Survival Analysis

Hsueh-Sheng Wu

CFDR Workshop Series

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BGSU Center for Family and Demographic Research

Outline

- Survival analysis steps
- Create data for survival analysis
  - Data for different analyses
  - The dependent variable in Life Table analysis and Cox Regression
  - Reshape data for Discrete-time analysis
- Analyze data
    - Life Table
    - Cox Regression without time-varying variables
    - Discrete-time without time-varying variables
    - Discrete-time with time-varying variables

STEPS for Survival Analysis

- What is the research question
- Locate and select variables
- Establish analytic sample
- Recode variables
- Create timing data for survival analysis
  - Life Tables and Cox Regression
  - Discrete-time analysis
- Analyze data
  - Life Table
  - Cox regression
  - Discrete-time

An example of conducting survival analysis

- Research Question:
  What factors are associated with the timing of first marriage ?

- Variables:
  - Dependent variable: Timing of first marriage

- Predictors:
  - Gender (male/female),
  - Race (black/non-black)
  - Age (continuous)
  - Expectation of marriage at Wave I (continuous)
  - High school graduation (yes/no)

- Weight variables:
  - Region: (West, Midwest, South, and Northeast)
  - Schools (Range 1 to 371)
  - Individual weights (Range 16.3183 to 6649.3618)

- An indicator of whether adolescents are included in the analytic sample
  - sub_pop (yes/no)

Analytic Sample

- The Sample Size:
  - 20, 745 adolescents participated in Wave 1 interview
  - 15, 170 adolescents provided information on marriages at Wave III interview
  - 14,253 adolescents has valid information on the timing of first marriage and weight variables at Wave I
  - 2,855 have married for the first time before Wave III interview
- Respondents who had first marriage before Wave III interview but were excluded from the analytic sample
  - 54 married before Wave I interview
  - 2 married before Age 14
  - 34 had first marriage, but did not have graduation time
- The analytic sample
  - Adolescents with valid responses to marital status, all the predictor variables, and weight variables. The final N = 13, 995.

Create data for survival analysis

- Data for different analysis

Table 1. Data for analyses not involving timing of first marriage

Name	Married	Female	High School Graduation
Tim	0	0	1
Sara	1	1	0
Tom	0	0	0
Sherry	1	1	1

Note:

Married: 1 = Married; 0 = Unmarried

Female: 1 = Female; 0 = Male

High School Graduation: 1 = Graduated from High School; 0 = Did not graduate from High School

Table 2. Data for Life Table and Cox Regression

Name	Married	Time (in months from W1) to getting married or being censored (reaching the W3 having never married)	Female	High School Graduation	Time (in months from W1 interview) to graduating from high school or being censored (i.e., reaching the W3 having not
Tim	0	3	0	1	3
Sara	1	3	1	0	3
Tom	0	5	0	0	5
Sherry	1	5	1	1	4

Note:

Married: 1 = Married; 0 = Unmarried

Female: 1 = Female; 0 = Male

High School Graduation: 1 = Graduated from High School; 0 = Did not graduate from High School

Table 3. Data for Discrete Time Analysis

Name	Month	Married	Female	High School Graduation
Tim	1	0	0	0
	2	0	0	0
	3	0	0	1
Sara	1	0	1	0
	2	0	1	0
	3	1	1	0
Tom	1	0	0	0
	2	0	0	0
	3	0	0	0
	4	0	0	0
	5	0	0	0
Sherry	1	0	1	0
	2	0	1	0
	3	0	1	0
	4	0	1	1
	5	1	1	1

Note:

Married: 1 = Married; 0 = Unmarried

Female: 1 = Female; 0 = Male

High School Graduation: 1 = Graduated from High School; 0 = Did not graduate from High School

Dependent Variable in Life Table and Cox Regression

- **Create the date indicator for:**

  - **Timing of first marriage**

```
gen marriage_t1 = ym(form_y1, form_m1)
label variable  marriage_t1 "century month
for getting married for the first time“
```

  - **Wave I interview**

```
gen interview_t1 = ym(iyear, imonth)
label variable interview_t1 "time for t1 interview"
```

  - **Wave III interview**

```
gen interview_t3 = ym(iyear3, imonth3)
label variable interview_t3 "time for t3 interview“
```

- **Calculate the number of months to first marriage since Wave I interview**

```
gen time1 = marriage_t1 - interview_t1  if (marriage_t1 ~=. & interview_t1~=.)
label variable time1 "time for those got married“
```

- **Calculate the number of months between Wave I and Wave III interview**

```
gen time2 = interview_t3-interview_t1
label variable time2 "time for those did not get married“
```

- **Calculate the number of months to first marriage or censoring**

```
gen time =.
label variable time "timing of the first marriage“
replace time = time1 if time1 ~=. & mar1 ==1
replace time = time2 if mar1 ==0
replace time =. if time1<0
```

Reshape data for Discrete Time Analysis

- **Use the data created for Cox Regression**

```
use "t:\temp\cox.dta", clear
```

Table 4. Data for Cox regression

Name	mar1	time	female	gra	gra_tm
Tim	0	3	0	1	3
Sara	1	3	1	0	3
Tom	0	5	0	0	5
Sherry	1	5	1	1	4

Noted:

mar1: 1 = married for the first time, 0 = did not marry for the first time

time: the number of months to the first marriage since Wave I interview or having never married

Female: 0 = Male, 1 = Female

gra: 1 = Graduated from High School, 0 = Did not

gra_tm: the number of months to high school graduation or having never graduated.

- **Expand each observation into multiple observations, depending on the number of months that each original observation needs to get married for the first time or become censored.**

```
expand time
```

Table 5. Data after using Stata "expand" command

Name	mar1	time	female	gra	gra_tm
Tim	0	3	0	1	3
Tim	0	3	0	1	3
Tim	0	3	0	1	3
Sara	1	3	1	0	3
Sara	1	3	1	0	3
Sara	1	3	1	0	3
Tom	0	5	0	0	5
Tom	0	5	0	0	5
Tom	0	5	0	0	5
Tom	0	5	0	0	5
Tom	0	5	0	0	5
Sherry	1	5	1	1	4
Sherry	1	5	1	1	4
Sherry	1	5	1	1	4
Sherry	1	5	1	1	4
Sherry	1	5	1	1	4

Noted: mar1: 1 = married for the first time, 0 = did not
time: the number of months to the first marriage since Wave I interview or having never married
Female: 0 = Male, 1 = Female
gra: 1 = Graduated from High School, 0 = Did not
gra_tm: the number of months to high school graduation or having never graduated.

- **Sort the data by the ID variable. Generate a variable "month" to indicate which month to which the observation now belongs.**

```
sort aid
by aid: gen month=_n
```

Table 6. Data after the "month" variable was generated

Name	mar1	time	female	gra	gra_tm	month
Tim	0	3	0	1	3	1
Tim	0	3	0	1	3	2
Tim	0	3	0	1	3	3
Sara	1	3	1	0	3	1
Sara	1	3	1	0	3	2
Sara	1	3	1	0	3	3
Tom	0	5	0	0	5	1
Tom	0	5	0	0	5	2
Tom	0	5	0	0	5	3
Tom	0	5	0	0	5	4
Tom	0	5	0	0	5	5
Sherry	1	5	1	1	4	1
Sherry	1	5	1	1	4	2
Sherry	1	5	1	1	4	3
Sherry	1	5	1	1	4	4
Sherry	1	5	1	1	4	5

Noted:

mar1: 1 = married for the first time, 0 = did not marry for the first time

time: the number of months to the first marriage since Wave I interview or having never married

Female: 0 = Male, 1 = Female

gra: 1 = Graduated from High School, 0 = Did not graduate from High School

gra_tm: the number of months to high school graduation or having never graduated.

- **Create a variable, married, to indicate the transition to first marriage.**

```
gen married=0
replace married=mar1 if month==time
```

Table 7. Data after the "married" variable was generated

Name	mar1	time	female	gra	gra_tm	month	married
Tim	0	3	0	1	3	1	0
Tim	0	3	0	1	3	2	0
Tim	0	3	0	1	3	3	0
Sara	1	3	1	0	3	1	0
Sara	1	3	1	0	3	2	0
Sara	1	3	1	0	3	3	1
Tom	0	5	0	0	5	1	0
Tom	0	5	0	0	5	2	0
Tom	0	5	0	0	5	3	0
Tom	0	5	0	0	5	4	0
Tom	0	5	0	0	5	5	0
Sherry	1	5	1	1	4	1	0
Sherry	1	5	1	1	4	2	0
Sherry	1	5	1	1	4	3	0
Sherry	1	5	1	1	4	4	0
Sherry	1	5	1	1	4	5	1

Noted: mar1: 1 = married for the first time, 0 = did not marry for the first time
time: the number of months to the first marriage since Wave I interview or having never married

Female: 0 = Male, 1 = Female
gra: 1 = Graduated from High School, 0 = Did not graduate from High School

gra_tm: the number of months to high school graduation or having never graduated.

- **Check the accuracy of timing of first marriage**

```
tab1 married if sub_pop ==1
```

- **Create a variable, graduated, to indicate the timing of high school graduation.**

```
gen graduated=0
replace graduated = gra if month >= gra_tm
```

Table 8. Data after the "graduated" variable was generated

Name	mar1	time	female	gra	gra_tm	month	married	graduated
Tim	0	3	0	1	3	1	0	0
Tim	0	3	0	1	3	2	0	0
Tim	0	3	0	1	3	3	0	1
Sara	1	3	1	0	3	1	0	0
Sara	1	3	1	0	3	2	0	0
Sara	1	3	1	0	3	3	1	0
Tom	0	5	0	0	5	1	0	0
Tom	0	5	0	0	5	2	0	0
Tom	0	5	0	0	5	3	0	0
Tom	0	5	0	0	5	4	0	0
Tom	0	5	0	0	5	5	0	0
Sherry	1	5	1	1	4	1	0	0
Sherry	1	5	1	1	4	2	0	0
Sherry	1	5	1	1	4	3	0	0
Sherry	1	5	1	1	4	4	0	1
Sherry	1	5	1	1	4	5	1	1

Noted:
mar1: 1 = married for the first time, 0 = did not marry for the first time
time: the number of months to the first marriage since Wave I interview or having never married
Female: 0 = Male, 1 = Female
gra: 1 = Graduated from High School, 0 = Did not graduate from High School
gra_tm: the number of months to high school graduation or having never graduated.

- ***Check the accuracy of high school graduation***

```
sort aid
by aid: gen N=_N
tab1 gra if supop==1 & N==month
```

Table 9. Data for checking the accuracy of high school graduation

Name	mar1	time	female	gra	gra_tm	month	married	graduated	N
Tim	0	3	0	1	3	1	0	0	3
Tim	0	3	0	1	3	2	0	0	3
Tim	0	3	0	1	3	3	0	1	3
Sara	1	3	1	0	3	1	0	0	3
Sara	1	3	1	0	3	2	0	0	3
Sara	1	3	1	0	3	3	1	0	3
Tom	0	5	0	0	5	1	0	0	5
Tom	0	5	0	0	5	2	0	0	5
Tom	0	5	0	0	5	3	0	0	5
Tom	0	5	0	0	5	4	0	0	5
Tom	0	5	0	0	5	5	0	0	5
Sherry	1	5	1	1	4	1	0	0	5
Sherry	1	5	1	1	4	2	0	0	5
Sherry	1	5	1	1	4	3	0	0	5
Sherry	1	5	1	1	4	4	0	1	5
Sherry	1	5	1	1	4	5	1	1	5

Noted: mar1: 1 = married for the first time, 0 = did not marry for the first time
time: the number of months to the first marriage since Wave I interview or having never married
Female: 0 = Male, 1 = Female
gra: 1 = Graduated from High School, 0 = Did not
gra_tm: the number of months to high school graduation or having never graduated.

Save the data set for future use

```
save "t:\temp\discrete.dta", replace
```

Analyze data

A. Life table

Stata commands:

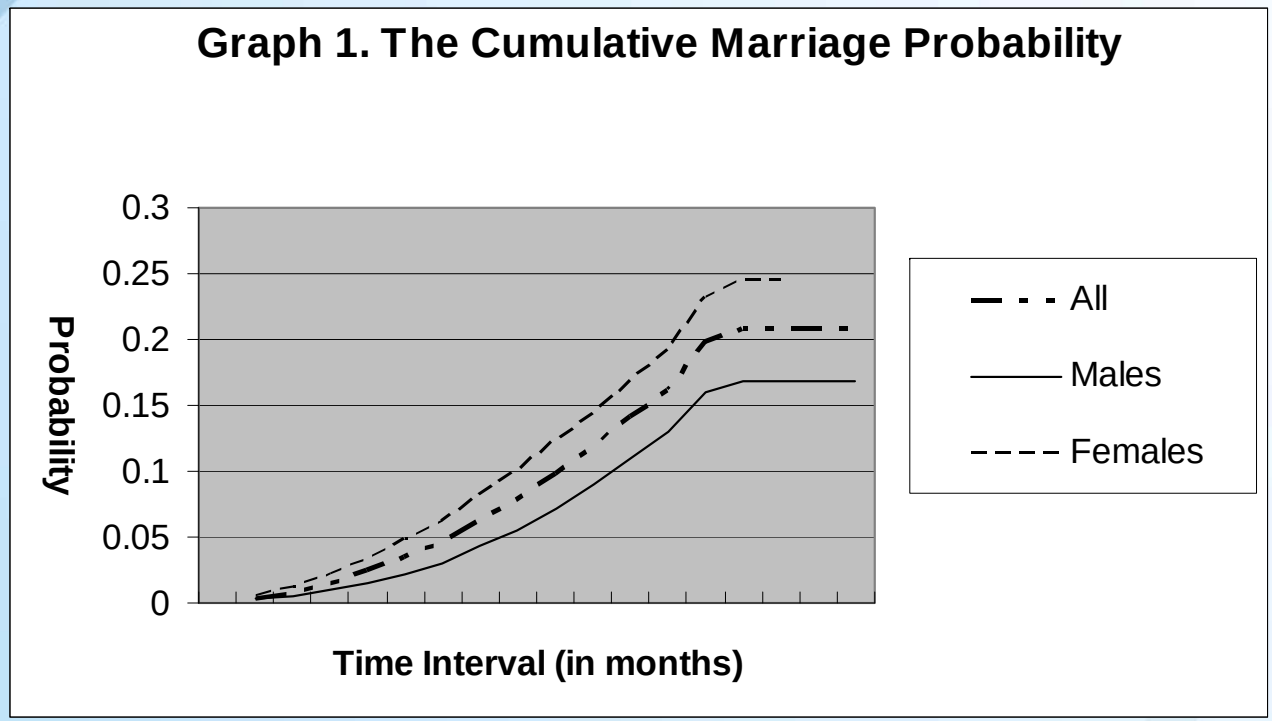
```
ltable time mar1 if sub_pop ==1, hazard
ltable time mar1 if sub_pop ==1
```

Results:

Life Table for the Whole Sample

Interval (in months)			# of Single Adolescents	# of Adolescents Married	Lost to Follow-Up	Hazards	Cumulative Marriage Probability
0	→	6	13995	54	0	0.0039	0.0039
6	→	12	13941	68	0	0.0049	0.0087
12	→	18	13873	95	0	0.0069	0.0155
18	→	24	13778	128	0	0.0093	0.0247
24	→	30	13650	155	0	0.0114	0.0357
30	→	36	13495	153	0	0.0114	0.0467
36	→	42	13342	232	0	0.0175	0.0632
42	→	48	13110	220	0	0.0169	0.079
48	→	54	12890	274	0	0.0215	0.0985
54	→	60	12616	273	0	0.0219	0.118
60	→	66	12343	323	0	0.0265	0.1411
66	→	72	12020	290	400	0.0248	0.1622
72	→	78	11330	327	7288	0.0435	0.1978
78	→	84	3715	25	3682	0.0134	0.2085
84	→	90	8	0	6	0	0.2085
90	→	96	2	0	1	0	0.2085
96	→	102	1	0	1	0	0.2085

Life Table Graph



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B. Cox regression without Time varying variables

•Stata commands

```
use "T:\temp\cox.dta", clear
svyset psuscid1 [pweight = gswgt1], strata(region1)
stset time, f(mar1)
svy, subpop(sub_pop): stcox female black age_t1 expect
```

• Results:

```
Survey: Cox regression

Number of strata   =         4                  Number of obs      =     14253
Number of PSUs     =       132                  Population size    =  16629862
                                                Subpop. no. of obs =     13995
                                                Subpop. size       =  16297823
                                                Design df          =       128
                                                F(   4,    125)    =    101.86
                                                Prob > F           =    0.0000

------------------------------------------------------------------------------
             |             Linearized
          _t | Haz. Ratio   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      female |   1.740813    .097873     9.86   0.000     1.557538    1.945654
       black |   .5463479   .0565109    -5.84   0.000     .4452316    .6704288
      age_t1 |   1.030068   .0019299    15.81   0.000     1.026256    1.033894
      expect |   1.266699   .0343744     8.71   0.000     1.200477    1.336573
------------------------------------------------------------------------------
```

C. Discrete-time Analysis without Time-varying Variables

- Stata commands:

```
use "T:\temp\discrete.dta", clear
svyset psuscid1 [pweight = gswgt1], strata(region1)
char month [omit] 77
xi: svy, subpop(sub_pop): logistic married i.month female black age_t1 expect
```

- Results:

```
Survey: Logistic regression
Number of strata   =         4                  Number of obs      =     1033582
Number of PSUs     =       132                  Population size    =  1209145097
                                                Subpop. no. of obs =     1010143
                                                Subpop. size       =  1178862615
                                                Design df          =         128
                                                F(  85,     44)    =       21.35
                                                Prob > F           =      0.0000
------------------------------------------------------------------------------
             |             Linearized
     married | Odds Ratio   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   _Imonth_1 |   .0855008   .0477686    -4.40   0.000     .0283055    .2582668
   _Imonth_2 |   .0622853   .0339932    -5.09   0.000     .0211541    .1833904
         .
         .
         .
  _Imonth_75 |    1.04427   .3475159     0.13   0.897     .5405591    2.017355
  _Imonth_76 |   1.187808   .3981339     0.51   0.609     .6119474     2.30557
  _Imonth_78 |   .3509662   .1625097    -2.26   0.025     .1404001    .8773308
  _Imonth_79 |   .1736188   .1291074    -2.35   0.020     .0398639    .7561599
  _Imonth_80 |   .6049959   .3388633    -0.90   0.371     .1997271    1.832601
  _Imonth_81 |   .3521969   .2508042    -1.47   0.145     .0860692    1.441196
  _Imonth_82 |   .1178069   .1170397    -2.15   0.033     .0164983    .8412027
      female |   1.745988   .0986846     9.86   0.000     1.561246     1.95259
       black |   .5448028   .0566048    -5.85   0.000     .4435634    .6691493
      age_t1 |   1.030225   .0019416    15.80   0.000     1.026391    1.034075
      expect |   1.268406    .03462     8.71   0.000     1.201722    1.338792
------------------------------------------------------------------------------
```

D. Discrete-time Analysis with a Time-varying Variable

- Stata commands:

```
use T:\temp\discrete, clear
svyset psuscid1 [pweight = gswgt1], strata(region1)
char month [omit] 77
 xi: svy, subpop(sub_pop): logistic married i.month female black age_t1 expect
graduated
```

- Results:

```
Survey: Logistic regression
Number of strata   =         4                  Number of obs      =     1033582
Number of PSUs     =       132                  Population size    =  1209145097
                                                Subpop. no. of obs =     1010143
                                                Subpop. size       =  1178862615
                                                Design df          =         128
                                                F(  86,     43)    =       21.55
                                                Prob > F           =      0.0000
------------------------------------------------------------------------------
             |             Linearized
     married | Odds Ratio   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   _Imonth_1 |   .0985339   .0562077    -4.06   0.000     .0318707    .3046348
   _Imonth_2 |   .0711091   .0398916    -4.71   0.000     .0234342    .2157742
         .
         .
         .
  _Imonth_75 |   1.043885   .3469749     0.13   0.897     .5407833    2.015034
  _Imonth_76 |   1.187321   .3974025     0.51   0.609     .6122765    2.302444
  _Imonth_78 |   .3518995   .1629764    -2.26   0.026      .140746    .8798348
  _Imonth_79 |   .1739343   .1292685    -2.35   0.020     .0399697    .7569009
  _Imonth_80 |   .6069465   .3397445    -0.89   0.374     .2005091    1.837244
  _Imonth_81 |   .3532947   .2515898    -1.46   0.146     .0863356    1.445719
  _Imonth_82 |   .1178734   .1171192    -2.15   0.033      .016504    .8418673
      female |   1.731455   .0973056     9.77   0.000     1.549238    1.935104
       black |   .5521323   .0567529    -5.78   0.000     .4505203    .6766624
      age_t1 |   1.028714   .0019135    15.22   0.000     1.024935    1.032508
      expect |   1.266885   .0345654     8.67   0.000     1.200305    1.337159
   graduated |   1.232447   .1226013     2.10   0.038     1.012242    1.500556
------------------------------------------------------------------------------
```

Conclusion

- Survival analysis examines the timing of an event and allows researchers to test factors that may lead to the occurrence of the event.
- For life Table and Cox Regression, there is a need to construct the variables indicating when the event and its predicators occurred. For discrete-time analysis, the data need to be transformed into person-period format.
- Discrete-time analysis is more flexible than Cox Regression.
  - The dummy variables for time can delineate the magnitude of hazards at each time point.
  - Time-varying variables can be easily included in the models
  - It can be extended to examine Multinomial logistic regression.
- For more information on survival analysis
  - Dr. Alfred Demaris has written a book, “Regression With Social Data: Modeling Continuous and Limited Response Variables”. This book provides detailed information about assumptions and estimations of several survival models.
  - Dr. Judith Singer and Dr. John Willett have published a book, called “Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence”. Data sets, computer programs, outputs and PowerPoint slides for the examples used in this book can be found at http://gseacademic.harvard.edu/alda/
  - University of California at Los Angeles has helpful information on using SAS, Stata, and SPSS for conducting survival analysis at http://www.ats.ucla.edu/stat/seminars/.
  - Dr. David Garson has provided excellent documents on Life Table, Cox Regression, and Event History at http://faculty.chass.ncsu.edu/garson/PA765/statnote.htm.

Handout

Outline of Handout

- Variables used for conducting survival analysis with Add Health data
- Constructing variables for Life Table Analysis and Cox regression
  - Timing of first marriage
  - Age at Wave I interview
  - High school graduation
- Constructing time-varying variables for discrete-time analysis
  - Status of first marriage
  - Status of high school graduation
- Stata commands for survival analysis
  - Life Table analysis
  - Cox regression without time-varying variables
  - Discrete-time analysis without time-varying variables
  - Discrete-time analysis with time-varying variables

Variables used for Conducting Survival Analysis with Add Health data

Table 1. Variables used for Conducting Survival Analysis with Add Health Data

Constructs	Original Variable Name	New variable Name	Response categories
First marriage and its covariates			
Marriage Sequence Number	h3mr_m_a	mar1	1st marriage[1]; legitimate skip [7]
Female	bio_sex3	female	male [1]; female [2]
Being Black	H3OD4B	black	marked [1]; Not marked[0]
Age at Wave I	N/A	N/A	N/A
Expectation of marriage at Wave I	h1ee13	expect	almost no chance [1]; some chance, but probably not [2]; a 50-50 chance [3]; a good chance [4]; almost certain [5];
High School Diploma	H3ED3	hsd	Marked [1]; Not marked[0]
GED or high school equivalency degree	H3ED2	ged	Marked [1]; Not marked[0]

Table 1. Variables used for Conducting Survival Analysis with Add Health Data (continued)

Constructs	Original Variable Names	New variable Name	Response categories
Variables related with timing			
Year of Interview at Wave I	iyear	interview_y1	From 1994 to 1995
Month of Interview at Wave I	imonth	interview_m1	From January to December
Year of Interview at Wave III	iyear3	interview_y3	From 2001 to 2002
Month of Interview at Wave III	imonth3	interview_m3	From January to December
Year of getting married for the first time	h3mr2m_a	form_y	From 1985 to 2002
Month of getting married for the first time	h3mr2y_a	form_m	From January to December
Year of Birth from Interview at Wave I	h1gi1y	birth_y1	From 1974 to 1983
Month of Birth from Interview at Wave I	h1gi1m	birth_m1	From January to December
Year of Birth from Interview at Wave III	h3od1y	birth_y3	From 1974 to 1983
Month of Birth from Interview at Wave III	h3od1m	birth_m1	From January to December
Year of getting High School Diploma	h3ed13y	hsd_y	From 1977 to 2002
Month of getting High School Diploma	h3ed13m	hsd_m	From January to December
Year of getting General Education Diploma	h3ed12y	ged_y	From 1977 to 2002
Month of getting General Education Diploma	h3ed12m	ged_m	From January to December

Table 1. Variables used for Conducting Survival Analysis with Add Health Data (continued)

Constructs	Original Variable Names	New variable Name	Response categories
Weights variables			
Weights for region at W1	region1		West [1]; Midwest [2]; South [3]; Northeast [4];
Weights for school at WI	psuscid1		Range 001 to 371
Grand Sample Weight - W1	gswgt1		Range 16.3183 to 6649.3618
Constructed variables			
Life Tables and Cox regression			
Timing of first marriage		time	Range 1-97
Age at Wave I interview		age_t1	Range 137 to 256
High school graduation in the data for Life Tables and Cox regression		gra	Graduated [1]; Did not graduate [0]
Timing of high school graduation		gra_tm	Range 1 to 84
Indicator of being included in the analytic sample		sub_pop	Being included [1]; Not being included [0]
Discrete-time analysis			
Status of first marriage in Discrete-time analysis		married	Graduated [1]; Did not graduate [0]
High school graduation in the data for Discrete Time analysis		graduated	Graduated [1]; Did not graduate [0]

Constructing variables for Life Table analysis and Cox regression

A. Timing of first marriage or being censored

- **Create a variable for timing of first marriage**

```
gen marriage_t1 = ym(form_y1, form_m1)
label variable  marriage_t1 "century month
for getting married for the first time“
```

- **Create a variable for timing of Wave I interview**

```
gen interview_t1 = ym(iyear, imonth)
label variable interview_t1 "time for t1 interview"
```

- **Create a variable for timing of Wave III interview**

```
gen interview_t3 = ym(iyear3, imonth3)
label variable interview_t3 "time for t3 interview“
```

- **Calculate the number of months to first marriage since Wave I interview**

```
gen time1 = marriage_t1 - interview_t1  if (marriage_t1 ~=. & interview_t1~=.)
label variable time1 "time for those got married“
```

- **Calculate the number of months between Wave I and Wave III interviews**

```
gen time2 = interview_t3-interview_t1
label variable time2 "time for those did not get married“
```

- **Calculate the number of months to first marriage or being censored**

```
gen time =.
label variable time "timing of the first marriage“
replace time = time1 if time1 ~=. & mar1 ==1
replace time = time2 if mar1 ==0
replace time =. if time1 <0
```

B. Age at Wave I Interview

- **Create a birth-year variable. If an adolescent did not report his/her birth year at Wave I interview, his/her report of birth-year at Wave III interview was used.**

```
gen birth_y = birth_y1
replace birth_y = birth_y3 if birth_y1 ==.
```

- **Create a birth-month variable. If an adolescent did not report his/her birth year at Wave I interview, his/her report of the birth-month data at Wave III interview was used.**

```
gen birth_m = birth_m1
replace birth_m = birth_m3 if birth_y1 ==.
```

- **Create the month indicator for age at Wave I**

```
gen birth_t1 = ym(birth_y, birth_m)
```

- **Create the age variable**

```
gen age_t1 = interview_t1 - birth_t1
label variable age_t1 “age at WI interview”
```

C. High School Graduation

C1. Status of high school graduation

- **Create an dummy variable to indicate the status of high school graduation.**

```
gen gra =.
label variable gra "have high school or GED diplomas"
label define gra 1 "yes" 0 "no"
label value gra gra
```

- **Adolescents are viewed as having graduated from high school if they had either high school diploma or general education diploma.**

```
replace gra = 1 if (hsd ==1 | ged ==1) & mar1 ~=.
replace gra = 0 if (hsd ==0 & ged ==0) & mar1 ~=.
replace gra = 0 if (hsd ==0 & ged ==.) & mar1 ~=.
replace gra = 0 if (hsd ==. & ged ==0) & mar1 ~=.
```

C2.Timing of high school graduation

- **Create the date indicator for the time when adolescent graduated from high school or being censored**

```
gen gra_t1 = ym(gra_y, gra_m)
label variable gra_t1 "time of graduating from high school“
```

- **Calculate the timing of high school graduation**

```
gen gra_tm = gra_t1 - interview_t1  if (gra_t1 ~=. & interview_t1~=.)
label variable gra_tm “time to high school graduation”
```

- **For respondents who graduated before Wave I interview, the value of gra_tm was set to 0.**

```
replace gra_tm = 0 if (gra_t1 < interview_t1) &
(gra_t1 ~=. & interview_t1 ~=.)
```

- **For respondents who graduated after Wave III interview, the value of gra_tm was set to the months between Wave I and III interviews**

```
replace gra_tm = interview_t3 - interview_t1 if (gra_t1 > interview_t3)
& (gra_t1 ~=. & interview_t3 ~=.)
```

Constructing time-varying variables for discrete-time analysis

A. the Status of first marriage

- **Expand the data, based on the timing of the first marriage. This step creates the person-period data for discrete-time analysis**

```
expand time
```

- **Sort the data, based on the ID variable. Create a variable, month, to indicate the number of month to which each personal record refers.**

```
sort aid
by aid: gen month=_n
```

- **Generate a variable, married, to indicate the status of first marriage. The value of the status of first marriage was initially set to 0, and this value changed to the value of marital status (i.e., mar1) if person-period records whose time indicators (i.e., month) have the same value as the variable for timing of first marriage (i.e., time).**

```
gen married=0
replace married=mar1 if month==time
```

- **Check the accuracy of the status of first marriage**

```
tab1 married if sub_pop ==1
```

B. Status of High School Graduation

- **Expand the data, based on the timing of the first marriage. This step creates the person-period data for discrete-time analysis**

```
expand time
```

- **Sort the data, based on the ID variable. Create a variable, month, to indicate the number of month to which each personal record refers.**

```
sort aid
by aid: gen month=_n
```

- **Generate a variable, graduated, to indicate the status of high school graduation. The value of the status of high school graduation was initially set to 0, and this value changes to the value of high graduation status (i.e., gra)for person-period records whose time indicators (i.e., month) have a values equals to or is grater than the value of the timing variable for high graduation (i.e., gra_m)**

```
gen graduated=0
replace graduated = gra if month >= gra_tm
```

- **Check the accuracy of high school graduation**

```
sort aid
by aid: gen N=_N
tab1 gra if supop==1 & N==month
```

Stata command for survival analysis

A. Life Table analysis

```
ltable time mar1 if sub_pop ==1, hazard

ltable time mar1 if sub_pop ==1
```

B. Cox Regression without time-varying variables

```
svyset psuscid1 [pweight = gswgt1], strata(region1)

stset time, f(mar1)

svy, subpop(sub_pop): stcox female black age_t1 expect
```

C. Discrete-time without time-varying variables

```
svyset psuscid1 [pweight = gswgt1], strata(region1)

char month [omit] 77

xi: svy, subpop(sub_pop): logistic married i.month female
black age_t1 expect
```

D. Discrete-time with time-varying variables

```
svyset psuscid1 [pweight = gswgt1], strata(region1)

char month [omit] 77

xi: svy, subpop(sub_pop): logistic married i.month female
black age_t1 expect graduated
```