Increasing Contraceptive Choice: Exploring Opportunities and Health Impacts in Indonesia

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Background and Significance

Contraceptives are far more than a method of preventing pregnancy—they represent a transformative tool for health and life opportunities for individuals capable of pregnancy. The broader implications of contraceptive access extend across multiple critical domains:

Health Impacts

Epidemiological evidence from the United States demonstrates significant health benefits:

- Improved pregnancy spacing reduces risks of premature births and low birth weight
- Enables management of complex health conditions such as diabetes and heart disease
- Supports mental health and overall well-being, i.e., decreases risk of depression

Socioeconomic Opportunities

Contraceptive choice is a powerful lever for individual empowerment:

- Enables women to pursue advanced education
- Supports career development and professional growth
- Enhances family planning and economic stability

Notably, each dollar invested in family planning generates $7 in healthcare cost savings, highlighting the broader societal impact.

Research Context

While these insights are drawn from U.S. data, they provide a robust theoretical framework for investigating contraceptive use in the Indonesian context.

Research Overview

Data Source

1987 National Indonesia Contraceptive Prevalence Survey (linked below)

Primary Research Question

What interventions can effectively increase contraceptive method utilization among women in this population?

Methodological Approach

Multiple logistic regression analysis

Key Finding

Education emerges as a critical intervention for increasing contraceptive use among women in this population.

Report Structure

0. Dataset Explanation
1. Exploratory Data Analysis
    - Variable Selection and Investigation
2. Relative Odds of Contraceptive Methods
3. Modeling and Predictive Strength of Independent Variables
4. Conclusions and Recommendations

Learn more about the benefits of contraceptive choice

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0. Data Information

Source: This data set is from a 1987 National Indonesia Contraceptive Prevalence Survey. All observations are married women who were definitely not pregnant or did not know yet. Questions on the survey covered topics regarding socio-economic status and general demographics.

Links: 1. Available on Kaggle 2. Available at the UC Irvine Machine Learning Library

Variable Information:

```
* Age - age of the woman
* Education - level of education woman has received (1=low, 4=high)
* Partner Education - level of education partner has received (1=low, 4=high)
* Number of Children - number of kids mothered by woman
* Religion=Islam - woman that identify as Muslim (0=No, 1=Yes)
* Currently Working - woman is currently employed (0=Yes, 1=No)
* Husbands Occupation - Not specified (categorical 1-4)
* Standard of Living - based on the standard of living index (1=low, 4=high)
* Media exposure - quality of media exposure (0=Good, 1=Not good)
* Contraceptive Method Used - 1=No-use, 2=Long-term, 3=Short-term
```

```r
df = read.csv('data/1987 Indonesia Contraception Prevalence Study.csv')
names(df)
```

```
##  [1] "Age"                    "Education"
##  [3] "Partner.Education"      "Number.of.Children"
##  [5] "Religion...Islam"       "Currently.working"
##  [7] "Husband.Occupation"     "Standard.of.Living"
##  [9] "Media.Exposure"         "Contraceptive.Method.Used"
```

1. Exploratory Data Analysis

- Description of Dataframe
- Missingness Check
- Investigation of Response Variable: Contraceptive Method
- Correlation Between Independant Variables

Description of Dataframe Dimensions:

```
print(dim(df))
```

```
## [1] 1473   10
```

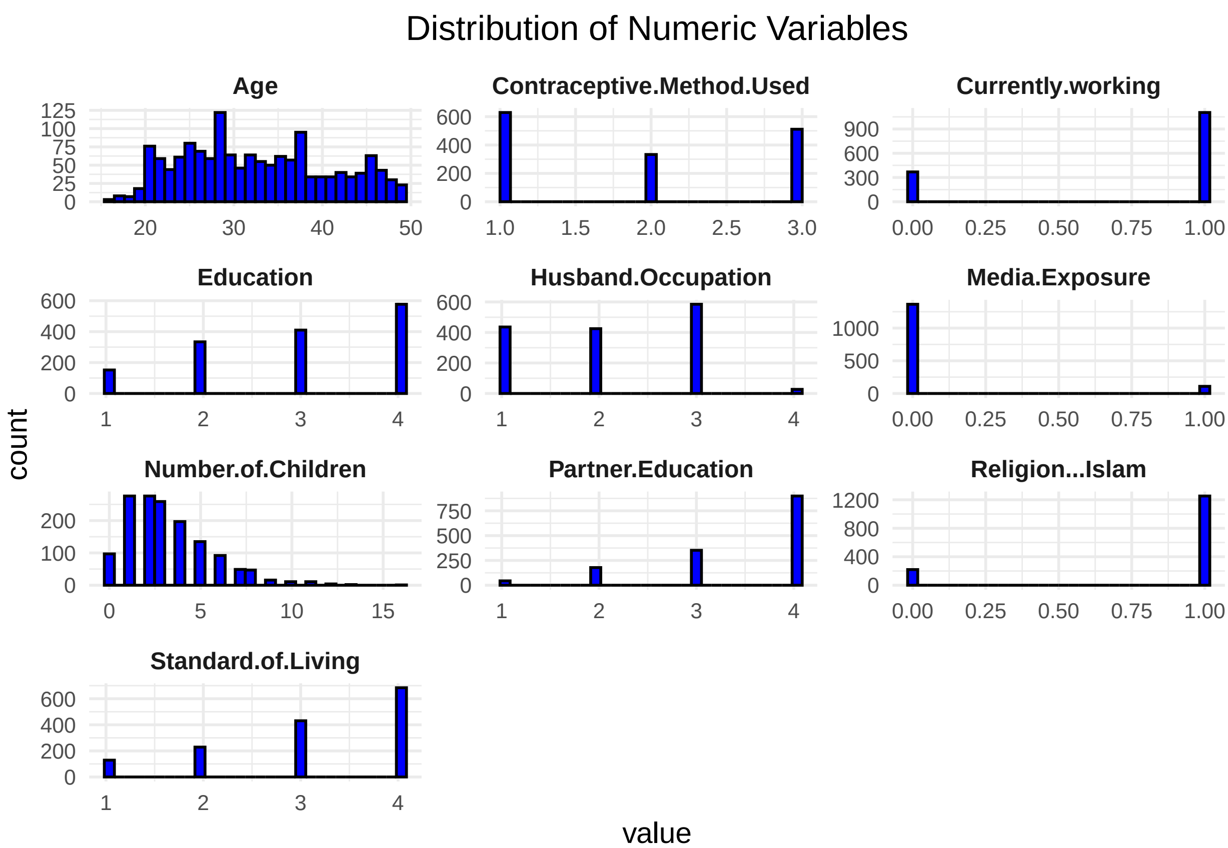
Data Types of the Varibles:

```
print(sapply(df, class))
```

```
##                       Age                 Education         Partner.Education
##                 "integer"                 "integer"                 "integer"
##        Number.of.Children          Religion...Islam         Currently.working
##                 "integer"                 "integer"                 "integer"
##        Husband.Occupation        Standard.of.Living            Media.Exposure
##                 "integer"                 "integer"                 "integer"
## Contraceptive.Method.Used
##                 "integer"
```

Looking at distributions of all variables (all cols are numeric):

```
create_numeric_histograms <- function(df, ncol = 3) {
 df %>%
   select(where(is.numeric)) %>%
   pivot_longer(cols = everything()) %>%
   ggplot(aes(x = value)) +
   geom_histogram(bins = 30, fill = "blue", color = "black") +
   facet_wrap(~ name, scales = "free", ncol = ncol) +
   theme_minimal() +
   theme(
     strip.text = element_text(face = "bold"),
     axis.text = element_text(size = 8),
     plot.title = element_text(hjust = 0.5)
   ) +
   labs(title = "Distribution of Numeric Variables")
}

create_numeric_histograms(df)
```



Missingness Check Missing Values:

```
print(colSums(is.na(df)))
```

```
##                     Age               Education       Partner.Education
##                       0                       0                       0
##      Number.of.Children        Religion...Islam       Currently.working
##                       0                       0                       0
##      Husband.Occupation      Standard.of.Living          Media.Exposure
##                       0                       0                       0
## Contraceptive.Method.Used
##                       0
```

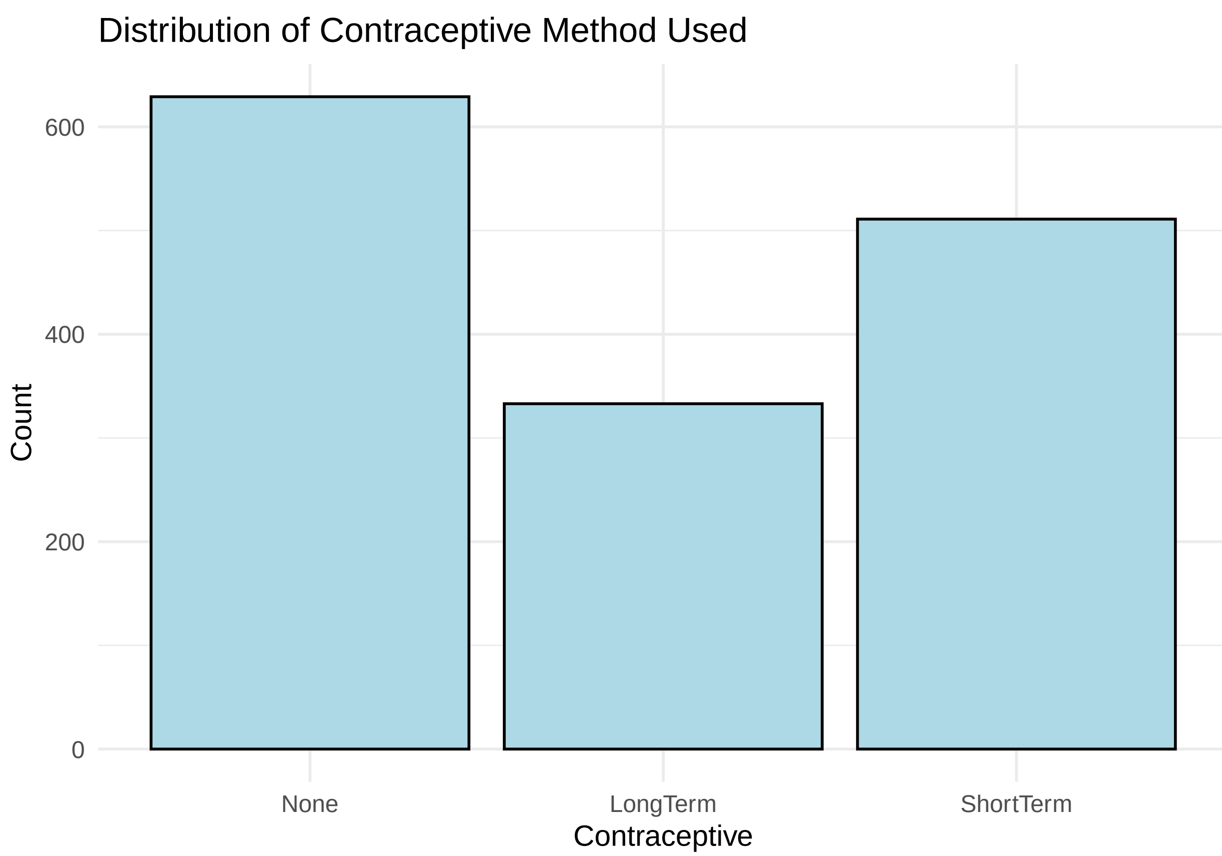
Investigation of Response Variable: Contraceptive Method Creating a new variable to reflect the following:

Contraceptive Method Used:

- 1 = No-use
- 2 = Long-term
- 3 = Short-term

```r
df$contraceptive.method <- as.factor(df$Contraceptive.Method.Used)
levels(df$contraceptive.method) <- c("None", "LongTerm", "ShortTerm")
ggplot(df, aes(x = contraceptive.method)) +
 geom_histogram(stat = "count", fill = "lightblue", color = "black") +
 theme_minimal() +
 labs(
   title = "Distribution of Contraceptive Method Used",
   x = "Contraceptive",
   y = "Count"
 )
```

```
## Warning in geom_histogram(stat = "count", fill = "lightblue", color = "black"):
## Ignoring unknown parameters: ‘binwidth‘, ‘bins‘, and ‘pad‘
```




```r
dplyr::count(df, contraceptive.method, sort = TRUE)
```

```
##   contraceptive.method   n
## 1                 None 629
## 2            ShortTerm 511
## 3             LongTerm 333
```

There are 3 unequal classes of contraceptive use. Most women (629 participants) in this sample do not use contraceptives, followed by short term contraceptive use (511 participants), and finally, about twenty-two percent of these women use long term contraceptives (333 participants).

Relationship Between Independant Variables Changing variables to factors so they appear correctly in the pairplot.

```r
df_factors = df
factor_cols = c("Education","Partner.Education","Religion...Islam",
                "Currently.working","Standard.of.Living","Media.Exposure")
df_factors[factor_cols] <- lapply(df_factors[factor_cols], factor)
```

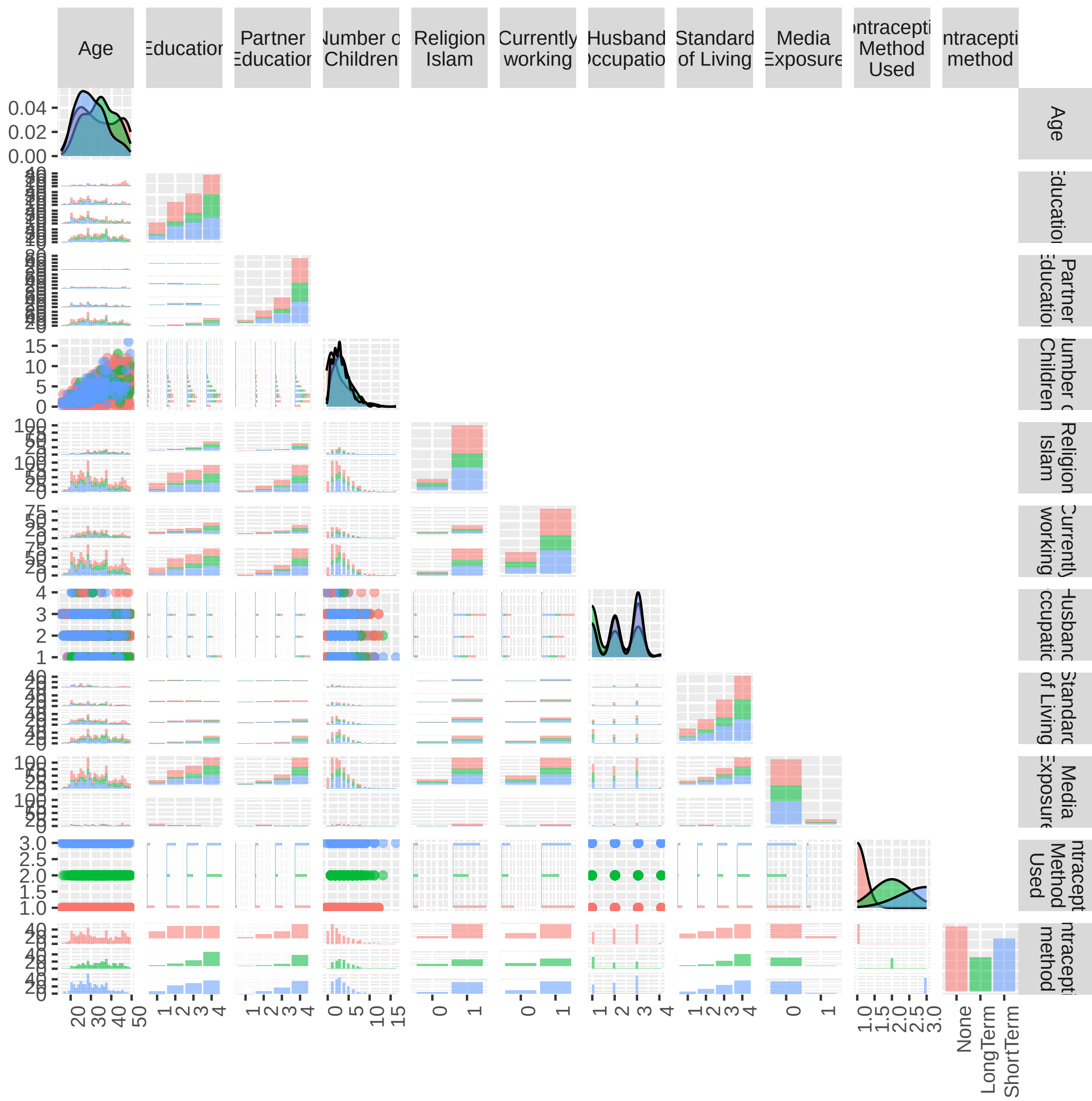
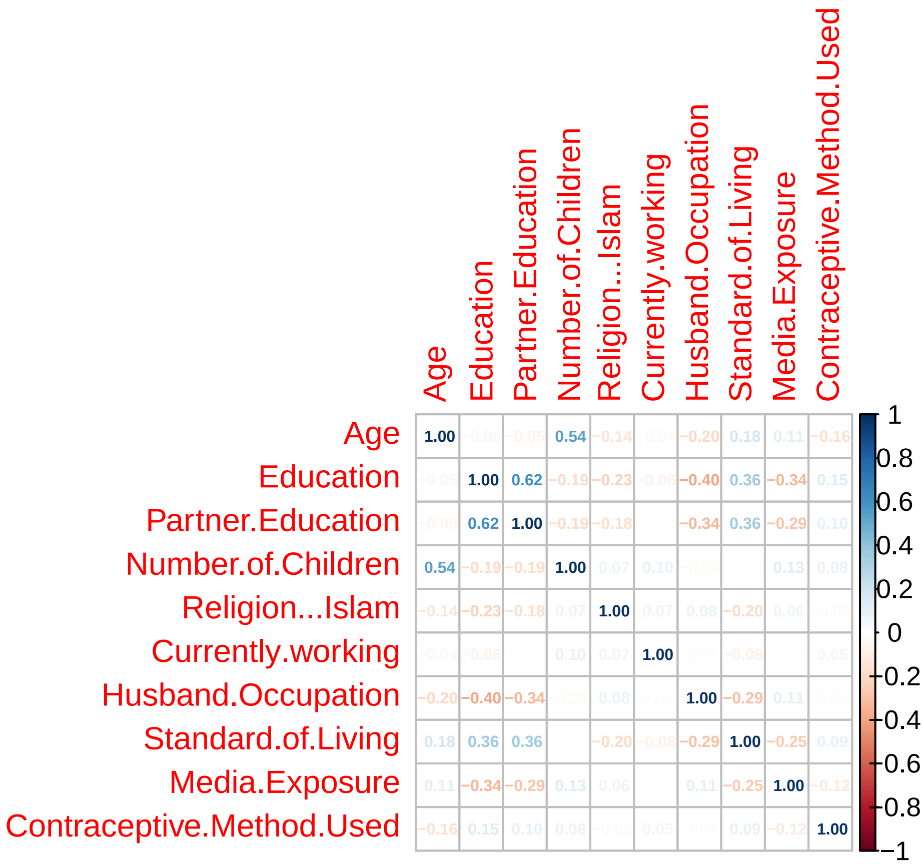


Figure 1: Pair Plot

Next I will look at correlations between variables for more information

```
cor_matrix=df %>%select(where(is.numeric))  %>% cor()

corrplot(cor_matrix,method="number",number.cex=0.5)
```



The variables with the largest correlation to contraceptive method used are Age, Education and Partner Education. Media Exposure also has some negative correlation, but the class is particularly unbalanced. Instead, I'm interested in Education and Partner Education, as these can be intervened upon to increase use of contraception and family planning in this population. Age I'll inspect as an explanatory variable.

2. Relative Odds of Contraception Method

```
model1 = multinom(df$Contraceptive.Method.Used~1)
```

```
## # weights:  6 (2 variable)
## initial  value 1618.255901
## final  value 1571.363231
## converged
```

```
summary(model1)
```

```
## Call:
## multinom(formula = df$Contraceptive.Method.Used ~ 1)
```

```
##
## Coefficients:
##   (Intercept)
## 2  -0.6359864
## 3  -0.2077754
##
## Std. Errors:
##   (Intercept)
## 2  0.06777021
## 3  0.05955488
##
## Residual Deviance: 3142.726
## AIC: 3146.726
```

Based on a null "mlogit" model, the relative odds of certain form of Contraceptive Use relative to neither are:

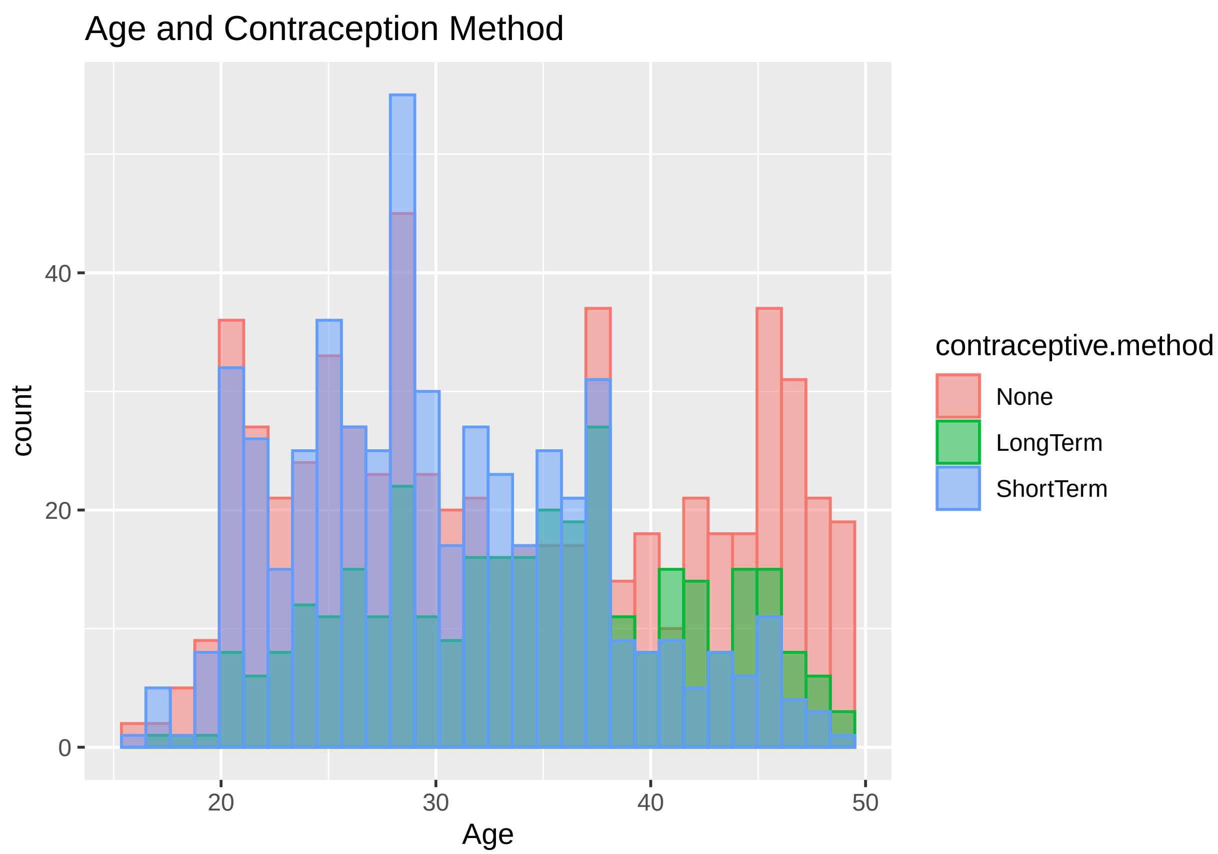
- P(*Long-Term Contraception*)/P(No Use)=exp(-0.6359864)= *0.529*
- P(*Short-Term Contraception*)/P(No Use)=exp(-0.2077754)= *0.812*

There is a higher probability of Short Term Contraceptive use, than Long Term Contraceptive use, relative to None. However, it is MOST likely that no contraception is used.

3. Modelling and Predictive Strength of Independent Variables

```
ggplot(df, aes(x=Age, fill= contraceptive.method, color=contraceptive.method)) +
  geom_histogram(alpha=0.5,position="identity") + ggtitle("Age and Contraception Method")
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



Without modeling, I can see some relationships between Age and contraceptive method. It looks like the women in sample over 40 years old have a higher chance of choosing no contraceptive method, or long-term contraception. They are distinct from the rest of the sample in that they prefer long-term over short term contraception. Otherwise, short term is more popular. In particular, it also looks like short term contraception is most popular from late 20's to mid 30's.

```
model2=multinom(contraceptive.method ~ Age, data = df)
```

```
## # weights:  9 (4 variable)
## initial  value 1618.255901
## final  value 1538.602530
## converged
```

```
summary(model2)
```

```
## Call:
## multinom(formula = contraceptive.method ~ Age, data = df)
##
## Coefficients:
##           (Intercept)         Age
## LongTerm    -1.114493  0.01411370
## ShortTerm    1.374399 -0.04975711
##
## Std. Errors:
##           (Intercept)         Age
```

```
## LongTerm    0.2881547 0.008224668
## ShortTerm   0.2491427 0.007654223
##
## Residual Deviance: 3077.205
## AIC: 3085.205
```

```
z <- summary(model2)$coefficients/summary(model2)$standard.errors
p <- (1 - pnorm(abs(z), 0, 1)) * 2
p
```

```
##            (Intercept)          Age
## LongTerm  1.098712e-04 8.615819e-02
## ShortTerm 3.457904e-08 7.999579e-11
```

With a p-value of 0.05 , the Age term is significant.

Relative probabilities $Log(P(LongTerm)/P(None))=-1.114493+0.01411370*Age $

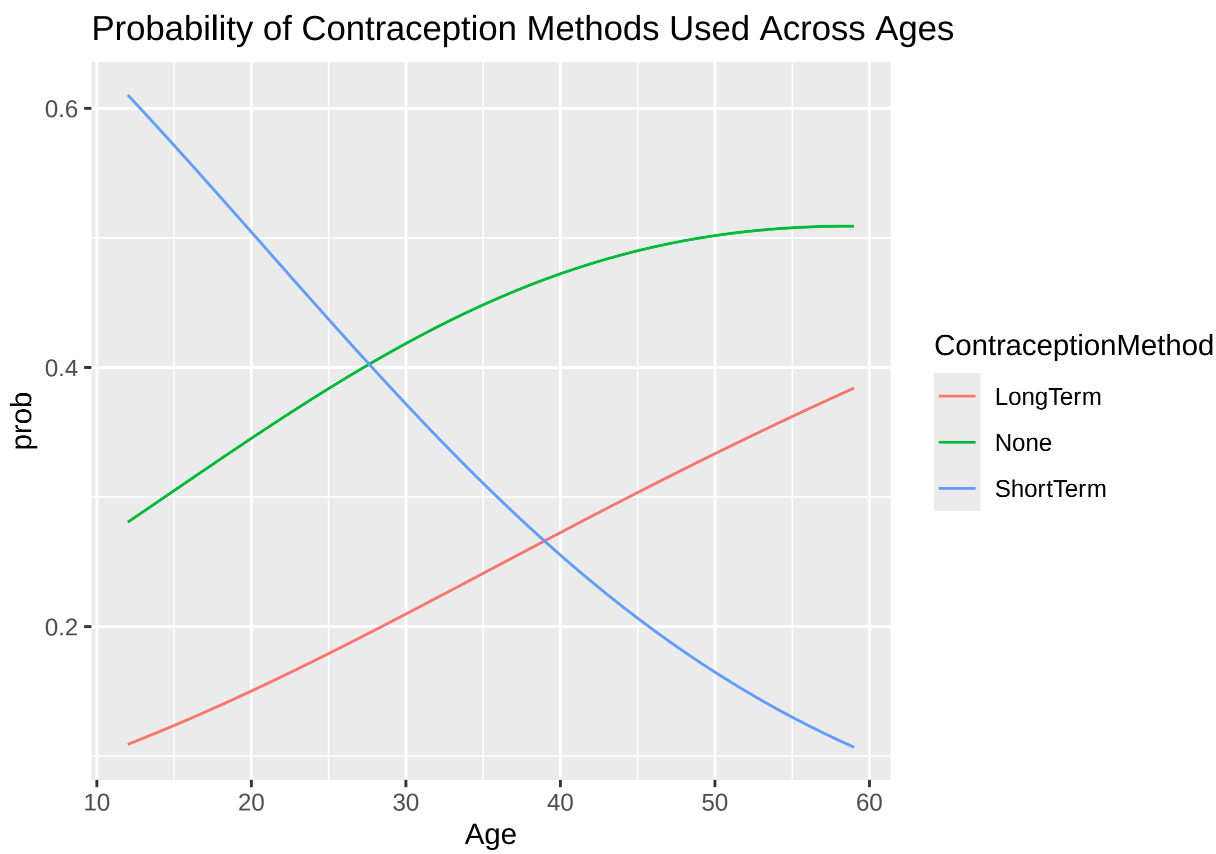
$Log(P(ShortTerm)/P(None)) = 1.374399 - 0.04975711 * Age$

For example:

- The odds ratio of long term contraception to no contraception for a 29 year old is 4.59
- The odds ratio of short term contraception to no contraception for an 18 year old is 1.614089

Graphing the probability of Contraceptive Method use across ages:

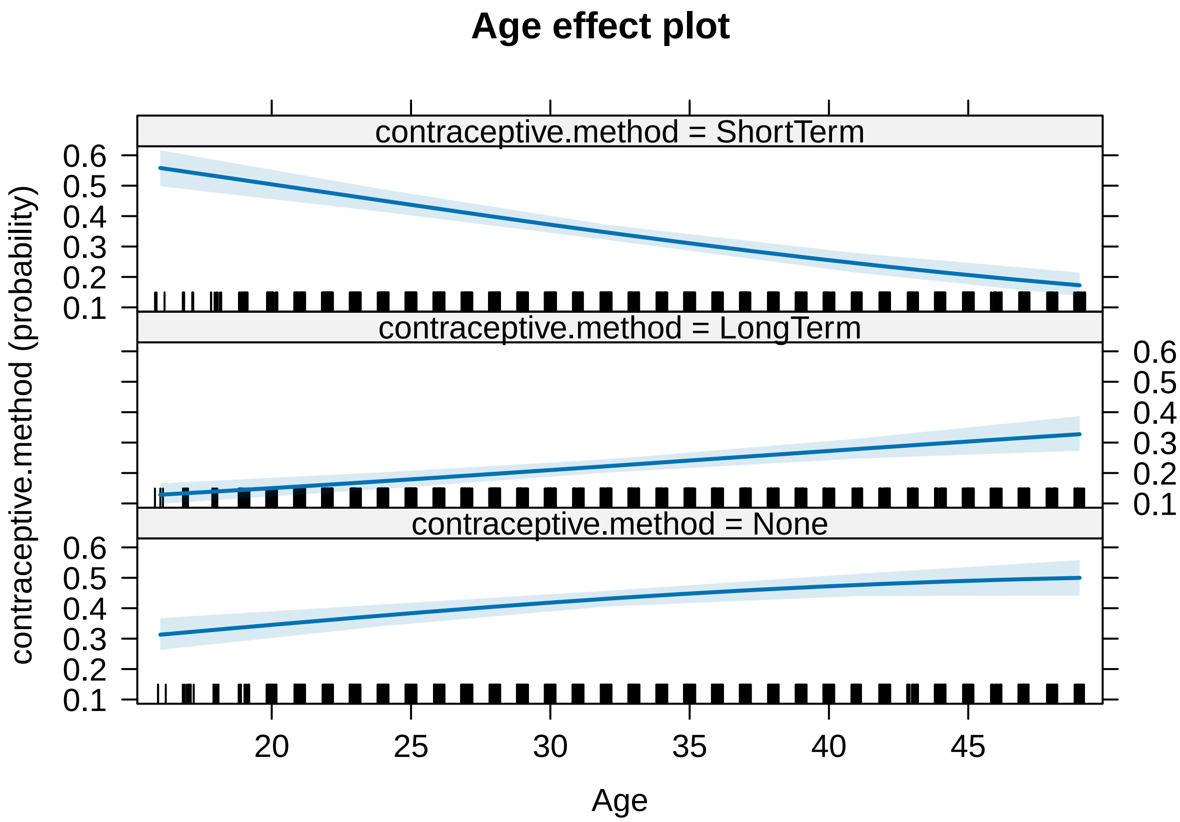
```
newdata = as.data.frame(matrix(0,48,1))
names(newdata) = c("Age")
newdata[,1] = 12:59
pred = predict(model2,newdata=newdata, type="probs")

new_predict <- cbind(newdata, pred)
#head(new_predict)
prob_plot <- new_predict %>%
  pivot_longer(2:4, names_to = "ContraceptionMethod", values_to = "prob")

ggplot(prob_plot, aes(x=Age, y=prob, group=ContraceptionMethod)) +
  geom_line(aes(color=ContraceptionMethod)) +
  ggtitle("Probability of Contraception Methods Used Across Ages")
```



Interestingly, it is predicted that using short-term contraception is much higher for younger participants, at greater than 40% probability of usage for those under 20 years old. As the age in the sample increases, predicted long-term contraceptive use increases, and short-term declines. Predicted use of no contraception surpasses short term around the age of 30. This is all reflected in the histogram printed above.

Following is the same chart, but broken out into contraceptive method:

```
plot(Effect("Age",model2))
```



Education and Contraceptive Type

Education and Partner's Education are strongly correlated. First I will add them separately, then as an interaction term if appropriate.

```
model3=multinom(contraceptive.method ~ Age + Education + Partner.Education, data = df)
```

```
## # weights:  15 (8 variable)
## initial  value 1618.255901
## iter  10 value 1472.478497
## final  value 1468.563869
## converged
```

```
summary(model3)
```

```
## Call:
## multinom(formula = contraceptive.method ~ Age + Education + Partner.Education,
##     data = df)
##
## Coefficients:
##           (Intercept)         Age Education Partner.Education
## LongTerm   -3.9048594  0.01882748 0.8859641       -0.03227119
## ShortTerm   0.3977791 -0.04657558 0.2677880        0.03383691
##
```

```
## Std. Errors:
##           (Intercept)         Age  Education Partner.Education
## LongTerm    0.4763635 0.008795481 0.10249389        0.12404645
## ShortTerm   0.3636809 0.007702697 0.07612793        0.09253532
##
## Residual Deviance: 2937.128
## AIC: 2953.128
```

Adding these terms has reduced the effect of age significantly.

The Partner Education variable seems weak. It is a very small coefficient, with a relatively large standard error.

It seems like a participant's education has a large positive effect on the relative odds of choosing Long Term contraception over no contraception. It has a smaller positive effect on the relative odds of choosing short term education.

Interestingly, the education of the partner has a small negative effect on the relative odds of choosing long term contraception, and a small positive effect on relative odds of choosing short term contraception. However, the effect of this is very small, with a huge confidence interval. With a significance test we find that this does not pass the alpha level (0.05). Therefore, I'm dropping this variable

```
z <- summary(model3)$coefficients/summary(model3)$standard.errors
p <- (1 - pnorm(abs(z), 0, 1)) * 2
p
```

```
##            (Intercept)          Age    Education Partner.Education
## LongTerm  2.220446e-16 3.230743e-02 0.0000000000         0.7947450
## ShortTerm 2.740610e-01 1.478808e-09 0.0004354596         0.7146152
```

Education and Age are a significant term, but Partner.Education is not (alpha level 0.05). I will be dropping Partner Education for further analysis.

```
model4=multinom(contraceptive.method ~ Age + Education, data = df)
```

```
## # weights:  12 (6 variable)
## initial  value 1618.255901
## iter  10 value 1468.708898
## final  value 1468.706497
## converged
```

```
summary(model4)
```

```
## Call:
## multinom(formula = contraceptive.method ~ Age + Education, data = df)
##
## Coefficients:
##           (Intercept)         Age Education
## LongTerm   -3.9684874  0.01884403 0.8699694
## ShortTerm   0.4668048 -0.04662449 0.2842928
##
## Std. Errors:
##           (Intercept)         Age  Education
```

```
## LongTerm    0.4088587 0.008795574 0.08121775
## ShortTerm   0.3106686 0.007699104 0.06119004
##
## Residual Deviance: 2937.413
## AIC: 2949.413
```

```
z <- summary(model4)$coefficients/summary(model4)$standard.errors
p <- (1 - pnorm(abs(z), 0, 1)) * 2
p
```

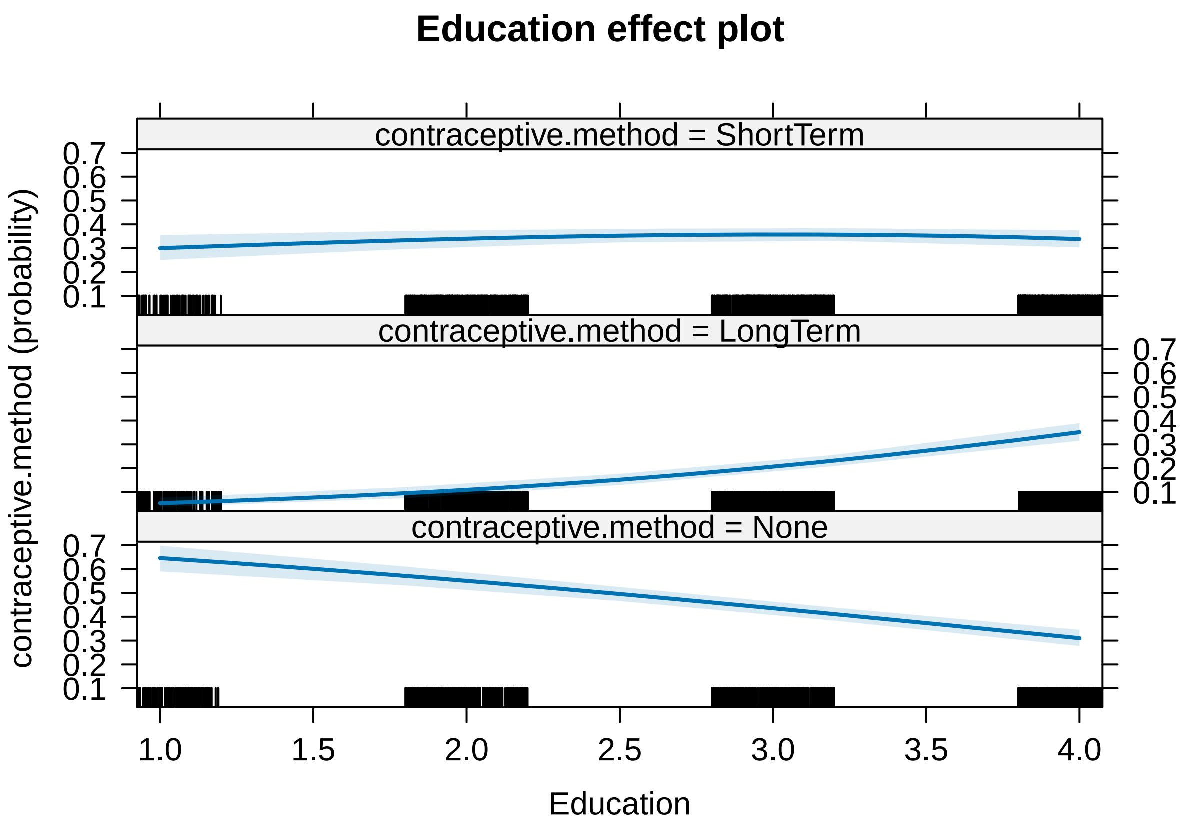
```
##           (Intercept)          Age    Education
## LongTerm    0.0000000 3.215775e-02 0.000000e+00
## ShortTerm   0.1329472 1.396925e-09 3.383303e-06
```

Both coefficients pass the alpha level of 0.05

Average Predicted Probabilities for Education:

Here is the effect education has on the probability of using each contraceptive method:

```
plot(Effect("Education",model4))
```

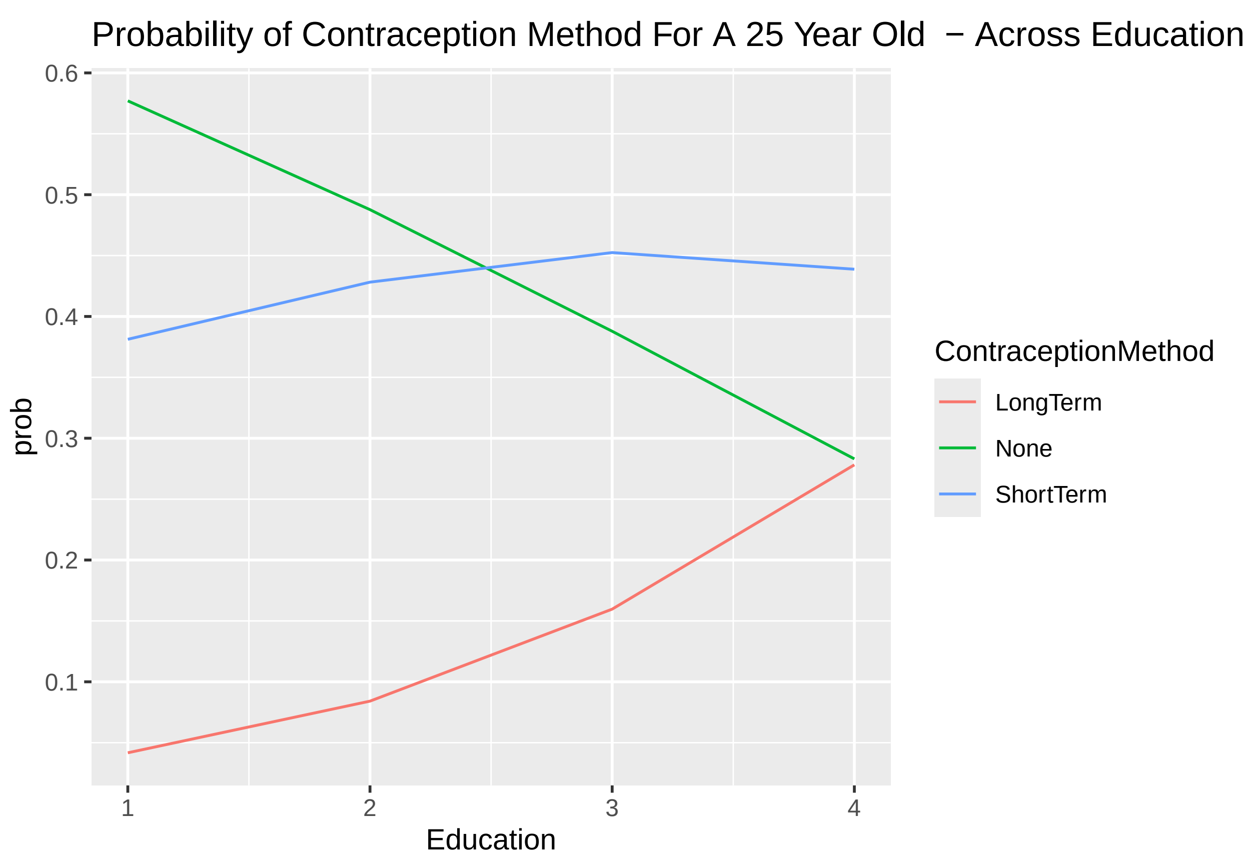


Another way to look at this is for one age. Here is a plot of the generalized probability of 25 year olds in this population, and their contraceptive method choice:

```r
newdata = as.data.frame(matrix(0,4,2))
names(newdata) = c("Education","Age")
newdata[,1] = c(1,2,3,4)
newdata[,2] = 25
pred = predict(model4,newdata=newdata, type="probs")

new_predict <- cbind(newdata, pred)
#head(new_predict)
prob_plot <- new_predict %>%
  pivot_longer(3:5, names_to = "ContraceptionMethod", values_to = "prob")
head(prob_plot)
```

```
## # A tibble: 6 x 4
##   Education   Age ContraceptionMethod   prob
##       <dbl> <dbl> <chr>                <dbl>
## 1         1    25 None                0.577
## 2         1    25 LongTerm            0.0417
## 3         1    25 ShortTerm           0.381
## 4         2    25 None                0.488
## 5         2    25 LongTerm            0.0841
## 6         2    25 ShortTerm           0.428
```

```r
ggplot(prob_plot, aes(x=Education, y=prob, group=ContraceptionMethod)) +
  geom_line(aes(color=ContraceptionMethod)) +
  ggtitle("Probability of Contraception Method For A 25 Year Old  - Across Education Levels")
```



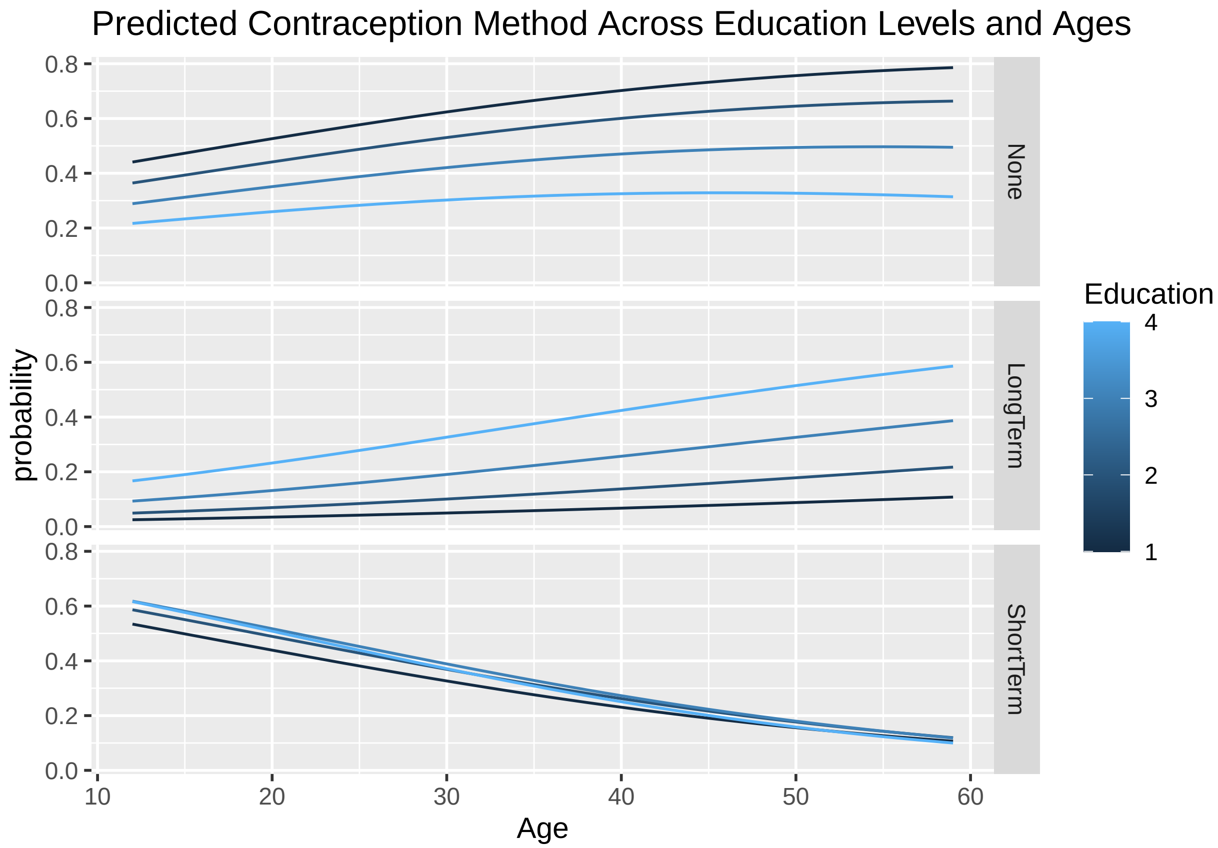
There is a steep negative association between education and the use of no Contraception, and a positive association between education and long term contraceptive choice for a 25 year old similar to a participant in this dataset. The probability of short term contraception use rises slightly with higher education.

Now to combine both Age and Education. This graph shows how Education impacts probability of contraceptive choice across ages:

```
newd <- data.frame(Education = rep(c(1,2,3,4), each = 48), Age = rep(c(12:59),4))

pp.ed <- cbind(newd, predict(model4, newdata = newd, type = "probs", se = TRUE))

by(pp.ed[, 3:5], pp.ed$Education, colMeans)
```

```
## pp.ed$Education: 1
##       None   LongTerm  ShortTerm
## 0.64928554 0.06153994 0.28917452
## ------------------------------------------------------------
## pp.ed$Education: 2
##      None  LongTerm ShortTerm
## 0.5507942 0.1247513 0.3244545
## ------------------------------------------------------------
## pp.ed$Education: 3
##      None  LongTerm ShortTerm
## 0.4294132 0.2310356 0.3395512
## ------------------------------------------------------------
## pp.ed$Education: 4
##      None  LongTerm ShortTerm
## 0.2984758 0.3785432 0.3229810
```

```
lpp <- melt(pp.ed, id.vars = c("Education", "Age"), value.name = "probability")

ggplot(lpp, aes(x = Age, y = probability, color = Education)) + geom_line(aes(group=Education)) + facet_
  ggtitle("Predicted Contraception Method Across Education Levels and Ages")
```



As age and education increase, so does the probability of using long term contraception.

4. Conclusions and Recommendations

The strongest model of this analysis included Age and Education.

This shows that education level is a great way to increase the use of contraceptives in women across ages. We can see here that those with high levels of education are the least likely to use no contraceptives, and the most likely to use long or short term contraceptives.