Survival Analysis of Transfer Students

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NCAIR 2023 – 50th Annual Conference
Back Together Again

LEARNING OBJECTIVES

- DESCRIBE THE IMPORTANCE TO HIGHER EDUCATION INSTITUTIONS OF INVESTIGATING THE FACTORS THAT CONTRIBUTE TO TRANSFER STUDENT SUCCESS;
- IDENTIFY FACTORS THAT PAST RESEARCH AND THE CURRENT STUDY HAVE DETERMINED INFLUENCE THE LIKELIHOOD OF DROP OUT FOR TRANSFER STUDENTS; AND
- RECOGNIZE HOW THE SURVIVAL ANALYSIS STATISTICAL TECHNIQUE CAN BE USED TO ASSIST IN THE UNDERSTANDING OF TRANSFER STUDENT SUCCESS.

AGENDA

- Background of the Study
- Literature Review
- Methods
- Study Results
- Discussion and Q & A

BACKGROUND OF THE STUDY

- Definition of Transfer Students
- Importance of Studying Transfer Students
- Survival Analysis Vs. Traditional Regression Methods

LITERATURE REVIEW

Key Factors Impacting Transfer student retention and graduation

- Factors found in regression and descriptive analyses
    - Demographic
    - Community College Credential
    - Transferred Credit Hours
    - Transfer Institution Type

- Factors found in survival analysis
    - Demographic
    - Academic Achievement
    - College Experience

RESEARCH QUESTIONS

1. What is the estimated survival rate of transfer students within eight semesters after enrollment?

2. Are there significant differences between the survival rates of the following sub-groups: age, majors, major changing, transfer GPA, transfer credit hours, financial aid, and enrollment status?

3. What are the effects of covariates on transfer students' drop out?

VARIABLES

- Age at matriculation
- Transfer credits at entry
- GPA at entry
- Matriculation into a STEM field (Y/N)
- Changed major in first year (Y/N)
- Enrollment intensity in term 1 (full-time/part-time)
- Financial aid received in first term (Y/N)
- Gender
- Race/ethnicity (URM) (Y/N)

STUDY POPULATION

11,267 students who entered institution between 2010 and 2017 as new transfer students in Fall or Summer.

24% URM

54% Female

21% enrolled as STEM majors

16.5% changed majors in first year

74% enrolled full-time in first semester

74% received financial aid

STUDY POPULATION

Variable	Min	Q1	Median	Q3	Max
Age at matriculation	15	20	21	27	72
Transfer Credits	1	40	57	69	207
Transfer GPA	1.16	2.75	3.07	3.43	4

Outcome Variable: Event

- Student status at end of study
  - Graduated or Continuing enrollment -> 0
  - Drop out (did not persist) -> 1

Example:

ID	Time (Semester)	Event (Status)	*Note	Other variables
001	2	1	Dropped out	…
002	5	0	Graduated	…
003	8	0	Continuing	…
004	8	1	Dropped out	…
005	8	0	Graduated	…

RESEARCH QUESTION 1

What is the estimated survival rate of transfer students within eight semesters after enrollment?

METHOD

Kaplan–Meier Model

SURVIVAL FUNCTION AND KAPLAN-MEIER ESTIMATOR

The survival function, $\boldsymbol{S(t)}$ expresses the probability that a subject's true survival time T will exceed time t.

$$S(t) = Pr(T > t)$$

Example: $S(1) = Pr(T > 1)$

The Kaplan-Meier (KM) estimator is a very popular non-parametric method to estimate the survival function $\boldsymbol{S(t)}$.

$$\hat{S}(t) = \prod_{t_i < t} \left(1 - \frac{events_i}{number\ at\ risk_i}\right)$$

Proportion of those at risk that survive time point t_i

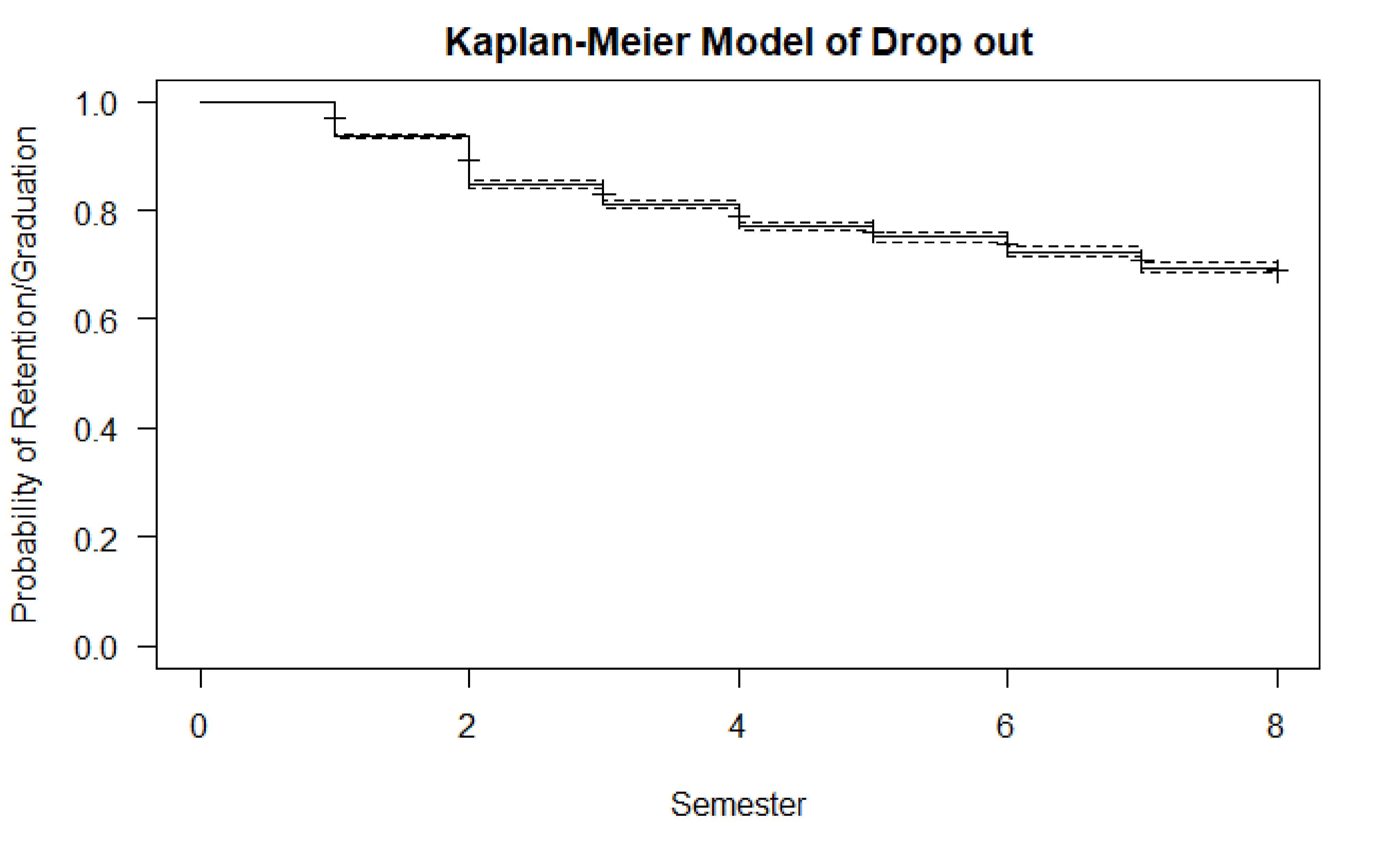
RESULTS: KAPLAN–MEIER MODEL

Table of Kaplan-Meier survival function

Semester	Estimated survival probability	lower 95% CI	upper 95% CI	Hazard Rate
1	0.936	0.932	0.941	0.064
2	0.847	0.840	0.854	0.095
3	0.810	0.802	0.817	0.044
4	0.772	0.764	0.780	0.047
5	0.751	0.743	0.759	0.027
6	0.724	0.716	0.733	0.036
7	0.695	0.686	0.705	0.040
8	0.681	0.671	0.692	0.020

Estimated survival probability: $\hat{S}(t)$

Hazard Rate: $\frac{events_i}{number\ at\ risk_i}$


Kaplan-Meier Model of Drop out
Probability of Retention/Graduation
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
Semester

RESEARCH QUESTION 2

Are there significant differences between the survival rates of the following sub-groups: age, majors, major changing, transfer GPA, transfer credit hours, financial aid, gender, race/ethnicity and enrollment status?

METHOD

Stratified Kaplan–Meier Model

SUBGROUPS FOR NUMERICAL VARIABLE

Age categories:

- 24 and younger
- 25 and older

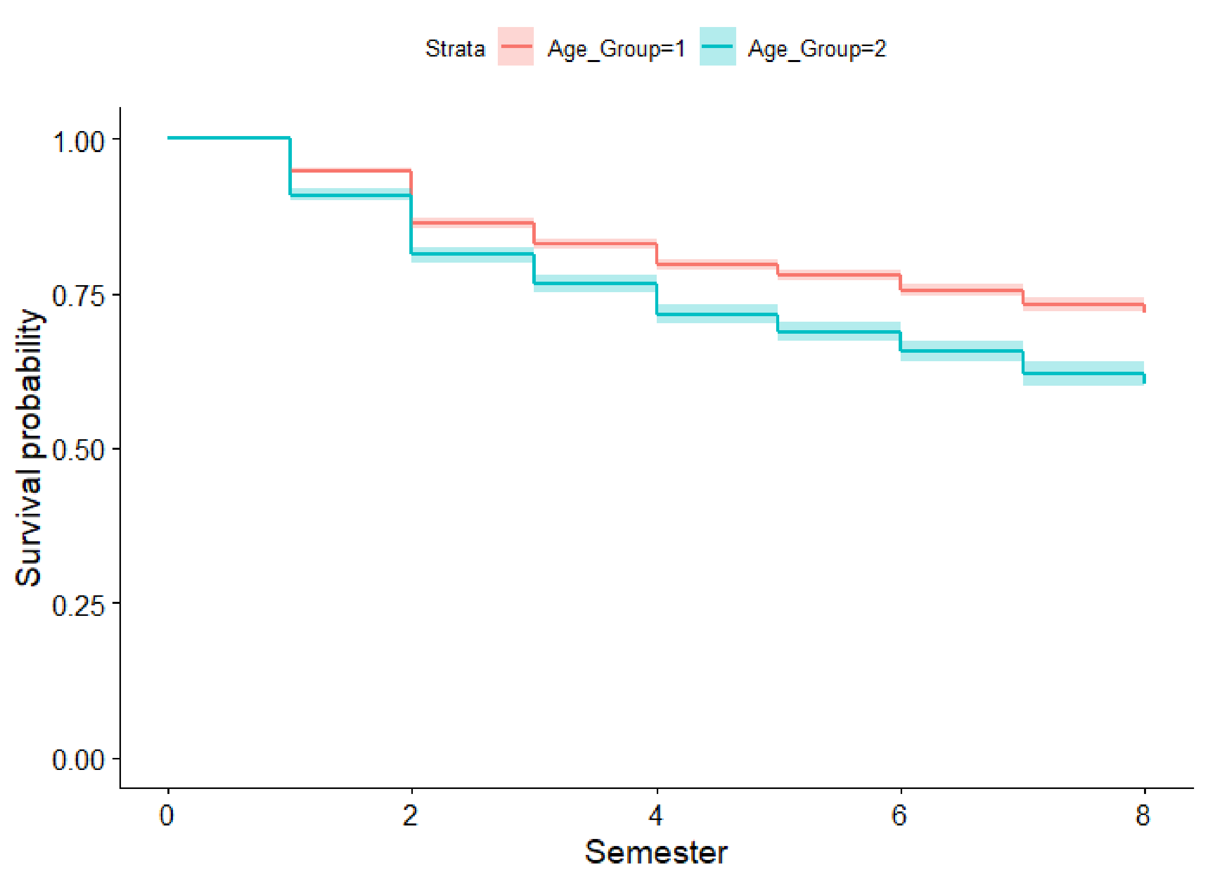
Transfer Hours categories:

- 0-29
- 30-59
- 60-89
- 90 or more

Transfer GPA categories:

- 2.49 and below
- 2.50 to 2.99
- 3.00 to 4.00

STRATIFIED BY AGE GROUP



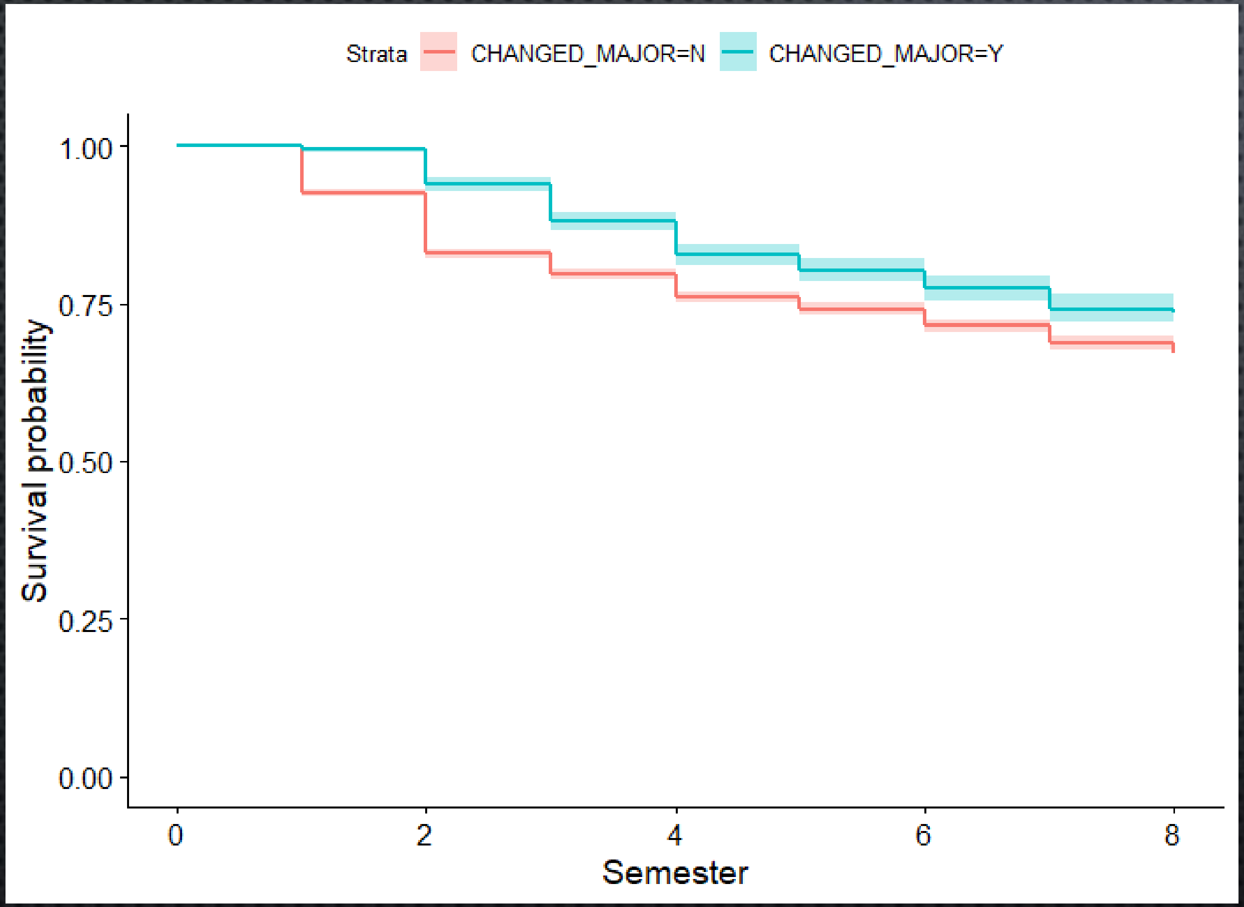
Gehan-Wilcoxon test

	N	Observed	Expected	(O-E)^2/E	(O-E)^2/V
Age_Group=1	7727	1665	1908	30.9	121
Age_Group=2	3540	1076	833	70.8	121

Chisq= 121 on 1 degrees of freedom, p= <2e-16

Age Group 1: 24 and younger
Age Group 2: 25 and older

STRATIFIED BY MAJOR CHANGE

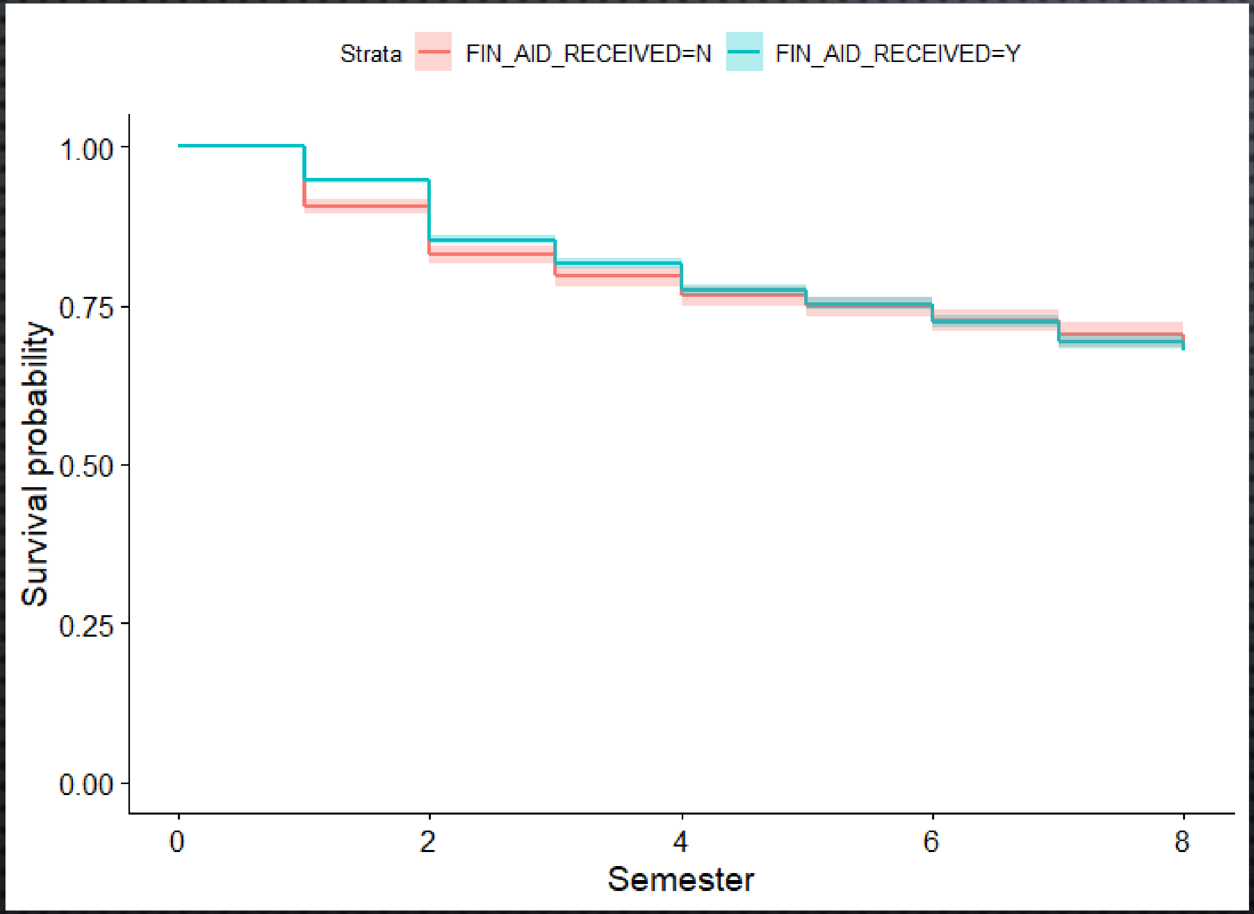


Gehan-Wilcoxon test

	N	Observed	Expected	(O-E)^2/E	(O-E)^2/V
CHANGED_MAJOR=N	9405	2379	2248	7.54	50.3
CHANGED_MAJOR=Y	1862	363	493	34.36	50.3

Chisq= 50.3 on 1 degrees of freedom, p= 1e-12

STRATIFIED BY FINANCIAL AID

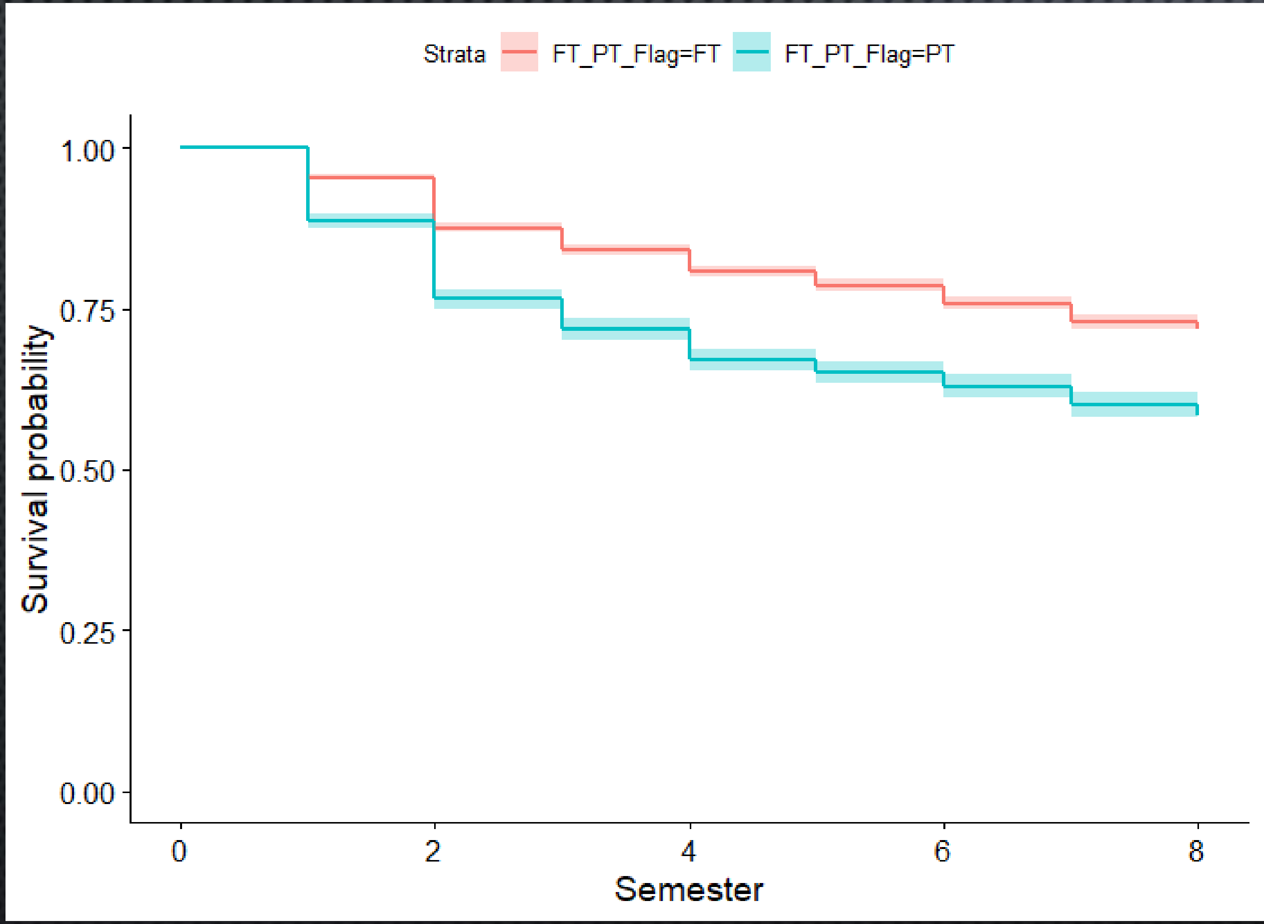


Gehan-Wilcoxon test

	N	Observed	Expected	(O-E)^2/E	(O-E)^2/V
FIN_AID_RECEIVED=N	2879	712	688	0.773	1.23
FIN_AID_RECEIVED=Y	8388	2030	2053	0.259	1.23

Chisq= 1.2 on 1 degrees of freedom, p= 0.3

STRATIFIED BY FULL TIME / PART TIME

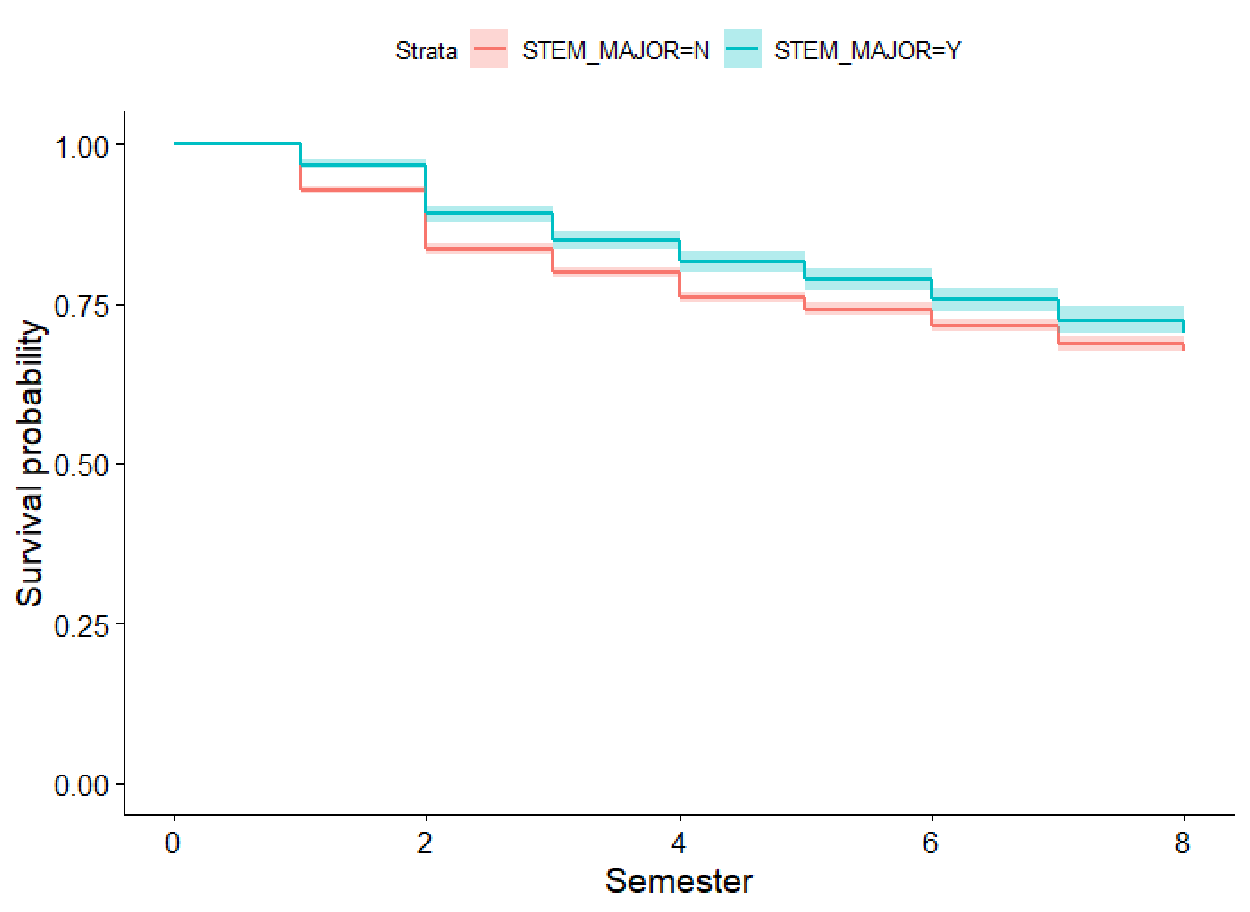


Gehan-Wilcoxon test

	N	Observed	Expected	(O-E)^2/E	(O-E)^2/V
FT_PT_Flag =FT	8341	1737	2055	49.3	235
FT_PT_Flag =PT	2926	1005	687	147.6	235

Chisq= 235 on 1 degrees of freedom, p= <2e-16

STRATIFIED BY STEM

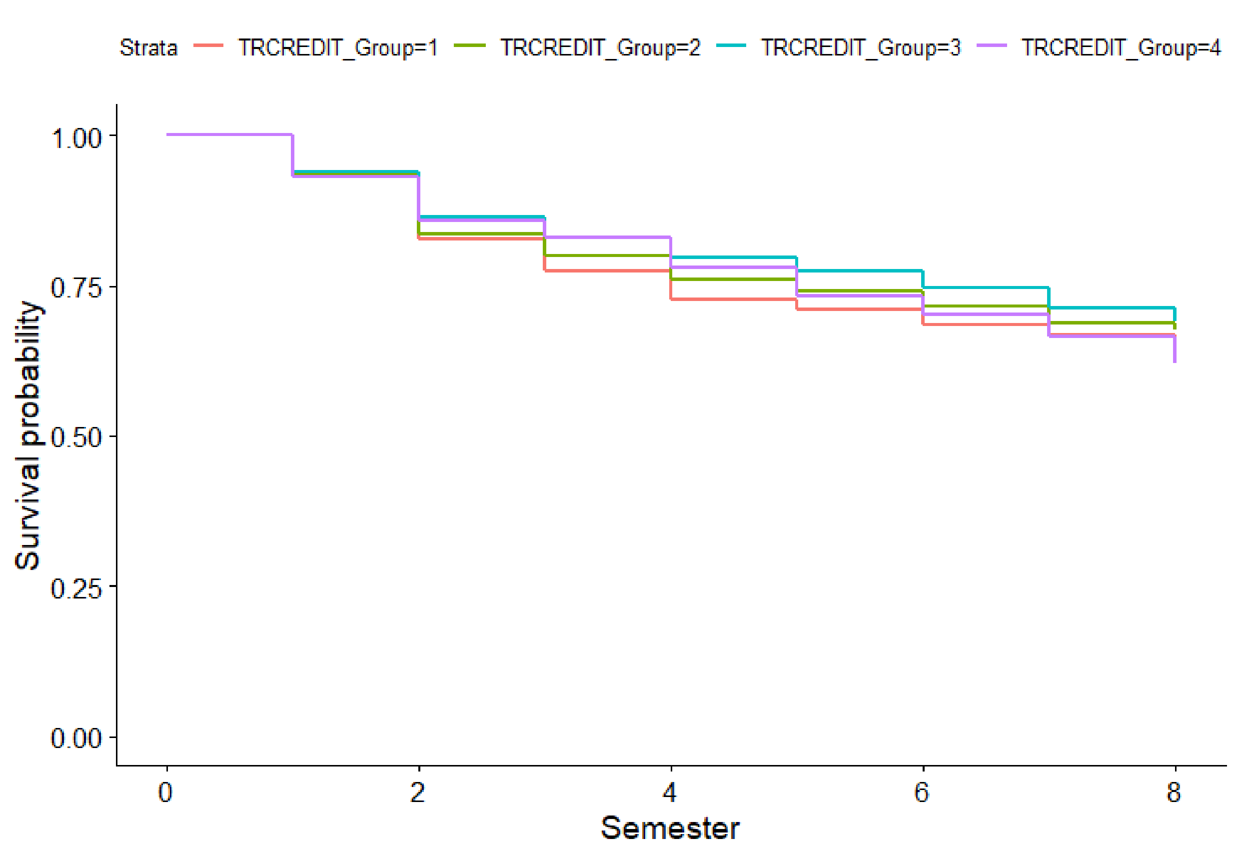


Gehan-Wilcoxon test

	N	Observed	Expected	(O-E)^2/E	(O-E)^2/V
STEM_MAJOR=N	8861	2487	2389	4.02	19.1
STEM_MAJOR=Y	2406	593	691	13.90	19.1

Chisq= 19.1 on 1 degrees of freedom, p= 1e-05

STRATIFIED BY TRANSFER CREDIT GROUP



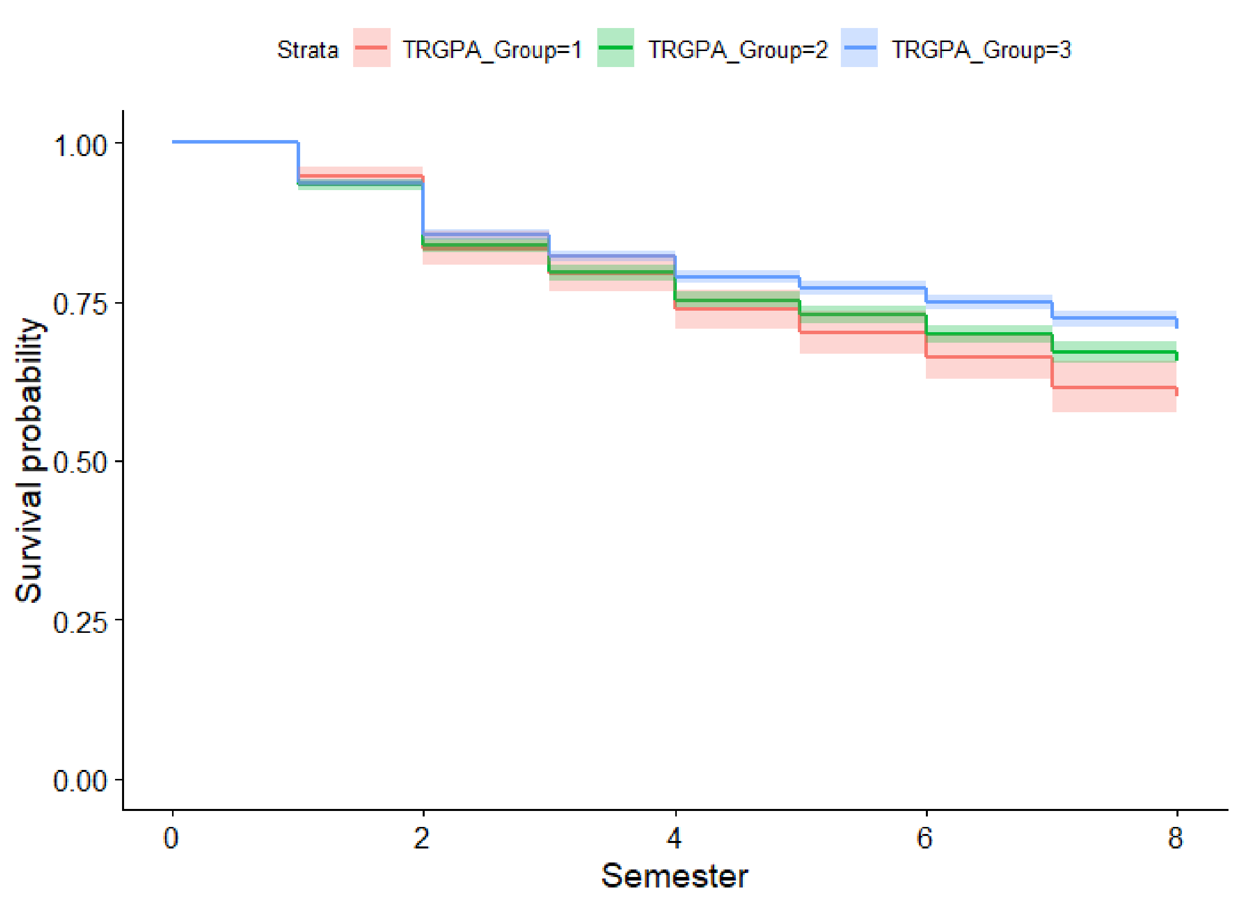
Gehan-Wilcoxon test

	N	Observed	Expected	(O-E)^2/E	(O-E)^2/V
TRCREDIT_Group=1	1216	352	310	5.48	7.434
TRCREDIT_Group=2	4846	1242	1196	1.75	3.708
TRCREDIT_Group=3	4371	955	1048	8.17	15.764
TRCREDIT_Group=4	834	193	187	0.16	0.204

Chisq= 18.6 on 3 degrees of freedom, p= 3e-04

Transfer Credit Group = 1: 0-29
Transfer Credit Group = 2: 30-59
Transfer Credit Group = 3: 60-89
Transfer Credit Group = 4: 90 or more

STRATIFIED BY TRANSFER GPA GROUP



Gehan-Wilcoxon test

	N	Observed	Expected	(O-E)^2/E	(O-E)^2/V
TRGPA_Group=1	747	219	180	8.18	10.4
TRGPA_Group=2	4197	1108	1014	8.76	16.6
TRGPA_Group=3	6323	1415	1547	11.37	31.1

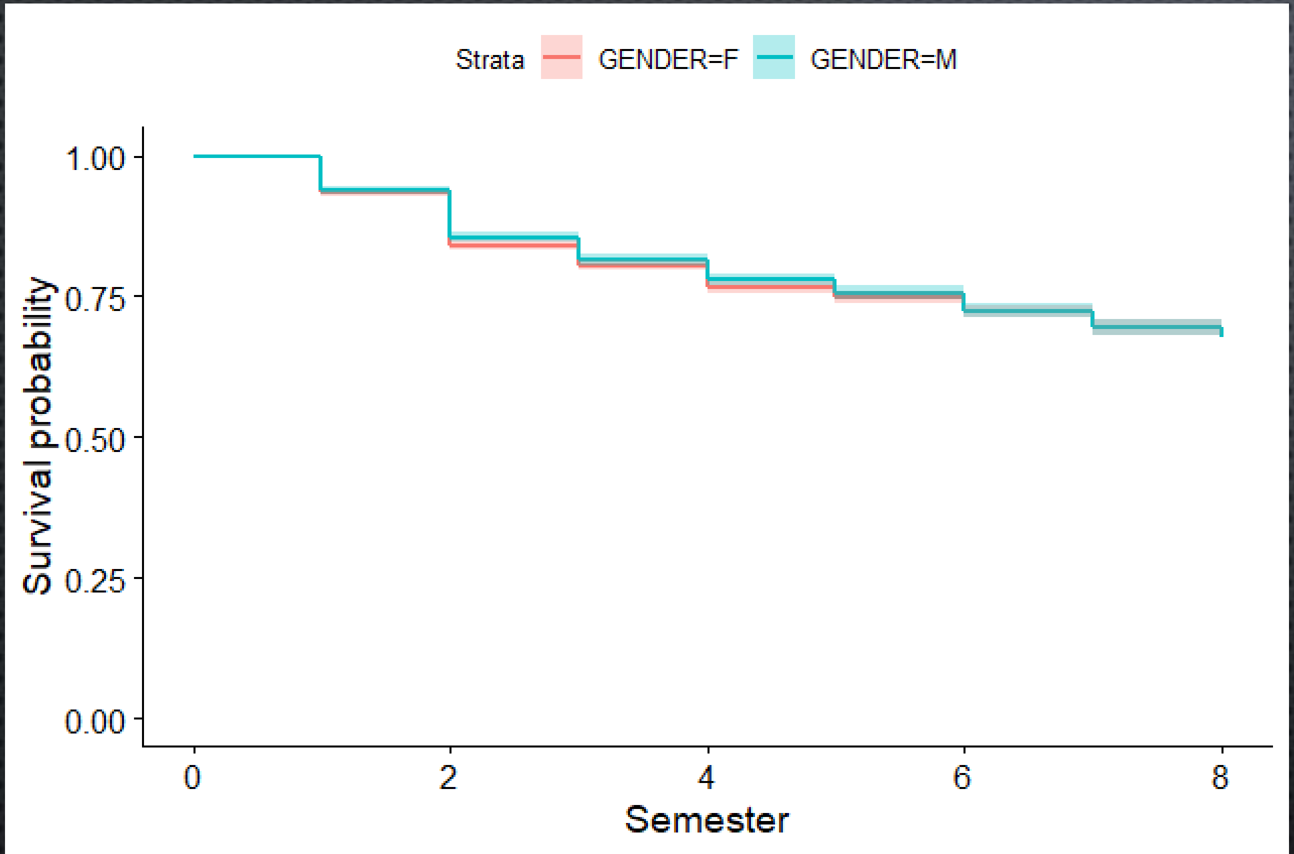
Chisq= 33.7 on 2 degrees of freedom, p= 5e-08

Transfer GPA Group = 1: 2.49 and below

Transfer GPA Group = 2: 2.50 to 2.99

Transfer GPA Group = 3: 3.00 to 4.00

STRATIFIED BY GENDER

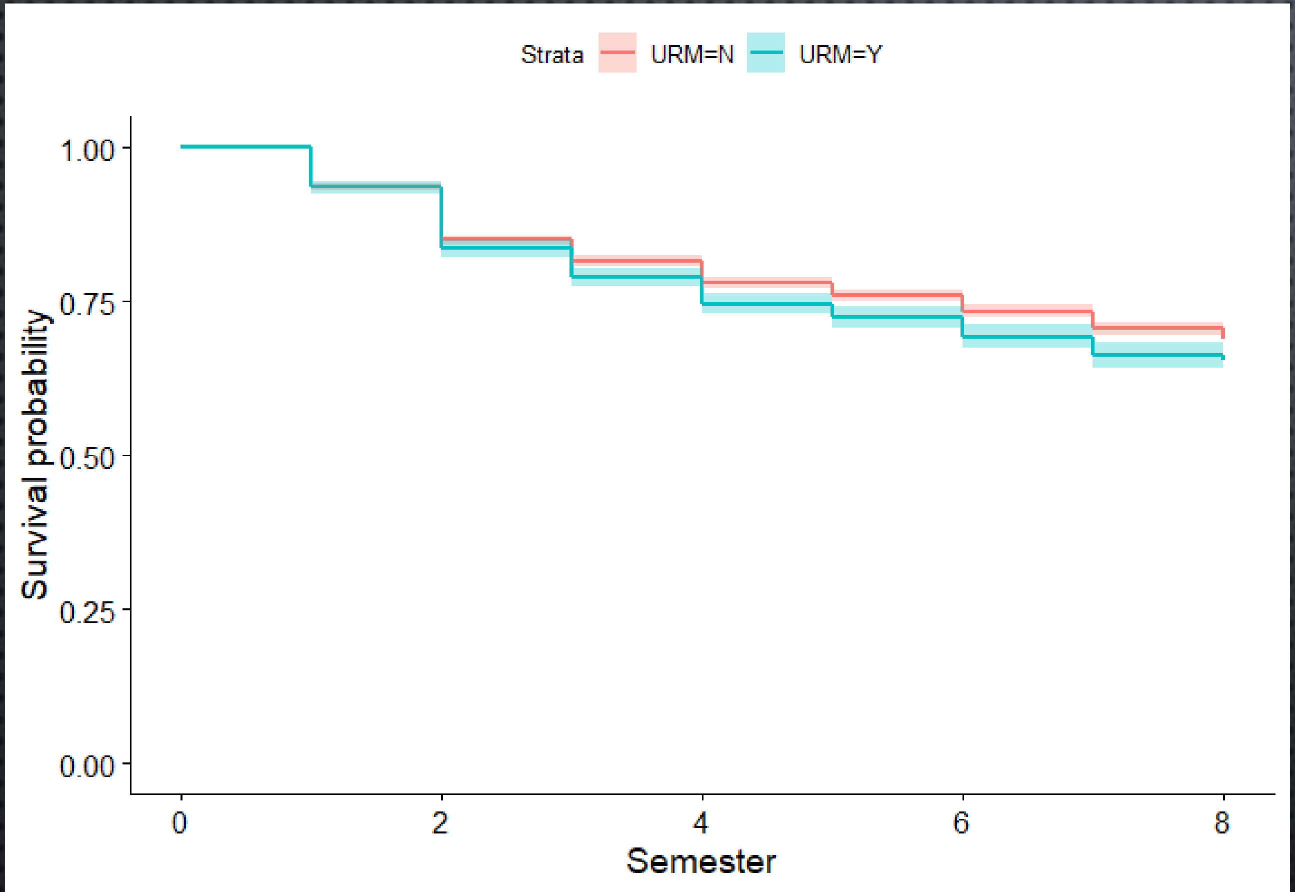


Gehan-Wilcoxon test

	N	Observed	Expected	(O-E)^2/E	(O-E)^2/V
GENDER=F	6134	1499	1480	0.258	0.669
GENDER=M	5132	1242	1262	0.303	0.669

Chisq= 0.7 on 1 degrees of freedom, p= 0.4

STRATIFIED BY RACE/ETHNICITY



Gehan-Wilcoxon test

	N	Observed	Expected	(O-E)^2/E	(O-E)^2/V
URM=N	8585	2015	2088	2.59	13
URM=Y	2681	727	653	8.29	13

Chisq= 13 on 1 degrees of freedom, p= 3e-04

FACTORS THAT AFFECT THE OUTCOME

- AGE
- MAJOR CHANGE
- FULL TIME / PART TIME
- STEM / NON-STEM
- TRANSFER CREDIT
- TRANSFER GPA
- RACE/ETHNICITY

RESEARCH QUESTION 3

What are the effects of covariates on transfer students' drop out?

METHOD

Cox Proportional Hazards Model

Refined model:
Stratified Cox Proportional Hazards Model

COX-PROPORTIONAL HAZARD MODEL

Cox proportional hazards model estimates changes to the hazard function, $h(t)$. The Cox model can estimate the effects of multiple predictors(covariates) on the hazard function.

$$h(t|X_1 = x_1) = h_0(t) * e^{(b_1 * x_1)}$$

$h(t|X_1 = x_1)$: the hazard at time t for a subject with predictor X_1 equal to the value x_1

$h_0(t)$: the baseline hazard at time t, the hazard for a subject with all predictors equal to zero

$e^{(b_1 * x_1)}$: the *hazard ratio* comparing the hazard for a subject with $X_1 = x_1$ to a subject with $X_1 = 0$

Cox model does not require specification of the baseline hazard function, $h_0(\mathrm{t})$, the hazard function for a subject with zero on all covariates.

HAZARD RATIO

$h(t|X_1 = 0) = h_0(t) * e^{(b_1*0)} = h_0(t)$

$h(t|X_1 = 1) = h_0(t) * e^{(b_1*1)}$

Hazard Ratio = $\frac{h(t|X_1 = 1)}{h(t|X_1 = 0)} = e^{b_1}$

comparing the hazard for treatment to controls

HR = 0.5 means that treatment has half the hazard of control, or 50% decrease.

HR = 2 means that treatment has double the hazard of control, or 100% increase.

e^{b_1} express the hazard ratio for a 1-unit increase in the covariate.

b_1 itself is the log-hazard ratio.

COX MODEL WITH MULTIPLE PREDICTORS

$$h(t|X_1, X_2, \ldots X_n) = h_0(t) * e^{(b_1X_1+b_2X_2+\cdots+b_nX_n)}$$

b_i e^{b_i} : the hazard ratio of covariate X_i

	coef	exp(coef)	se(coef)	z	Pr(>|z|)	
AGE_AT_MATRIC	0.0132528	1.0133410	0.0024818	5.340	9.30e-08	***
STEM_MAJORY	-0.2066710	0.8132872	0.0461482	-4.478	7.52e-06	***
CHANGED_MAJORY	-0.3293599	0.7193840	0.0528970	-6.226	4.77e-10	***
TRANSFER_UG_GPA	-0.2091169	0.8113004	0.0285073	-7.336	2.21e-13	***
TRANSFER_CREDIT_HOURS	-0.0070707	0.9929542	0.0009005	-7.852	4.10e-15	***
URMY	0.1628344	1.1768417	0.0411060	3.961	7.45e-05	***
FT_PT_FlagPT	0.5290839	1.6973765	0.0450434	11.746	< 2e-16	***

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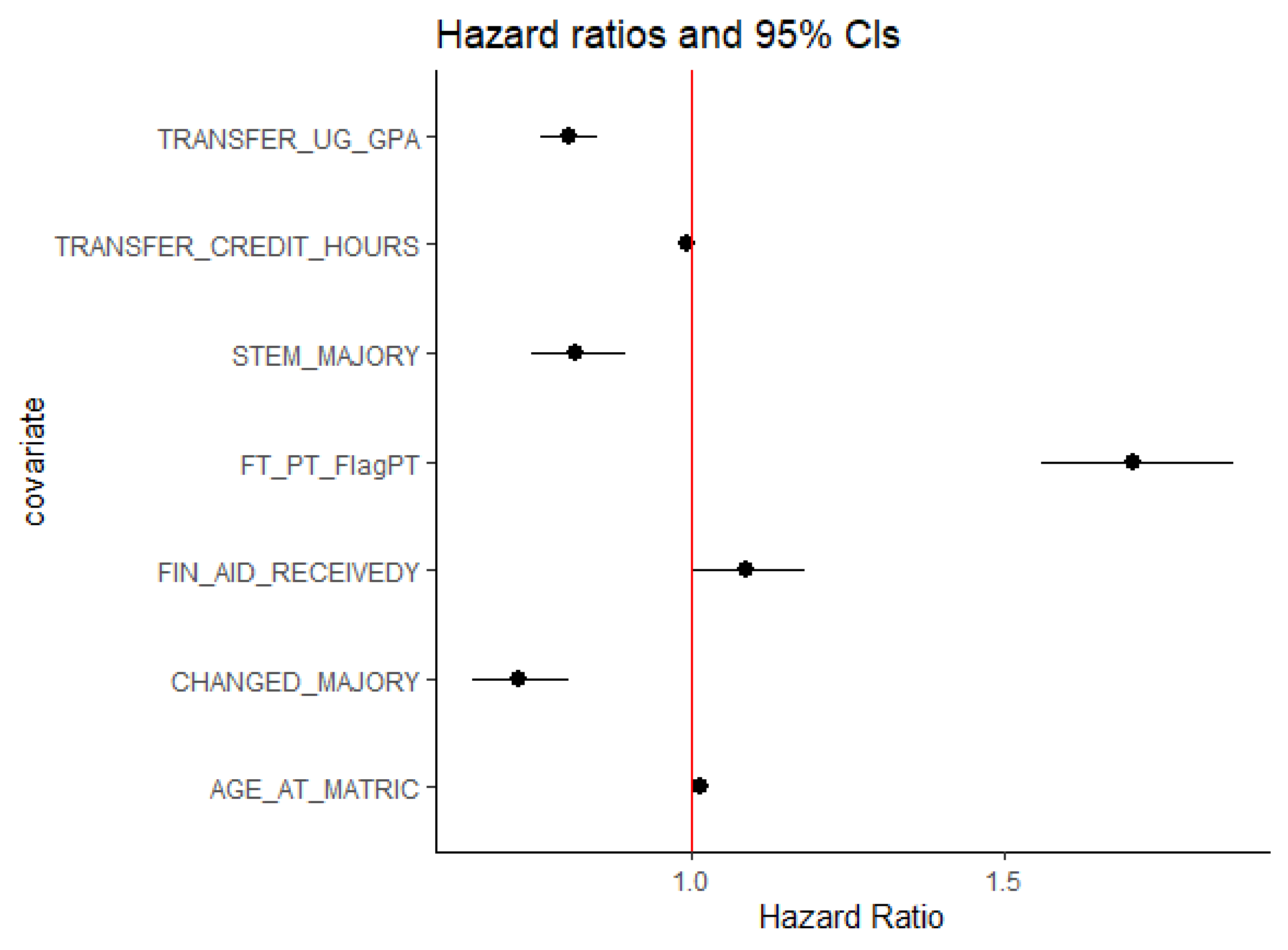
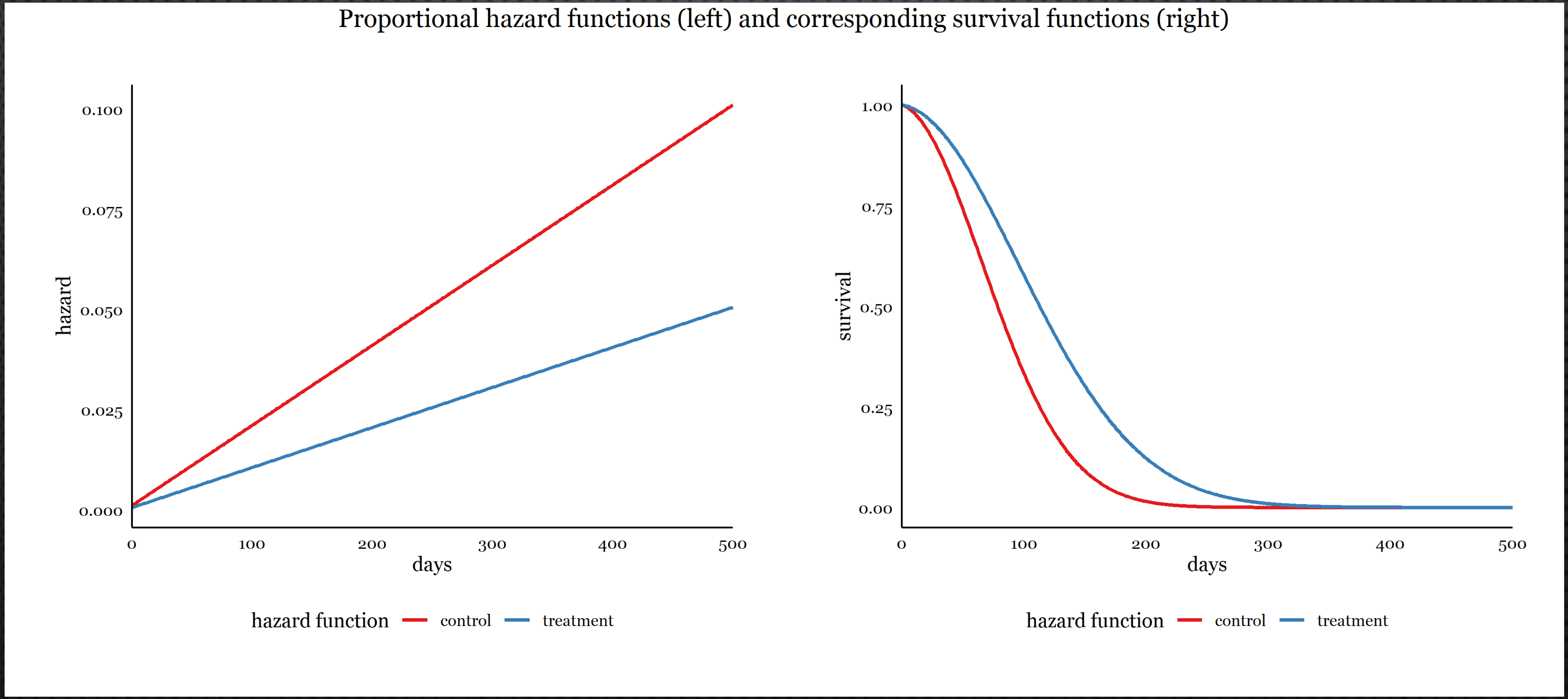
RESULTS: COX-PROPORTIONAL HAZARD MODEL



PROPORTIONALITY ASSUMPTION

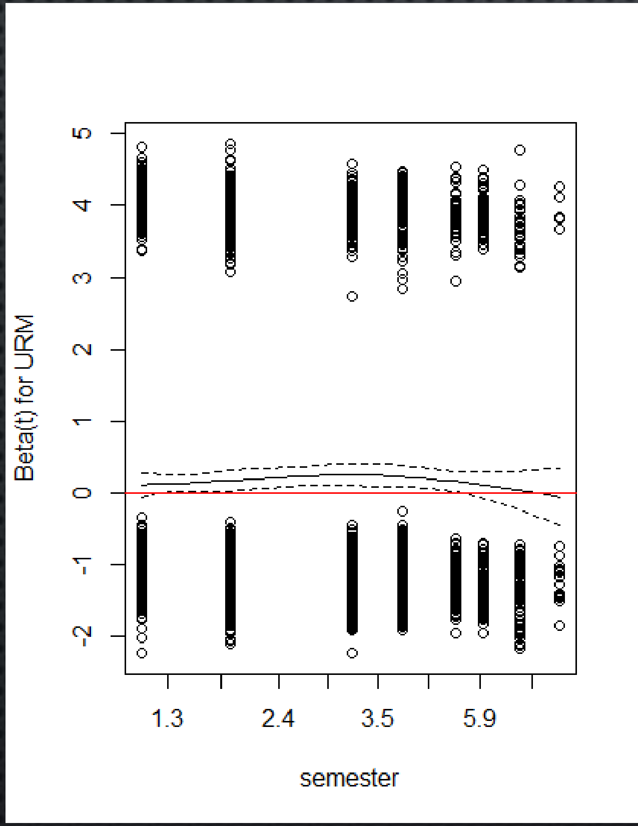
The standard Cox model assumes proportional hazards, which means that the effects of covariates are constant over time



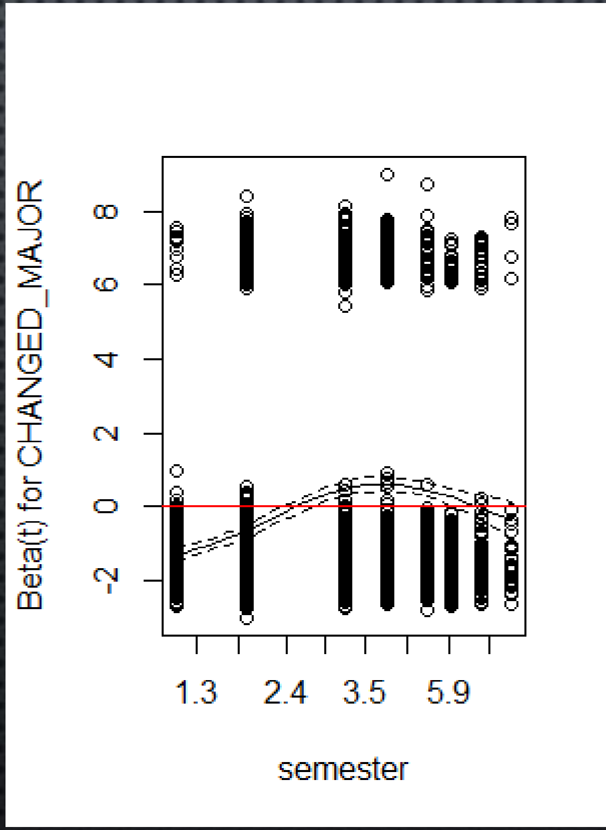
https://stats.oarc.ucla.edu/wp-content/uploads/2022/05/survival_r.html#(33)

CHECKING THE PROPORTIONALITY ASSUMPTION

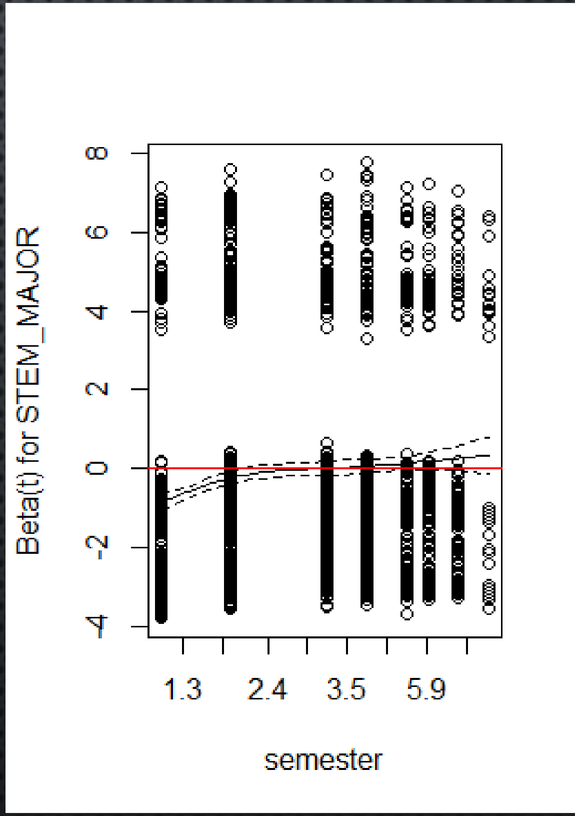
Smoothed Schoenfeld residuals



Proportional



Time-varying



Time-varying

CHECKING THE PROPORTIONALITY ASSUMPTION

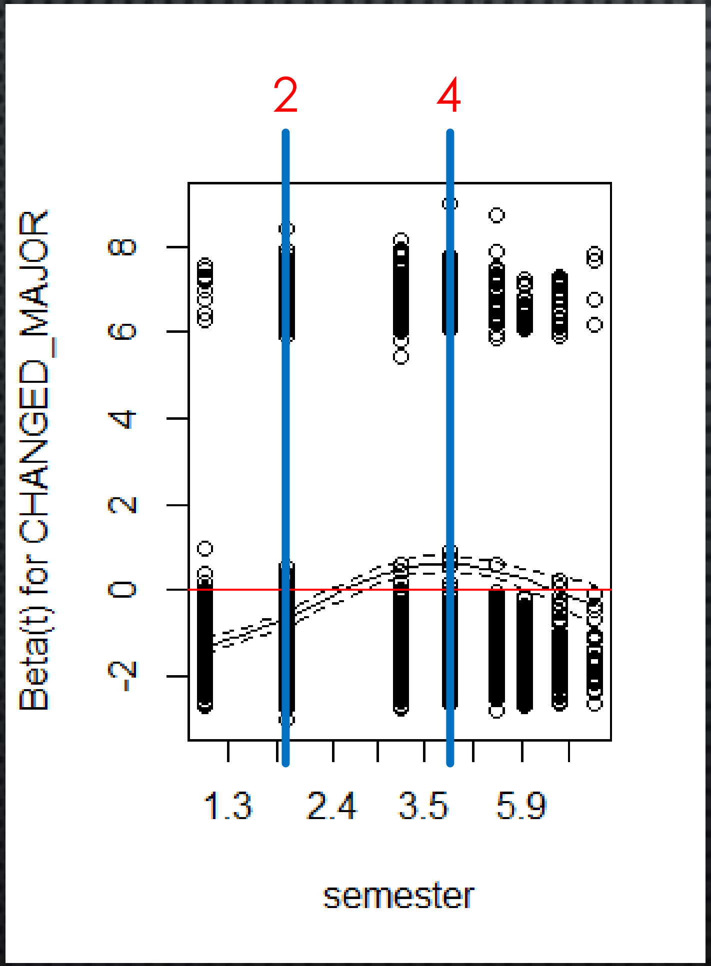
	chisq	df	p
AGE_AT_MATRIC	0.608	1	0.436
STEM_MAJOR	42.103	1	8.7e-11
CHANGED_MAJOR	129.063	1	< 2e-16
TRANSFER_UG_GPA	7.537	1	0.006
TRANSFER_CREDIT_HOURS	4.197	1	0.041
URM	1.813	1	0.178
FT_PT_Flag	40.799	1	1.7e-10

violation of the proportionality assumption

The cox.zph function will test proportionality of all the predictors in the model.

A p-value less than 0.05 indicates a violation of the proportionality assumption.

DEAL WITH TIME-VARYING COEFFICIENTS: STRATIFIED COX MODEL



In the stratified Cox model:

- the Cox model is estimated separately in each stratum
- the baseline hazard function is allowed to be different across strata
  - this can accommodate the non-proportional effects of the stratification variable
- the parameter estimates are then averaged across strata to generate one final set of estimates

DEAL WITH TIME-VARYING COEFFICIENTS: STRATIFIED COX MODEL

Stratum 1: Semester 1 , 2　　Stratum 2: Semester 3 , 4　　Stratum 3: Semester 5 - 8

		coef	exp(coef)	se(coef)	z	Pr(>|z|)	
average	AGE_AT_MATRIC	0.0133526	1.0134421	0.0024793	5.386	7.22e-08	***
	TRANSFER_UG_GPA	-0.2083737	0.8119036	0.0285816	-7.290	3.09e-13	***
	TRANSFER_CREDIT_HOURS	-0.0070348	0.9929899	0.0008987	-7.827	4.98e-15	***
	URMY	0.1612789	1.1750127	0.0411088	3.923	8.74e-05	***
stratified	STEM_MAJOR:strata(tgroup)tgroup=1	-0.5063585	0.6026863	0.0672493	-7.530	5.09e-14	***
	STEM_MAJOR:strata(tgroup)tgroup=2	0.0080230	1.0080553	0.0854077	0.094	0.92516	
	STEM_MAJOR:strata(tgroup)tgroup=3	0.2878625	1.3335740	0.0976119	2.949	0.00319	**
	strata(tgroup)tgroup=1:CHANGED_MAJOR	-1.1301415	0.3229875	0.0976580	-11.572	< 2e-16	***
	strata(tgroup)tgroup=2:CHANGED_MAJOR	0.3989203	1.4902148	0.0818070	4.876	1.08e-06	***
	strata(tgroup)tgroup=3:CHANGED_MAJOR	0.0216448	1.0218807	0.1094653	0.198	0.84325	
	strata(tgroup)tgroup=1:FT_PT_Flag	0.6555032	1.9261116	0.0549751	11.924	< 2e-16	***
	strata(tgroup)tgroup=2:FT_PT_Flag	0.4972412	1.6441791	0.0785099	6.333	2.40e-10	***
	strata(tgroup)tgroup=3:FT_PT_Flag	0.1225132	1.1303340	0.1001945	1.223	0.22142	

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CONCLUSIONS

- With each additional year of age at matriculation, the drop out probability increases 1% on average.
- With each 1-point increase in transfer UG GPA, the drop out probability decreases 19% on average.
- With each 10 transfer credits increase, the drop out probability decreases 7% on average.
- URM students are 18% more likely to drop out compared with non-URM students on average.

CONCLUSIONS

- In the first two semesters, STEM majors are 40% less likely to drop out than non-STEM students, but after 4 semesters, they are 33% more likely to drop out than non-STEM students.

- In the first two semesters, students who changed major are 68% less likely to drop out than those did not change major. But from semester three to four, students who changed major are 50% more likely to drop out than those that did not change major. After four semesters, there is no difference.

- In the first two semesters, part-time students are 90% more likely to drop out than full-time students. From semester three to four, they are 60% more likely to drop out. After four semesters, there is no difference.

DISCUSSION: BENEFITS OF SURVIVAL ANALYSIS

- ALLOWS US TO MEASURE THE EFFECT OF FACTORS IN STUDENT SUCCESS THAT VARY OVER TIME THAT LOGISTIC REGRESSION OR MULTIPLE LINEAR REGRESSION ARE UNABLE TO DO.
- PROVIDES INSIGHT INTO WHEN AND HOW INTERVENTIONS MIGHT BE MOST SUCCESSFUL, E.G.,
    - HELPING STUDENTS TO CHOOSE THE APPROPRIATE MAJOR IN THE FIRST YEAR
    - PROVIDING RESOURCES TO HELP TRANSFER STUDENTS ENROLL FULL-TIME, AT LEAST IN THEIR FIRST FEW SEMESTERS
    - REVIEWING POLICIES & PRACTICES THAT MIGHT PREVENT STUDENTS FROM GETTING FULL CREDIT FOR TRANSFERRED COURSES THAT COUNT TOWARD A DEGREE PROGRAM AND/OR GRADUATION

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Please take the opportunity at your earliest convenience to let the planning committee know your thoughts about this year's conference and where you would like to meet next year.

Appendix: R Code

```
# Loading packages ------------------------------------------------------

library(survival)

library(tidyverse)

library(survminer)

library(broom)


# Data importing and processing ------------------------------------------

dataset<- readxl::read_xlsx("Survival_Analysis_dataset.xlsx",sheet = "Sheet1" ) %>% data.frame()


# Subgroup Data

dataset$Age_Group <- with(dataset, case_when (AGE_AT_MATRIC <= 24 ~ 1,

                              AGE_AT_MATRIC > 24 ~ 2))


dataset$TRGPA_Group <- with(dataset, case_when (TRANSFER_UG_GPA < 2.5 ~ 1,

                               TRANSFER_UG_GPA < 3 ~ 2,

                               TRANSFER_UG_GPA <= 4 ~ 3))


dataset$TRCREDIT_Group <- with(dataset, case_when (TRANSFER_CREDIT_HOURS < 30~ 1,

                                 TRANSFER_CREDIT_HOURS < 60 ~ 2,

                                 TRANSFER_CREDIT_HOURS < 90 ~ 3,

                                 TRANSFER_CREDIT_HOURS >= 90 ~ 4))


dataset <- dataset %>%

  mutate(across(c(NCCCS_TRANSFER_IND, UNC_TRANSFER_IND, CHANGED_MAJOR,

            FIN_AID_RECEIVED, NEED_BASED, MERIT, PELL, LOAN, FT_PT_Flag,

            COURSE_DELIVERY, STEM_MAJOR, Age_Group, TRGPA_Group, TRCREDIT_Group, GENDER,
URM), as.factor)) %>%
```

```
  select(Time, Event_Q, AGE_AT_MATRIC, TRANSFER_CREDIT_HOURS, TRANSFER_UG_GPA,
CHANGED_MAJOR, FIN_AID_RECEIVED, FT_PT_Flag, STEM_MAJOR, Age_Group, TRGPA_Group,
TRCREDIT_Group, GENDER, URM

  )

attach(dataset)


# fit the Kaplan-Meier model for the entire data -------------------------

km.model.Q <- survfit(Surv(Time,Event_Q)~1, type="kaplan-meier")

# summary the "step function"

summary(km.model.Q)


# plot the KM function

plot(km.model.Q,conf.int = T, xlab = "semester", ylab = "Survival probility", main= "Kaplan Meier Model
of Drop Out",las=1, mark.time = T)


# Stratified KM Model ---------------------------------------------------

# variable PT/FT

km.model.Q.PT_FT <- survfit(Surv(Time,Event_Q)~FT_PT_Flag, type="kaplan-meier")

summary(km.model.Q.PT_FT)


## use ggsurvplot to plot

ggsurvplot(km.model.Q.PT_FT,data = dataset, conf.int=T, xlab = "Semester", mark.time = F, censor=F)


## gehan-wilcoxon test: set rho = 1

## H0: survival curves across 2 or more groups are equivalent

## HA: survival curves across 2 or more groups are not equivalent

survdiff(Surv(Time,Event_Q)~FT_PT_Flag, rho = 1)



# Cox Proportional Hazard Model ----------------------------------------------------------------
```

```
# fit the Cox-proportional hazard model

cox.model <- coxph(Surv(Time,Event_Q) ~ AGE_AT_MATRIC + STEM_MAJOR +
          CHANGED_MAJOR + TRANSFER_UG_GPA + TRANSFER_CREDIT_HOURS + URM +
          FT_PT_Flag, data = dataset)

summary(cox.model)


## Checking proportional hazard assumption ---------------------------------------------------------------

# H0: covariate effect (Hazards) is constant (proportional) over time

# Ha: covariate effect (Hazards) changes over

zp <- cox.zph(cox.model)

plot(cox.zph(cox.model)[1], xlab = "semester")

abline(h=0,col="red")


# stratified cox ph model ----------------------------------------------

## set cut point of semesters

dataset.split <- survSplit(Surv(Time,Event_Q)~., data=dataset, cut = c(2, 4),episode = "tgroup",id="id")

dataset.split$FT_PT_Flag <- as.numeric (dataset.split$FT_PT_Flag)

dataset.split$STEM_MAJOR <- as.numeric (dataset.split$STEM_MAJOR)

dataset.split$CHANGED_MAJOR <- as.numeric (dataset.split$CHANGED_MAJOR)


## stratified model

stratified_model1 <- coxph(Surv(tstart,Time,Event_Q)~ AGE_AT_MATRIC + STEM_MAJOR:strata(tgroup)
+ CHANGED_MAJOR:strata(tgroup) +  TRANSFER_UG_GPA + TRANSFER_CREDIT_HOURS + URM +
FT_PT_Flag:strata(tgroup), data=dataset.split)

summary(stratified_model1)

cox.zph(stratified_model1)
```