

# Lab 4 - Multinomial Regression

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Lab Goal: Predict voting frequency using demographic variables Data source: FiveThirtyEight “Why Many Americans Don’t Vote” survey Method: Multinomial logistic regression

## 0.1 Data

The data for this assignment comes from an online Ipsos survey that was conducted for the FiveThirtyEight article “[Why Many Americans Don’t Vote](#)”. You can read more about the survey design and respondents in the README of the [GitHub repo](#) for the data.

Respondents were asked a variety of questions about their political beliefs, thoughts on multiple issues, and voting behavior. We will focus on using the demographic variables and someone’s party identification to understand whether a person is a probable voter.

The variables we’ll focus on were (definitions from the codebook in data set GitHub repo):

- **ppage**: Age of respondent
- **educ**: Highest educational attainment category.
- **race**: Race of respondent, census categories. Note: all categories except Hispanic were non-Hispanic.
- **gender**: Gender of respondent
- **income\_cat**: Household income category of respondent
- **Q30**: Response to the question “Generally speaking, do you think of yourself as a...”
  - 1: Republican
  - 2: Democrat
  - 3: Independent
  - 4: Another party, please specify
  - 5: No preference

- -1: No response
- **voter\_category**: past voting behavior:
  - **always**: respondent voted in all or all-but-one of the elections they were eligible in
  - **sporadic**: respondent voted in at least two, but fewer than all-but-one of the elections they were eligible in
  - **rarely/never**: respondent voted in 0 or 1 of the elections they were eligible in

You can read in the data directly from the GitHub repo:

```
library(nnet)
library(car)
library(tidyverse)
library(emmeans)
library(ggeffects)
library(knitr)
library(patchwork)
library(broom)
library(parameters)
library(easystats)
```

```
voter_data <- read_csv("https://raw.githubusercontent.com/fivethirtyeight/data/master/non-voter")
```

## 1 Lab

- The variable **Q30** contains the respondent’s political party identification. Make a new variable that simplifies **Q30** into four categories: “Democrat”, “Republican”, “Independent”, “Other” (“Other” also includes respondents who did not answer the question).

```
voter_data <- voter_data %>%
  mutate(pol_ident_new = case_when(
    Q30==1 ~ "Rep",
    Q30==2 ~ "Dem",
    Q30==3 ~ "Indep",
    TRUE ~ "Other"
  ))
```

- The variable **voter\_category** identifies the respondent’s past voter behavior. Relevel the variable to make rarely/never the baseline level, followed by sporadic, then always

```
voter_data <- voter_data %>%
  mutate(voter_category = factor(voter_category, levels = c("rarely/never", "sporadic", "alw
```

- Center the age variable to make the intercept more interpretable. That is, so that it reflects the log-odds for an average-aged person rather than a 0-year old person

```
voter_data <- voter_data %>%
  mutate(ppage_centered = ppage - mean(ppage, na.rm = TRUE))
```

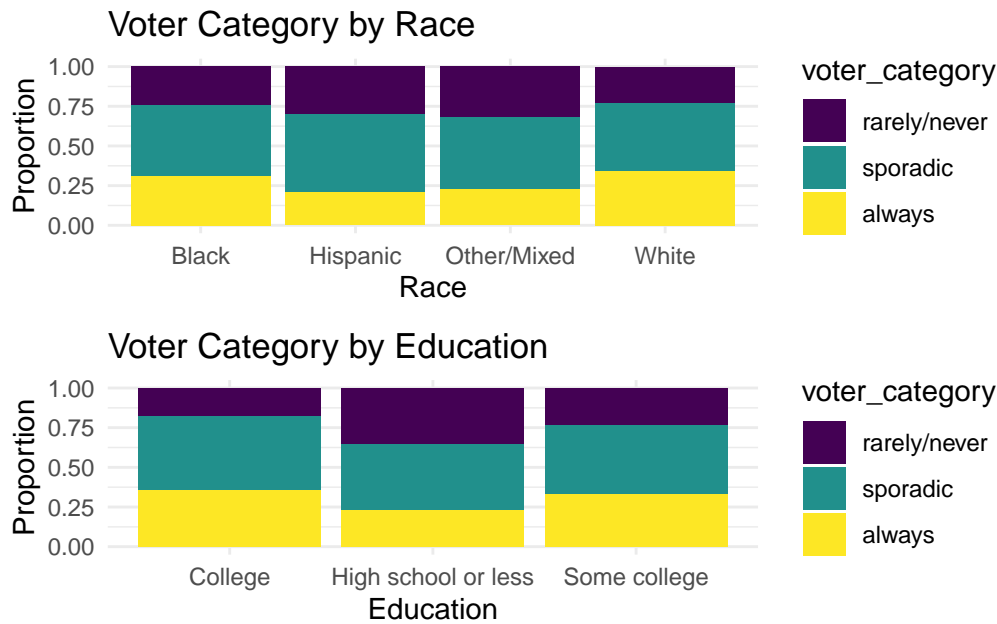
- In the [FiveThirtyEight article](https://www.mikelee.co/posts/2020-02-08-recreate-fivethirtyeight-chicklet-stacked-bar-chart-in-ggplot2), the authors include visualizations of the relationship between the voter category and demographic variables such as race, age, education, etc. Select two demographic variables. For each variable, try to replicate the visualizations and interpret the plot to describe its relationship with voter category. Have fun with it: <https://www.mikelee.co/posts/2020-02-08-recreate-fivethirtyeight-chicklet-stacked-bar-chart-in-ggplot2>.

```
# library
library(ggplot2)
library(viridis)
library(cowplot)

# Plot for race
plot_race <- ggplot(voter_data, aes(x = race, fill = voter_category)) +
  geom_bar(position = "fill") +
  scale_fill_viridis_d() +
  labs(title = "Voter Category by Race", x = "Race", y = "Proportion") +
  theme_minimal()

# Plot for education
plot_educ <- ggplot(voter_data, aes(x = educ, fill = voter_category)) +
  geom_bar(position = "fill") +
  scale_fill_viridis_d() +
  labs(title = "Voter Category by Education", x = "Education", y = "Proportion") +
  theme_minimal()

# Combine plots
combined_plot <- plot_race + plot_educ + plot_layout(ncol = 1)
combined_plot
```



From the plot, Black and White vote more frequently than Hispanic and Other. Also the higher the education (college > high school or less), the more frequent the voting.

- Fit a model using mean-centered age, race, gender, income, and education to predict voter category. Show the code used to fit the model, but do **not** display the model output.

```
library(nnet)

# Fit the multinomial logistic regression model
model <- multinom(voter_category ~ ppage_centered + race + gender + income_cat + educ, data = )

# weights: 36 (22 variable)
initial value 6411.501317
iter 10 value 5869.948482
iter 20 value 5728.474131
final value 5693.312867
converged
```

- *Should party identification be added to the model?*
- #Hint: Use an anova test to make the determination

```
# Fit a model without party identification
model_without_party <- multinom(voter_category ~ ppage_centered + race + gender + income_cat
```

```
# weights: 36 (22 variable)
initial value 6411.501317
iter 10 value 5869.948482
iter 20 value 5728.474131
final value 5693.312867
converged
```

```
# Fit a model with party identification
model_with_party <- multinom(voter_category ~ ppage_centered + race + gender + income_cat +
```

```
# weights: 45 (28 variable)
initial value 6411.501317
iter 10 value 5818.012349
iter 20 value 5709.034111
iter 30 value 5621.228937
final value 5616.390878
converged
```

```
# Perform ANOVA to compare models
anova_test <- anova(model_without_party, model_with_party)

# Display the ANOVA test results
anova_test
```

					Model	Resid.	df
1		ppage_centered + race + gender + income_cat + educ				11650	
2		ppage_centered + race + gender + income_cat + educ + pol_ident_new				11644	
	Resid. Dev	Test	Df	LR stat.	Pr(Chi)		
1	11386.63		NA	NA	NA		
2	11232.78	1 vs 2	6	153.844	0		

> #Enter answer based on your code: since  $p < .005$ , yes

Use the model you select for the remainder of the assignment.

## 1.1 LRT

- Run the full model and report overall significance of each of the terms

```
# Run the full model
model <- multinom(voter_category ~ ppage_centered + race + gender + income_cat + educ + pol_
```

```
# weights: 45 (28 variable)
initial value 6411.501317
iter 10 value 5818.012349
iter 20 value 5709.034111
iter 30 value 5621.228937
final value 5616.390878
converged
```

```
# Report overall significance of each of the terms
summary(model)
```

Call:

```
multinom(formula = voter_category ~ ppage_centered + race + gender +
  income_cat + educ + pol_ident_new, data = voter_data)
```

Coefficients:

	(Intercept)	ppage_centered	raceHispanic	raceOther/Mixed	raceWhite
sporadic	1.731560	0.04568619	0.04023859	-0.3324253	-0.07753808
always	1.490383	0.05820752	-0.34101920	-0.6004751	0.12720746
		genderMale	income_cat\$40-75k	income_cat\$75-125k	
sporadic	-0.09005897	-0.0737542388		0.01249916	
always	-0.19218925	-0.0003681586		0.16519710	
		income_catLess than \$40k	educHigh school or less	educSome college	
sporadic		-0.5878096		-0.8532927	-0.2928893
always		-0.6640936		-1.2672114	-0.3303234
		pol_ident_newIndep	pol_ident_newOther	pol_ident_newRep	
sporadic		-0.3924293	-0.940448	-0.08380513	
always		-0.5623037	-1.400990	-0.16176773	

Std. Errors:

	(Intercept)	ppage_centered	raceHispanic	raceOther/Mixed	raceWhite
sporadic	0.1360829	0.002324481	0.1280060	0.1590604	0.1078495
always	0.1468958	0.002565596	0.1497456	0.1853844	0.1187785
		genderMale	income_cat\$40-75k	income_cat\$75-125k	
sporadic	0.07217151	0.1113653		0.1066254	
always	0.07966046	0.1211677		0.1142763	
		income_catLess than \$40k	educHigh school or less	educSome college	
sporadic		0.1137398		0.09739887	0.09520334

always	0.1270306	0.10882778	0.10240769
pol_ident_newIndep			
sporadic	0.09769615	0.1062288	0.1027674
always	0.10692855	0.1312004	0.1101431

Residual Deviance: 11232.78

AIC: 11288.78

```
# Likelihood ratio tests for each term
lrtest <- car::Anova(model, type = "II", test = "LR")
lrtest
```

Analysis of Deviance Table (Type II tests)

Response: voter\_category

	LR	Chisq	Df	Pr(>Chisq)
ppage_centered	638.30	2	< 2.2e-16	***
race	52.65	6	1.379e-09	***
gender	6.03	2	0.0491	*
income_cat	67.72	6	1.198e-12	***
educ	154.14	4	< 2.2e-16	***
pol_ident_new	153.84	6	< 2.2e-16	***

Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

Everything is significant

## 1.2 Marginal Effects Political Group - Emmeans

```
# Get estimated marginal means from the model
multinomial_analysis <- emmeans(model, ~ pol_ident_new | voter_category)

# Calculate contrasts
coefs <- contrast(regrid(multinomial_analysis, "log"), "trt.vs.ctrl1", by = "pol_ident_new")
# You can add a parameter to the above command, ref = newbaseline, if you want to change bas

# Update and display the contrasts
update(coefs, by = "contrast") %>%
  kable(format = "markdown", digits = 3)
```

contrast	pol_ident_new	estimate	SE	df	t.ratio	p.value
sporadic - (rarely/never)	Dem	0.961	0.070	28	13.722	0.000
always - (rarely/never)	Dem	0.480	0.074	28	6.498	0.000
sporadic - (rarely/never)	Indep	0.591	0.077	28	7.643	0.000
always - (rarely/never)	Indep	-0.049	0.084	28	-0.590	0.900
sporadic - (rarely/never)	Other	0.078	0.087	28	0.902	0.747
always - (rarely/never)	Other	-0.835	0.110	28	-7.577	0.000
sporadic - (rarely/never)	Rep	0.883	0.084	28	10.469	0.000
always - (rarely/never)	Rep	0.327	0.089	28	3.672	0.004

### 1.3 Marginal Effects of Education - Emmeans

```
# Get estimated marginal means from the model for education
multinomial_analysis_educ <- emmeans(model, ~ educ | voter_category)

# Calculate contrasts for education
coefs_educ <- contrast(regrid(multinomial_analysis_educ, "log"), "trt.vs.ctrl1", by = "educ")

# Update and display the contrasts for education
update(coefs_educ, by = "contrast") %>%
  kable(format = "markdown", digits = 3)
```

contrast	educ	estimate	SE	df	t.ratio	p.value
sporadic - (rarely/never)	College	0.986	0.076	28	12.904	0.000
always - (rarely/never)	College	0.477	0.080	28	5.960	0.000
sporadic - (rarely/never)	High school or less	0.187	0.069	28	2.705	0.031
always - (rarely/never)	High school or less	-0.711	0.080	28	-8.883	0.000
sporadic - (rarely/never)	Some college	0.707	0.074	28	9.512	0.000
always - (rarely/never)	Some college	0.167	0.079	28	2.114	0.112

- Next, plot the predicted probabilities of voter category as a function of Age and Party ID

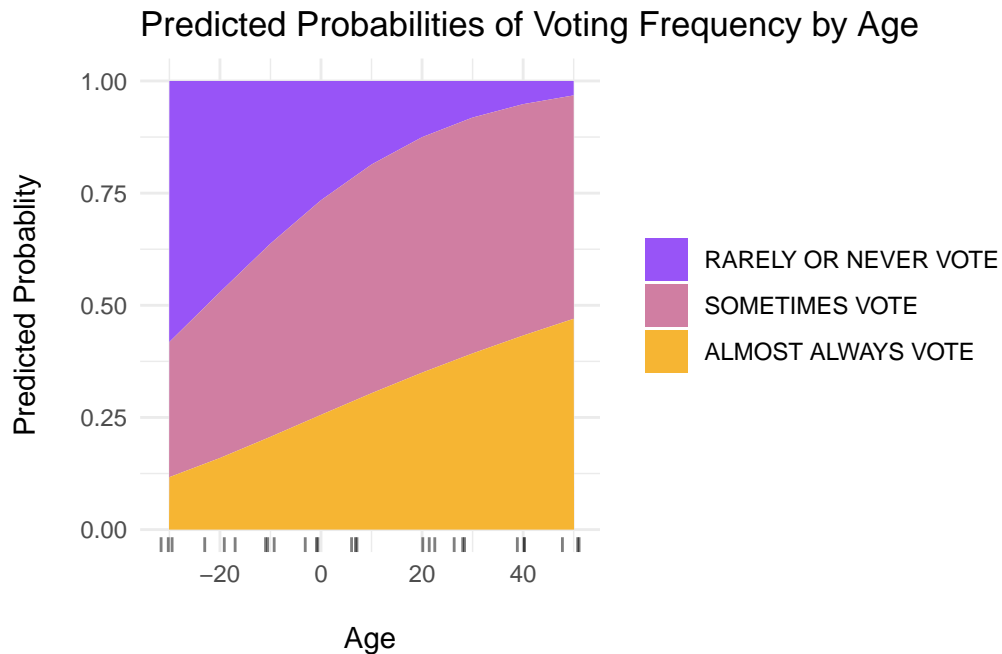
```
ggemmeans(model, terms = c("ppage_centered")) %>%
  ggplot(., aes(x = x, y = predicted, fill = response.level)) +
  geom_area() +
  geom_rug(sides = "b", position = "jitter", alpha = .5) +
  labs(x = "\nAge", y = "Predicted Probability\n", title = "Predicted Probabilities of Voter Category by Age") +
  scale_fill_manual(values = c("Dem" = "#1f77b4", "Indep" = "#ff7f0e", "Other" = "#2ca02c", "Rep" = "#d62728"))
```



```

name = NULL,
values = c("always" = "#F6B533", "sporadic" = "#D07EA2", "rarely/never" = "#9854F7")
labels = c("RARELY OR NEVER VOTE", "SOMETIMES VOTE", "ALMOST ALWAYS VOTE")
breaks = c("rarely/never", "sporadic", "always")
) +
theme_minimal()

```



- Plot predicted probabilities as a function of education and voting frequency.

```

library(ggplot2)
library(dplyr)

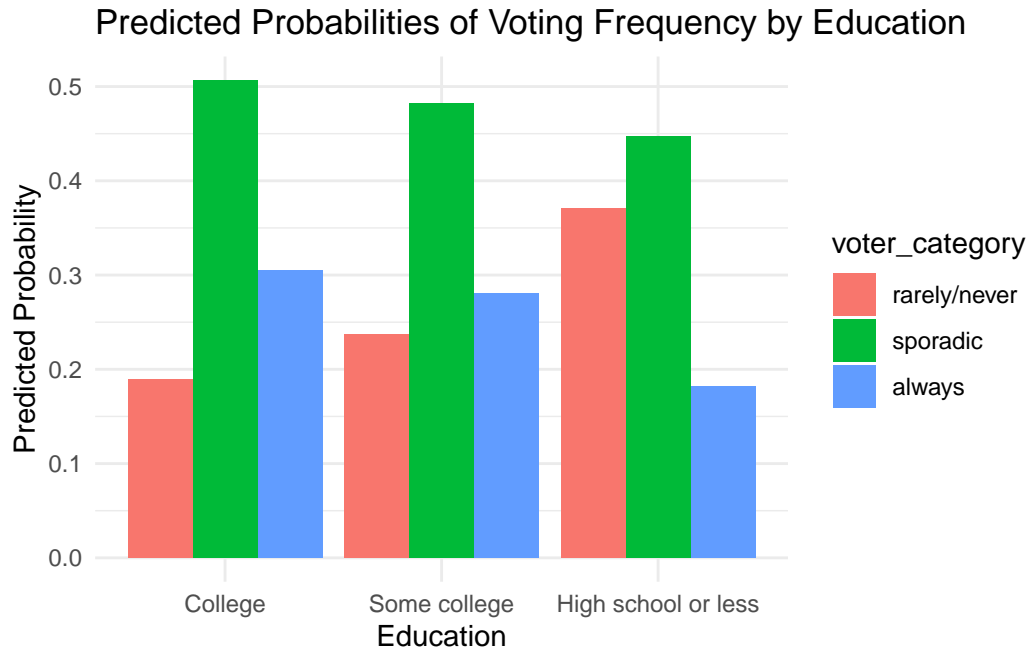
# Convert ggemmeans output to a dataframe
pred_data <- ggemmeans(model, terms = "educ") %>% as.data.frame()

# Rename columns correctly
colnames(pred_data)[colnames(pred_data) == "x"] <- "educ" # Rename 'x' to 'educ'
colnames(pred_data)[colnames(pred_data) == "response.level"] <- "voter_category" # Rename 'response.level' to 'voter_category'

# Ensure factors are properly formatted
pred_data$educ <- factor(pred_data$educ, levels = unique(pred_data$educ))
pred_data$voter_category <- factor(pred_data$voter_category, levels = c("rarely/never", "sporadic", "always"))

```

```
# Plot the predicted probabilities
ggplot(pred_data, aes(x = educ, y = predicted, fill = voter_category)) +
  geom_col(position = "dodge") +
  labs(x = "Education", y = "Predicted Probability",
       title = "Predicted Probabilities of Voting Frequency by Education") +
  theme_minimal()
```



### Differences between political groups and voting behavior - Emmeans

```
multi_an <- emmeans(model, ~ pol_ident_new|voter_category)

coefs = contrast(regrid(multi_an, "log"), "trt.vs.ctrl1", by="pol_ident_new")

update(coefs, by = "contrast") %>%
  kable(format = "markdown", digits = 3)
```

contrast	pol_ident_new	estimate	SE	df	t.ratio	p.value
sporadic - (rarely/never)	Dem	0.961	0.070	28	13.722	0.000
always - (rarely/never)	Dem	0.480	0.074	28	6.498	0.000
sporadic - (rarely/never)	Indep	0.591	0.077	28	7.643	0.000

contrast	pol_ident_new	estimate	SE	df	t.ratio	p.value
always - (rarely/never)	Indep	-0.049	0.084	28	-0.590	0.900
sporadic - (rarely/never)	Other	0.078	0.087	28	0.902	0.747
always - (rarely/never)	Other	-0.835	0.110	28	-7.577	0.000
sporadic - (rarely/never)	Rep	0.883	0.084	28	10.469	0.000
always - (rarely/never)	Rep	0.327	0.089	28	3.672	0.004

```
# get difference between yes-no and fair-excellent
contrast(coefs, "revpairwise", by = "contrast") %>%
  kable(format = "markdown", digits = 3)
```

contrast1	contrast	estimate	SE	df	t.ratio	p.value
Indep - Dem	sporadic - (rarely/never)	-0.370	0.094	28	-3.933	0.003
Other - Dem	sporadic - (rarely/never)	-0.883	0.103	28	-8.578	0.000
Other - Indep	sporadic - (rarely/never)	-0.513	0.107	28	-4.807	0.000
Rep - Dem	sporadic - (rarely/never)	-0.078	0.099	28	-0.787	0.860
Rep - Indep	sporadic - (rarely/never)	0.292	0.099	28	2.965	0.029
Rep - Other	sporadic - (rarely/never)	0.805	0.109	28	7.404	0.000
Indep - Dem	always - (rarely/never)	-0.529	0.101	28	-5.255	0.000
Other - Dem	always - (rarely/never)	-1.315	0.125	28	-10.508	0.000
Other - Indep	always - (rarely/never)	-0.786	0.129	28	-6.072	0.000
Rep - Dem	always - (rarely/never)	-0.153	0.104	28	-1.470	0.468
Rep - Indep	always - (rarely/never)	0.376	0.104	28	3.605	0.006
Rep - Other	always - (rarely/never)	1.162	0.130	28	8.969	0.000

### Differences between education level and voting behavior - Emmeans

Last part of the assignment: Interpret the results from running the following code for your model

```
multi_an <- emmeans(model, ~ educ|voter_category)

coefs = contrast(regrid(multi_an, "log"), "trt.vs.ctrl1", by="educ")

update(coefs, by = "contrast") %>%
  kable(format = "markdown", digits = 3)
```

contrast	educ	estimate	SE	df	t.ratio	p.value
sporadic - (rarely/never)	College	0.986	0.076	28	12.904	0.000
always - (rarely/never)	College	0.477	0.080	28	5.960	0.000
sporadic - (rarely/never)	High school or less	0.187	0.069	28	2.705	0.031
always - (rarely/never)	High school or less	-0.711	0.080	28	-8.883	0.000
sporadic - (rarely/never)	Some college	0.707	0.074	28	9.512	0.000
always - (rarely/never)	Some college	0.167	0.079	28	2.114	0.112

```
# get difference between yes-no and fair-excellent
contrast(coefs, "revpairwise", by = "contrast") %>%
  kable(format = "markdown", digits = 3)
```

contrast1	contrast	esti- mate	SE	df	t.ratio	p.value
High school or less - College	sporadic - (rarely/never)	-0.799	0.095	28	-8.416	0.000
Some college - College	sporadic - (rarely/never)	-0.278	0.092	28	-3.030	0.014
Some college - High school or less	sporadic - (rarely/never)	0.520	0.088	28	5.920	0.000
High school or less - College	always - (rarely/never)	-1.188	0.104	28	-11.394	0.000
Some college - College	always - (rarely/never)	-0.310	0.097	28	-3.207	0.009
Some college - High school or less	always - (rarely/never)	0.878	0.098	28	8.995	0.000

## Interpretation of the Marginal Effects Analysis

The table presents pairwise comparisons of predicted probabilities for voter categories based on **education levels**. The contrasts indicate how education level affects the likelihood of being in different voter categories (**sporadic** or **always** voters) compared to **rarely/never voters**.

### 1. Sporadic Voting vs. Rarely/Never Voting

- **High School or Less vs. College:** Estimate = **-0.799** ( $p < .001$ )  
→ Those with a high school education are significantly **less likely** to vote sporadically compared to college graduates.

- **Some College vs. College:** Estimate = **-0.278** ( $p = .014$ )  
→ Those with some college education are also **less likely** to vote sporadically than college graduates, but the effect is smaller.
- **Some College vs. High School or Less:** Estimate = **0.520** ( $p < .001$ )  
→ Those with some college education are **more likely** to vote sporadically compared to high school graduates.

## 2. Always Voting vs. Rarely/Never Voting

- **High School or Less vs. College:** Estimate = **-1.188** ( $p < .001$ )  
→ High school graduates are **far less likely** to always vote compared to college graduates.
- **Some College vs. College:** Estimate = **-0.310** ( $p = .009$ )  
→ Those with some college education are also **less likely** to always vote than college graduates, but the effect is smaller.
- **Some College vs. High School or Less:** Estimate = **0.878** ( $p < .001$ )  
→ Those with some college education are **significantly more likely** to always vote compared to high school graduates.

## Conclusion

- **Higher education is associated with more frequent voting behavior.**
- **College graduates are the most consistent voters** (higher probability of being in the “Always” category).
- **People with only a high school diploma are the least likely to vote regularly.**
- **Some college education increases voting probability compared to only high school but does not reach the level of full college graduates.**