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Basic School Grade Retention in Ghana with Applications of Cox Proportional Hazard Model and Mann Whitney's U Test

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Abstract This paper combined survey and survival studies with the aim of identifying risk factors for grade retention in Ghana. A sample of 120 basic school teachers comprising 60 male and 60 female across the 10 regions of Ghana responded to a four point likert scale with 15 items to measure perceived risk factors in the 120 sampled basic schools in Ghana. The distribution of the data did not approach the normal distribution so Mann Whitney's U Test was employed in the analysis of the likert items. The findings of the survey research were validated with the findings of the cohort study. The second part of the study consisted of a cohort study of one private and one public school (selected through random sampling) from grade one to grade 9. Identified risk factors of grade retention in Ghana through the nonparametric analysis included children with learning difficulty (special needs), non- existing or non-operational counseling units, schools in rural community, abysmal average score, pupil in JHS level, pupil in Upper Primary level, Child's low interest in school, Truancy and also the quest for Basic school authorities to obtain 100% pass rate in BECE results tends to increase their reluctance to register pupils who have poor academic record. The effect size for 15 Mann Whitney's U Tests showed among others that 29.9% variability in the ranks was accounted for by "Truancy". 78.2% variability in the ranks was accounted for by "Private School". 37.5% variability in the ranks was accounted for by "Upper Primary status". 16.9% variability in the ranks was accounted for by "Child interest in school". 12.1% variability in the ranks was accounted for by "Desire of school to produce 100% passes in BECE". The findings of the Cox PH Model validated grade level, truancy, children with learning difficulties, child's low interest in school and low academic average score as risk predictors of grade retention in Ghana. Sex was not a significant predictor by Cox PH Model analysis. The study recommended for school authorities in Ghana to initiate interventions for pupils who show at least one of the risk factors identified in this research particularly for those pupils who show truancy which was the highest impact on grade retention, as shown by Cox PH Model analysis.

Keywords Basic School Retention, Cox Proportional Hazards, Survey, Nonparametric, Mann Whitney U Test, Risk factors

1. Introduction

Related literature supports the general policy that students whose academic achievements do not reflect adequate mastery of a particular grade's syllabus would often not have the prerequisite background to be able to cope with the subsequent grade's work. This is a general practice universally mainly due to the progressive and cumulative state of the national and international school curriculum worldwide. Students who appear to have inadequate mastery of a particular grade's work are often required to repeat the current grade for to help the child to be adequately prepared for a higher grade's work [1,2,3,4].

Cox proportional hazards models have been applied extensively in diverse areas including education, engineering and epidemiology studies. Cox proportional hazards models and survival studies have been applied to the time to dropout of students in Introductory to Statistics course at the University of Montana. As part of the conclusions of the study, covariates such age and ACT scores of students were found to be insignificant predictors of dropout rates. The study found significant relationship between dropout rate of students and the number of previous math courses taken by students [5]. Survival Analysis have also been applied to study the dropout rates of students in their first year in the University. The study developed a predictive model for student dropout. The study concluded that students with

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higher grade point average were more likely to remain in school for the subsequent semesters compared to students with lower grade point average. The study advocated for at-risk students to be supported administratively [6].

Another study sought to examine the effect of some socioeconomic and socio-demographic variables on the retention rates of secondary school students. Some of these variables included school track, nationality, sex, Grade point average, immigrant status among others. The outcome of the study revealed the factors that are linked with higher risk of dropping out of school. These factors included students from deprived districts, students who are immigrants, students who are male, academic achievement of students. However, female students, native students, students from schools of higher districts and those in higher tracks were associated with less risks of retention The study formulated a mathematical model (Cox proportional hazard model) for the predictors [7].

2. Method

The study was made up of two parts. One part was a survey research that sought to find the significant predictors of grade retention in Ghana using a sample of 120 basic school teachers randomly selected from 120 basic schools across all the regions in Ghana. The data was collected by random sampling from a population of this category of teachers who were enrolled in a sandwich degree programme at the University of Cape Coast and have come from all regions across Ghana. Tables 5 and 6 give details of the regional representation of selected teachers and the potential factors of grade retention given in a form of a four point likert with 15 potential factors of grade retention in Ghana. The second part of the study comprised of a cohort study of two randomly sampled basic schools (one private and one public) which studied cohorts from grade one to grade nine. The cohort study was to validate the perceived factors of grade retention from the survey. The survey analysis failed normality assumptions so Mann Whitney's U test was used for the analysis. The Cox proportional hazard model was adopted to identify and quantify the significant factors of grade retention. The IBM SPSS version 23 was used for the analysis.

In the cohort study, the enrolment records of pupils in grade one (each for randomly selected private and public school) were followed to JHS 3 (Grade 9). Pupils either experienced the event of interest (grade retention) or were censored. For pupils who experienced the event, the variable responsible was checked and noted. These variables were coded in the hazard analysis. For situations where there was no proper documentation, the respective class teachers were interviewed to obtain relevant information. Mann Whitney's U test was used to understand whether perception on grade retention among Basic school teachers, where perception was measured on ordinal scale differed based on gender (our dependent variable being "perception about grade retention" and our independent variable being gender which has two groups (male or female). The variables were ordinal (4-point likert items) with one dependent variable (i.e. perception of grade retention). There was also one independent variable (i.e. sex) which was categorical (male or female). The observations were independent. Fifteen separate Mann Whitney U test were run for each independent variable. The effect sizes were then computed.

Null Hypothesis: The distribution of perception of grade retention is the same across categories of group.

Alternative Hypothesis: The distribution of perception of grade retention is not the same across categories of group.

The Cox PH model is widely used for several reasons including that the effect (hazard ratio) can be estimated with the value of $h_0(t)$ (i.e. baseline hazard) being unknown. The exponential section of the model ensures a nonnegative fitted hazard. Again, the robust nature of the Cox PH model makes it popular since it fits the data properly, irrespective of which parametric model is appropriate [8].

The **Cox PH Model** is given by:

$$h(t,X) = h_0(t)e^{\sum_{i=1}^{p}\beta_i X_i} \tag{1}$$

where $X = (X_1, X_2, X_3, \dots, X_p)$ are explanatory or predictor variables.

$h_0(t)$ is the baseline hazard function.

The corresponding estimates of the $\beta's$ in the general Cox model shown in (1) are known as the maximum likelihood (ML) estimates which are denoted by $\widehat{\beta_i}$

The **Hazard Ratio** is computed as:

$$\widehat{HR} = \frac{\hat{h}(t,\boldsymbol{X}^*)}{\hat{h}(t,\boldsymbol{X})} \tag{2}$$

Where $\boldsymbol{X}^* = (\boldsymbol{X}^*_1, \boldsymbol{X}^*_2, \boldsymbol{X}^*_3, \dots, \boldsymbol{X}^*_p)$ and $X = (X_1, X_2, X_3, \dots, X_p)$

$$\widehat{HR} = \frac{\hat{h}(t,\boldsymbol{X}^*)}{\hat{h}(t,\boldsymbol{X})} = \frac{\hat{h}(t)e^{\sum_{i=1}^{p}\widehat{\beta_i}X^*_i}}{\hat{h}(t)e^{\sum_{i=1}^{p}\widehat{\beta_i}X_i}} = e^{\sum_{i=1}^{p}\widehat{\beta}_i(X_i^*-X_i)}$$
$$= \exp\left[\sum_{i=1}^{p}\beta_i(X_i^* - X_i)\right] \tag{3}$$

3. Analysis

Table 1. Omnibus Tests of Model Coefficients

-2 Log Likelihood	Overall (score)			Change From Previous Step			Change From Previous Block		
	Chi-square	df	Sig.	Chi-square	df	Sig.	Chi-square	df	Sig.
61.816	20.782	6	.002	23.193	6	.001	23.193	6	.001

Table 2. Variables in the Equation (Public School)

	B	SE	Wald	df	Sig.	Exp(B)	95.0% CI for Exp(B)	
							Lower	Upper
Grade Level	-2.372	.962	6.084	1	.014	.093	.014	.614
Truancy	2.260	1.003	5.081	1	.024	9.583	1.343	68.373
Learning Difficulty	-1.165	.488	5.697	1	.017	.312	.120	.812
Child's interest in Schooling	-1.928	.746	6.677	1	.010	.145	.034	.628
Sex of child	-1.036	.678	2.336	1	.126	.355	.094	1.340
Academic Rank	-2.259	1.027	4.840	1	.028	.104	.014	.781

The Cox proportional hazards model is represented as:

$$\widehat{h_i}(t) = exp\begin{Bmatrix} -2.372X_{1i} + 2.260X_{2i} - 1.165X_{3i} \\ -1.928X_{4i} - 2.259X_{5i} \end{Bmatrix} h_0(t),$$

where $h_0(t)$ is the hazard rate for a school with higher levels of covariates.

The sex covariate was excluded from the model since it was found to be a statistically insignificant predictor.

From the public school analysis, the results show that lower grade pupils (grade 1 to 3) were 0.093 times less at risk of grade retention compared to upper grade pupils (B = -2.372; HR: 0.093; CI: 0.14-0.614). Pupils who are truants were found to be 9.583 times more at risk of the event than those who were not truants (B = 2.260; HR: 9.583; CI: 1.343-68.373). Pupils with no learning difficulty were found to 0.312 times less likely (B = -1.165; HR: 0.120; CI: 0.12-0.812) to experience the event compared to those with learning difficulty. Again, pupils with interest in schooling were found to be 0.145 times less at risk in comparison with pupils with little or no interest in schooling (B = -1.928; HR: 0.145; CI: 0.034-0.628). Pupils with high class based academic achievement rank were found to be 0.104 times less likely to experience the event of interest compared to those with lower ranking (B = -2.259; HR: 0.104; CI: 0.014-0.781). However, sex/gender was not a significant predictor of grade retention ($p > 0.05$).

Table 3. Omnibus Tests of Model Coefficients

-2 Log Likelihood	Overall (score)			Change From Previous Step			Change From Previous Block		
	Chi-square	df	Sig.	Chi-square	df	Sig.	Chi-square	df	Sig.
59.378	21.523	6	.001	25.631	6	.000	25.631	6	.000

a. Beginning Block Number 1. Method = Enter

Table 4. Variables in the Equation (Private School)

	B	SE	Wald	df	Sig.	Exp(B)	95.0% CI for Exp(B)	
							Lower	Upper
Grade Level	-2.555	1.010	6.397	1	.011	.078	.011	.563
Truancy	2.299	.995	5.338	1	.021	9.960	1.417	69.996
Special need	-1.899	.735	6.672	1	.010	.150	.035	.632
Child's interest in School	-1.939	.768	6.373	1	.012	.144	.032	.648
Sex of child	-.657	.753	.761	1	.383	.518	.118	2.269
Child labor	-1.954	.957	4.164	1	.041	.142	.022	.926

Similarly, from private school analysis, the results show that lower grade pupils (grade 1 to 3) were 0.078 times less at risk of grade retention compared to upper grade pupils (B = -2.555; HR: 0.078; CI: 0.011-0.563). Pupils who are truants were found to be 9.960 times more at risk of the event than those who were not truants (B = 2.2299; HR: 9.960; CI: 1.417-69.996). Pupils with no learning difficulty were found to 0.312 times less likely (B = -1.165; HR: 0.120; CI: 0.12-0.812) to experience the event compared to those with learning difficulty. Again, pupils with interest in schooling were found to be 0.145 times less at risk in comparison with pupils with little or no interest in schooling (B = -1.928; HR: 0.145; CI: 0.034-0.628). Pupils with high class based academic achievement rank were found to be 0.104 times less likely to experience the event of interest compared to those with lower ranking (B = -2.259; HR: 0.104; CI: 0.014-0.781). However, sex/gender was not a significant predictor of grade retention ($p > 0.05$).

The cox proportional hazards model is represented as:

$$\widehat{h_i}(t) = exp\begin{Bmatrix} -2.555X_{1i} + 2.299X_{2i} - 1.899X_{3i} \\ -1.939X_{4i} - 1.954X_{5i} \end{Bmatrix} h_0(t),$$

where $h_0(t)$ is the baselinehazard rate.

Table 5. Teacher Regional Demographics information

	Sex		
Region	Male	Female	Total
Greater Accra	9	9	18
Ashanti	10	10	20
Eastern	6	6	12
Northern	5	5	10
Western	5	5	10
Brong Ahafo	5	5	10
Volta	5	5	10
Central	5	5	10
Upper East	5	5	10
Upper West	5	5	10
	60	**60**	**120**

Table 6. Prospective Factors of Grade retention in Basic Schools of Ghana

Item	Strongly Agree (SA)	Agree (A)	Disagree (D)	Strongly Disagree (SD)
1. School community (Sub-urban)				
2. School community (Rural)				
3. Overall Average score				
4. Operational Counseling unit				
5. Private school				
6. Public school				
7. Learning difficulty				
8. JHS status				
9. Upper primary status				
10. Lower primary status				
11. Child interest in school				
12. Sex				
13. Desire of school to produce 100% passes in BECE				
14. Age				
15. Truancy				

In Table 6, respondents were to grade how strongly these factors contribute to grade retention in Ghana.

Table 7 shows the mean ranks of the 15 factors of grade retention under test. Gustafson (1998), [9] found that men and women differ in risk perception. There is evidence of some difference in means in the perceived factors of grade retention in Ghana among male and female Basic school teachers (Table 7) and there is the need to find out if these differences are significant.

Table 7. Ranks Statistics

	Sex	N	Mean Rank	Sum of Ranks
Item1	Female	60	59.00	3540.00
	Male	60	62.00	3720.00
	Total	120		
Item2	Female	60	45.50	2730.00
	Male	60	75.50	4530.00
	Total	120		
Item3	Female	60	57.00	3420.00
	Male	60	64.00	3840.00
	Total	120		
Item4	Female	60	57.50	3450.00
	Male	60	63.50	3810.00
	Total	120		
Item5	Female	60	34.00	2040.00
	Male	60	87.00	5220.00
	Total	120		
Item6	Female	60	62.20	3732.00
	Male	60	58.80	3528.00
	Total	120		
Item7	Female	60	55.96	3357.50
	Male	60	65.04	3902.50
	Total	120		
Item8	Female	60	53.50	3210.00
	Male	60	67.50	4050.00
	Total	120		
Item9	Female	60	78.50	4710.00
	Male	60	42.50	2550.00
	Total	120		
Item10	Female	60	60.57	3634.00
	Male	60	60.43	3626.00
	Total	120		
Item11	Female	60	72.20	4332.00
	Male	60	48.80	2928.00
	Total	120		
Item12	Female	60	61.50	3690.00
	Male	60	59.50	3570.00
	Total	120		
Item13	Female	60	67.00	4020.00
	Male	60	54.00	3240.00
	Total	120		
Item14	Female	60	65.37	3922.00
	Male	60	55.63	3338.00
	Total	120		
Item15	Female	60	44.00	2640.00
	Male	60	77.00	4620.00
	Total	120		

Table 8(a). Ranks Statistics

	Item1	Item2	Item3	Item4	Item5	Item6
Mann-Whitney U	1710.000	900.000	1590.000	1620.000	210.000	1698.000
Wilcoxon W	3540.000	2730.000	3420.000	3450.000	2040.000	3528.000
Z	-.782	-5.532	-2.715	-2.503	-9.648	-.583
Asymp. Sig. (2-tailed)	.434	.000	.007	.012	.000	.560

Table 8(b). Test Statistics

	Item7	Item8	Item9	Item10	Item11	Item12
Mann-Whitney U	1527.500	1380.000	720.000	1796.000	1098.000	1740.000
Wilcoxon W	3357.500	3210.000	2550.000	3626.000	2928.000	3570.000
Z	-2.166	-2.939	-6.680	-.040	-4.489	-.386
Asymp. Sig. (2-tailed)	.030	.003	.000	.968	.000	.700

Table 8(c). Test Statistics

	Item13	Item14	Item15
Mann-Whitney U	1410.000	1508.000	810.000
Wilcoxon W	3240.000	3338.000	2640.000
Z	-3.802	-1.739	-5.961
Asymp. Sig. (2-tailed)	.000	.082	.000

The null hypothesis that distribution of perception of grade retention is the same across categories of group was rejected $(p < 0.05)$ for items 2, 3, 4, 5, 7, 8, 9 and 11, 13 and 15. However, we failed to reject the null hypothesis $(p > 0.5)$ for items 1, 6, 10, 12, and 14.

Table 9. Effect Size

ITEM	Z	Effect Size
1	-0.782	0.005139
2	-5.532	0.257168
3	-2.715	0.061943
4	-2.503	0.052647
5	-9.648	0.782218
6	-0.583	0.002856
7	-2.166	0.039425
8	-2.939	0.072586
9	-6.68	0.374978
10	-0.04	1.34E-05
11	-4.489	0.169337
12	-0.386	0.001252
13	-3.802	0.121472
14	-1.739	0.025413
15	-5.961	0.298601

Table 8 shows the output of Mann Whitney's U test on the responses of the 120 respondents. The grouping variable among the respondent was sex. The outputs show a number of the perceived significant predictors of grade retention in the basic school of Ghana. A number of the factors were not significant risk factors of grade retention (p>0.05) by the Mann Whitney's U test analysis of the responses. These included sub-urban school community, public school, lower primary level, sex, and average age. Rural school community was a significant risk predictor of grade retention in Ghana. This means that a child who is in basic school located in a rural community in Ghana is at a higher risk of grade retention. Also, overall average score of a particular pupil is a significant predictor of the event of interest. A child whose overall average score is abysmally below average is at risk of the event. Also it was evident from the results that basic schools with well operational counseling units have lower risk of grade retention and vice versa. Again, a child in a private school is at risk of grade retention. Other risk factors of grade retention in Ghana included learning difficulty (special needs), JHS level, Upper Primary level, Child's interest in school, Truancy and the quest of Basic schools to maintain a certain academic record (e.g. maintain 100% passes in BECE).

Table 9 shows the results of computed effect sizes of 15 separate Mann Whitney's U Tests. The results show that 25.7% variability in the ranks was accounted for by "rural school community". Again, 6.2% variability in the ranks was accounted for by "overall average score" of pupils. Also, 5.3% variability in the ranks was accounted for by Operational Counseling unit. 78.2% variability in the ranks was accounted for by "Private School". 3.9% variability in the ranks was accounted for by "learning difficulty". In addition, 7.3% variability in the ranks was accounted for by "JHS level". 37.5% variability in the ranks was accounted for by "Upper Primary status". 16.9% variability in the ranks was accounted for by "Child interest in school". 12.1% variability in the ranks was accounted for by "Desire

of school to produce 100% passes in BECE" and 29.9% variability in the ranks was accounted for by "Truancy".

4. Conclusions

This paper combined survey and survival studies with the aim of identifying risk factors for grade retention in Ghana. A sample of 120 basic school teachers comprising 60 male and 60 female across the 10 regions of Ghana responded to a four point likert with 15 items to measure perceived risk factors in the 120 sampled basic schools in Ghana. The data was found to be nonparametric and so Mann Whitney's U Test was employed in the analysis of the likert items. The findings of the survey research were validated with the findings of the cohort study. The second part of the study consisted of a cohort study of one private and one public school (selected through convenience sampling) of pupils from grade one to grade 9. Cox Proportional hazard was employed in quantifying and modeling the risk of pupils with respect to the covariates. The results show among other findings that pupils who are truants are respectively 9.583 and 9.960 times at risk of grade retention in public and private schools compared to those who are not truants in Ghana. Pupils at the upper grade level (grade 4 to 9) are respectively 0.093 and 0.078 times at risk of the event than those at the lower grade in the public and private schools. Other significant risk factors included pupils with learning difficulty; pupils' interest in school, class average. Another significant risk factor of grade retention was a school's quest to maintain some academic record which includes obtaining 100% passes in BECE.

From the public school analysis, the results show that lower grade pupils (grade 1 to 3) were 0.093 times less at risk of grade retention compared to upper grade pupils (B = -2.372; HR: 0.093; CI: 0.14-0.614). Pupils who are truants were found to be 9.583 times more at risk of the event than those who were not truants (B = 2.260; HR: 9.583; CI: 1.343-68.373). Pupils with no learning difficulty were found to 0.312 times less likely to (B = -1.165; HR: 0.120; CI: 0.12-0.812) to experience the event compared to those with learning difficulty. Again, pupils with interest in schooling were found to be 0.145 times less at risk in comparison with pupils with little or no interest in schooling (B = -1.928; HR: 0.145; CI: 0.034-0.628). Pupils with high class based academic achievement rank were found to be 0.104 times less likely to experience the event of interest compared to those with lower ranking (B = -2.259; HR: 0.104; CI: 0.014-0.781). However, sex/gender was not a significant predictor of grade retention ($p > 0.05$).

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The effect size of Mann Whitney U Test show that 25.7% variability in the ranks was accounted for by "rural school community". Again, 6.2% variability in the ranks was accounted for by "overall average score" of pupils. Also, 5.3% variability in the ranks was accounted for by Operational Counseling unit. 78.2% variability in the ranks was accounted for by "Private School". 3.9% variability in the ranks was accounted for by "learning difficulty". In addition, 7.3% variability in the ranks was accounted for by "JHS level". 37.5% variability in the ranks was accounted for by "Upper Primary status". 16.9% variability in the ranks was accounted for by "Child interest in school". 12.1% variability in the ranks was accounted for by "Desire of school to produce 100% passes in BECE" and 29.9% variability in the ranks was accounted for by "Truancy".

5. Recommendations

The study recommends for school authorities in Ghana to put interventions in place for pupils who show at least one of the risk factors identified in this research particularly for those pupils who show truancy which was the highest quantified risk factor by Cox PH Model analysis.

Limitations of the Study

The cohort study could not validate all the factors found to be significant predictors in the survey analysis because the data was not available for all the variables in the cohort study. Again, only two schools were incorporated in the cohort study. The cohort study included a follow-up from grade one to the ninth grade.

Implications for Future Studies

Future studies can include more schools in the study in order to get more robust results. Future studies can consider increasing the survival time to extend to the senior high school level.

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