_1	$1-d_1/n_1$	$1(1-d_1/n_1)$
2	t_2	d_2	c_2	n_2	d_2/n_2	$1-d_2/n_2$	$1(1-d_1/n_1)(1-d_2/n_2)$
3	t_3	d_3	c_3	n_3	d_3/n_3	$1-d_3/n_3$	.
.	.	.	.	.	.		.
k	t_k	d_k	c_k	n_k	d_k/n_k	$1-d_k/n_k$	$1(1-d_1/n_1).\ (1-d_k/n_k)$
∑		m	N-m				

2.3 Estimation of the integrated hazard function

When T is continuous, we have seen previously that, s (t) = $e^{-H(t)}$, where H(t) is the integrated hazard function. By using logarithms, it gives Log s (t) = -H (t) and now H (t) = -log s (t). For the discrete case, s (t) = ∏ ($1-h_j$). The K-M estimator, s (t) = ∏ ($1-h_j$) = ∏ ($1-d_j/r_j$). H (t) = -log s (t) = -∑log ($1-d_j/r_j$). $h_j = d_j/r_j$, therefore H(t) = -∑log($1-h_j$) for the discrete case. If the h_j are small then $h_j \approx -\log(1-h_j)$ so that H (t) = $\sum h_j$.

H (t) ≈ $\sum d_j/n_j$, which is the Nelson-Aallen estimator of H (t). In tabular form, it is given as

Table 2: Survival curve based on Nelson Aalen estimation

j	t_j	d_j	c_j	n_j	d_j/n_j	$H(t)=\sum(d_j/n_j)$
0	t_0	0	c_0	$n_o=N$	0	0
.	.	.	.	.	.	.
k	t_k	d_k	c_k	n_k	dk/nk	$0+d_1/n_1+\ldots d_k/n_k$

$n_{j+1} = n_j-(d_j+c_j)$ for j = 0,1,2,3… k

Interval	H (t)
$t_0 \le t \le t_1$	0
$t_1 \le t \le t_2$	d_1/n_1
.	.
$t \ge t_k$	d_k/n_k

2.4 Testing of Hypothesis of survival curves

The research used the log-rank test statistic to test H_0: s_1 (t) = s_2 (t) against H_1:s_1 (t) ≠ s_2 (t), where farm A was assumed to be the control farm, and farm B was the treatment farm. Let $t_1<t_2<\ldots<t_k$, be the times to death of broilers that are ordered. If at time t_j, for j=1, 2... k. d_j= total number of events, n_j=broilers at risk, d_{ij}= number of deaths for farm i, i=1,2. n_{ij}= those at risk in farm i=1, 2. This information can be summarized in a 2x2 contingency table as follows. At time t_j

Table 3: A 2x2 table used to compute value for log rank test for equality of curves

	Number dead	Number alive	Number at risk
Farm A	d_{1j}	$n_{ij}-d_{1j}$	n_{1j}
Farm B	d_{2j}	$n_{2j}-d_{2j}$	n_{2j}
	d_j	n_j-d_j	n_j

The pr(x=d_j) = [($n_{1j}d_{1j}$) ($n_{2j}d_{2j}$)/(n_jd_j)], for d1j = 0, 1, 2, 3… dj. E(x=d_{1j}) = d_jn_{1j}/n_j ≈ E (d_{1j}), E(x) = mγ/(m+n). Var(x=d_{1j}) = $n_{1j}n_{2j}(n_j-d_j)d_j/n_j^2(n_j-1)$. If X~N (μ, δ^2), then Z = (x-μ)/δ~N(0, 1), $Z^2 = [(X-\mu)/\delta]^2 \sim \chi^2$ with 1 df. Let Y=$\sum d_{1j}$, number of deaths for all the times for la Nyevu poultry farm. E(Y) = ∑E (d_{1j}), var(Y) = ∑var(d_{1j}). If Y, is standardized, then Z = [Y-E(Y)]/√(var Y). E (Z) = 0 and var(Z) = 1. if, Z = [[$\sum d_{1J}-\sum E(d_{1j})$]/√(∑var$d_{1j}$)] ~ N(0, 1), then $Z^2 \sim \chi^2$ with 1 df. This is the log-rank test statistic. If the Z^2 calculated value is less than χ^2 with 1 df at 95% level of significance then the null hypothesis is rejected, otherwise it is accepted.

3. Results

The results were obtained using the R software for data analysis

Table 4: Kaplan-Meier survival estimates of the broilers in Farm A

Times observed to death of broilers	Number of broilers at risk of death	Number of broilers observed to die	Survival probabilities	Standard error	Confidence interval	
					Lower 95%	Upper 95%
14	18	4	0.778	0.098	0.608	0.996
21	13	2	0.658	0.114	0.469	0.923
28	5	2	0.395	0.160	0.179	0.872

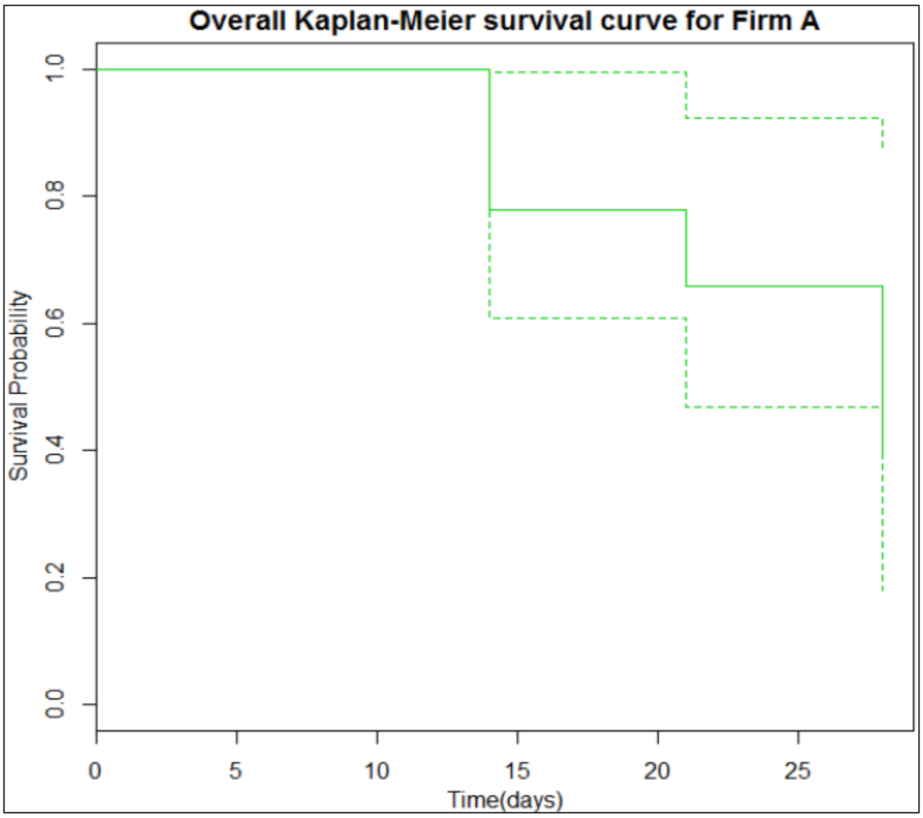

Fig 1: Kaplan-Meier survival curve for the broilers in farm A.

Table 5: Kaplan-Meier Survival estimates for the broilers in farm B.

Time to Death (in Days)	Number at Risk of Death	Number Observed to Die	Survival Probabilities	Standard Error	Confidence interval	
					Lower 95%	Upper 95%
7	30	1	0.967	0.0328	0.905	1.000
14	23	3	0.841	0.0736	0.708	0.998
21	14	3	0.660	0.1088	0.478	0.912
28	7	1	0.566	0.1278	0.364	0.881

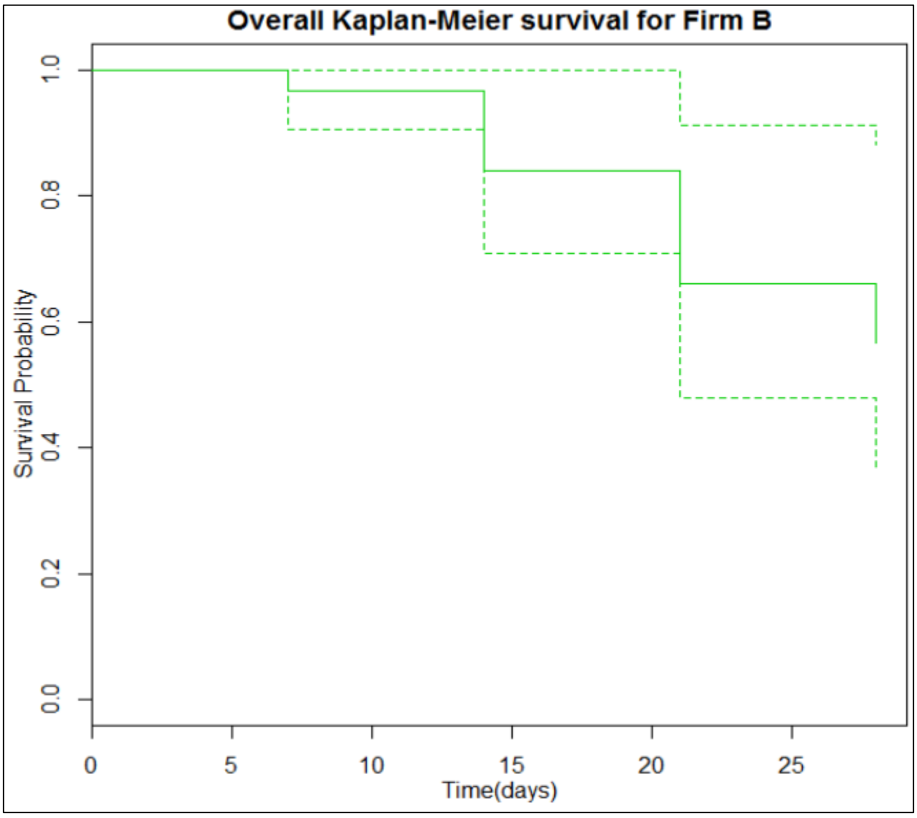

Fig 2: Kaplan-Meier Survival curve for the broilers in farm B.

Table 6: Log-rank test results for comparing the survival rates of broilers in farms A and B.

Firm	Number at Risk of Death	Observed Deaths	Expected Deaths	$(O-E)^2/E$	$(O-E)^2/V$
Farm A	20	8	7.13	0.1060	0.225
Farm B	30	8	8.87	0.0852	0.225

Chisq=0.2 on 1 degrees of freedom, p=0.635

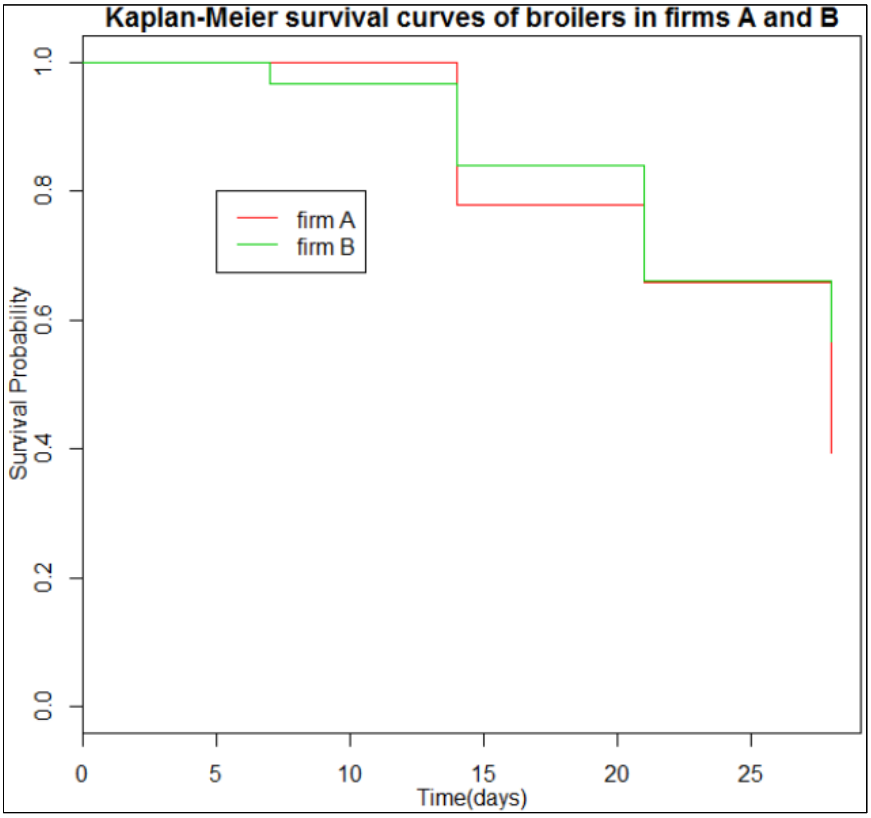

Fig 3: Survival curves of broilers in farms A and B.

As the K-M curves indicate, broilers in farm A have similar survival rates as compared to broilers in farm B. The difference in the survival rates of the broilers in farms A and B are non-significant at 0.05 level of significance with a p-value of 0.635 which is greater than 0.05.

Table 7: Results of fitting the Cox PH model to assess the effect of the covariate firm on the

	Coef	Exp (coef)	Exp (-coef)	Se (coef)	z	Pr (>|z|)	Confidence imterval	
							Lower 95%	Upper 95%
FarmB	-0.2188	0.8034	1.245	0.5007	-0.437	0.662	0.3011	2.144

Survival of broilers. Concordance = 0.519 (se=0.079). Rsquare = 0.004 (max possible = 0.884). Likelihood ratio test = 0.19 on 1 degree of freedom, p=0.6624, Wald test = 0.19 on 1 degree of freedom, p=0.6621. Score (logrank test) = 0.19 on 1 degree of freedom, p=0.6614

Table 8: Results of evaluating the proportional hazards assumption on the covariate firm using Schoenfeld residuals.

	Rho	Chisq	P
Farm B	-0.0821	0.109	0.741

These results indicate that the proportional hazards assumption was not violated at 5% level of significance in the entire study period with a p-value of 0.741 which is greater than 0.05. The proportionality assumption was also assessed graphically by plotting the scaled Schoenfeld residuals of the covariate firm against log-time. There was no trend or pattern with time throughout the study period.

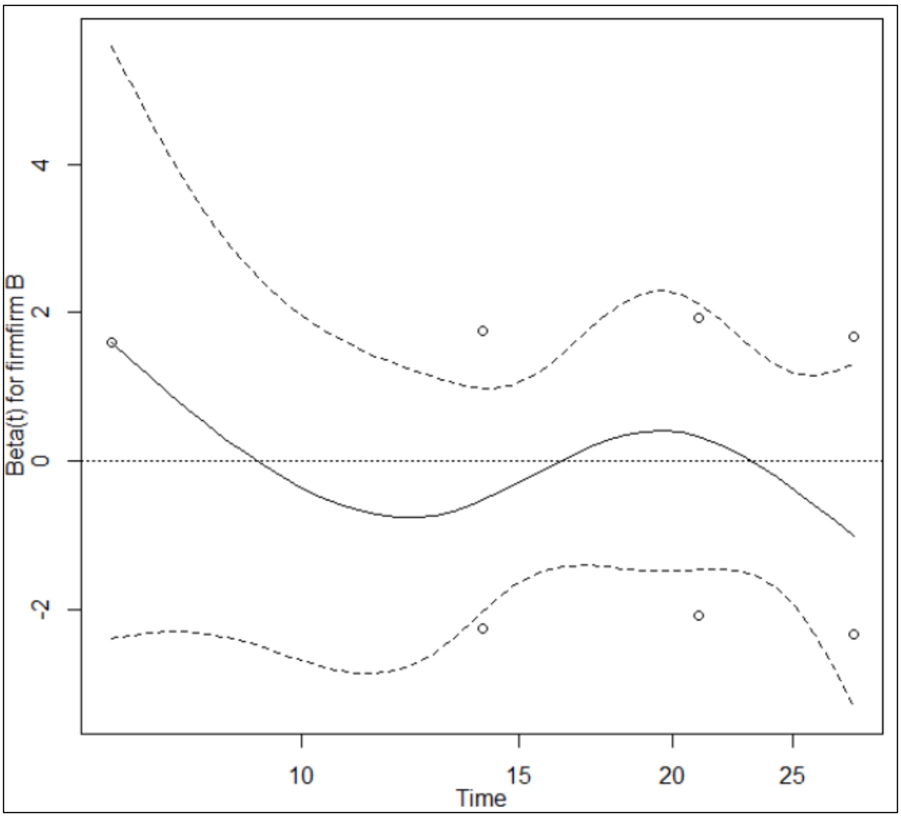

Fig 4: The plot of the scaled Schoenfeld residuals of the covariate farm against log time.

4. Discussion
It is therefore apparent that there is no significant difference between the survival rates of the broilers in the two select poultry farms. Such a scenario borders on the fact that agriculturalists should do even more to sensitize the farmers on proper farming procedures so as to increase revenue and reduce losses

5. Conclusion
The government should put more resources in terms of personnel and money in the grassroots to enable each farmer gets information on the best poultry methods to undertake in order to realize the millennium goals.

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