Survival Analysis of Breastfeeding Cessation

STAT 639V Survival Analysis Final Project

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Contents

Introduction

Breastfeeding has been a topic of academic and public interest since the invention of formula and the feeding bottle in the 19th century (Stevens, Patrick, and Pickler 2009). Since the invention of baby formula, breastfeeding rates have reduced dramatically. The breastfeeding rate was 90% in the 20th century, but has decreased to approximately 37% in the 21st century (Gaynor 2003; Victora et al. 2016). This trend has many scientists concerned (McFadden et al. 2016; Pérez-Escamilla 2020; Pomeranz et al. 2021).

The importance of breastfeeding in low and middle-income nations is widely acknowledged. In low-income nations, unclean water in formula is a death sentence for an infant. Perhaps this partially explains why the prevalence of breastfeeding is higher in low and middle-income nations than in high-income nations. A large body of scientific research spanning public health studies to cell biology experiments show the importance of promoting infant breastfeeding everywhere (Walters, Phan, and Mathisen 2019). From kick-starting the infant's gut microbiome via human milk oligosaccharides, to the transfer of important immune molecules (e.g. IgA) to transfer of stem cells (Hassiotou and Hartmann 2014) and micro-RNAs from mother to infant suggested to regulate infant gene expression (Munch et al. 2013; Esch et al. 2020). Beyond positive impacts on the child's current and future health, benefits have been shown for the breast feeding mother as well (León-Cava et al. 2002). From the World Health Organization to the American Academy of Pediatrics (Eidelman et al. 2012), most doctors and organizations avidly support exclusive breastfeeding during the first six month of an infant's life.

It is apparent that breastfeeding is important for health – or is it? Despite the ubiquity of recommendations regarding breastfeeding, there exists less high quality data on the topic than might be expected. Ethical considerations make the gold standard double-blind experimental design a non-starter, so observational studies and their confounding baggage are the norm in breastfeeding literature. A hallmark study in the 1990's in Belarus called the PROBIT trial involved 17,000 mothers which were experimentally "treated" with promotion of breastfeeding while the control group was not (Kramer et al. 2001). The results of this trial were mixed. In the context of immediate health benefits of the child, breast feeding showed a significant reduction in: number of gastrointestinal infections, likelihood of eczema and other rashes. However, no significant differences were seen in any other considered outcomes (e.g., respiratory infections, ear infections, wheezing, mortality). Regarding long-term outcomes, the PROBIT trial found no effect on any long-term outcomes measured. Sibling studies, which compare outcomes of siblings pairs where one was breastfed while the other bottle fed, find no impact on any measured outcomes (Colen and Ramey 2014; Raissian and Su 2018).

It has been argued that the differences seen in many observational studies comparing breast and bottle fed infants are the result of maternal selection. In other words, mothers are not deciding randomly whether to feed their infants with breast or bottle. In the US, mothers who breastfeed tend to be more highly educated and wealthier than mothers who bottle feed. A recent study suggests

> *"…most physical health benefits associated with breastfeeding are likely attributable to demographic characteristics such as race and socioeconomic status, and other difficult to measure unobservable characteristics."* - (Raissan and Su, 2018)

The controversy is not against breastfeeding, especially in low-income nations, rather it is promoting communication evidence-based of the magnitude of benefits of breastfeeding.

It is in the context of thinking about a mother's breastfeeding decisions through a socioeconomic lens that this project examines time to cessation of breastfeeding data of new mothers from the National Longitudinal Survey of Youth (NSLY, 1995). A finding that demographic factors have no effect on time to cessation of breastfeeding would be unexpected based on the claims of Raissian and Su (2018). A finding of significant differences does not confirm their assertions, but rather provides valuable information about relevant demographic variables related to breast feeding cessation and context for considering some observational research finding drastic benefits of breast feeding. Additionally, this analysis shows the utility of survival analysis methodology in time-to-event scenarios such as breast feeding cessation.

The Data

This project utilizes data on breastfeeding decisions of young mothers compiled from the National Longitudinal Survey of Youth (NLSY, 1995) personal interviews conducted by the United States Bureau of Labor Statistics branch of the US Department of Labor. All NLSY files are public access, and can be downloaded from http://www.bls.gov/nls/nlsy79.html. The data set was compiled as part of the text *Survival Analysis Techniques for Censored and truncated data* by Klein and Moeschberger (2003), available in the `KMsurv` package as `bfeed`.

Variables

The data is comprised of data from 927 new mothers, with 10 variables recorded for each individual. Descriptions for each variable recorded can be seen in Table 1 below. There are six categorical variables, of which only `race` of mother has more than two categories. There are 4 numerical variables, all discrete integers with a sufficient number of values to loosely approximate continuity.

Table 1: List of variable IDs and their definitions

No.	Variable ID	Variable definition
1	duration	duration of breastfeeding (weeks)
2	delta	indicator of child weaning
3	race	race of mother
4	poverty	mother in poverty
5	smoke	mother smoked at birth of child
6	alcohol	mother used alcohol at birth of child
7	agemth	age of mother at birth of child
8	ybirth	year of birth
9	yschool	education level of mother (years of school)
10	pc3mth	prenatal care after 3rd month

The *event* in this data is self-reported cessation of breastfeeding of new mothers interviewed. In the context of time-to-event analysis, the indicator variable for whether or not breastfeeding had been ceased at the time of the interview was `delta`, and the time from birth of the child to cessation of breastfeeding is coded as the variable `duration`. If the mother has not yet stopped breastfeeding the child at the time of the interview, then the `duration` variable instead represents time from birth of the child to time of the interview. In the context of survival analysis, these data are considered to be right-censored. In other words, for these patients the study stopped before the event of stopping breastfeeding had not yet occurred. It is unclear the exact definition of *completing breast feeding* utilized in the survey methodology. Whether this means the end of utilizing breast milk as the sole food source for the child vs completely removing breast milk from the infant's diet. To summarize, variables three through ten in Table 1 are candidate predictors for variable one while accounting for the censoring of some participants indicated via variable two.

Experimental Design

Data on breastfeeding used in this study has been extracted from a large set of surveys sampling several thousand individuals, many of whom have been surveyed over decades. The NLSY79 Child and Young Adult surveys include a wide variety of information on children born to female respondents of the NLSY79 surveys. Parents reported in interviews on many aspects of the raising of their child, among that corpus of information are the data shown here.

Participants were chosen randomly from the United States population for the study, so responses from all 50 states and outlying territories are included in the sample. Detailed information about the design of the survey is available at https://www.bls.gov/nls/nlsy79.htm#intro-to-sample. Relevant surveys were conducted from 1979 through 1986 and questions related to breastfeeding were asked to mothers who had given birth in the past 12 months. Information about duration of breastfeeding was provided by mothers via memory recall.

Responses to other variables (e.g. smoking at the time of birth) were also provided by the mother. A sample of the data itself can be seen in Table 2. The `SurvObj` variable combines the `duration` and `delta` variables to give duration with participants who were still breastfeeding at last interview denoted with the `+` symbol.

Table 2: Time to cessation of breastfeeding data set

duration	delta	race	poverty	smoke	alcohol	agemth	ybirth	yschool	pc3mth	SurvObj
16	yes	white	no	no	yes	24	1982	14	no	16
1	yes	white	no	yes	no	26	1985	12	no	1
4	no	white	no	no	no	25	1985	12	no	4+
3	yes	white	no	yes	yes	21	1985	9	no	3
36	yes	white	no	yes	no	22	1982	12	no	36

Censoring and Missing Values

In this data set, a total of 35 mothers were still breastfeeding their infant at the time of their final data collection interview. Most of these censoring events occurred in the final year(s) of the study, when time from birth to final interview was significantly less than the nearly 10 years from birth of child to final interview of the earliest participants in the study. The compiled dataset does not contain any information about possible patient drop-out or missed interviews.

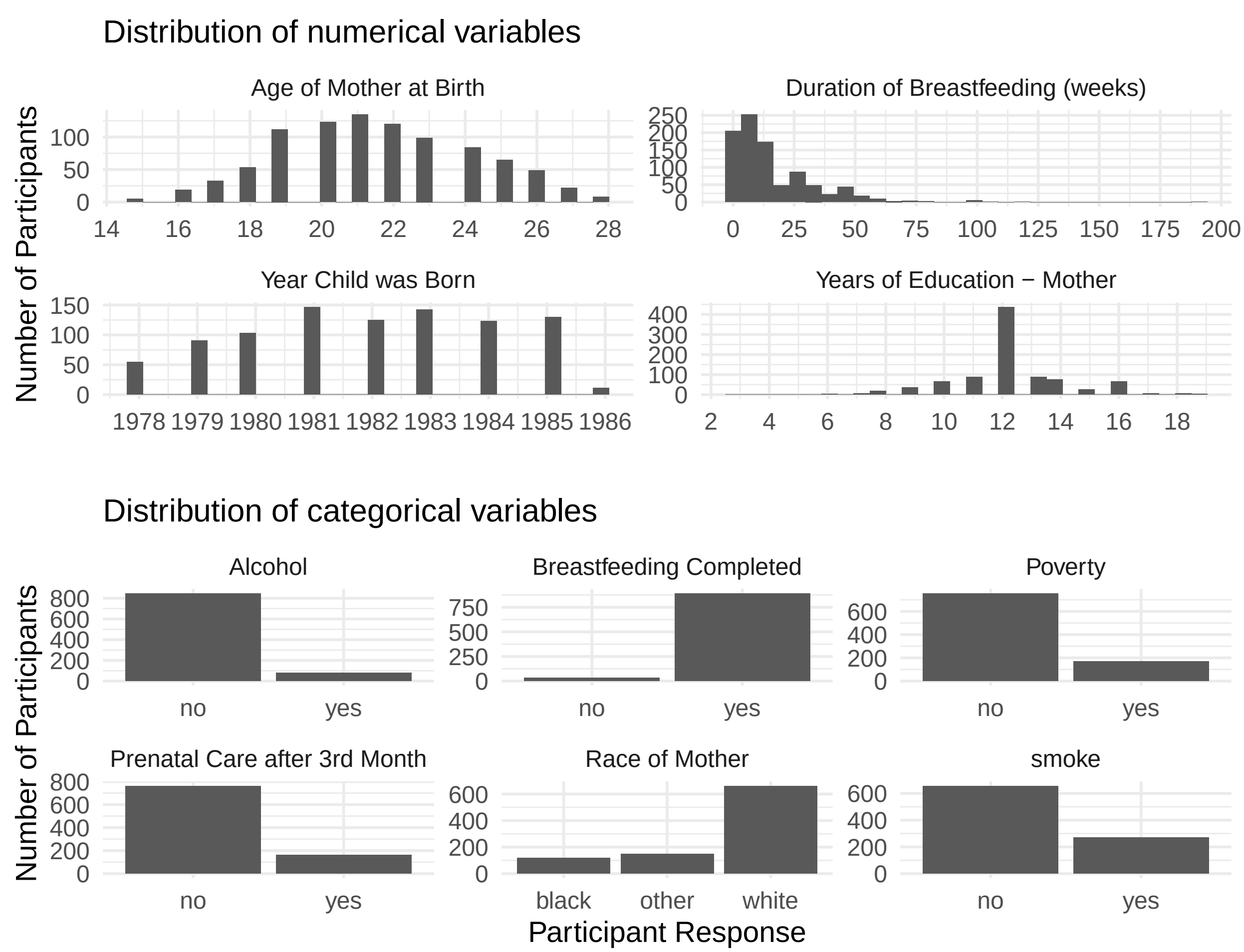

Figure 1: Distributions of categorical and numerical variables comprising the data set.

The Data - Visualized

DELTETHISMAYBE:Exploration of the data (continued)

Methods and Data Analysis

[insert a summary of techniques that are used here: KM curves, log-rank test, parametric tests, and cox PH test]

Kaplan Meier Survival Estimates

The Kaplan-Meier curve shows an estimate of the time to an event, which here represents the time in weeks until a mother stops breastfeeding her child.

A Kaplan-Meier curve of all of the data can be seen in figure 3 below.

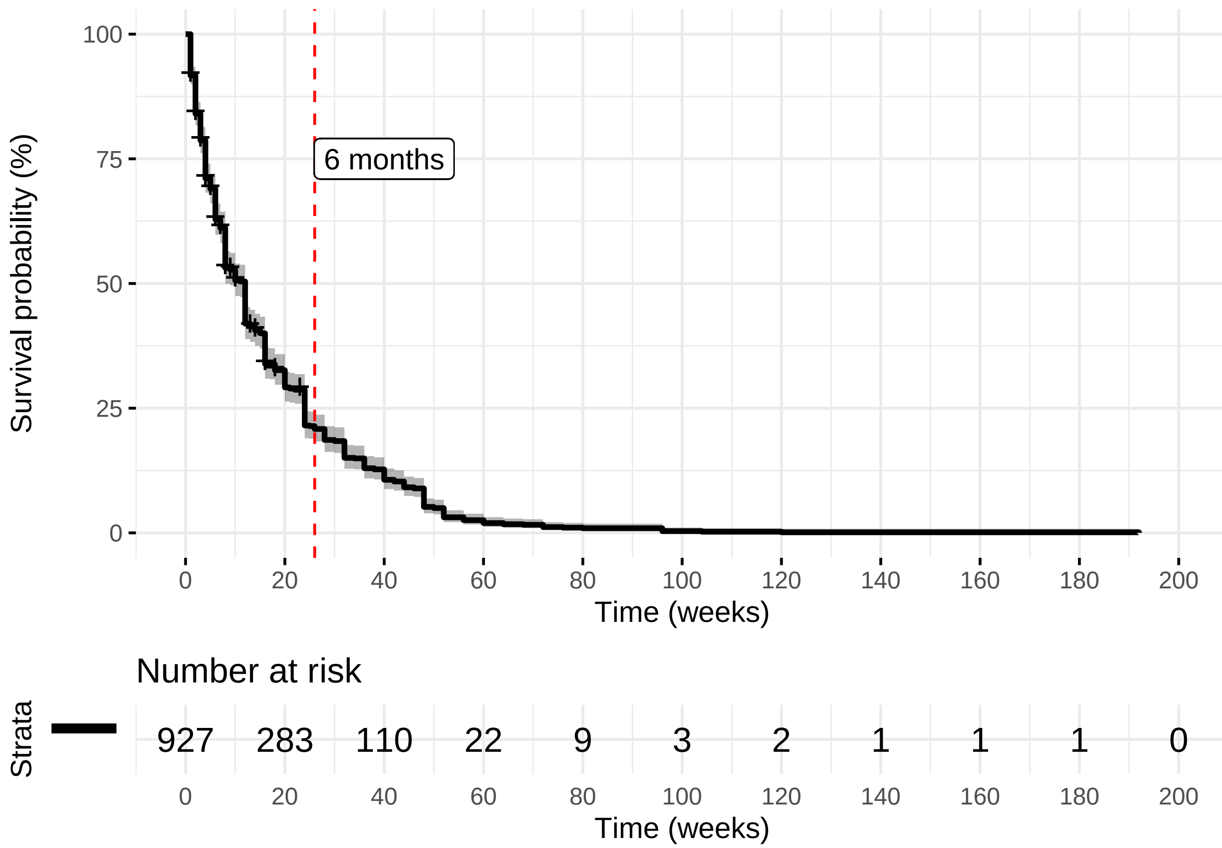

Figure 2: KM curve for all participants for duration of breastfeeding.

The red dashed line on these curves corresponds to the 6 months of breastfeeding milestone, which is the WHO recommendation for breastfeeding children [cite]. Based on the KM curve in figure 2, only 0.21% of mothers interviewed reported breastfeeding their children at least 6 months (CI = (0.18% , 0.24%)). The KM estimate for median duration of breastfeeding was 12 weeks, which is 14 weeks short of the WHO recommended 6 month minimum.

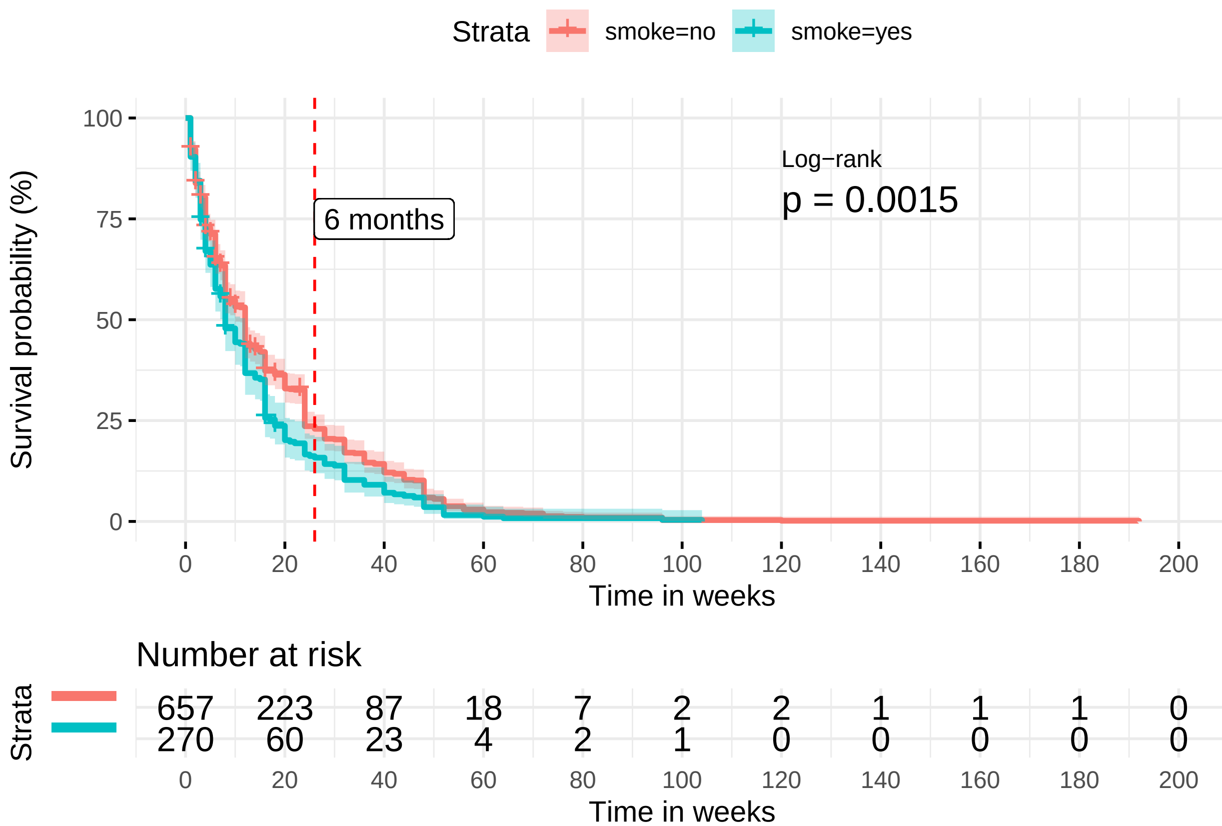

Figure 3: KM curve for duration of breastfeeding according to whether mother smoked when child was born.

KM curve - Cross Group Comparisons

The log-rank test can be used to compare if the difference between these curves is significant. We can see in Figure X above that there appears to be a difference in survival curves between mothers who smoked at birth of their child and mothers who did not. Given differences at early time points are considered more important from a public health perspective, the peto-peto modification would be an appropriate tool to use for testing for a difference at earlier time points in this data.

Some categorical variables are composed of more than two variables. The chi-squared generalization of the log-rank test, implemented in the R package `survival` with the function `survdiff()` can be utilized, testing for whether at least one of the curves is significantly different.

Table 3: p-values of log-rank test for difference in breastfeeding duration according to variable

Variable ID	p-value	p-value.signif
race	0.0177198	*
poverty	0.3984539	ns
smoke	0.0014886	**
alcohol	0.1562283	ns
pc3mth	0.6872395	ns

The KM curve is not the ideal approach for resolving the effect of numerical predictor variables on the response variable breastfeeding duration. Other approaches described below are better suited to elucidating these types of variables.

Kaplan-Meier Curve Assumptions

Given that (1) earlier ages of stopping breastfeeding are often considered more important and (2) ages of stopping breastfeeding likely are right skewed, the peto-peto

With KM curve for all participants, I want to add a median "survival time" => better let's put percent that make it to 6mo (the who recommended minimum time), then I can do the same thing for some of the groups that have been broken up so they can be compared.

Parametric Survival Estimates

(e.g., assumptions, statistical models, parameter estimations, goodness-of-fit test, cross-group comparisons, predictions and validations, etc)

Moving beyond univariate analyses, parametric survival models allow for description of numerical and multivariate models. There are several models that exist for modeling survival data.

Exponential

Assumptions of the exponential survival model

goodness of fit

Parameter Estimates

Predictions and Validations

Weibull

Assumptions of the Weibull survival model

goodness of fit

Parameter Estimates

Predictions and Validations

Lognormal

TODO: create a supplemental figure to be referenced in this section in order to show how `bfeed$duration` looks when log transformed (it becomes normal yay)

Assumptions of the lognormal survival model

Parameter Estimates

goodness of fit

Predictions and Validations

Cox Proportional Hazards Model

In contrast to the parametric models above, the Cox PH model is semi-parametric. The baseline hazard of the model is nonparametric

[(e.g., assumptions, statistical models, parameter estimations, goodness-of-fit test, cross-group comparisons, predictions and validations, etc)]

Assumptions of the Cox PH survival model

goodness of fit

Parameter Estimates

Predictions and Validations

Discussion

(e.g., strengths and shortcomings of your model, and possible improvements)

weaknesses:

The approach to data collection for this study relies on accurate recall and participant truthfulness. Given that mothers' choices around raising their child are often stigmatized and human recall of previous events is suboptimal, the data is likely imperfect.

Conclusion

References

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Statistical Models

Parametric model: Exponential vs Weibull

```
##
## Call:
## survreg(formula = SurvObj ~ race + poverty + smoke + alcohol +
##     agemth + ybirth + yschool + pc3mth, data = bfeed, dist = "exponential")
##                Value Std. Error     z       p
## (Intercept) 175.2188    39.6410  4.42 9.9e-06
## raceblack    -0.1944     0.1050 -1.85 0.06408
## raceother    -0.3253     0.0967 -3.37 0.00076
## povertyyes    0.2165     0.0932  2.32 0.02014
## smokeyes     -0.2679     0.0792 -3.38 0.00072
## alcoholyes   -0.1565     0.1227 -1.28 0.20217
## agemth        0.0174     0.0188  0.93 0.35395
## ybirth       -0.0875     0.0201 -4.35 1.3e-05
## yschool       0.0571     0.0231  2.48 0.01332
## pc3mthyes     0.0543     0.0900  0.60 0.54599
##
## Scale fixed at 1
##
## Exponential distribution
## Loglik(model)= -3382   Loglik(intercept only)= -3409.3
##  Chisq= 54.51 on 9 degrees of freedom, p= 1.5e-08
## Number of Newton-Raphson Iterations: 4
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ race + poverty + smoke + alcohol +
##     agemth + ybirth + yschool, data = bfeed, dist = "exponential")
##                Value Std. Error     z       p
## (Intercept) 173.2055    39.5333  4.38 1.2e-05
## raceblack    -0.1890     0.1046 -1.81 0.07080
## raceother    -0.3237     0.0966 -3.35 0.00081
## povertyyes    0.2200     0.0930  2.37 0.01798
## smokeyes     -0.2652     0.0791 -3.35 0.00080
## alcoholyes   -0.1549     0.1227 -1.26 0.20679
## agemth        0.0172     0.0188  0.92 0.35931
## ybirth       -0.0865     0.0200 -4.31 1.6e-05
## yschool       0.0559     0.0230  2.43 0.01517
##
## Scale fixed at 1
##
## Exponential distribution
## Loglik(model)= -3382.2   Loglik(intercept only)= -3409.3
##  Chisq= 54.14 on 8 degrees of freedom, p= 6.5e-09
## Number of Newton-Raphson Iterations: 4
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ race + poverty + smoke + alcohol +
```

```
##     yschool + ybirth, data = bfeed, dist = "exponential")
##               Value Std. Error     z       p
## (Intercept) 156.1664    34.9804  4.46 8.0e-06
## raceblack    -0.2007     0.1039 -1.93 0.05334
## raceother    -0.3233     0.0967 -3.34 0.00083
## povertyyes    0.2119     0.0926  2.29 0.02203
## smokeyes     -0.2643     0.0791 -3.34 0.00083
## alcoholyes   -0.1543     0.1226 -1.26 0.20818
## yschool       0.0658     0.0202  3.26 0.00112
## ybirth       -0.0777     0.0177 -4.39 1.1e-05
##
## Scale fixed at 1
##
## Exponential distribution
## Loglik(model)= -3382.6   Loglik(intercept only)= -3409.3
##  Chisq= 53.29 on 7 degrees of freedom, p= 3.2e-09
## Number of Newton-Raphson Iterations: 4
## n= 927

##
## Call:
## survreg(formula = SurvObj ~ race + poverty + smoke + yschool +
##     ybirth, data = bfeed, dist = "exponential")
##               Value Std. Error     z       p
## (Intercept) 157.0951    34.9186  4.50 6.8e-06
## raceblack    -0.2023     0.1039 -1.95 0.05152
## raceother    -0.3246     0.0968 -3.36 0.00079
## povertyyes    0.2003     0.0921  2.18 0.02960
## smokeyes     -0.2796     0.0780 -3.58 0.00034
## yschool       0.0633     0.0201  3.15 0.00162
## ybirth       -0.0782     0.0177 -4.43 9.5e-06
##
## Scale fixed at 1
##
## Exponential distribution
## Loglik(model)= -3383.4   Loglik(intercept only)= -3409.3
##  Chisq= 51.77 on 6 degrees of freedom, p= 2.1e-09
## Number of Newton-Raphson Iterations: 4
## n= 927

##
## Call:
## survreg(formula = SurvObj ~ race + smoke + yschool + ybirth,
##     data = bfeed, dist = "exponential")
##               Value Std. Error     z       p
## (Intercept) 159.7446    34.9462  4.57 4.9e-06
## raceblack    -0.1733     0.1031 -1.68 0.09283
## raceother    -0.3096     0.0966 -3.20 0.00136
## smokeyes     -0.2669     0.0780 -3.42 0.00062
## yschool       0.0503     0.0191  2.64 0.00837
## ybirth       -0.0794     0.0177 -4.49 7.0e-06
##
## Scale fixed at 1
##
```

```
## Exponential distribution
## Loglik(model)= -3385.8   Loglik(intercept only)= -3409.3
##  Chisq= 46.89 on 5 degrees of freedom, p= 6e-09
## Number of Newton-Raphson Iterations: 4
## n= 927

##
## Call:
## survreg(formula = SurvObj ~ smoke + yschool + ybirth, data = bfeed,
##     dist = "exponential")
##                Value Std. Error     z       p
## (Intercept) 161.8842    34.7731  4.66 3.2e-06
## smokeyes     -0.2017     0.0754 -2.67 0.00750
## yschool       0.0632     0.0188  3.37 0.00075
## ybirth       -0.0806     0.0176 -4.59 4.5e-06
##
## Scale fixed at 1
##
## Exponential distribution
## Loglik(model)= -3391.3   Loglik(intercept only)= -3409.3
##  Chisq= 35.89 on 3 degrees of freedom, p= 7.9e-08
## Number of Newton-Raphson Iterations: 5
## n= 927

##
## Call:
## survreg(formula = SurvObj ~ yschool + ybirth, data = bfeed, dist = "exponential")
##                Value Std. Error     z       p
## (Intercept) 165.9710    34.8736  4.76 1.9e-06
## yschool       0.0741     0.0182  4.06 4.8e-05
## ybirth       -0.0828     0.0176 -4.69 2.7e-06
##
## Scale fixed at 1
##
## Exponential distribution
## Loglik(model)= -3394.8   Loglik(intercept only)= -3409.3
##  Chisq= 28.92 on 2 degrees of freedom, p= 5.2e-07
## Number of Newton-Raphson Iterations: 5
## n= 927

##
## Call:
## survreg(formula = SurvObj ~ ybirth, data = bfeed, dist = "exponential")
##                Value Std. Error     z       p
## (Intercept) 118.2389    32.7880  3.61 0.00031
## ybirth       -0.0582     0.0165 -3.52 0.00043
##
## Scale fixed at 1
##
## Exponential distribution
## Loglik(model)= -3403.1   Loglik(intercept only)= -3409.3
##  Chisq= 12.46 on 1 degrees of freedom, p= 0.00042
## Number of Newton-Raphson Iterations: 4
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ race + poverty + smoke + alcohol +
##     agemth + ybirth + yschool + pc3mth, data = bfeed, dist = "weibull")
##                 Value Std. Error     z       p
## (Intercept) 175.29620   39.55209  4.43 9.3e-06
## raceblack    -0.19448    0.10474 -1.86 0.06336
## raceother    -0.32521    0.09644 -3.37 0.00075
## povertyyes    0.21657    0.09294  2.33 0.01980
## smokeyes     -0.26789    0.07903 -3.39 0.00070
## alcoholyes   -0.15640    0.12245 -1.28 0.20153
## agemth        0.01737    0.01872  0.93 0.35363
## ybirth       -0.08752    0.02006 -4.36 1.3e-05
## yschool       0.05705    0.02302  2.48 0.01321
## pc3mthyes     0.05433    0.08975  0.61 0.54501
## Log(scale)   -0.00244    0.02555 -0.10 0.92382
##
## Scale= 0.998
##
## Weibull distribution
## Loglik(model)= -3382   Loglik(intercept only)= -3408.6
##  Chisq= 53.07 on 9 degrees of freedom, p= 2.8e-08
## Number of Newton-Raphson Iterations: 5
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ race + poverty + smoke + alcohol +
##     agemth + ybirth + yschool, data = bfeed, dist = "weibull")
##                Value Std. Error     z       p
## (Intercept) 173.2760    39.4547  4.39 1.1e-05
## raceblack    -0.1890     0.1044 -1.81 0.07012
## raceother    -0.3236     0.0964 -3.36 0.00079
## povertyyes    0.2201     0.0928  2.37 0.01771
## smokeyes     -0.2652     0.0790 -3.36 0.00078
## alcoholyes   -0.1548     0.1224 -1.26 0.20620
## agemth        0.0172     0.0187  0.92 0.35901
## ybirth       -0.0865     0.0200 -4.32 1.5e-05
## yschool       0.0558     0.0230  2.43 0.01507
## Log(scale)   -0.0022     0.0255 -0.09 0.93139
##
## Scale= 0.998
##
## Weibull distribution
## Loglik(model)= -3382.2   Loglik(intercept only)= -3408.6
##  Chisq= 52.7 on 8 degrees of freedom, p= 1.2e-08
## Number of Newton-Raphson Iterations: 5
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ race + poverty + smoke + alcohol +
##     yschool + ybirth, data = bfeed, dist = "weibull")
##                 Value Std. Error     z       p
```

```
## (Intercept) 156.25987   34.93343  4.47 7.7e-06
## raceblack    -0.20070    0.10365 -1.94 0.05283
## raceother    -0.32319    0.09650 -3.35 0.00081
## povertyyes    0.21201    0.09238  2.30 0.02173
## smokeyes     -0.26429    0.07893 -3.35 0.00081
## alcoholyes   -0.15421    0.12237 -1.26 0.20761
## yschool       0.06571    0.02016  3.26 0.00111
## ybirth       -0.07777    0.01766 -4.40 1.1e-05
## Log(scale)   -0.00201    0.02555 -0.08 0.93720
##
## Scale= 0.998
##
## Weibull distribution
## Loglik(model)= -3382.6   Loglik(intercept only)= -3408.6
##  Chisq= 51.85 on 7 degrees of freedom, p= 6.2e-09
## Number of Newton-Raphson Iterations: 5
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ race + poverty + smoke + yschool +
##     ybirth, data = bfeed, dist = "weibull")
##                 Value Std. Error     z       p
## (Intercept) 157.15980   34.89373  4.50 6.7e-06
## raceblack    -0.20230    0.10374 -1.95 0.05118
## raceother    -0.32457    0.09663 -3.36 0.00078
## povertyyes    0.20031    0.09194  2.18 0.02935
## smokeyes     -0.27958    0.07792 -3.59 0.00033
## yschool       0.06328    0.02007  3.15 0.00162
## ybirth       -0.07822    0.01764 -4.43 9.3e-06
## Log(scale)   -0.00137    0.02556 -0.05 0.95721
##
## Scale= 0.999
##
## Weibull distribution
## Loglik(model)= -3383.4   Loglik(intercept only)= -3408.6
##  Chisq= 50.32 on 6 degrees of freedom, p= 4e-09
## Number of Newton-Raphson Iterations: 5
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ race + smoke + yschool + ybirth,
##     data = bfeed, dist = "weibull")
##                 Value Std. Error     z       p
## (Intercept) 159.63315   35.04486  4.56 5.2e-06
## raceblack    -0.17322    0.10333 -1.68 0.09365
## raceother    -0.30970    0.09687 -3.20 0.00139
## smokeyes     -0.26688    0.07814 -3.42 0.00064
## yschool       0.05042    0.01915  2.63 0.00848
## ybirth       -0.07937    0.01772 -4.48 7.5e-06
## Log(scale)    0.00231    0.02552  0.09 0.92784
##
## Scale= 1
```

```
##
## Weibull distribution
## Loglik(model)= -3385.8   Loglik(intercept only)= -3408.6
##  Chisq= 45.45 on 5 degrees of freedom, p= 1.2e-08
## Number of Newton-Raphson Iterations: 5
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ smoke + yschool + ybirth, data = bfeed,
##     dist = "weibull")
##                 Value Std. Error     z       p
## (Intercept) 161.50221   35.06995  4.61 4.1e-06
## smokeyes     -0.20175    0.07607 -2.65 0.00800
## yschool       0.06355    0.01894  3.36 0.00079
## ybirth       -0.08044    0.01773 -4.54 5.7e-06
## Log(scale)    0.00832    0.02554  0.33 0.74463
##
## Scale= 1.01
##
## Weibull distribution
## Loglik(model)= -3391.3   Loglik(intercept only)= -3408.6
##  Chisq= 34.55 on 3 degrees of freedom, p= 1.5e-07
## Number of Newton-Raphson Iterations: 5
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ yschool + ybirth, data = bfeed, dist = "weibull")
##                Value Std. Error     z       p
## (Intercept) 165.2997    35.3232  4.68 2.9e-06
## yschool       0.0746     0.0185  4.03 5.5e-05
## ybirth       -0.0825     0.0179 -4.62 3.9e-06
## Log(scale)    0.0127     0.0255  0.50    0.62
##
## Scale= 1.01
##
## Weibull distribution
## Loglik(model)= -3394.7   Loglik(intercept only)= -3408.6
##  Chisq= 27.72 on 2 degrees of freedom, p= 9.6e-07
## Number of Newton-Raphson Iterations: 5
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ ybirth, data = bfeed, dist = "weibull")
##                Value Std. Error     z       p
## (Intercept) 116.8541    33.4165  3.50 0.00047
## ybirth       -0.0575     0.0169 -3.41 0.00064
## Log(scale)    0.0182     0.0256  0.71 0.47841
##
## Scale= 1.02
##
```

```
## Weibull distribution
## Loglik(model)= -3402.8   Loglik(intercept only)= -3408.6
##  Chisq= 11.51 on 1 degrees of freedom, p= 0.00069
## Number of Newton-Raphson Iterations: 5
## n= 927

##
## Call:
## survreg(formula = SurvObj ~ race + poverty + smoke + alcohol +
##     agemth + ybirth + yschool + pc3mth, data = bfeed, dist = "lognormal")
##                Value Std. Error     z       p
## (Intercept) 163.0387    45.0965  3.62 0.00030
## raceblack    -0.1703     0.1195 -1.42 0.15434
## raceother    -0.2858     0.1095 -2.61 0.00906
## povertyyes    0.1926     0.1044  1.85 0.06500
## smokeyes     -0.2228     0.0894 -2.49 0.01267
## alcoholyes   -0.1660     0.1383 -1.20 0.23006
## agemth        0.0151     0.0215  0.70 0.48232
## ybirth       -0.0818     0.0229 -3.58 0.00035
## yschool       0.0915     0.0260  3.52 0.00043
## pc3mthyes     0.0296     0.1024  0.29 0.77283
## Log(scale)    0.1365     0.0236  5.77 7.7e-09
##
## Scale= 1.15
##
## Log Normal distribution
## Loglik(model)= -3380.2   Loglik(intercept only)= -3402.8
##  Chisq= 45.16 on 9 degrees of freedom, p= 8.6e-07
## Number of Newton-Raphson Iterations: 3
## n= 927

##
## Call:
## survreg(formula = SurvObj ~ race + poverty + smoke + alcohol +
##     agemth + ybirth + yschool, data = bfeed, dist = "lognormal")
##                Value Std. Error     z       p
## (Intercept) 161.7216    44.8658  3.60 0.00031
## raceblack    -0.1692     0.1195 -1.42 0.15674
## raceother    -0.2844     0.1094 -2.60 0.00935
## povertyyes    0.1961     0.1036  1.89 0.05842
## smokeyes     -0.2221     0.0893 -2.49 0.01292
## alcoholyes   -0.1653     0.1383 -1.20 0.23191
## agemth        0.0147     0.0215  0.69 0.49312
## ybirth       -0.0811     0.0228 -3.56 0.00036
## yschool       0.0910     0.0259  3.51 0.00045
## Log(scale)    0.1365     0.0236  5.78 7.7e-09
##
## Scale= 1.15
##
## Log Normal distribution
## Loglik(model)= -3380.2   Loglik(intercept only)= -3402.8
##  Chisq= 45.08 on 8 degrees of freedom, p= 3.6e-07
## Number of Newton-Raphson Iterations: 3
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ race + poverty + smoke + alcohol +
##     yschool + ybirth, data = bfeed, dist = "lognormal")
##                Value Std. Error     z       p
## (Intercept) 145.3860    38.0284  3.82 0.00013
## raceblack    -0.1792     0.1186 -1.51 0.13068
## raceother    -0.2847     0.1094 -2.60 0.00926
## povertyyes    0.1874     0.1028  1.82 0.06851
## smokeyes     -0.2202     0.0893 -2.47 0.01366
## alcoholyes   -0.1614     0.1382 -1.17 0.24281
## yschool       0.0995     0.0228  4.37 1.3e-05
## ybirth       -0.0728     0.0192 -3.78 0.00015
## Log(scale)    0.1367     0.0236  5.78 7.4e-09
##
## Scale= 1.15
##
## Log Normal distribution
## Loglik(model)= -3380.5   Loglik(intercept only)= -3402.8
##  Chisq= 44.61 on 7 degrees of freedom, p= 1.6e-07
## Number of Newton-Raphson Iterations: 3
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ race + poverty + smoke + yschool +
##     ybirth, data = bfeed, dist = "lognormal")
##                Value Std. Error     z       p
## (Intercept) 145.7593    38.0517  3.83 0.00013
## raceblack    -0.1799     0.1187 -1.52 0.12948
## raceother    -0.2834     0.1095 -2.59 0.00965
## povertyyes    0.1801     0.1027  1.75 0.07954
## smokeyes     -0.2357     0.0884 -2.67 0.00765
## yschool       0.0976     0.0227  4.29 1.8e-05
## ybirth       -0.0730     0.0192 -3.79 0.00015
## Log(scale)    0.1374     0.0236  5.81 6.2e-09
##
## Scale= 1.15
##
## Log Normal distribution
## Loglik(model)= -3381.2   Loglik(intercept only)= -3402.8
##  Chisq= 43.25 on 6 degrees of freedom, p= 1e-07
## Number of Newton-Raphson Iterations: 3
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ race + smoke + yschool + ybirth,
##     data = bfeed, dist = "lognormal")
##                Value Std. Error     z       p
## (Intercept) 146.8739    38.1150  3.85 0.00012
## raceblack    -0.1485     0.1175 -1.26 0.20620
## raceother    -0.2717     0.1095 -2.48 0.01306
## smokeyes     -0.2252     0.0883 -2.55 0.01077
```

```
## yschool       0.0884     0.0222  3.99 6.7e-05
## ybirth       -0.0735     0.0193 -3.81 0.00014
## Log(scale)    0.1391     0.0236  5.88 4.0e-09
##
## Scale= 1.15
##
## Log Normal distribution
## Loglik(model)= -3382.7   Loglik(intercept only)= -3402.8
##  Chisq= 40.18 on 5 degrees of freedom, p= 1.4e-07
## Number of Newton-Raphson Iterations: 3
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ smoke + yschool + ybirth, data = bfeed,
##     dist = "lognormal")
##                Value Std. Error     z       p
## (Intercept) 149.7212    38.2083  3.92 8.9e-05
## smokeyes     -0.1664     0.0856 -1.94  0.0521
## yschool       0.0993     0.0218  4.56 5.0e-06
## ybirth       -0.0750     0.0193 -3.88  0.0001
## Log(scale)    0.1427     0.0236  6.04 1.6e-09
##
## Scale= 1.15
##
## Log Normal distribution
## Loglik(model)= -3386.1   Loglik(intercept only)= -3402.8
##  Chisq= 33.39 on 3 degrees of freedom, p= 2.7e-07
## Number of Newton-Raphson Iterations: 3
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ yschool + ybirth, data = bfeed, dist = "lognormal")
##                Value Std. Error     z       p
## (Intercept) 149.4927    38.2869  3.90 9.4e-05
## yschool       0.1072     0.0214  5.01 5.5e-07
## ybirth       -0.0750     0.0194 -3.87 0.00011
## Log(scale)    0.1448     0.0236  6.13 9.1e-10
##
## Scale= 1.16
##
## Log Normal distribution
## Loglik(model)= -3388   Loglik(intercept only)= -3402.8
##  Chisq= 29.63 on 2 degrees of freedom, p= 3.7e-07
## Number of Newton-Raphson Iterations: 3
## n= 927
```

```
##
## Call:
## survreg(formula = SurvObj ~ ybirth, data = bfeed, dist = "lognormal")
##               Value Std. Error     z       p
## (Intercept) 82.4388    36.3920  2.27   0.023
```

```
## ybirth      -0.0405     0.0184 -2.20   0.028
## Log(scale)   0.1580     0.0237  6.68 2.4e-11
##
## Scale= 1.17
##
## Log Normal distribution
## Loglik(model)= -3400.4   Loglik(intercept only)= -3402.8
##  Chisq= 4.83 on 1 degrees of freedom, p= 0.028
## Number of Newton-Raphson Iterations: 2
## n= 927
```

```
## # ----------------------------------------------------------------------------------------------------
## # Initial Model:
## Call:
## coxph(formula = formula, data = data, method = "efron")
##
##   n= 927, number of events= 892
##
##          coef exp(coef) se(coef)     z Pr(>|z|)
## smoke 0.22702   1.25486  0.07374 3.079  0.00208 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##       exp(coef) exp(-coef) lower .95 upper .95
## smoke     1.255     0.7969     1.086      1.45
##
## Concordance= 0.526  (se = 0.009 )
## Likelihood ratio test= 9.18  on 1 df,   p=0.002
## Wald test            = 9.48  on 1 df,   p=0.002
## Score (logrank) test = 9.52  on 1 df,   p=0.002
##
## # ----------------------------------------------------------------------------------------------------
## ### iter num = 1, Forward Selection by LR Test: + race
## Call:
## coxph(formula = Surv(duration, delta) ~ smoke + race, data = data,
##     method = "efron")
##
##   n= 927, number of events= 892
##
##          coef exp(coef) se(coef)     z Pr(>|z|)
## smoke 0.27943   1.32237  0.07552 3.700 0.000216 ***
## race  0.15893   1.17226  0.04550 3.493 0.000478 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##       exp(coef) exp(-coef) lower .95 upper .95
## smoke     1.322     0.7562     1.140     1.533
## race      1.172     0.8531     1.072     1.282
##
## Concordance= 0.551  (se = 0.011 )
## Likelihood ratio test= 20.82  on 2 df,   p=3e-05
## Wald test            = 21.3  on 2 df,   p=2e-05
## Score (logrank) test = 21.4  on 2 df,   p=2e-05
##
```

```
## --------------- Variance Inflating Factor (VIF) ---------------
## Multicollinearity Problem: Variance Inflating Factor (VIF) is bigger than 10 (Continuous Variable) o
##    smoke     race
## 1.022593 1.022593
## # -----------------------------------------------------------------------------------------------
## ### iter num = 2, Forward Selection by LR Test: + ybirth
## Call:
## coxph(formula = Surv(duration, delta) ~ smoke + race + ybirth,
##     data = data, method = "efron")
##
##   n= 927, number of events= 892
##
##           coef exp(coef) se(coef)     z Pr(>|z|)
## smoke  0.29709   1.34594  0.07574 3.922 8.77e-05 ***
## race   0.16719   1.18198  0.04558 3.668 0.000245 ***
## ybirth 0.05569   1.05727  0.01680 3.315 0.000917 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##        exp(coef) exp(-coef) lower .95 upper .95
## smoke      1.346     0.7430     1.160     1.561
## race       1.182     0.8460     1.081     1.292
## ybirth     1.057     0.9458     1.023     1.093
##
## Concordance= 0.565  (se = 0.012 )
## Likelihood ratio test= 31.87  on 3 df,   p=6e-07
## Wald test            = 32.19  on 3 df,   p=5e-07
## Score (logrank) test = 32.33  on 3 df,   p=4e-07
##
## --------------- Variance Inflating Factor (VIF) ---------------
## Multicollinearity Problem: Variance Inflating Factor (VIF) is bigger than 10 (Continuous Variable) o
##    smoke     race   ybirth
## 1.044828 1.044811 1.001262
## # -----------------------------------------------------------------------------------------------
## ### iter num = 3, Forward Selection by LR Test: + yschool
## Call:
## coxph(formula = Surv(duration, delta) ~ smoke + race + ybirth +
##     yschool, data = data, method = "efron")
##
##   n= 927, number of events= 892
##
##             coef exp(coef) se(coef)      z Pr(>|z|)
## smoke    0.24504   1.27768  0.07837  3.127  0.00177 **
## race     0.14201   1.15258  0.04664  3.045  0.00233 **
## ybirth   0.07172   1.07435  0.01790  4.007 6.14e-05 ***
## yschool -0.04985   0.95137  0.01908 -2.613  0.00898 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##         exp(coef) exp(-coef) lower .95 upper .95
## smoke      1.2777     0.7827    1.0957    1.4898
## race       1.1526     0.8676    1.0519    1.2629
## ybirth     1.0744     0.9308    1.0373    1.1127
## yschool    0.9514     1.0511    0.9165    0.9876
```

```
##
## Concordance= 0.575  (se = 0.012 )
## Likelihood ratio test= 38.7  on 4 df,   p=8e-08
## Wald test            = 39.05  on 4 df,   p=7e-08
## Score (logrank) test = 39.19  on 4 df,   p=6e-08
##
## --------------- Variance Inflating Factor (VIF) ---------------
## Multicollinearity Problem: Variance Inflating Factor (VIF) is bigger than 10 (Continuous Variable) o
##    smoke     race   ybirth  yschool
## 1.182042 1.059091 1.002535 1.131705
## # -----------------------------------------------------------------------------------------------------
## ### iter num = 4, Forward Selection by LR Test: + poverty
## Call:
## coxph(formula = Surv(duration, delta) ~ smoke + race + ybirth +
##     yschool + poverty, data = data, method = "efron")
##
##   n= 927, number of events= 892
##
##             coef exp(coef) se(coef)      z Pr(>|z|)
## smoke    0.25749   1.29368  0.07844  3.282  0.00103 **
## race     0.15221   1.16440  0.04675  3.256  0.00113 **
## ybirth   0.07068   1.07324  0.01789  3.951 7.78e-05 ***
## yschool -0.06232   0.93958  0.02002 -3.113  0.00185 **
## poverty -0.19924   0.81935  0.09228 -2.159  0.03085 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##         exp(coef) exp(-coef) lower .95 upper .95
## smoke      1.2937     0.7730    1.1093    1.5087
## race       1.1644     0.8588    1.0625    1.2761
## ybirth     1.0732     0.9318    1.0363    1.1115
## yschool    0.9396     1.0643    0.9034    0.9772
## poverty    0.8194     1.2205    0.6838    0.9818
##
## Concordance= 0.576  (se = 0.012 )
## Likelihood ratio test= 43.51  on 5 df,   p=3e-08
## Wald test            = 43.75  on 5 df,   p=3e-08
## Score (logrank) test = 43.83  on 5 df,   p=3e-08
##
## --------------- Variance Inflating Factor (VIF) ---------------
## Multicollinearity Problem: Variance Inflating Factor (VIF) is bigger than 10 (Continuous Variable) o
##    smoke     race   ybirth  yschool  poverty
## 1.206682 1.072935 1.005629 1.129337 1.042396
## # =====================================================================================================
## *** Stepwise Final Model (in.lr.test: sle = 0.15; out.lr.test: sls = 0.15; variable selection restri
## Call:
## coxph(formula = Surv(duration, delta) ~ smoke + race + ybirth +
##     yschool + poverty, data = data, method = "efron")
##
##   n= 927, number of events= 892
##
##             coef exp(coef) se(coef)      z Pr(>|z|)
## smoke    0.25749   1.29368  0.07844  3.282  0.00103 **
## race     0.15221   1.16440  0.04675  3.256  0.00113 **
```

```
## ybirth   0.07068   1.07324  0.01789  3.951 7.78e-05 ***
## yschool -0.06232   0.93958  0.02002 -3.113  0.00185 **
## poverty -0.19924   0.81935  0.09228 -2.159  0.03085 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##         exp(coef) exp(-coef) lower .95 upper .95
## smoke      1.2937     0.7730    1.1093    1.5087
## race       1.1644     0.8588    1.0625    1.2761
## ybirth     1.0732     0.9318    1.0363    1.1115
## yschool    0.9396     1.0643    0.9034    0.9772
## poverty    0.8194     1.2205    0.6838    0.9818
##
## Concordance= 0.576  (se = 0.012 )
## Likelihood ratio test= 43.51  on 5 df,   p=3e-08
## Wald test            = 43.75  on 5 df,   p=3e-08
## Score (logrank) test = 43.83  on 5 df,   p=3e-08
##
## --------------- Variance Inflating Factor (VIF) ---------------
## Multicollinearity Problem: Variance Inflating Factor (VIF) is bigger than 10 (Continuous Variable) o
##    smoke     race   ybirth  yschool  poverty
## 1.206682 1.072935 1.005629 1.129337 1.042396
```

Cox Proportional Hazards model of time-independent variables

Cox model approach is a semi-parametric model useful with fixed-time covariates

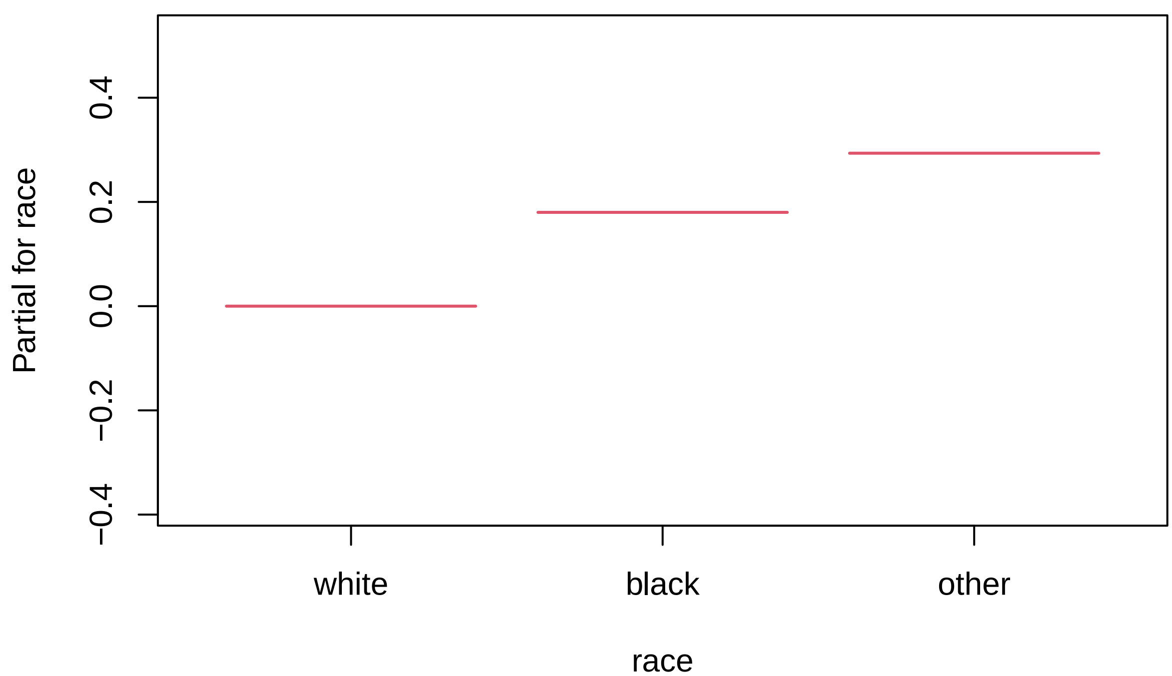
here is the cox model of the entire bfeed dataset:

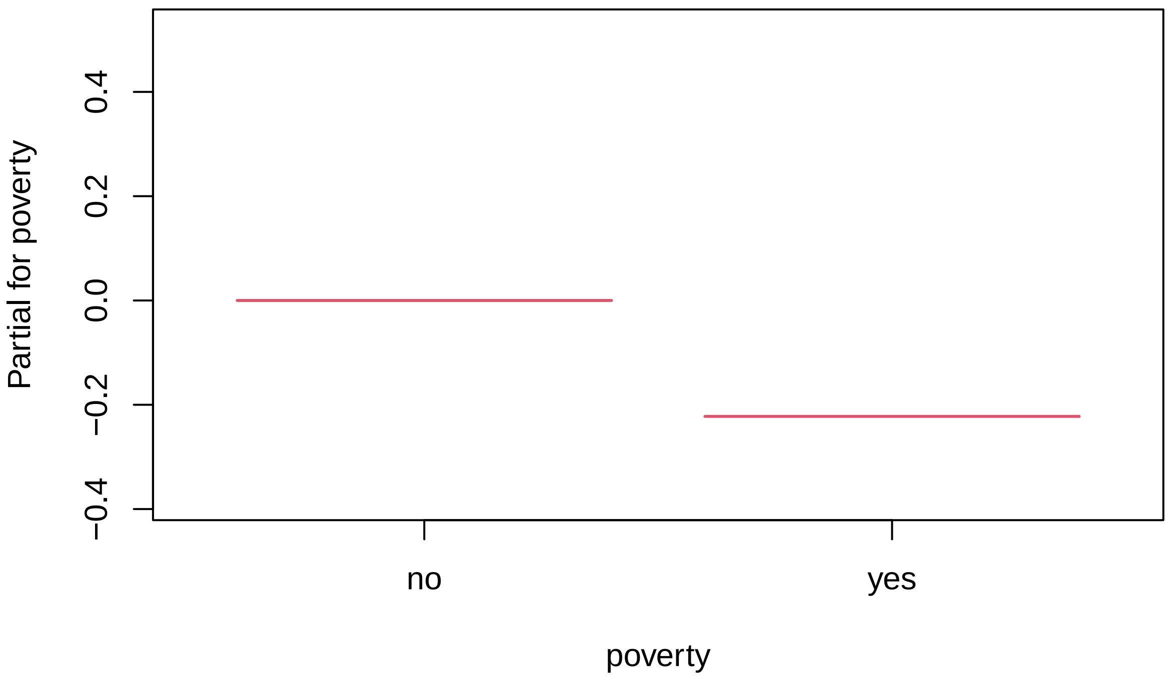
```
m1 <- coxph(SurvObj ~ race + poverty + smoke + alcohol + agemth + ybirth +
              yschool, data = bfeed)
summary(m1)
```

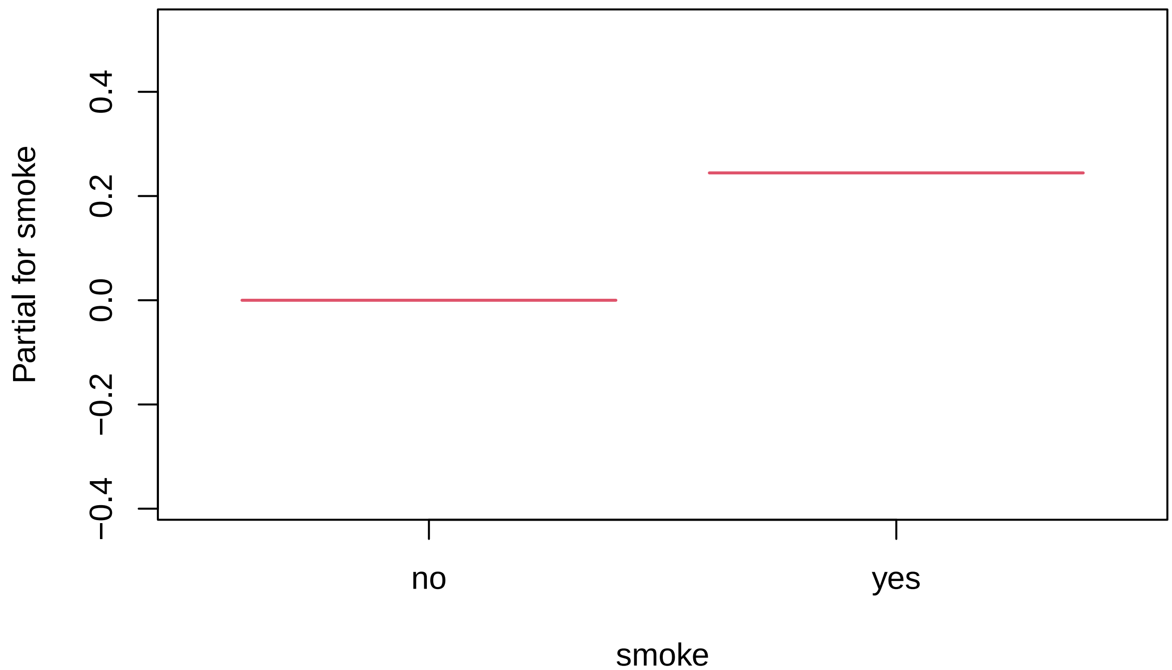
```
## Call:
## coxph(formula = SurvObj ~ race + poverty + smoke + alcohol +
##     agemth + ybirth + yschool, data = bfeed)
##
##   n= 927, number of events= 892
##
##                 coef exp(coef) se(coef)      z Pr(>|z|)
## raceblack   0.18000   1.19721  0.10503  1.714 0.086561 .
## raceother   0.29350   1.34112  0.09709  3.023 0.002504 **
## povertyyes -0.22222   0.80074  0.09364 -2.373 0.017638 *
## smokeyes    0.24435   1.27679  0.07948  3.074 0.002109 **
## alcoholyes  0.15937   1.17277  0.12297  1.296 0.194979
## agemth     -0.01551   0.98461  0.01881 -0.824 0.409676
## ybirth      0.07864   1.08182  0.02036  3.863 0.000112 ***
## yschool    -0.05668   0.94490  0.02309 -2.455 0.014103 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##            exp(coef) exp(-coef) lower .95 upper .95
## raceblack     1.1972     0.8353    0.9745    1.4709
```

```
## raceother      1.3411     0.7456    1.1087    1.6222
## povertyyes     0.8007     1.2488    0.6665    0.9620
## smokeyes       1.2768     0.7832    1.0926    1.4920
## alcoholyes     1.1728     0.8527    0.9216    1.4924
## agemth         0.9846     1.0156    0.9490    1.0216
## ybirth         1.0818     0.9244    1.0395    1.1259
## yschool        0.9449     1.0583    0.9031    0.9886
##
## Concordance= 0.577  (se = 0.012 )
## Likelihood ratio test= 45.97  on 8 df,   p=2e-07
## Wald test            = 46.29  on 8 df,   p=2e-07
## Score (logrank) test = 46.33  on 8 df,   p=2e-07
```

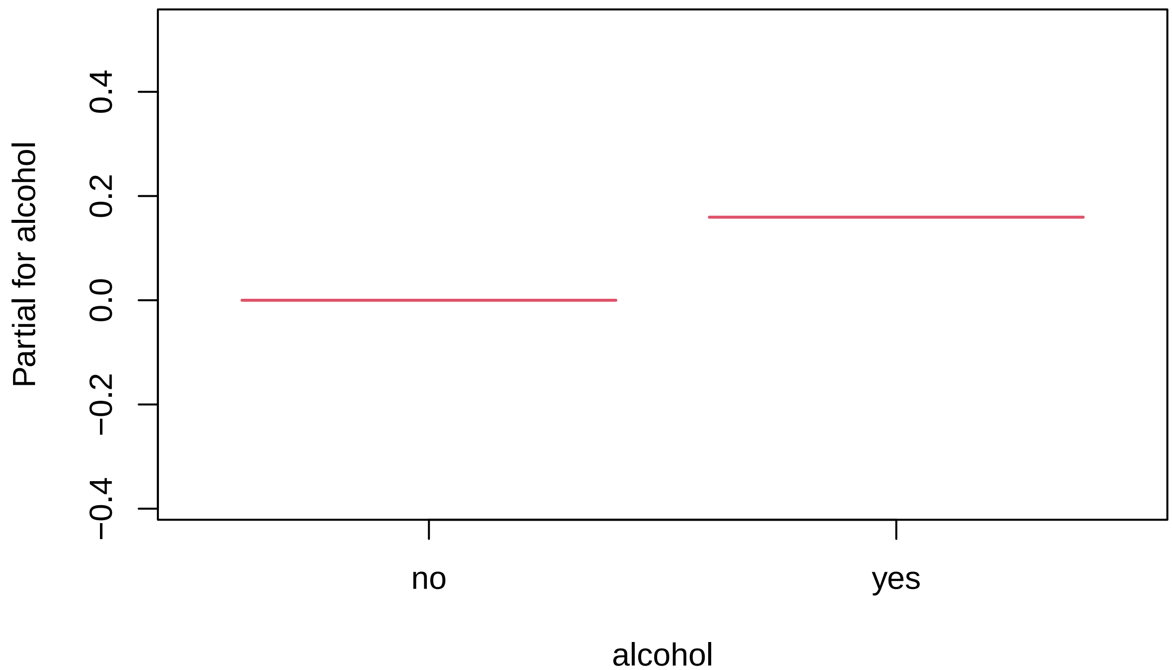
```
termplot(m1)
```

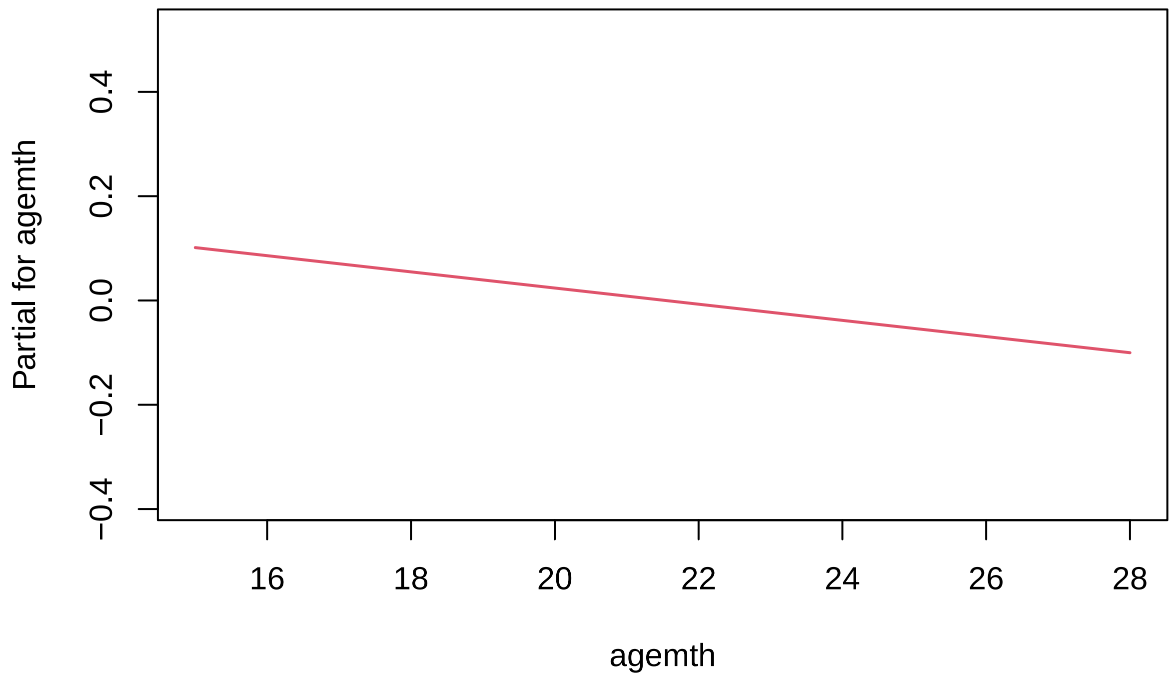


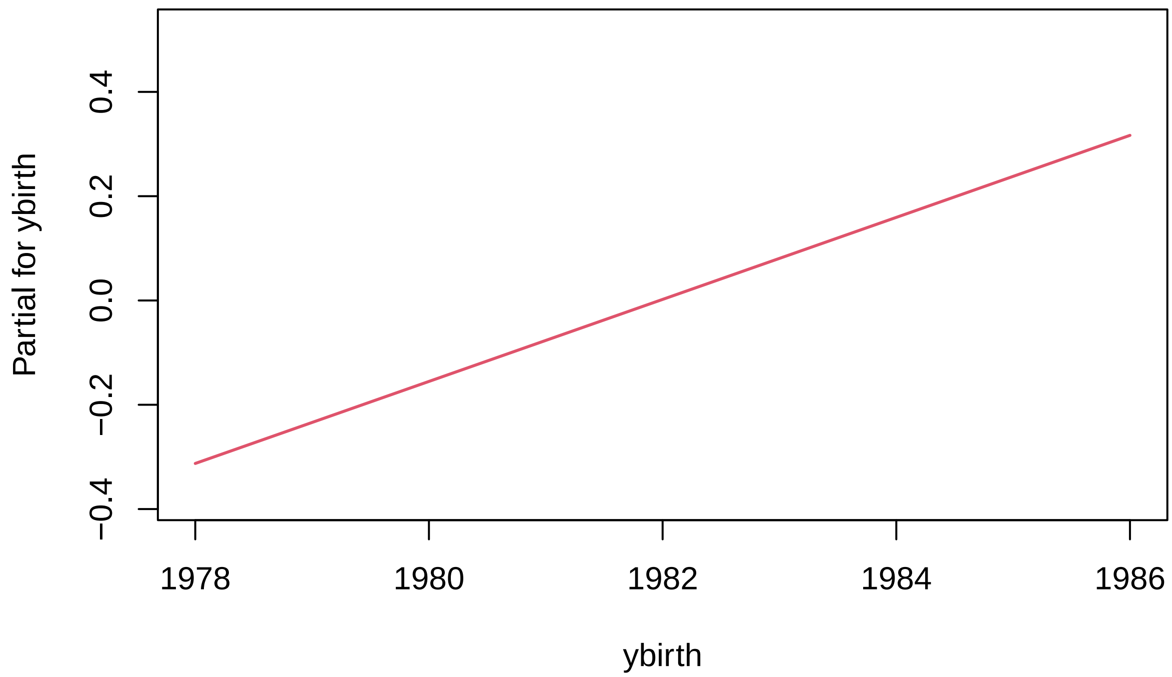

Partial for poverty
0.4
0.2
0.0
−0.2
−0.4
no
yes
poverty



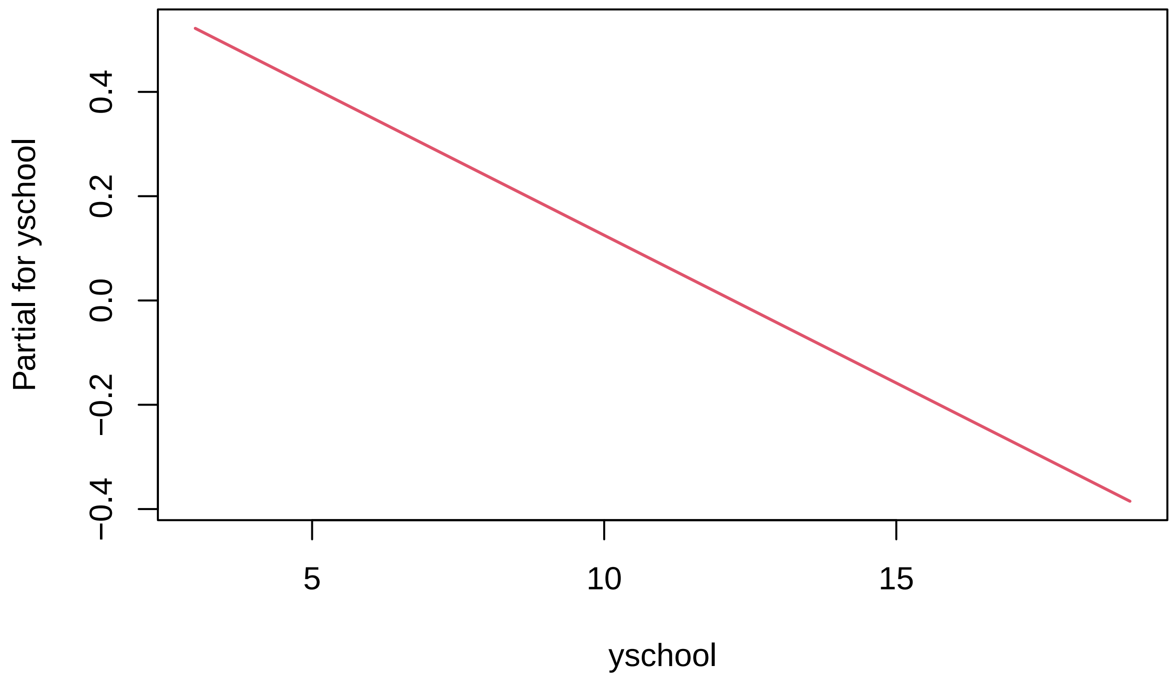
Partial for smoke
0.4
0.2
0.0
−0.2
−0.4
no
yes
smoke


Partial for alcohol
0.4
0.2
0.0
−0.2
−0.4
no
yes
alcohol


Partial for agemth
0.4
0.2
0.0
−0.2
−0.4
16
18
20
22
24
26
28
agemth



Partial for ybirth
−0.4
−0.2
0.0
0.2
0.4
1978
1980
1982
1984
1986
ybirth

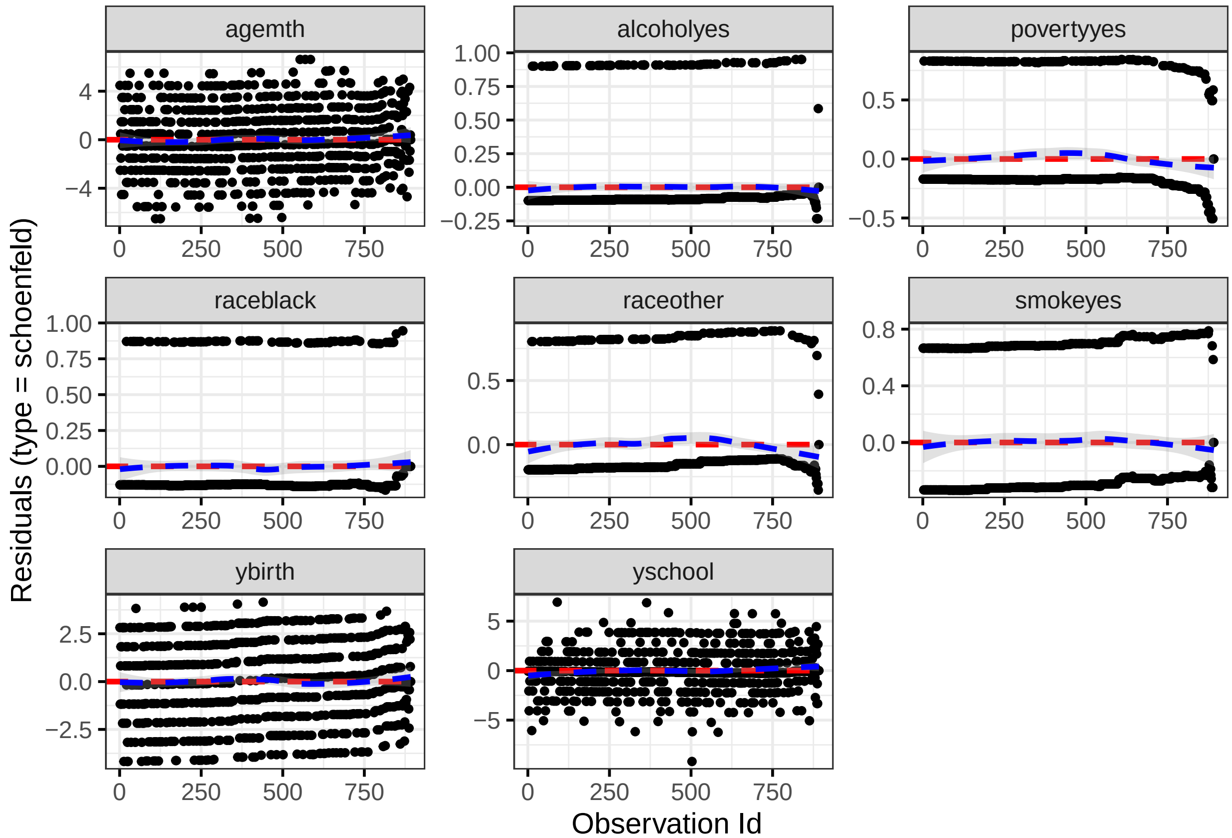



```
cox.zph(m1)
```

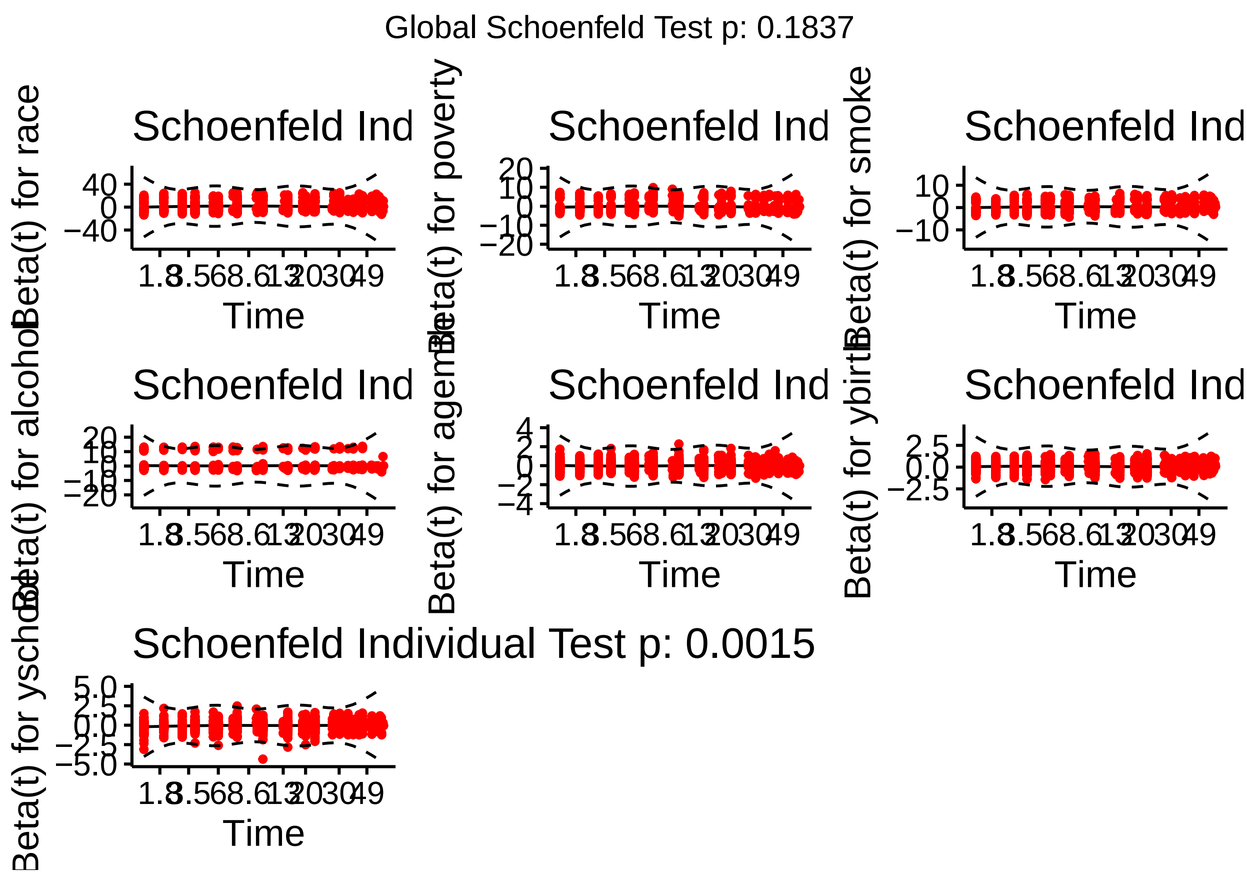
```
##          chisq df      p
## race      1.947  2 0.3778
## poverty   2.731  1 0.0984
## smoke     0.165  1 0.6849
## alcohol   0.049  1 0.8249
## agemth    3.692  1 0.0547
## ybirth    0.758  1 0.3838
## yschool  10.103  1 0.0015
## GLOBAL   11.329  8 0.1837
```

```
ggcoxdiagnostics(m1, type = "schoenfeld")
```

```
## `geom_smooth()` using formula 'y ~ x'
```




```
#alternative code to above line  (I think)
ggcoxzph(cox.zph(m1))
```

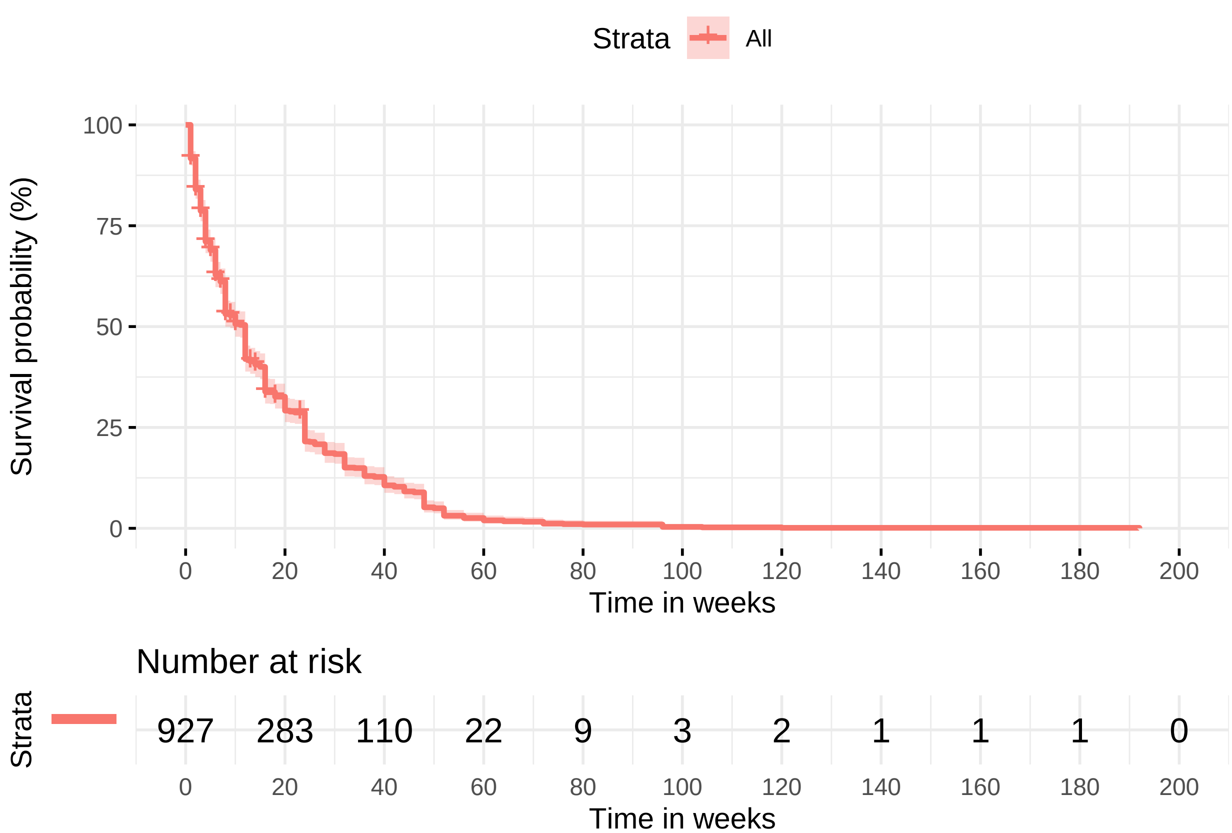


Cross-Group Comparisons

Kaplan Meier Curve of entire dataset combined:

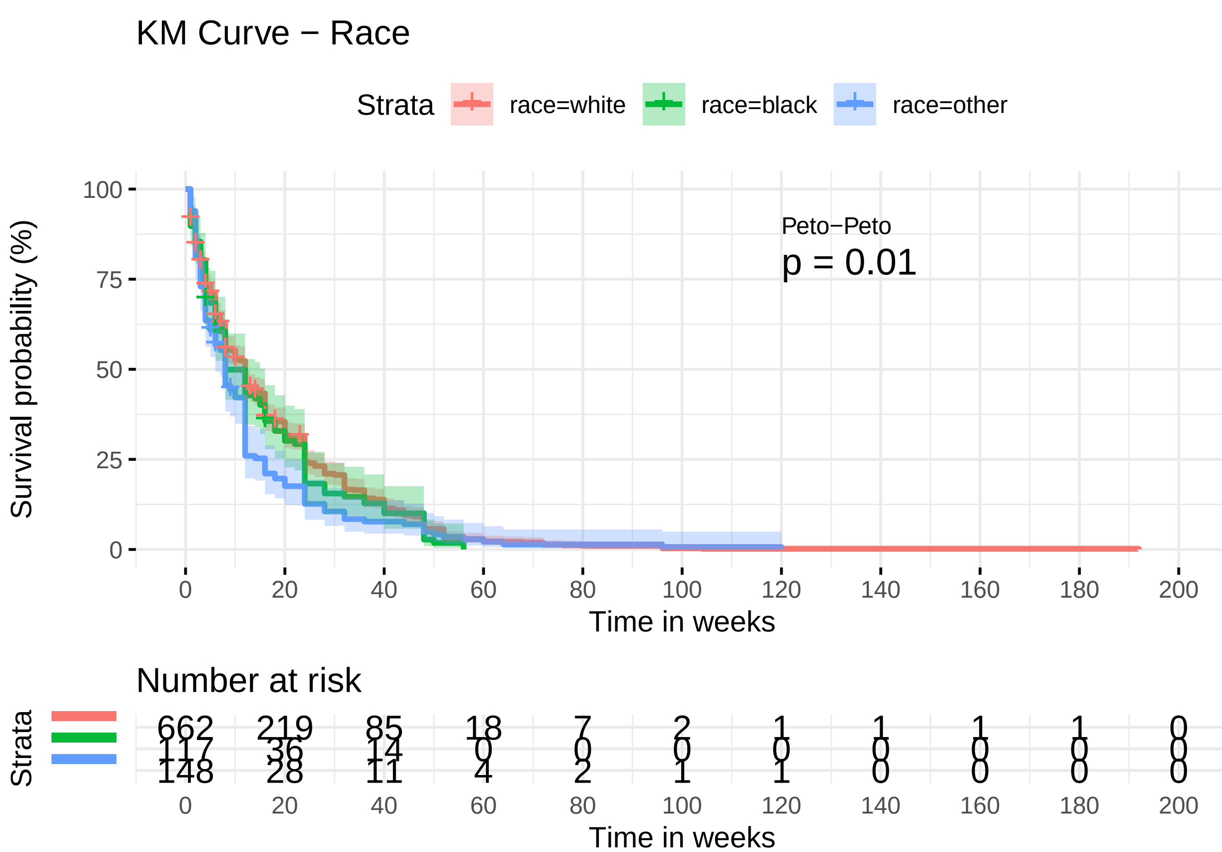
```
# create survival object:
km.as.one <- survfit(SurvObj ~ 1, data = bfeed)
# summary(km.as.one)

km.by.race <- survfit(SurvObj ~ race, data = bfeed)

km.by.poverty <- survfit(SurvObj ~ poverty, data = bfeed)

km.by.education <- survfit(SurvObj ~ education, data = bfeed)

km.by.smoke <- survfit(SurvObj ~ smoke, data = bfeed)

km.by.alcohol <- survfit(SurvObj ~ alcohol, data = bfeed)

km.by.agemth <- survfit(SurvObj ~ agemth, data = bfeed)

km.by.pc3mth <- survfit(SurvObj ~ pc3mth, data = bfeed)

km.by.ybirth <- survfit(SurvObj ~ ybirth, data = bfeed)

#KM plot combining all participants
```

```
ggsurvplot(
   km.as.one,                  # survfit object with calculated statistics.
   data = bfeed,                # data used to fit survival curves.
   risk.table = TRUE,           # show risk table.
   #pval = TRUE,                 # show p-value of log-rank test.
   #conf.int = TRUE,             # show confidence intervals for
                                # point estimates of survival curves.
   xlim = c(0,200),             # present narrower X axis, but not affect
                                # survival estimates.
   xlab = "Time in weeks",      # customize X axis label.
   break.time.by = 20,          # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,   # show bars instead of names in text annotations
                                # in legend of risk table
  # palette = "uchicago",         # change colors to be pretty
  log.rank.weights = "S1",     # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,         # p-val text size
  # title = "KM Curve - Duration of Breast Feeding",
  fun = "pct"                   #show survival function as percentage
)
```

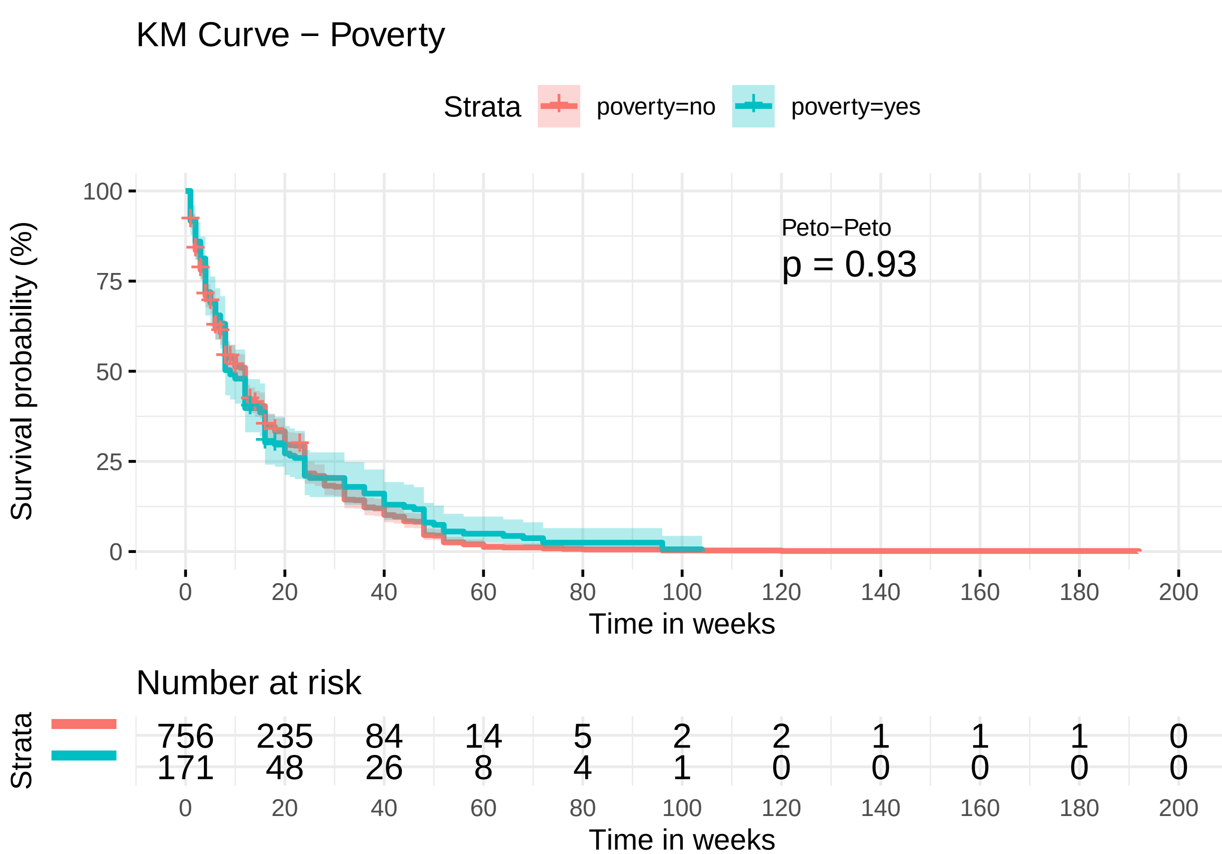



```
#KM curve according to race
ggsurvplot(
```

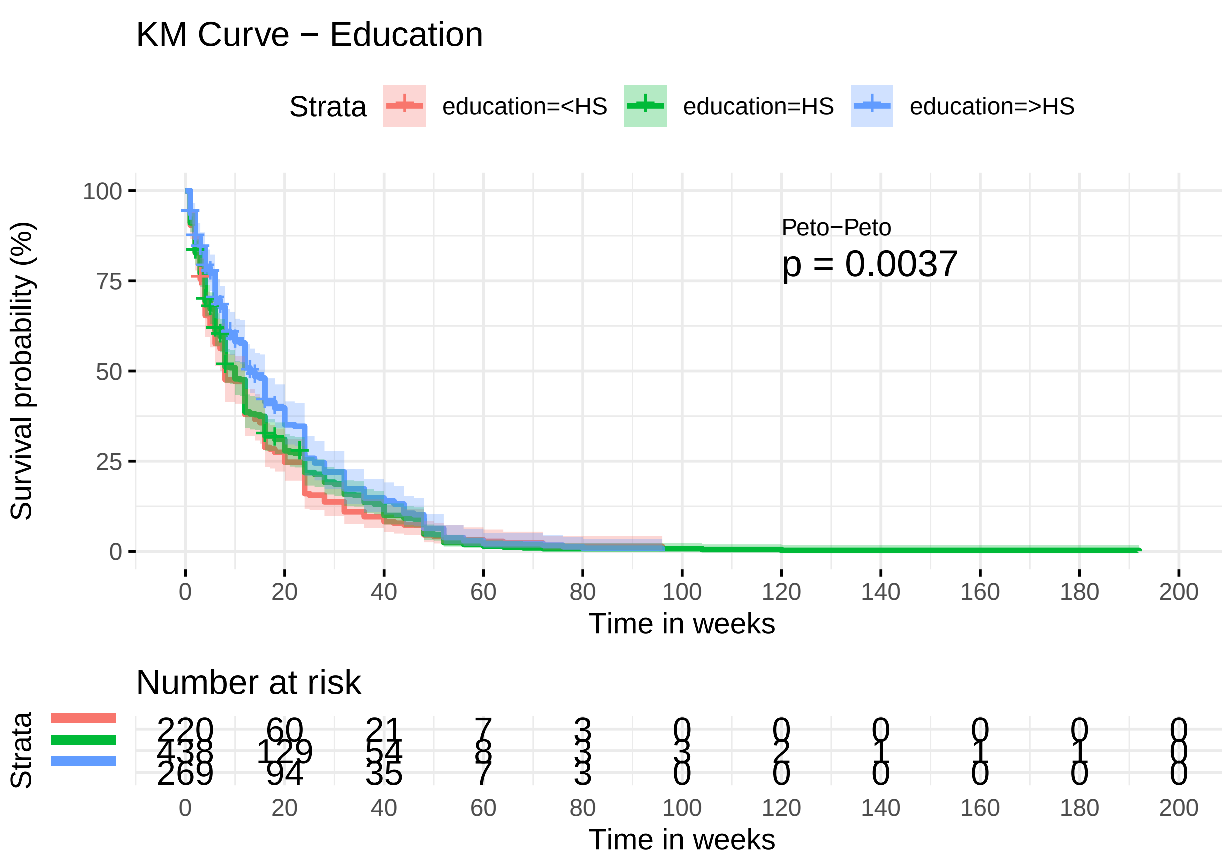
```
   km.by.race,                 # survfit object with calculated statistics.
   data = bfeed,               # data used to fit survival curves.
   risk.table = TRUE,          # show risk table.
   pval = TRUE,                # show p-value of log-rank test.
   pval.coord = c(120,80),     # location of pval
   pval.method = TRUE,          # show type of pval shown
   conf.int = TRUE,            # show confidence intervals for
                               # point estimates of survival curves.
   xlim = c(0,200),            # present narrower X axis, but not affect
                               # survival estimates.
   xlab = "Time in weeks",     # customize X axis label.
   break.time.by = 20,         # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                               # in legend of risk table
  # palette = "uchicago",        # change colors to be pretty
  log.rank.weights = "S1",    # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,       # p-val text size
  title = "KM Curve - Race",
  fun = "pct"                 #show survival function as percentage
)
```



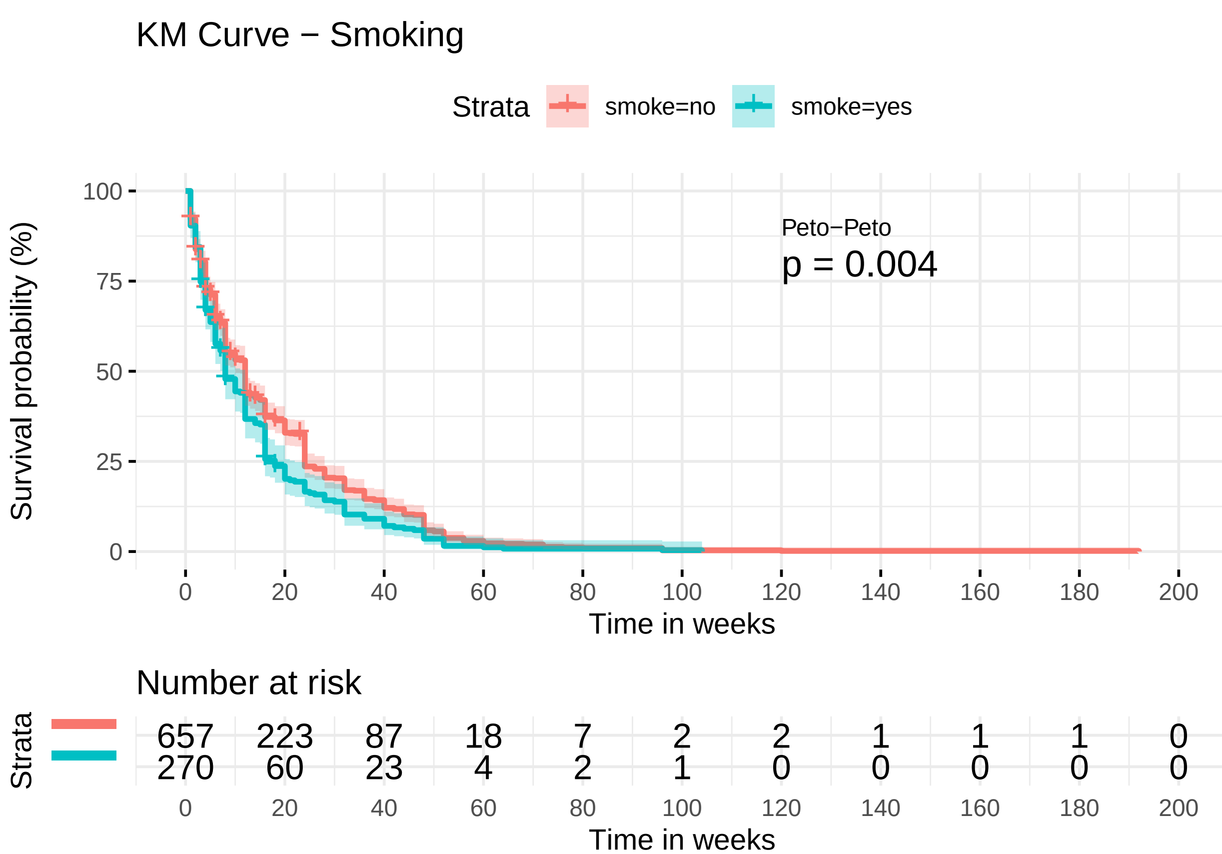
```r
#KM curve according to poverty
ggsurvplot(
   km.by.poverty,               # survfit object with calculated statistics.
   data = bfeed,             # data used to fit survival curves.
   risk.table = TRUE,        # show risk table.
   pval = TRUE,              # show p-value of log-rank test.
   pval.coord = c(120,80),   # location of pval
   pval.method = TRUE,        # show type of pval shown
   conf.int = TRUE,          # show confidence intervals for
                             # point estimates of survival curves.
   xlim = c(0,200),          # present narrower X axis, but not affect
                             # survival estimates.
   xlab = "Time in weeks",   # customize X axis label.
   break.time.by = 20,       # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                             # in legend of risk table
  # palette = "uchicago",      # change colors to be pretty
  log.rank.weights = "S1",   # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,      # p-val text size
  title = "KM Curve - Poverty",
  fun = "pct"                #show survival function as percentage
)
```



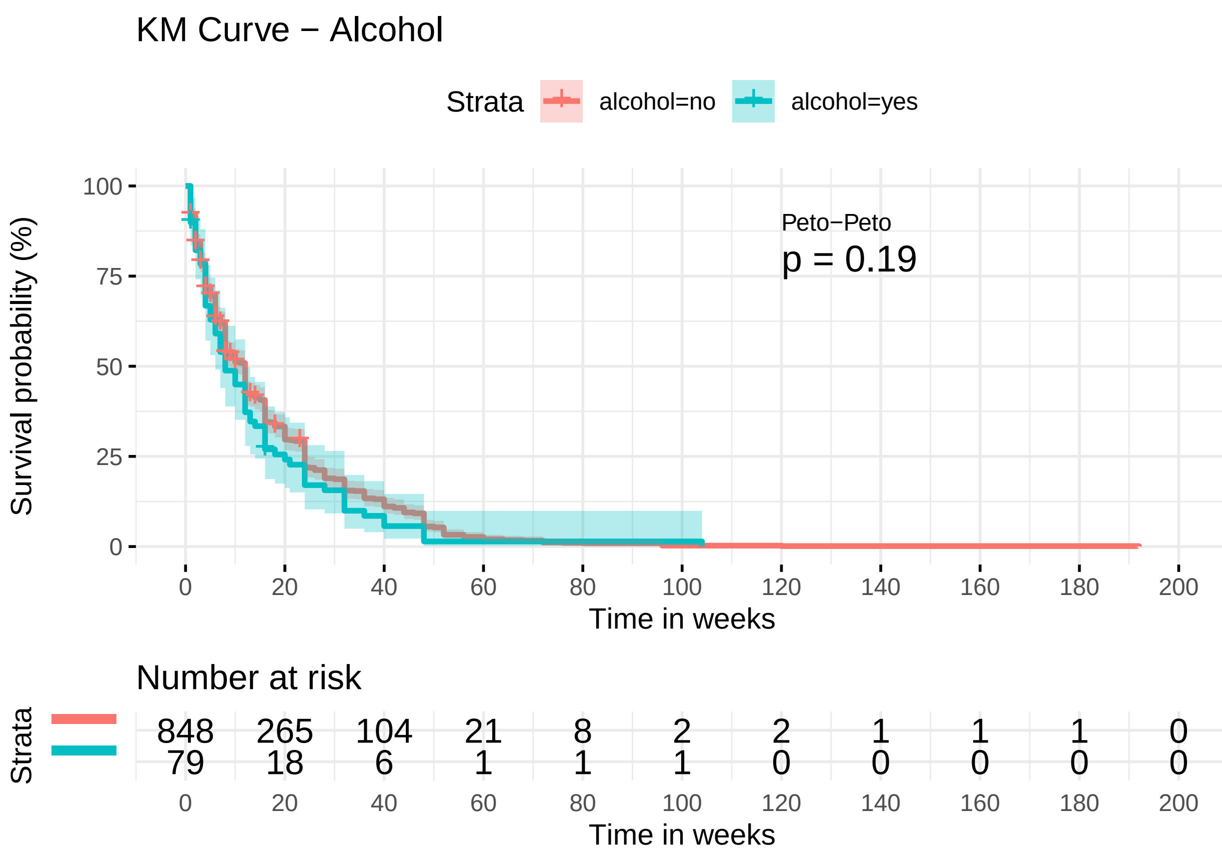
```
#KM curve according to education
ggsurvplot(
   km.by.education,                # survfit object with calculated statistics.
   data = bfeed,              # data used to fit survival curves.
   risk.table = TRUE,         # show risk table.
   pval = TRUE,               # show p-value of log-rank test.
   pval.coord = c(120,80),    # location of pval
   pval.method = TRUE,         # show type of pval shown
   conf.int = TRUE,           # show confidence intervals for
                              # point estimates of survival curves.
   xlim = c(0,200),           # present narrower X axis, but not affect
                              # survival estimates.
   xlab = "Time in weeks",    # customize X axis label.
   break.time.by = 20,        # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                              # in legend of risk table
  # palette = "uchicago",       # change colors to be pretty
  log.rank.weights = "S1",    # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,       # p-val text size
  title = "KM Curve - Education",
  fun = "pct"                 #show survival function as percentage
)
```



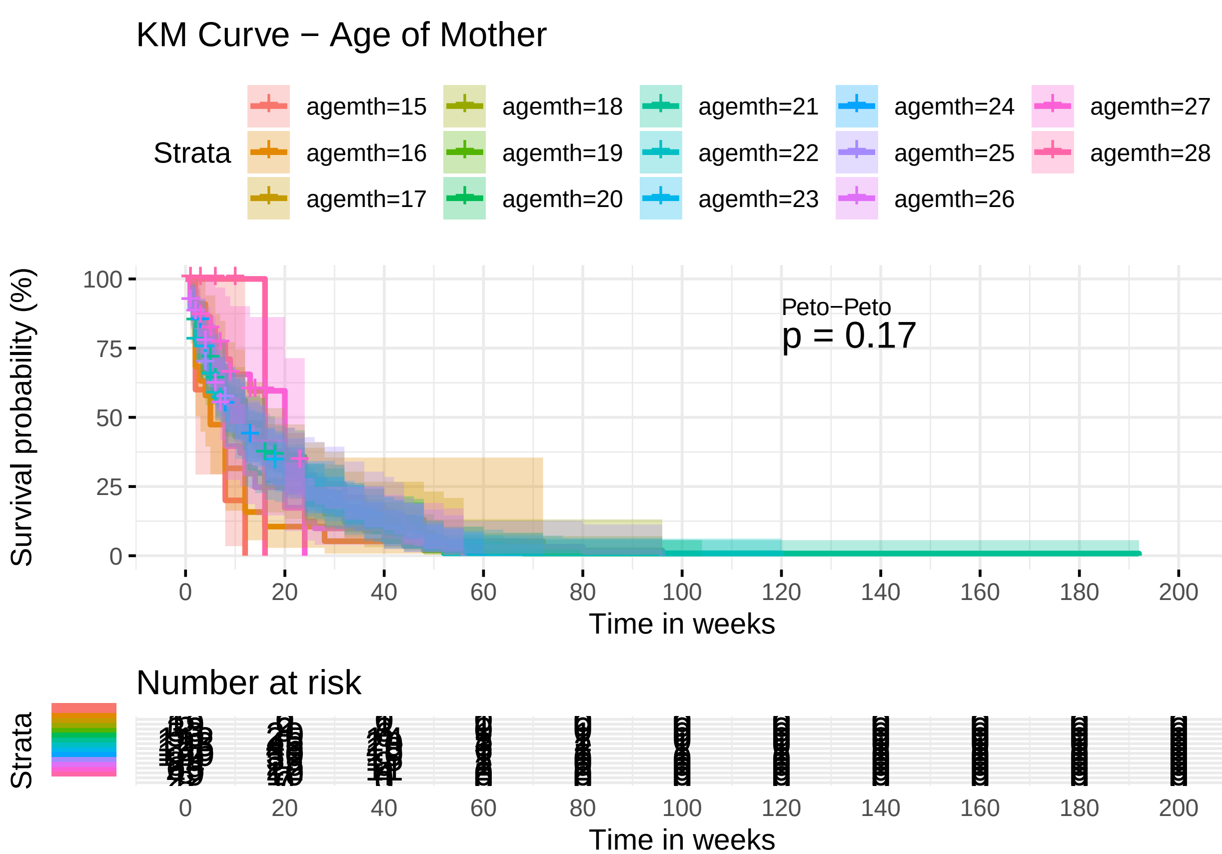
```
#KM curve according to smoking
ggsurvplot(
   km.by.smoke,                 # survfit object with calculated statistics.
   data = bfeed,               # data used to fit survival curves.
   risk.table = TRUE,          # show risk table.
   pval = TRUE,                # show p-value of log-rank test.
   pval.coord = c(120,80),     # location of pval
   pval.method = TRUE,          # show type of pval shown
   conf.int = TRUE,            # show confidence intervals for
                               # point estimates of survival curves.
   xlim = c(0,200),            # present narrower X axis, but not affect
                               # survival estimates.
   xlab = "Time in weeks",     # customize X axis label.
   break.time.by = 20,         # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                               # in legend of risk table
  # palette = "uchicago",        # change colors to be pretty
  log.rank.weights = "S1",    # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,       # p-val text size
  title = "KM Curve - Smoking",
  fun = "pct"                 #show survival function as percentage
)
```



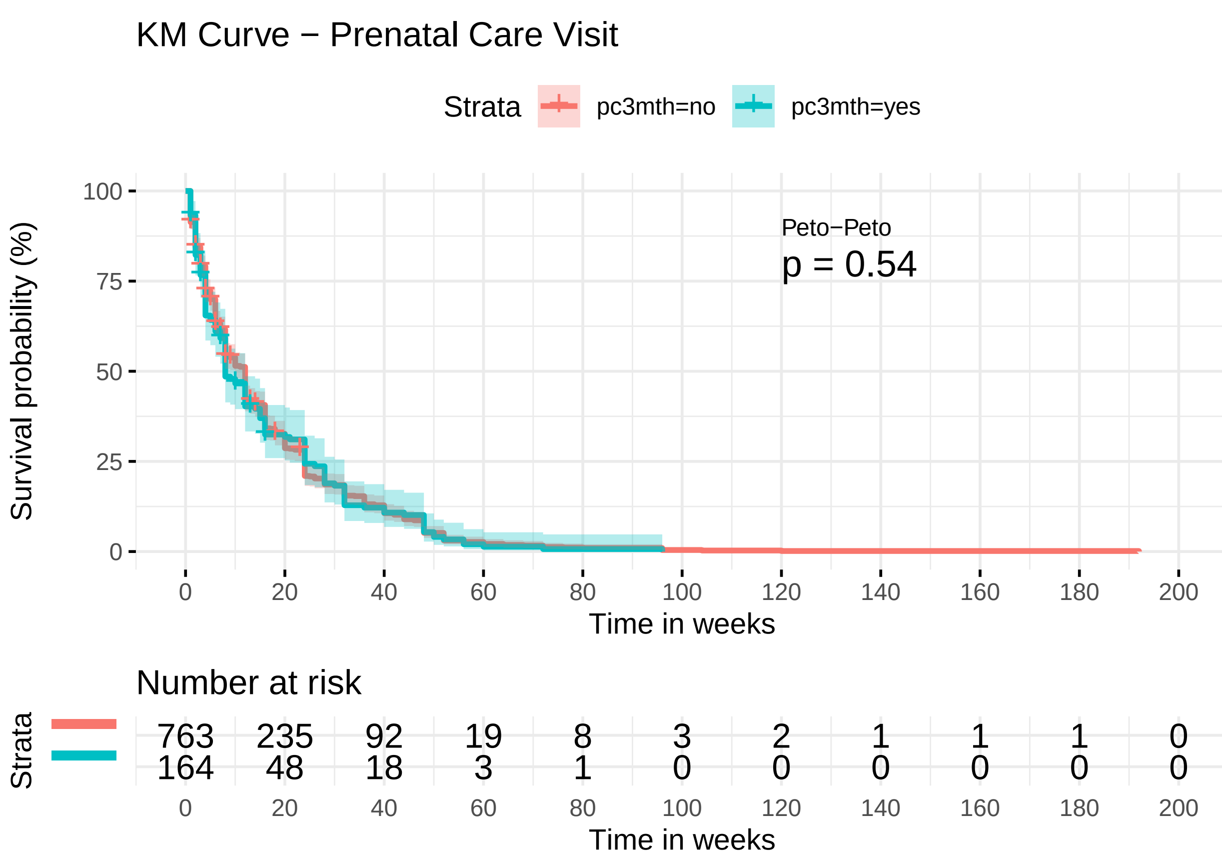
```r
#KM curve according to alcohol
ggsurvplot(
   km.by.alcohol,               # survfit object with calculated statistics.
   data = bfeed,              # data used to fit survival curves.
   risk.table = TRUE,         # show risk table.
   pval = TRUE,               # show p-value of log-rank test.
   pval.coord = c(120,80),    # location of pval
   pval.method = TRUE,         # show type of pval shown
   conf.int = TRUE,           # show confidence intervals for
                              # point estimates of survival curves.
   xlim = c(0,200),           # present narrower X axis, but not affect
                              # survival estimates.
   xlab = "Time in weeks",    # customize X axis label.
   break.time.by = 20,        # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                              # in legend of risk table
  # palette = "uchicago",       # change colors to be pretty
  log.rank.weights = "S1",    # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,       # p-val text size
  title = "KM Curve - Alcohol",
  fun = "pct"                 #show survival function as percentage
)
```



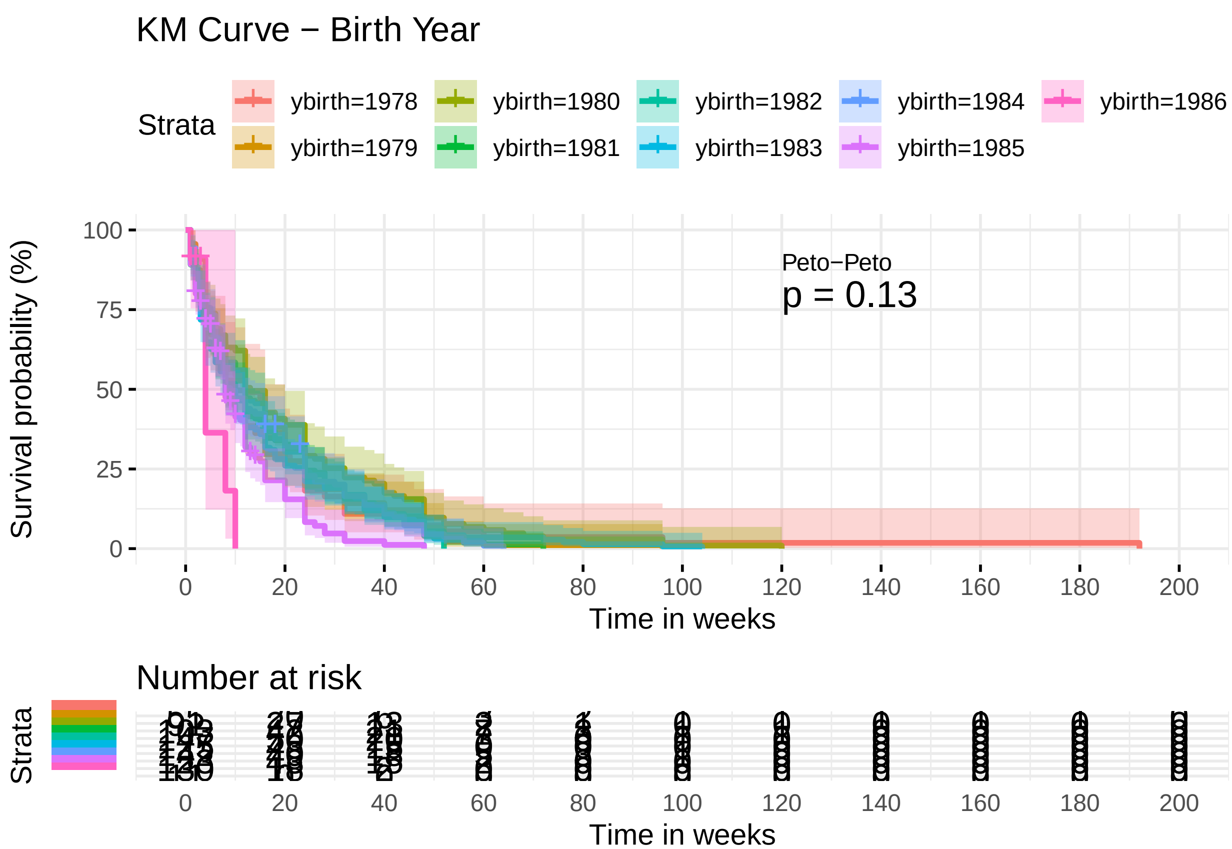
```r
#KM curve according to age of mother at birth of child
ggsurvplot(
   km.by.agemth,               # survfit object with calculated statistics.
   data = bfeed,             # data used to fit survival curves.
   risk.table = TRUE,        # show risk table.
   pval = TRUE,              # show p-value of log-rank test.
   pval.coord = c(120,80),   # location of pval
   pval.method = TRUE,        # show type of pval shown
   conf.int = TRUE,          # show confidence intervals for
                             # point estimates of survival curves.
   xlim = c(0,200),          # present narrower X axis, but not affect
                             # survival estimates.
   xlab = "Time in weeks",   # customize X axis label.
   break.time.by = 20,       # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                             # in legend of risk table
  # palette = "uchicago",      # change colors to be pretty
  log.rank.weights = "S1",   # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,      # p-val text size
  title = "KM Curve - Age of Mother",
  fun = "pct"                #show survival function as percentage
)
```



```
#KM curve according to prenatal care after 3rd month
ggsurvplot(
   km.by.pc3mth,                # survfit object with calculated statistics.
   data = bfeed,              # data used to fit survival curves.
   risk.table = TRUE,         # show risk table.
   pval = TRUE,               # show p-value of log-rank test.
   pval.coord = c(120,80),    # location of pval
   pval.method = TRUE,         # show type of pval shown
   conf.int = TRUE,           # show confidence intervals for
                              # point estimates of survival curves.
   xlim = c(0,200),           # present narrower X axis, but not affect
                              # survival estimates.
   xlab = "Time in weeks",    # customize X axis label.
   break.time.by = 20,        # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                              # in legend of risk table
  # palette = "uchicago",       # change colors to be pretty
  log.rank.weights = "S1",    # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,       # p-val text size
  title = "KM Curve - Prenatal Care Visit",
  fun = "pct"                 #show survival function as percentage
)
```



```
#KM curve according to birth year
ggsurvplot(
   km.by.ybirth,                # survfit object with calculated statistics.
   data = bfeed,              # data used to fit survival curves.
   risk.table = TRUE,         # show risk table.
   pval = TRUE,               # show p-value of log-rank test.
   pval.coord = c(120,80),    # location of pval
   pval.method = TRUE,         # show type of pval shown
   conf.int = TRUE,           # show confidence intervals for
                              # point estimates of survival curves.
   xlim = c(0,200),           # present narrower X axis, but not affect
                              # survival estimates.
   xlab = "Time in weeks",    # customize X axis label.
   break.time.by = 20,        # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                              # in legend of risk table
  # palette = "uchicago",       # change colors to be pretty
  log.rank.weights = "S1",    # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,       # p-val text size
  title = "KM Curve - Birth Year",
  fun = "pct"                 #show survival function as percentage
)
```



<!–# It is in this context

The prevalence of breastfeeding behaviors is lower

Researchers and public health organizations have touted the benefits of breastfeeding for infants [cite][][].

Social determinants of health have profound impacts on life outcomes.

There is a preponderance of evidence that childhood experiences significantly impact life trajectories. Improving child health has been a top priority for the World Health Organization for decades [cite].

Previous research has shown that the age at which a child stops breastfeeding has significant effects on later development [CITE]. An increased understanding of how to –>

Supplemental Figures

lognormal transformation of Duration of Breastfeeding

```
# bfeed %>%
#   mutate(lognormduration = lognormal(duration))
```

code used to create this report

```
# create survival object:
km.as.one <- survfit(SurvObj ~ 1, data = bfeed)
# summary(km.as.one)

km.by.race <- survfit(SurvObj ~ race, data = bfeed)

km.by.poverty <- survfit(SurvObj ~ poverty, data = bfeed)

km.by.education <- survfit(SurvObj ~ education, data = bfeed)

km.by.smoke <- survfit(SurvObj ~ smoke, data = bfeed)

km.by.alcohol <- survfit(SurvObj ~ alcohol, data = bfeed)

km.by.agemth <- survfit(SurvObj ~ agemth, data = bfeed)

km.by.pc3mth <- survfit(SurvObj ~ pc3mth, data = bfeed)

km.by.ybirth <- survfit(SurvObj ~ ybirth, data = bfeed)

#KM plot combining all participants
ggsurvplot(
   km.as.one,               # survfit object with calculated statistics.
   data = bfeed,             # data used to fit survival curves.
   risk.table = TRUE,        # show risk table.
   #pval = TRUE,              # show p-value of log-rank test.
   #conf.int = TRUE,          # show confidence intervals for
                            # point estimates of survival curves.
   xlim = c(0,200),          # present narrower X axis, but not affect
                            # survival estimates.
```

```r
   xlab = "Time in weeks",   # customize X axis label.
   break.time.by = 20,       # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                             # in legend of risk table
  # palette = "uchicago",      # change colors to be pretty
  log.rank.weights = "S1",   # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,      # p-val text size
  title = "KM Curve - Duration of Breast Feeding",
  fun = "pct"                #show survival function as percentage
)

#KM curve according to race
ggsurvplot(
   km.by.race,               # survfit object with calculated statistics.
   data = bfeed,             # data used to fit survival curves.
   risk.table = TRUE,        # show risk table.
   pval = TRUE,              # show p-value of log-rank test.
   pval.coord = c(120,80),   # location of pval
   pval.method = TRUE,        # show type of pval shown
   conf.int = TRUE,          # show confidence intervals for
                             # point estimates of survival curves.
   xlim = c(0,200),          # present narrower X axis, but not affect
                             # survival estimates.
   xlab = "Time in weeks",   # customize X axis label.
   break.time.by = 20,       # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                             # in legend of risk table
  # palette = "uchicago",      # change colors to be pretty
  log.rank.weights = "S1",   # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,      # p-val text size
  title = "KM Curve - Race",
  fun = "pct"                #show survival function as percentage
)

#KM curve according to poverty
ggsurvplot(
   km.by.poverty,               # survfit object with calculated statistics.
   data = bfeed,             # data used to fit survival curves.
   risk.table = TRUE,        # show risk table.
   pval = TRUE,              # show p-value of log-rank test.
   pval.coord = c(120,80),   # location of pval
   pval.method = TRUE,        # show type of pval shown
   conf.int = TRUE,          # show confidence intervals for
                             # point estimates of survival curves.
   xlim = c(0,200),          # present narrower X axis, but not affect
                             # survival estimates.
   xlab = "Time in weeks",   # customize X axis label.
```

```
   break.time.by = 20,       # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                             # in legend of risk table
  # palette = "uchicago",      # change colors to be pretty
  log.rank.weights = "S1",   # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,      # p-val text size
  title = "KM Curve - Poverty",
  fun = "pct"                #show survival function as percentage
)

#KM curve according to education
ggsurvplot(
   km.by.education,               # survfit object with calculated statistics.
   data = bfeed,             # data used to fit survival curves.
   risk.table = TRUE,        # show risk table.
   pval = TRUE,              # show p-value of log-rank test.
   pval.coord = c(120,80),   # location of pval
   pval.method = TRUE,        # show type of pval shown
   conf.int = TRUE,          # show confidence intervals for
                             # point estimates of survival curves.
   xlim = c(0,200),          # present narrower X axis, but not affect
                             # survival estimates.
   xlab = "Time in weeks",   # customize X axis label.
   break.time.by = 20,       # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                             # in legend of risk table
  # palette = "uchicago",      # change colors to be pretty
  log.rank.weights = "S1",   # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,      # p-val text size
  title = "KM Curve - Education",
  fun = "pct"                #show survival function as percentage
)


#KM curve according to smoking
ggsurvplot(
   km.by.smoke,               # survfit object with calculated statistics.
   data = bfeed,             # data used to fit survival curves.
   risk.table = TRUE,        # show risk table.
   pval = TRUE,              # show p-value of log-rank test.
   pval.coord = c(120,80),   # location of pval
   pval.method = TRUE,        # show type of pval shown
   conf.int = TRUE,          # show confidence intervals for
                             # point estimates of survival curves.
   xlim = c(0,200),          # present narrower X axis, but not affect
                             # survival estimates.
   xlab = "Time in weeks",   # customize X axis label.
```

```
   break.time.by = 20,       # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                             # in legend of risk table
  # palette = "uchicago",      # change colors to be pretty
  log.rank.weights = "S1",   # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,      # p-val text size
  title = "KM Curve - Smoking",
  fun = "pct"                #show survival function as percentage
)


#KM curve according to alcohol
ggsurvplot(
   km.by.alcohol,               # survfit object with calculated statistics.
   data = bfeed,             # data used to fit survival curves.
   risk.table = TRUE,        # show risk table.
   pval = TRUE,              # show p-value of log-rank test.
   pval.coord = c(120,80),   # location of pval
   pval.method = TRUE,        # show type of pval shown
   conf.int = TRUE,          # show confidence intervals for
                             # point estimates of survival curves.
   xlim = c(0,200),          # present narrower X axis, but not affect
                             # survival estimates.
   xlab = "Time in weeks",   # customize X axis label.
   break.time.by = 20,       # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                             # in legend of risk table
  # palette = "uchicago",      # change colors to be pretty
  log.rank.weights = "S1",   # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,      # p-val text size
  title = "KM Curve - Alcohol",
  fun = "pct"                #show survival function as percentage
)

#KM curve according to age of mother at birth of child
ggsurvplot(
   km.by.agemth,              # survfit object with calculated statistics.
   data = bfeed,             # data used to fit survival curves.
   risk.table = TRUE,        # show risk table.
   pval = TRUE,              # show p-value of log-rank test.
   pval.coord = c(120,80),   # location of pval
   pval.method = TRUE,        # show type of pval shown
   conf.int = TRUE,          # show confidence intervals for
                             # point estimates of survival curves.
   xlim = c(0,200),          # present narrower X axis, but not affect
                             # survival estimates.
   xlab = "Time in weeks",   # customize X axis label.
```

```
   break.time.by = 20,       # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                             # in legend of risk table
  # palette = "uchicago",      # change colors to be pretty
  log.rank.weights = "S1",   # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,      # p-val text size
  title = "KM Curve - Age of Mother",
  fun = "pct"                #show survival function as percentage
)

#KM curve according to prenatal care after 3rd month
ggsurvplot(
   km.by.pc3mth,               # survfit object with calculated statistics.
   data = bfeed,             # data used to fit survival curves.
   risk.table = TRUE,        # show risk table.
   pval = TRUE,              # show p-value of log-rank test.
   pval.coord = c(120,80),   # location of pval
   pval.method = TRUE,        # show type of pval shown
   conf.int = TRUE,          # show confidence intervals for
                             # point estimates of survival curves.
   xlim = c(0,200),          # present narrower X axis, but not affect
                             # survival estimates.
   xlab = "Time in weeks",   # customize X axis label.
   break.time.by = 20,       # break X axis in time intervals by 500.
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                             # in legend of risk table
  # palette = "uchicago",      # change colors to be pretty
  log.rank.weights = "S1",   # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,      # p-val text size
  title = "KM Curve - Prenatal Care Visit",
  fun = "pct"                #show survival function as percentage
)

#KM curve according to birth year
ggsurvplot(
   km.by.ybirth,               # survfit object with calculated statistics.
   data = bfeed,             # data used to fit survival curves.
   risk.table = TRUE,        # show risk table.
   pval = TRUE,              # show p-value of log-rank test.
   pval.coord = c(120,80),   # location of pval
   pval.method = TRUE,        # show type of pval shown
   conf.int = TRUE,          # show confidence intervals for
                             # point estimates of survival curves.
   xlim = c(0,200),          # present narrower X axis, but not affect
                             # survival estimates.
   xlab = "Time in weeks",   # customize X axis label.
   break.time.by = 20,       # break X axis in time intervals by 500.
```

```r
   ggtheme = theme_minimal(),# customize plot and risk table with a theme.
  risk.table.y.text.col = T, # colour risk table text annotations.
  risk.table.y.text = FALSE,  # show bars instead of names in text annotations
                              # in legend of risk table
  # palette = "uchicago",       # change colors to be pretty
  log.rank.weights = "S1",    # Peto Peto test for log-rank test
  pval.method.coord = c(120,90), # location of p-value text
  pval.method.size = 3,       # p-val text size
  title = "KM Curve - Birth Year",
  fun = "pct"                 #show survival function as percentage
)
```

```r
bfeed %>%
  ggplot(aes(x=ybirth, y=duration, color = delta)) +
  geom_point()+ geom_smooth(method = "lm")
```

```
## `geom_smooth()` using formula 'y ~ x'
```

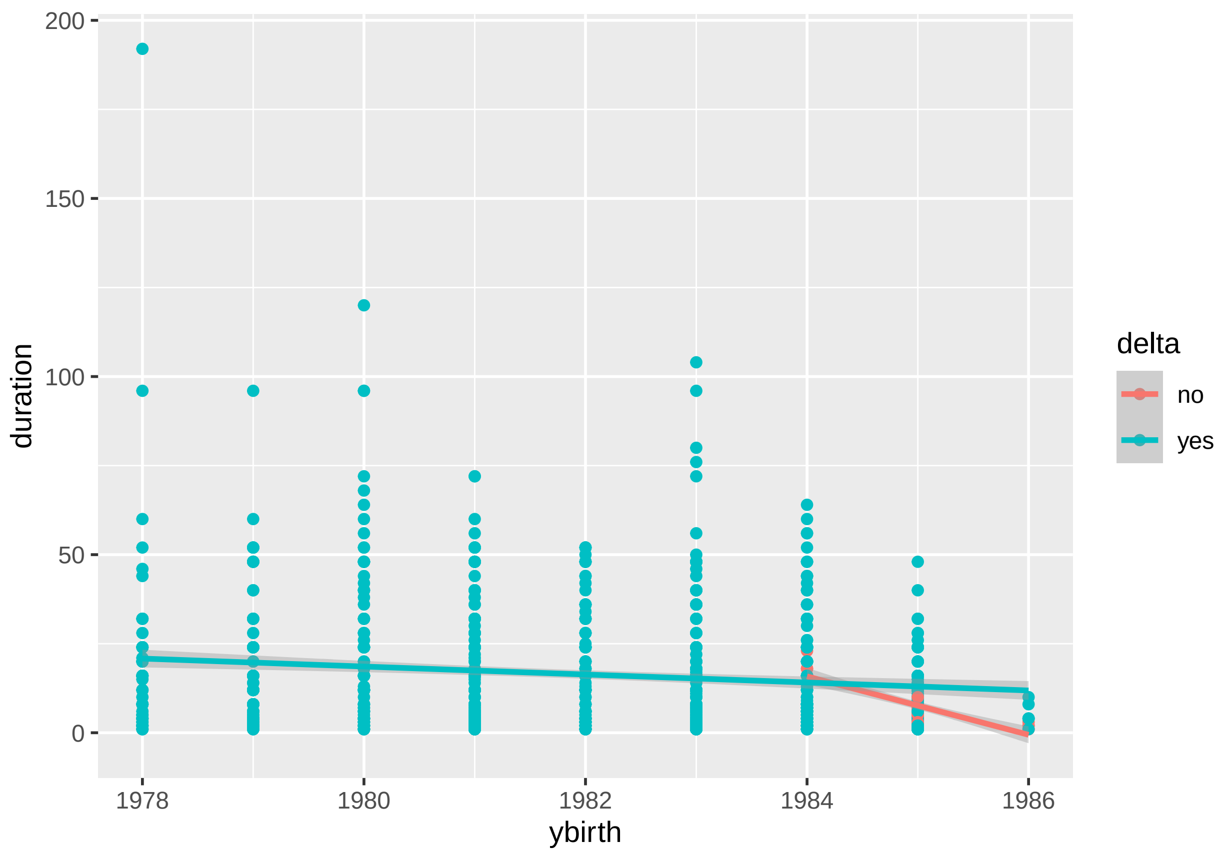


Figure S1: correlation between birth year and duration of breastfeeding