# The Predictive Validity of an University Admissions Test: A Survival Analysis Approach

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Currently in South Africa the school leaving examination serves as the sole gatekeeper to selective HE institutions. Access to these institutions is based solely on academic achievement at school. This is particularly problematic given applicants' uneven access to resources and vastly different schooling opportunities due to the historical imbalances created through Apartheid. This has lead to a situation where certain individuals potential to learn is underestimated and their access to higher education is essentially blocked. As Hill (2002) points out, "if valid and reliable tests can be developed to assess such potential, the education system will be able to effectively nurture students who are better positioned to benefit from HE."

Furthermore the phased introduction of a new system of school assessment in 2006 and frequent allegations of corruption and inefficiencies in school examination administration have made it necessary to develop additional reliable instruments to assess applicants who wish to enter HE.

One of the core reasons for existence of the Alternative Admissions Research Project (AARP) is the need for an assessment tool which endeavours to widen access into the University of Cape Town. It is therefore the objective of the AARP to develop a battery of relevant admissions tests that identify educationally talented students with the potential to succeed. In order to realise this goal it is critical for the AARP to engage in research to assess the impact of its tests. This research most frequently takes the form of predictive studies. It is necessary to illustrate that tests developed by AARP work in selecting students from a diverse group of applicants who successfully engage with generic university tasks and go on to graduate.

There is an entire body of research focusing on issues of student retention, dropout and throughput from HE (cf. Tinto, 1975; Willett and Singer, 1991; Pascarella and Terenzini, 1991; Murtaugh, Burns and Schuster, 1999). Investigations into retention, dropout and throughput are vital to academic planning and central to the implied costs imposed on society, the institution and the individual (DesJardins, 2002). Social costs include reduced economic output of non-graduates versus graduates. Predictably the dropout of what we have come to call "disadvantaged students" may result in further racial and socioeconomic disparity in future generations. The costs to the institutions themselves is that imbalances between intake and graduation comes with major budgetary and financial implications. For the individual the costs of leaving the institution without graduating imply a loss in potential earnings, less preference in job choice as well as a host of personal and emotional issues.

Predictive validity is defined as a measure which accurately forecasts how a person will think, act, or feel in the future. As applied to the university testing context it implies the prediction of future academic performance of students against their scores on a testing instrument. Predictive studies in the testing arena most often take the form of correlations, Z scores and regression analysis'. The use of these statistics to measure the predictive power of a testing instrument in HE seems straightforward but this is seldom the case.

As reported by Yeld and Visser (2000) there are a number of design and measurement issues which arise when adopting traditional methods to assess predictive validity. Linn (1989) raises the issue of highly selective samples and points out that using such a sample repeatedly yields a pessimistic view of predictive validity. A truncated and self-selected group of test writers will tend to yield a higher or lower correlation coefficient in comparison to a sample which was randomly selected.

Studies into the predictive validity of assessment tools often make many suppositions which directly influence the outcomes of the study. One example is where regression and correlation studies investigating course level performance are often hampered by excessively small sample sizes as sample sizes diminish in the second and third year respectively. Enlarging

samples sizes by combining course often leads to limitations in the strength of the findings due to limitations of fit between course structure and assessment.

Using correlation methods longitudinally to assess the impact of testing instruments in a HE setting also masks the fact that courses have changed over the years in terms of content, structure, presentation and assessment.

Similarly academic development programmes and other course interventions which are prevalent in HE institutions in South Africa may have impacted positively on the performance of weak incoming students and this serves to further depress the correlation co-efficient when correlating testing instrument scores with course performance scores (Cliff, Hanslo, Herman, Fish, and Visser, 2002).

Defining the criterion of success also has an impact. Many evaluation studies use first year performance as the criterion but this has been shown to be a poor predictor of success further up the curriculum (Griesel, 1999). Another complication is that many students dropout of HE studies due to non-academic reasons (e.g. financial, motivational, health) – these numbers are quite significant and complicate predictive studies which use graduation as the criterion of success as they have not reached the destination event (Yeld and Visser, 2000).

## NEW METHODOLOGIES

One technique which overcomes many of the statistical complications suggested above is survival analysis. Survival analysis is a useful statistical technique for answering questions that deal with the duration of events and was originally developed by biostatisticians modeling human lifetimes (Cox, 1972; Kalbfleisch & Prentice, 1980; Miller, 1981). It is only in the last 2 decades that this method has gained popularity in other fields such as institutional research. Using the method in a Higher Education setting the focus is shifted from “human lifetimes” to student retention (life cycle) and graduation rates (deaths) (See: Willet & Singer, 1991; Huff & Fang, 1999). A powerful advantage of survival analysis is that by constructing hazard models of students’ careers, we can investigate and compare not only whether particular groups of interest (e.g. Race or Gender) drop out but also when they are most likely to do so (Boonzaaier, 2000). The models can be used to study the relative risk of different groups of interest leaving university and they lend themselves to a variety of questions such as: Are students more at risk of leaving during particular stages of their careers? Does the profile of risk differ among groups? Do particular policies and programs have an impact? To what extent do assessment instruments better predict the risk of dropping out due to academic reasons only?

One of the key features of survival analysis is its usefulness in incorporating censored observations. Censoring occurs when an individual does not experience the event of interest. For the purposes of this paper, a student is regarded as censored if he/she does not experience the event of interest - exclusion due to academic reasons. Therefore students who drop out due to financial difficulty or illness are viewed as being censored.

In traditional statistical methods censored events are treated with extreme caution. Censored cases are removed from the analysis and the average length of time until exclusion for the remaining cases is examined. However, this practice creates two major problems. The first is that this may result in an unacceptably small data set. Secondly, this results in a biased sample and has a negative effect on the distribution of survival times. In a survival analysis censored data is incorporated rather than discarded.

A number of assumptions are recognized when performing a survival analysis. The main assumption is that students continuing at university eventually qualify. Thus students who are still in the institution are classified as successful as they are not classified as having been excluded on academic grounds yet.

## ASSESSING THE PREDICTIVE VALIDITY OF AN ADMISSIONS TEST AT UCT

As stated previously it is the primary objective of the AARP to develop a battery of relevant admissions tests that identify educationally talented students with the potential to succeed at UCT. All applicants are invited to write the test on a voluntary basis. One such test is the PTEEP (Placement Test in English for Educational Purposes). The PTEEP is an English language test written by applicants to any faculty. The test incorporates a combination of multiple choice questions and productive pieces and includes elements of teaching, modelling, and practice.

The AARP is also tasked with assisting UCT's goals of equity and access. The project distinguishes between differences in the educational backgrounds of writers. The project classifies writers according to their educational histories into a number of groups – the two most prominent being students who come from an ex-HOA (ex-House of Assembly, or, Model C) schooling background and students who come from an ex-DET (ex-Department and Training) schooling background. During Apartheid, South African authorities encouraged an educational landscape based on a racially-defined skewing. Ex-DET schools which were attended by black South Africans were under-resourced and undeveloped. Conversely, the mainly white attended ex-HOA schools had access to vast pools of resources. Put bluntly an applicant from an ex-DET background can be classified as "disadvantaged" and an applicant from an ex-HOA background as "advantaged".

UCT admits applicants on the basis of their Senior Certificate School Leaving Examination Points and based on the recommendations of those that have written the AARP tests. To investigate the predictive validity of the PTEEP test, it was decided to compare the academic progress of the top AARP performers with those at the bottom. Students who wrote the AARP tests as applicants were classified as top performers if they obtained a score ranked in the top three deciles ie. Top 30%, and as bottom performers if they obtained a score ranked in the bottom three deciles.

In addition, the top and bottom performers were also compared with a non-AARP group. The non-AARP group consists of students who did not write the AARP test and thus were admitted solely on the basis of their Senior Certificate School Leaving Examination Points or the equivalent thereof. This allowed us to compare the top PTEEP performers, the bottom PTEEP performers and a large control group of students who met the traditional entrance requirements to gain access to study at UCT.

## RESEARCH AIMS

a) A comparison of students from Ex-HOA and Ex-DET backgrounds, and whether they differ with regard to School Leaving Examination Points and PTEEP Scores. This would demonstrate whether our groups of interest should be viewed separately.

b) A comparison of the Top 30% of PTEEP performers with the Bottom 30% of PTEEP performers with regard to their mean survival times and hazard rates over the duration of their time spent at UCT. This would demonstrate whether the test is able to reliably spread scores of the groups of interest in a valid manner.

c) A comparison of the group of students who got access to UCT solely by means of their School Leaving Examination Points results (non-PTEEP group) with the groups mentioned in (b) above, with regard to their mean survival times and hazard rates over the duration of their time spent at UCT. This would illustrate the predictive validity of the testing instrument in comparison with the traditional admissions School Leaving Examination Points for the selected groups of interest.

## DESCRIPTION OF DATA SET

The data set consisted of 22 347 undergraduate degree students from all faculties who attended the University of Cape Town during the years 1995 to 2002. The 1995 cohort contributed eight years worth of data whereas the 2002 cohort only contributed data from one

year of study. Students were tracked each year to determine whether they were allowed to progress to their next year of study or whether they were excluded from the university for academic reasons. Promotion codes were obtained from a comprehensive student record database. Promotion codes were separated into three groups – continuing/graduated, excluded and withdrew in good standing. A student could withdraw from university having been allowed to progress but without graduating. These students were regarded as having withdrawn in good academic standing i.e. censored because they were not excluded on academic grounds. They were not eliminated from the analysis but included in the analysis for the length of time they remained at university.

## ANALYSIS AND RESULTS

### Preliminary Descriptive Stats

The first descriptive analysis was to examine whether there was a significant difference between our groups of interest. To justify splitting the groups into the - ex-HOA group and ex-DET group, as well as, the Top 30% and Bottom 30% - we examined each individually.

Table 1 below provides descriptive statistics on PTEEP scores for the groups of interest.

| Ex-Education Group | PTEEP Group | Sample Size | Mean PTEEP Score | Standard Deviation |
|---|---|---|---|---|
| Ex-DET | Top 30% | 620 | 56.80 | 8.02 |
| Ex-DET | Bottom 30% | 184 | 28.20 | 7.72 |
| Ex-HOA | Top 30% | 989 | 75.35 | 7.14 |
| Ex-HOA | Bottom 30% | 311 | 49.37 | 10.12 |

**Table 1:** Descriptive statistics on PTEEP score by ex-education department and PTEEP group

Clearly, the ex-HOA (advantaged) students far outperform the ex-DET (disadvantaged) students, and those who fall into the Top 30% of their group perform much better than those who are categorized in the Bottom 30%.

To justify using the non-AARP group which got access into UCT via the traditional route of meeting the School Leaving Examination Points score we examined the points of each group.

| Ex-education group | PTEEP Group | Sample size | Mean School Leaving Examination Points | Standard deviation |
|---|---|---|---|---|
| Ex-DET | Top 30% | 534 | 32.69 | 6.11 |
| Ex-DET | Bottom 30% | 154 | 30.05 | 3.91 |
| Ex-DET | non-PTEEP | 2061 | 32.28 | 5.35 |
| Ex-HOA | Top 30% | 906 | 37.71 | 5.83 |
| Ex-HOA | Bottom 30% | 288 | 32.67 | 4.13 |
| Ex-HOA | non-PTEEP | 12789 | 38.32 | 5.84 |

**Table 2:** Descriptive statistics on School Leaving Examination Points by ex-education department and PTEEP group

Table 2 above shows that Ex-HOA students generally enter university with higher School Leaving Examination Points score compared to ex-DET students. Once again this illustrates the need to examine survival in these groups separately. The gap in average School Leaving Examination Points between top and bottom PTEEP performers is larger for ex-HOA students compared to ex-DET students. And finally, there is not much difference between School Leaving Examination Points for PTEEP top performers and non-PTEEP students. Because PTEEP top performers and non-PTEEP School Leaving Examination Points performance is similar, one would expect that survival times would also be similar. However, the survival analysis shown later clearly illustrates that PTEEP top performers survive longer than those who've entered university based solely on their School Leaving Examination Points.

**Survival Analysis**

The ex-DET set of data is presented in Table 3 below to illustrate in detail the Kaplan-Meier method of calculating survival. It consists of 3698 students who are followed up until exclusion from university due to academic reasons. Survival estimates are calculated at each time of exclusion i.e. after each year of study at university.

| Survival Time | Number at risk $n_t$ | Number censored | Observed exclusions $d_t$ | Probability of surviving (%) $p_t$ | Cumulative probability of surviving (%) S(t) |
|---|---|---|---|---|---|
| 0 | 3698 | 0 | 0 | 100.00 | 100.00 |
| 1 | 3698 | 402 | 414 | 88.80 | 88.80 |
| 2 | 2882 | 306 | 369 | 87.20 | 77.43 |
| 3 | 2207 | 617 | 211 | 90.44 | 70.03 |
| 4 | 1379 | 608 | 119 | 91.37 | 63.99 |
| 5 | 652 | 328 | 52 | 92.02 | 58.88 |
| 6 | 272 | 177 | 18 | 93.38 | 54.99 |
| 7 | 77 | 60 | 1 | 98.70 | 54.27 |
| 8 | 16 | 16 | 0 | 100.00 | 54.27 |

**Table 3:** Kaplan-Meier estimates for ex-DET group

The survival probability starts at 1 when all subjects are in the study. After the first year survival drops to 88.80%, after the second year it drops to 77.43%, to 70.03% after the third year and it finally drops to 54.27% by the end of the eighth year. The ex-DET Kaplan-Meier probabilities, as well as those for the ex-HOA group (table available from authors), are plotted as a solid step curve in Figure 1 below. Note that the survivor functions (and hazard function presented later) are graphically displayed as chains of short line segments since duration time is measured discretely as progress codes are obtained at the end of each year.

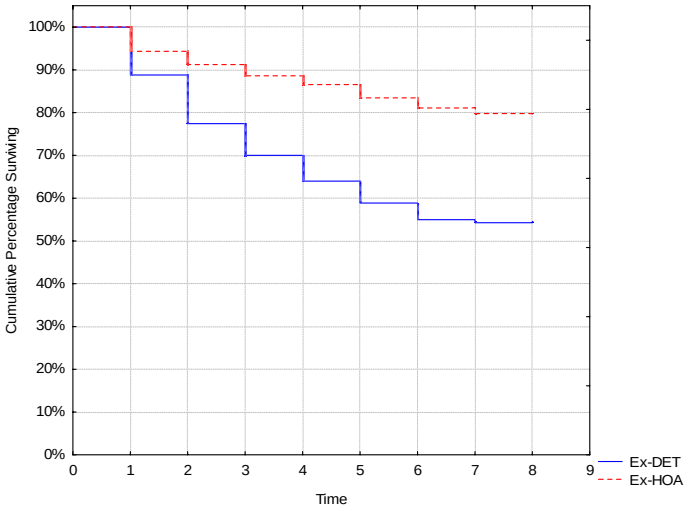


**Figure 1:** Survival functions by ex-education department

It is clear that time to exclusion differs for the two groups. Survival estimates are not that different after the first year of study. However, as time increases, so does the gap between the ex-HOA and ex-DET group. By the end of the eighth year survival has dropped to 54% in the ex-DET (disadvantaged) group but remains high at 80% in the ex-HOA (advantaged) group. A nonparametric log-rank test revealed that the time to exclusion was significantly different for the two groups ($z=26.26$, $p<0.001$). Therefore survival for the PTEEP Top 30%, PTEEP Bottom 30% and non-PTEEP groups are examined separately for the ex-HOA and ex-DET groups, as they exhibit very different survival patterns at UCT.

The survival functions graphed in Figure I above do not allow the identification of particularly risky times for exclusion. To investigate this phenomena we need to consider the hazard function which reveals the times at which students are most at risk of being excluded. The empirical hazard function for the two ex-education groups is tabulated in Table 4 and graphed in Figure 2 below.

| Year | Ex-HOA | Ex-DET |
|---|---|---|
| 1 | 6.45 (n=18649) | 12.58 (n=3698) |
| 2 | 3.68 (n=13720) | 14.50 (n=2882) |
| 3 | 3.93 (n=10536) | 11.77 (n=2207) |
| 4 | 3.55 (n=5638) | 11.72 (n=1379) |
| 5 | 5.36 (n=1510) | 11.26 (n=652) |
| 6 | 4.98 (n=466) | 10.32 (n=272) |
| 7 | 3.33 (n=56) | 2.15 (n=77) |

**Table 4:** Hazard estimates by ex-education department

The magnitude of the hazard represents the relative risk of exclusion for each of the time periods. In particular for the ex-DET group, the hazard of exclusion is 12.58% in the first year of study indicating that 12.58% of students are likely to be excluded in the first year of study. This rate increases and peaks to 14.50% in the second year indicating that ex-DET students are most at risk of being excluded in their second year. The hazard then decreases until it reaches 2.15% by the end of the seventh year. Because the sample becomes quite small towards the end of the study period these estimates become less reliable. The ex-HOA students are most at risk of being excluded in the first year of study.

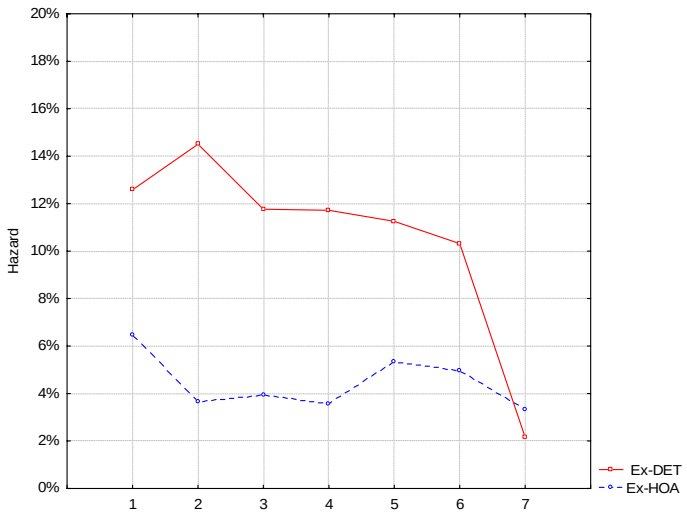


**Figure 2:** Hazard functions by ex-education department

Comparing the ex-education groups, the hazard of exclusion is consistently higher in the ex-DET group compared to the ex-HOA group. Quite interesting is the sharp decline in the hazard rate for the ex-DET group in the seventh year. It actually falls below the hazard rate for the ex-HOA group. However, the sample size is quite small by this point.

Ex-HOA Group

For brevity tables have been omitted and only figures are shown for the sections below. Tables are available from the authors.

The figures which summarise survival for the ex-HOA group is given below. The ex-HOA group only wrote the AARP tests from 1997 onwards and therefore only contributed 6 years worth of information, regarding PTEEP performance, to the study.

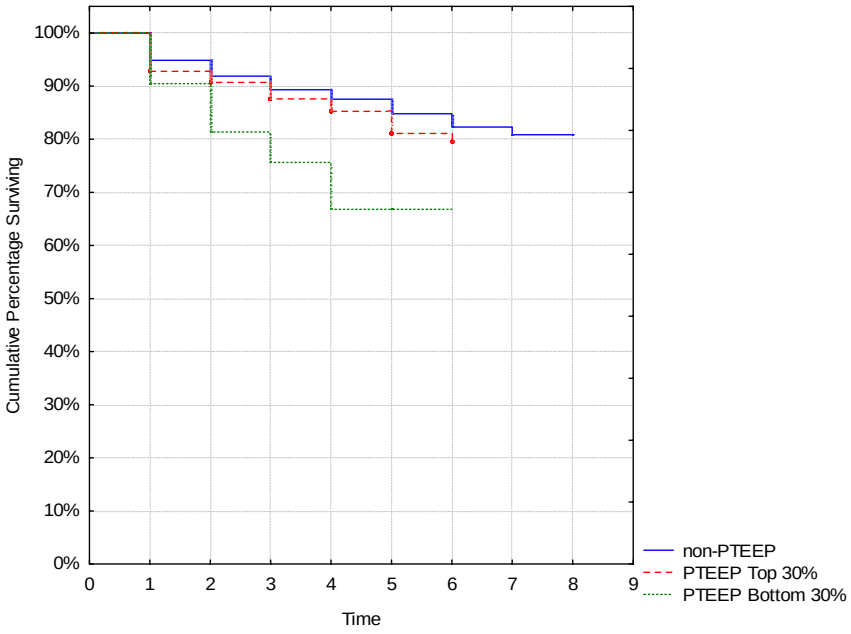


**Figure 3:** Survival functions of ex-HOA students by PTEEP group

Examination of the survival functions for the ex-HOA group reveals that the non-PTEEP group and the PTEEP Top 30% group are quite similar. After the sixth year survival has dropped to the low eighties in the non-PTEEP and PTEEP Top 30% groups respectively. However, the function for the Bottom 30% group indicates that time to exclusion for this group is shorter than that for the non-PTEEP and PTEEP Top 30% group. A log-rank test to compare multiple groups revealed that the groups differ with respect to exclusion time ($\chi^2$=43.63, p<0.001).

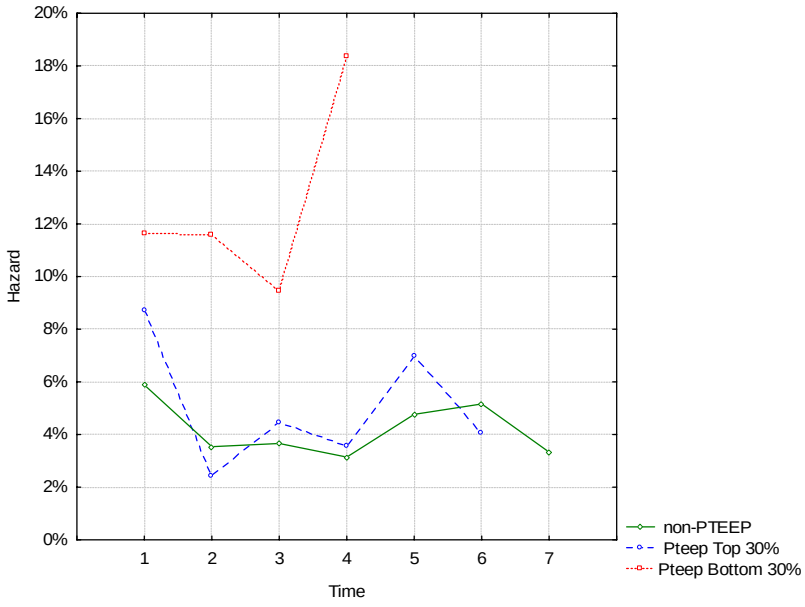


**Figure 4:** Hazard functions of ex-HOA students by PTEEP group

The hazard functions for the ex-HOA group support the inferences from the survival functions. The hazard rates are very similar for the non-PTEEP group and PTEEP Top performers. However, the probabilities of exclusion is higher for the PTEEP Bottom performers, with the probabilities peaking during the fourth year of study indicating that a PTEEP Bottom performer is most likely to be excluded at this point of their studies. Top performers and non-PTEEP students are most likely to be excluded within the first year of study.

**Ex-DET Group**

The probabilities of survival after each year at the University of Cape Town for the ex-DET group is plotted in Figure 5 below.

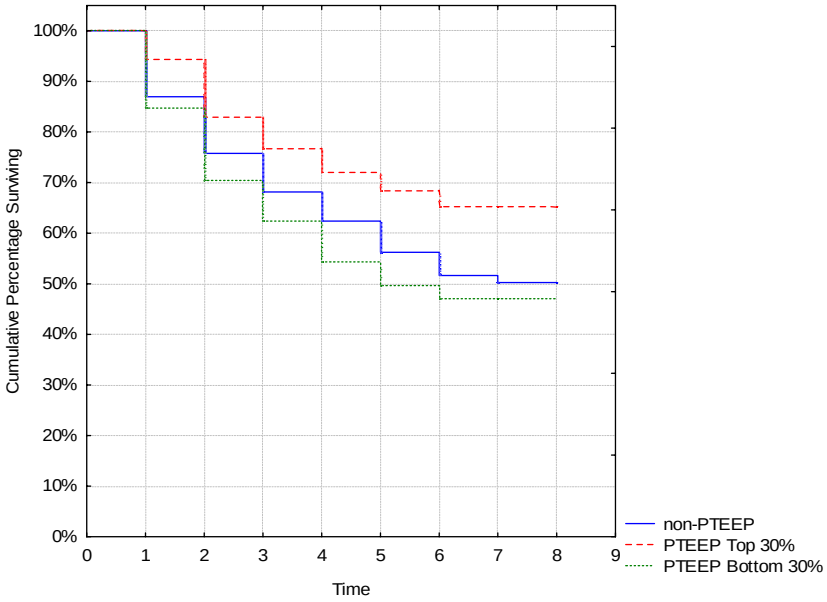


**Figure 5:** Survival functions of ex-DET students by PTEEP group

The patterns of survival for the PTEEP and non-PTEEP groups differ significantly from the ex-HOA group. The marked difference in time to exclusion of the PTEEP Top 30% and the non-PTEEP is more apparent in the ex-DET analysis compared to the ex-HOA group where they were very similar. The Top 30% group survives longer at university compared to the other two groups of students. In fact, the gaps between probabilities of exclusion appear to widen as time increases. As expected, bottom performers remain in the institution for a shorter time before being excluded for academic reasons. The median survival time for this group is 5 years as opposed to 7 years for non-PTEEP students and >8 years for top PTEEP performers. The difference in survival functions of the three groups is statistically significant ($\chi^2$=30.84, p<0.001).

This pattern of survival is quite interesting in the light of information contributed by the School Leaving Examination Points system. At the beginning of their studies, the top achievers in the PTEEP test and the non-PTEEP students (i.e. those gaining access via their School Leaving Examination Points) appear to be performing quite similarly when examining School Leaving Examination Points only (see Table 2 above). However, using a survival analysis approach, when one examines survival over time, those identified by the PTEEP as top performers survive longer at university compared to those who did not write the PTEEP test. Therefore, the university has a better likelihood of identifying a student's risk if the PTEEP is written as opposed to only considering the school leaving points as an access mechanism.

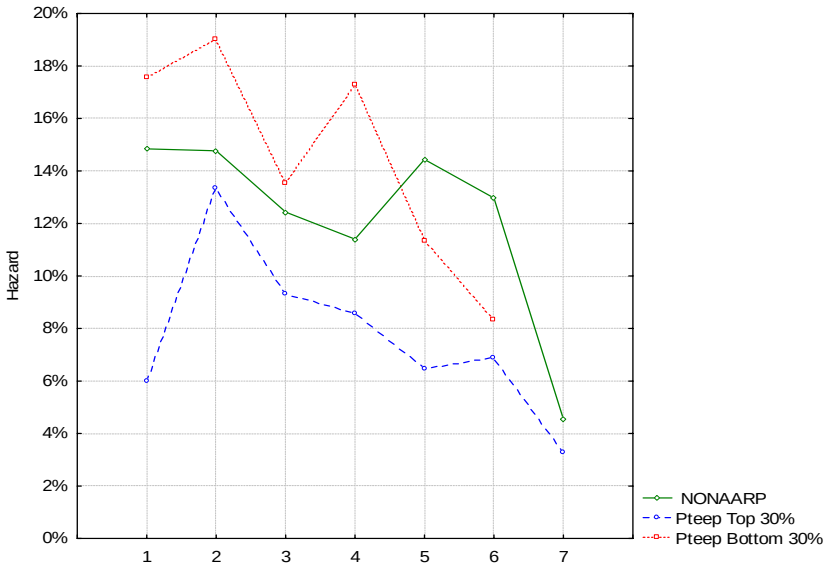


**Figure 6:** Hazard functions of ex-DET students by PTEEP group

Interesting patterns can be seen in the hazard functions for ex-DET students. The hazard for the top performers of the PTEEP is the lowest over all years. These students are most at risk of leaving during their second year of study but the risk gradually decreases after the second year. PTEEP bottom performers are most likely to be excluded in the second year. The non-PTEEP groups' hazard peaks after the first, second and fifth year of study, all indicating increased risk of exclusion.

## CONCLUSION

The use of a survival analysis approach to investigating predictive validity overcomes many of the challenges associated with traditional statistical approaches such as correlations and regression analyses. Most importantly it allows for the incorporating of censored data which would typically be omitted from an analysis.

In this study the survival analysis approach provided valuable insight into the attrition and throughput patterns of students at the University of Cape Town. The approach allowed us to answer questions regarding whether students drop out but also, through the use of the hazard function, it was able to illustrate exactly when the periods of risk were highest. This is particularly valuable in a Higher Education setting where it is vital to assess when students are most at risk of exclusion from an institution.

By stratifying the population of students into groups of interest, the ex-DET and ex-HOA groups, as well as PTEEP top performers, PTEEP poor performers, and traditional access students, we were able to compare them with regard to survival time at the university.

The initial descriptive statistics and survival analysis by ex-education department suggested looking at the two groups, ex-HOA group and ex-DET group, separately rather than grouping them together. The results of the analysis indicate that even though students might come to university with very similar School Leaving Examination Point scores, the PTEEP is able to provide useful additional information regarding risk of exclusion especially in the ex-DET group of students, where top PTEEP performers clearly display a lower likelihood of being excluded compared to the bottom PTEEP performers.

The study showed that ex-DET (disadvantaged) students were most at risk of exclusion during their second year of study, and that ex-HOA students were typically at risk during their first year. However, poor PTEEP performing ex-HOA students differed from top performers and non-PTEEP students in that their hazard of exclusion peaked during the fourth year of study. It may be worthwhile investigating this group to determine possible reasons for this late increase.

The most important finding of the analysis is that performance on the Placement Test in English for Educational Purposes (PTEEP) is as good a predictor of risk of dropout as the traditional Senior Certificate School Leaving Examination Points performance. For the ex-DET (disadvantaged) group in particular, the PTEEP appears to be a **consistently** better predictor when compared to the traditional Senior Certificate School Leaving Examination Points.

[A more complete version of this paper has been selected to appear in a forthcoming edition of the South African Journal of Higher Education]

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