# Introduction to Event History Analysis

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CFDR Workshop Series

February 21, 2022

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# Outline

- What is event history analysis?
- Event history analysis steps
- Create data for event history 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
- Conclusion

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# What is event history analysis?

- Event history analysis is a “time to event” analysis, that is, we follow subjects over time and observe at which point in time they experience the event of interest
- Event history analysis can establish the causal relation between independent variables and the dependent variable because of a clear temporal order of independent variables and the dependent variable.
- The data used for event history analysis can include all information from respondents that drop out of the study later.
- Both SAS and Stata can be used to conduct event history analysis, but Stata allows you to better take into account complex survey design

# What is event history analysis (continued)?

Examples:

Brown, Bulanda, & Lee (2012) Transitions Into And Out Of Cohabitation In Later Life. Journal Of Marriage And Family, 74, 774-793

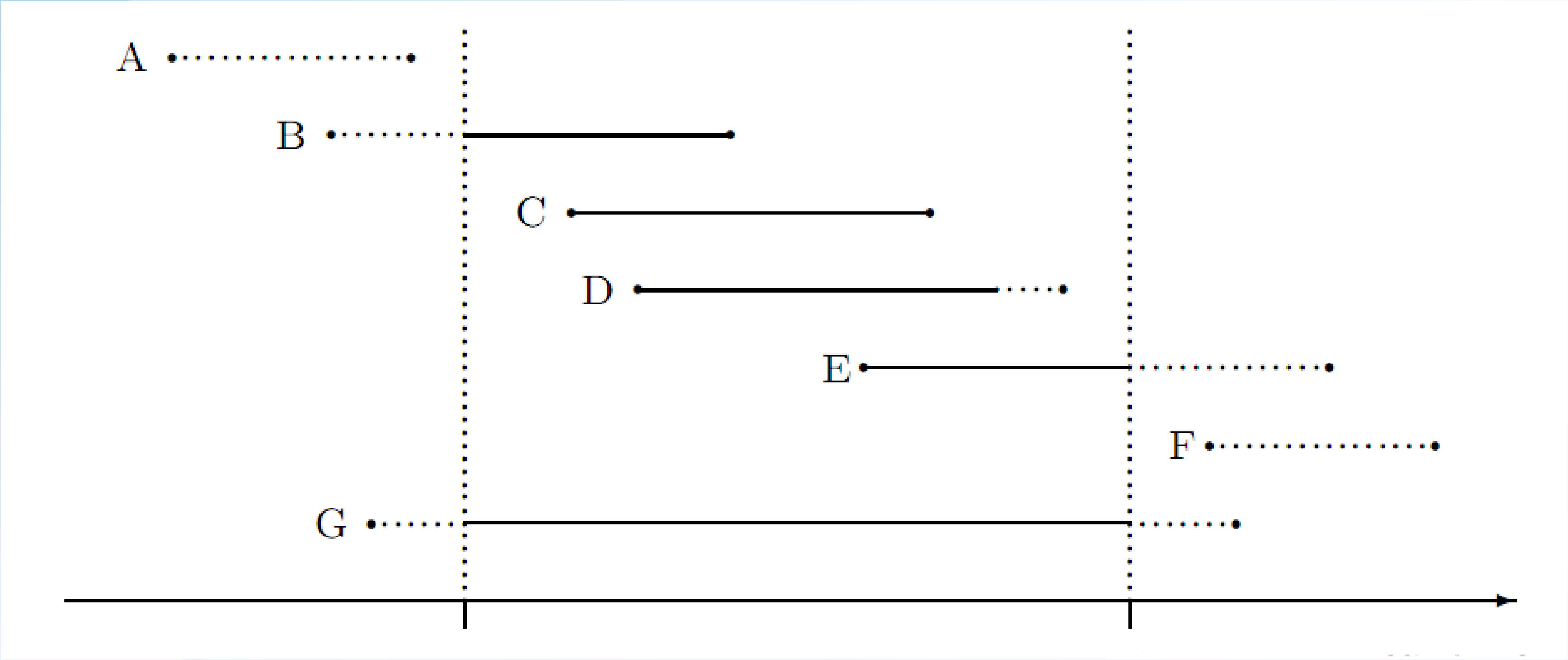
Kuhl, Warner, & Wilczak (2012) Adolescent Violent Victimization And Precocious Union Formation, Criminology,50,1089-1127

Longmore, Manning, & Giordano (2001) Preadolescent Parenting Strategies And Teens' Dating And Sexual Initiation: A Longitudinal Analysis. Journal Of Marriage And Family, 322-335

Manning & Cohen (2012) Premarital Cohabitation And Marital Dissolution: An Examination Of Recent Marriages ,Journal Of Marriage And Family, 74, 377-387

# What is event history analysis (continued)?

Figure 1. Different types of censoring




Start of the study (e.g., Wave I)

End of the study (e.g., Wave III)

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# What is event history analysis (continued)

- A is fully censored on the left
- B is partially censored on the left
- C is complete
- D is censored on the right within the study period
- E is censored on the right
- F is completely censored on the right
- G represents a duration that is left and right censored

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# STEPS for event history analysis

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

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# An example of conducting event history 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.

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# Create data for event history analysis

- Three different data formats for different analysis

Table 1. Data for analyses not involving the examination the 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

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Table 2. Data for Life Table and Cox Regression, and the timing of independent and dependent variables are included in the data file.

| 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, and the timining of independent and dependent variables are transformed into person-time data

| 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

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# 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
```

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# 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.

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- **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.

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- **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.

- **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.

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# Analyze data

A. Life table

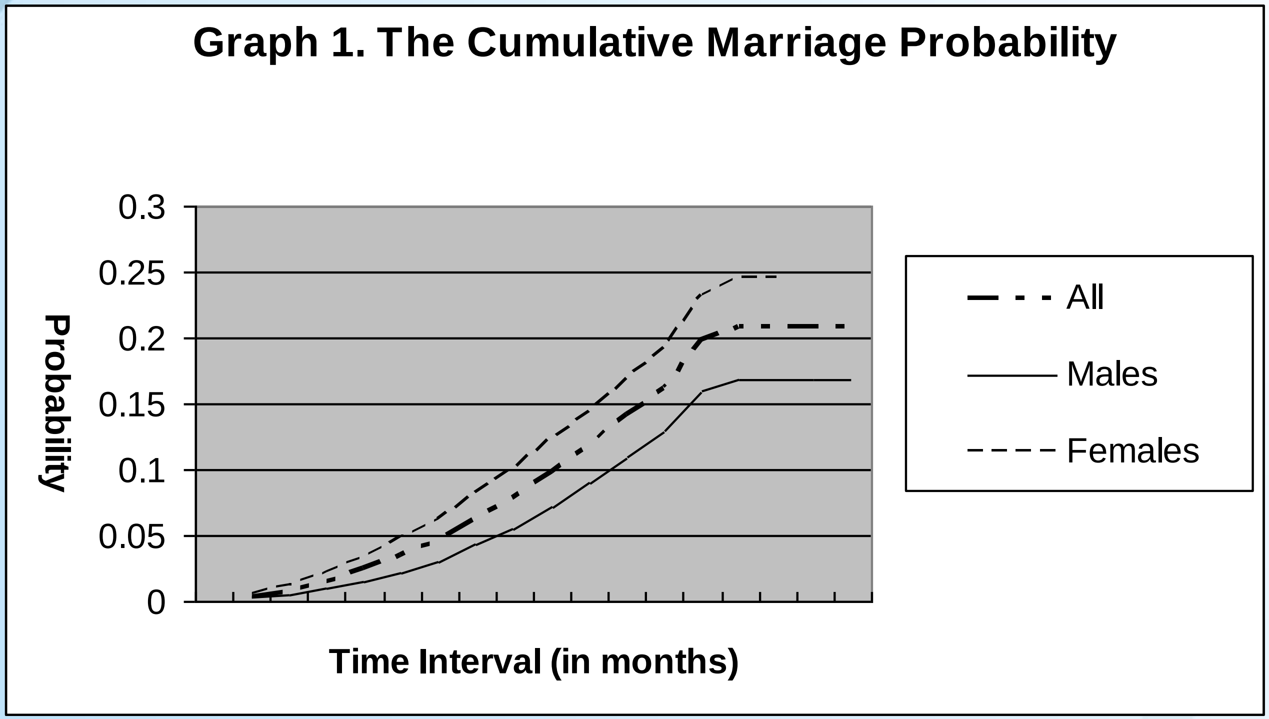
```
Stata commands:
ltable time mar1 if sub_pop ==1, hazard
ltable time mar1 if sub_pop ==1
```

```
Results:
```

Table 5. 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
------------------------------------------------------------------------------
```

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# 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

- Event history 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
  - People who know about logistic regression can easily understand discrete-time analysis.

- For more information on event history 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 event history 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.