STA440 Final Project

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```r
# Using readr for better performance
library(readr)
suicide_data <- read_csv("SuicideChina.csv")
```

```
## New names:
## Rows: 2571 Columns: 12
## -- Column specification
## -------------------------------------------------------- Delimiter: "," chr
## (7): Hospitalised, Died, Urban, Sex, Education, Occupation, method dbl (5):
## ...1, Person_ID, Year, Month, Age
## i Use ‘spec()‘ to retrieve the full column specification for this data. i
## Specify the column types or set ‘show_col_types = FALSE‘ to quiet this message.
## * ‘‘ -> ‘...1‘
```

```r
library(ggplot2)
library(dplyr)
```

```
##
## Attaching package: ’dplyr’

## The following objects are masked from ’package:stats’:
##
##     filter, lag

## The following objects are masked from ’package:base’:
##
##     intersect, setdiff, setequal, union
```

```r
library(pROC)
```

```
## Type ’citation("pROC")’ for a citation.

##
## Attaching package: ’pROC’

## The following objects are masked from ’package:stats’:
##
##     cov, smooth, var
```

```r
library(nnet)
library(car)
```

```
## Loading required package: carData
```

```
##
## Attaching package: 'car'
```

```
## The following object is masked from 'package:dplyr':
##
##     recode
```

```r
library(patchwork)
library(cowplot)
```

```
##
## Attaching package: 'cowplot'
```

```
## The following object is masked from 'package:patchwork':
##
##     align_plots
```

```r
head(suicide_data)
```

```
## # A tibble: 6 x 12
##    ...1 Person_ID Hospitalised Died  Urban  Year Month Sex      Age Education
##   <dbl>     <dbl> <chr>        <chr> <chr> <dbl> <dbl> <chr>  <dbl> <chr>
## 1     1         1 yes          no    no     2010    12 female    39 Secondary
## 2     2         2 no           yes   no     2009     3 male      83 primary
## 3     3         3 no           yes   no     2010     2 male      60 primary
## 4     4         4 no           yes   no     2011     1 male      73 primary
## 5     5         5 yes          no    no     2009     8 male      51 Secondary
## 6     6         6 no           yes   no     2009    11 male      62 iliterate
## # i 2 more variables: Occupation <chr>, method <chr>
```

```r
str(suicide_data)
```

```
## spc_tbl_ [2,571 x 12] (S3: spec_tbl_df/tbl_df/tbl/data.frame)
##  $ ...1        : num [1:2571] 1 2 3 4 5 6 7 8 9 10 ...
##  $ Person_ID   : num [1:2571] 1 2 3 4 5 6 7 8 9 10 ...
##  $ Hospitalised: chr [1:2571] "yes" "no" "no" "no" ...
##  $ Died        : chr [1:2571] "no" "yes" "yes" "yes" ...
##  $ Urban       : chr [1:2571] "no" "no" "no" "no" ...
##  $ Year        : num [1:2571] 2010 2009 2010 2011 2009 ...
##  $ Month       : num [1:2571] 12 3 2 1 8 11 1 10 7 1 ...
##  $ Sex         : chr [1:2571] "female" "male" "male" "male" ...
##  $ Age         : num [1:2571] 39 83 60 73 51 62 90 54 66 30 ...
##  $ Education   : chr [1:2571] "Secondary" "primary" "primary" "primary" ...
##  $ Occupation  : chr [1:2571] "household" "farming" "farming" "farming" ...
##  $ method      : chr [1:2571] "Other poison" "Hanging" "Hanging" "Hanging" ...
##  - attr(*, "spec")=
##   .. cols(
##   ..   ...1 = col_double(),
##   ..   Person_ID = col_double(),
##   ..   Hospitalised = col_character(),
##   ..   Died = col_character(),
##   ..   Urban = col_character(),
##   ..   Year = col_double(),
##   ..   Month = col_double(),
##   ..   Sex = col_character(),
##   ..   Age = col_double(),
##   ..   Education = col_character(),
##   ..   Occupation = col_character(),
##   ..   method = col_character()
##   .. )
##  - attr(*, "problems")=<externalptr>
```

```
summary(suicide_data)
```

```
##       ...1          Person_ID      Hospitalised           Died
##  Min.   :   1.0   Min.   :   1.0   Length:2571        Length:2571
##  1st Qu.: 643.5   1st Qu.: 643.5   Class :character   Class :character
##  Median :1286.0   Median :1286.0   Mode  :character   Mode  :character
##  Mean   :1286.0   Mean   :1286.0
##  3rd Qu.:1928.5   3rd Qu.:1928.5
##  Max.   :2571.0   Max.   :2571.0
##     Urban                Year          Month            Sex
##  Length:2571        Min.   :2009   Min.   : 1.000   Length:2571
##  Class :character   1st Qu.:2009   1st Qu.: 4.000   Class :character
##  Mode  :character   Median :2010   Median : 6.000   Mode  :character
##                     Mean   :2010   Mean   : 6.298
##                     3rd Qu.:2011   3rd Qu.: 9.000
##                     Max.   :2011   Max.   :12.000
##       Age          Education          Occupation           method
##  Min.   : 12.00   Length:2571        Length:2571        Length:2571
##  1st Qu.: 37.00   Class :character   Class :character   Class :character
##  Median : 53.00   Mode  :character   Mode  :character   Mode  :character
##  Mean   : 52.63
##  3rd Qu.: 69.00
##  Max.   :100.00
```

Let's do some EDA first

```
table(suicide_data$Died)
```

```
##
##   no  yes
## 1315 1256
```

```
table(suicide_data$Sex)
```

```
##
## female   male
##   1328   1243
```

```
table(suicide_data$Urban)
```

```
##
##      no unknown     yes
##    2213      81     277
```

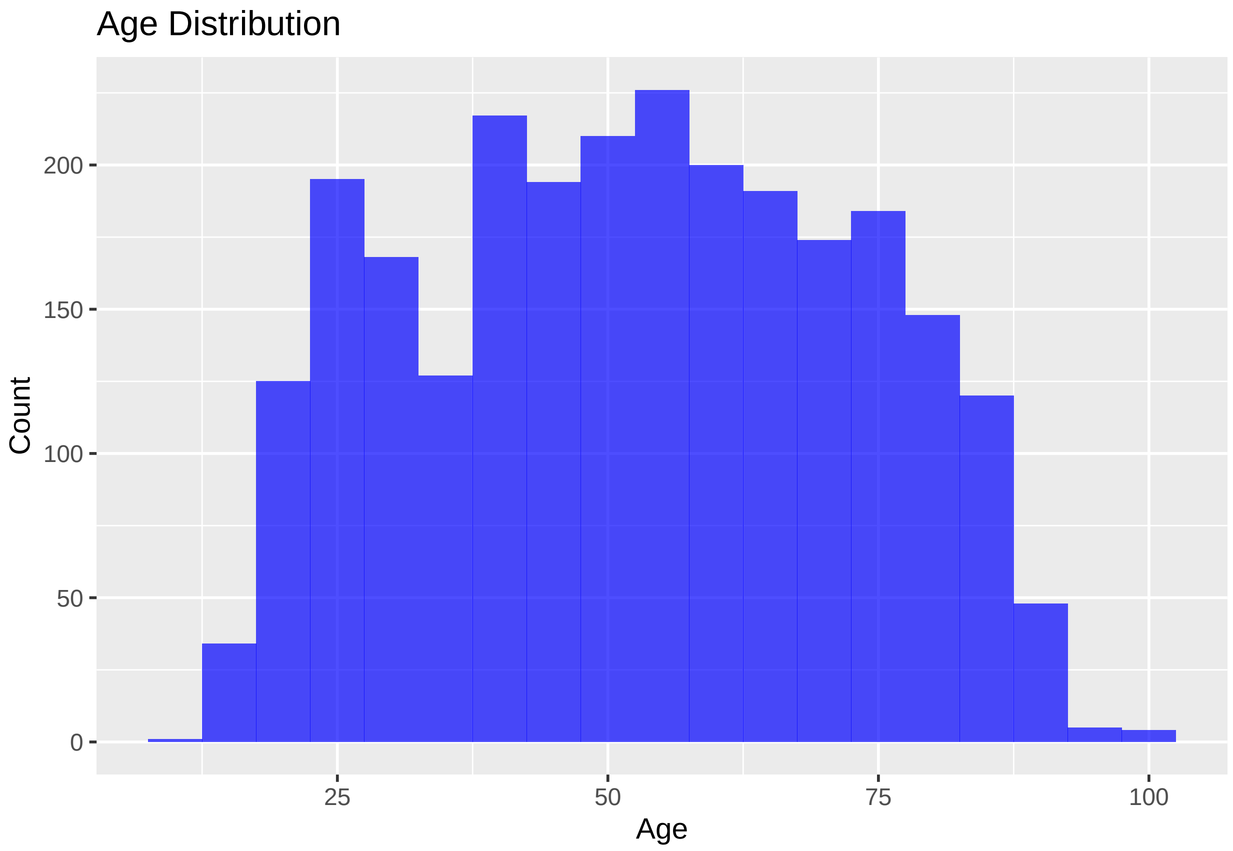
```
table(suicide_data$method)
```

```
##
##       Cutting       Drowning        Hanging        Jumping  Other poison
##            29             26            431             15           146
##        Others      Pesticide Poison unspec    unspecified
##             1           1768            107             48
```

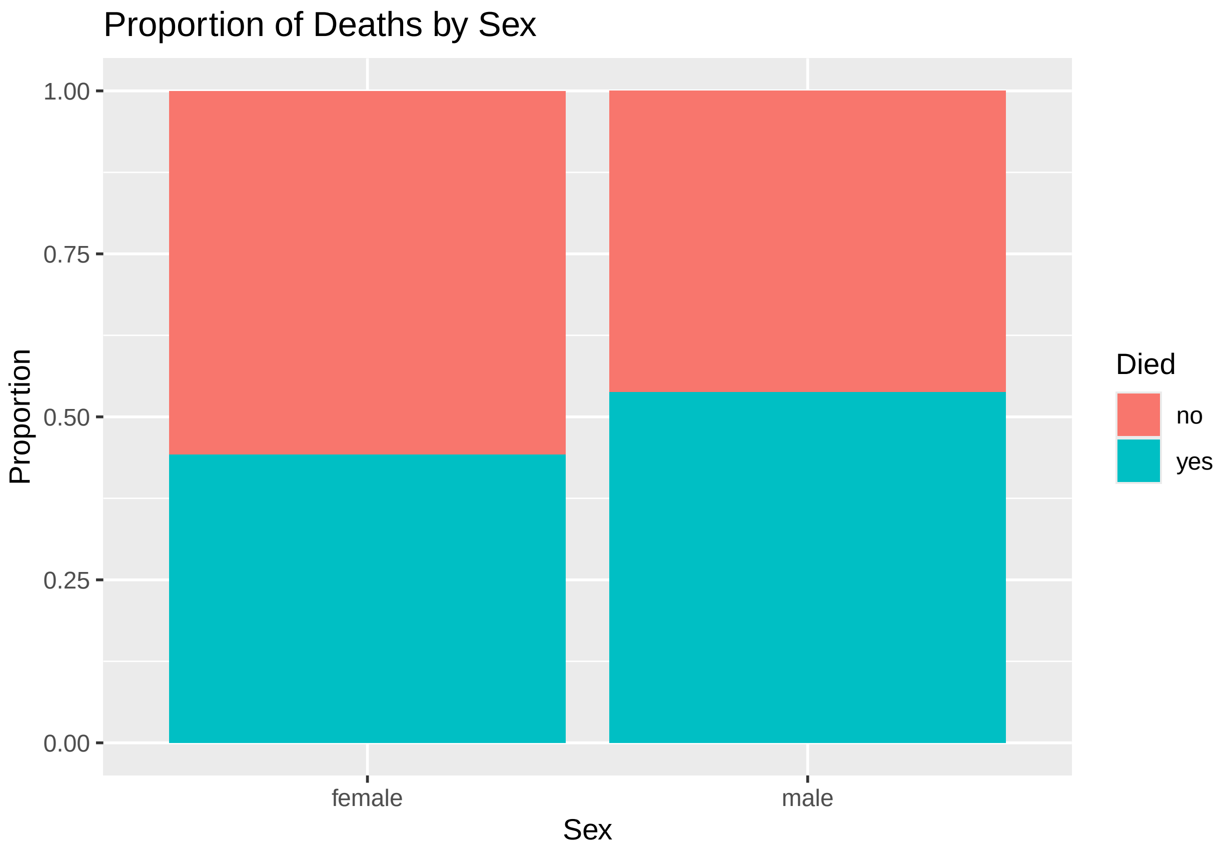
```
summary(suicide_data$Age)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   12.00   37.00   53.00   52.63   69.00  100.00
```

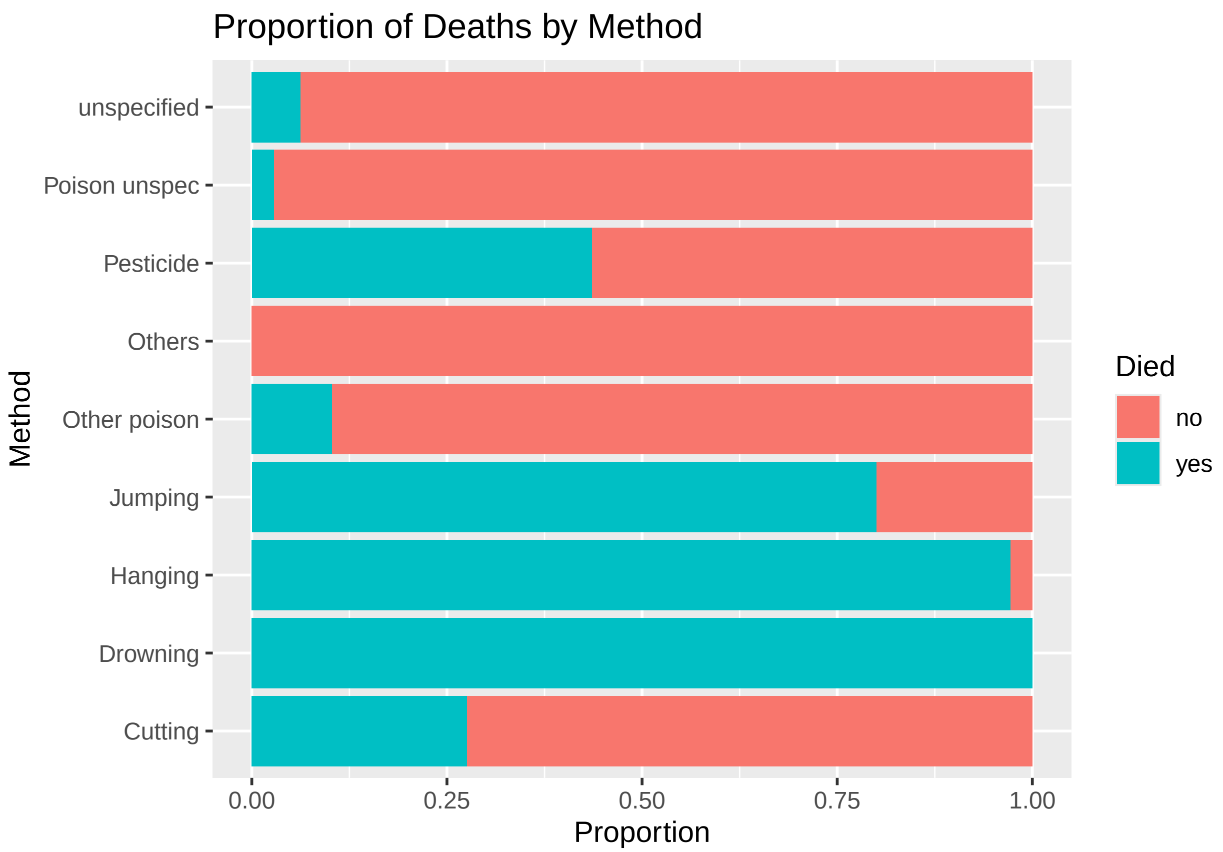
```
ggplot(suicide_data, aes(x = Age)) +
  geom_histogram(binwidth = 5, fill = "blue", alpha = 0.7) +
  labs(title = "Age Distribution", x = "Age", y = "Count")
```



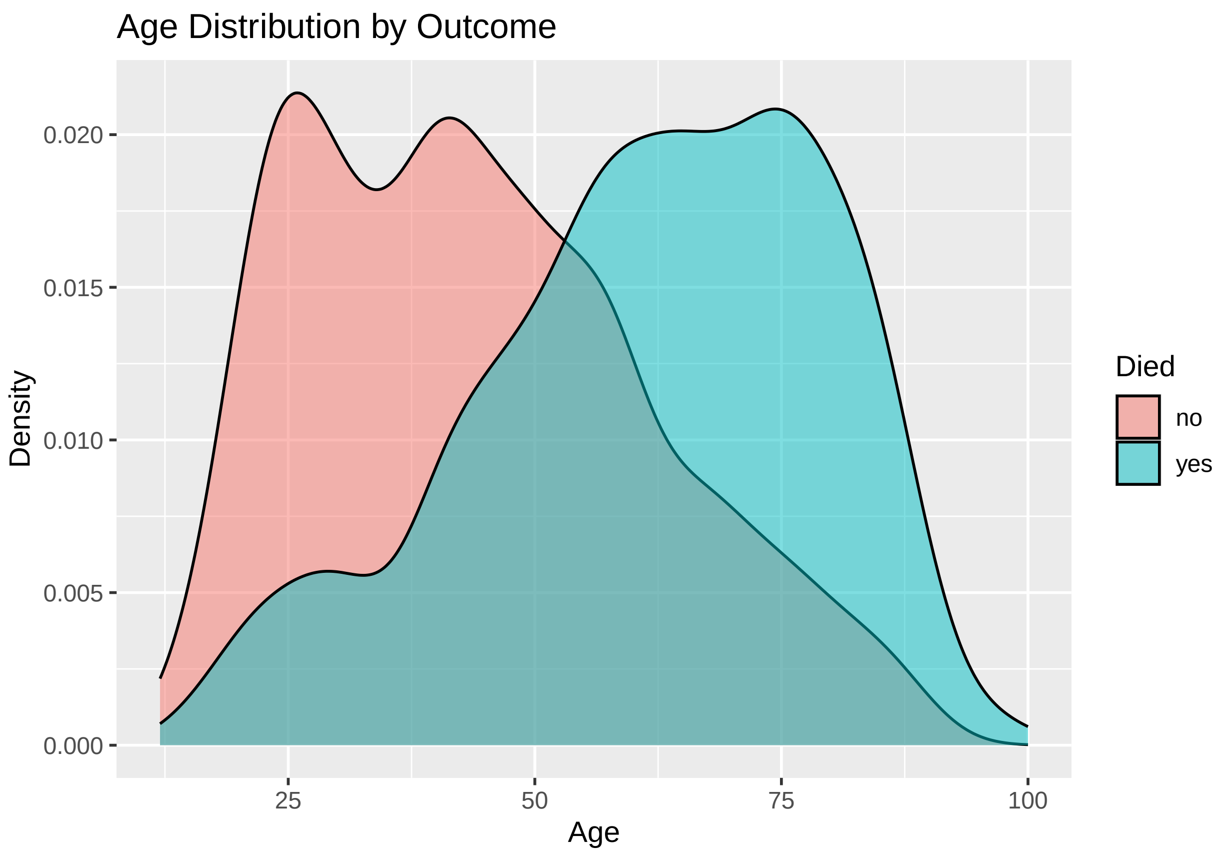
```
ggplot(suicide_data, aes(x = Sex, fill = Died)) +
  geom_bar(position = "fill") +
  labs(title = "Proportion of Deaths by Sex", x = "Sex", y = "Proportion", fill = "Died")
```



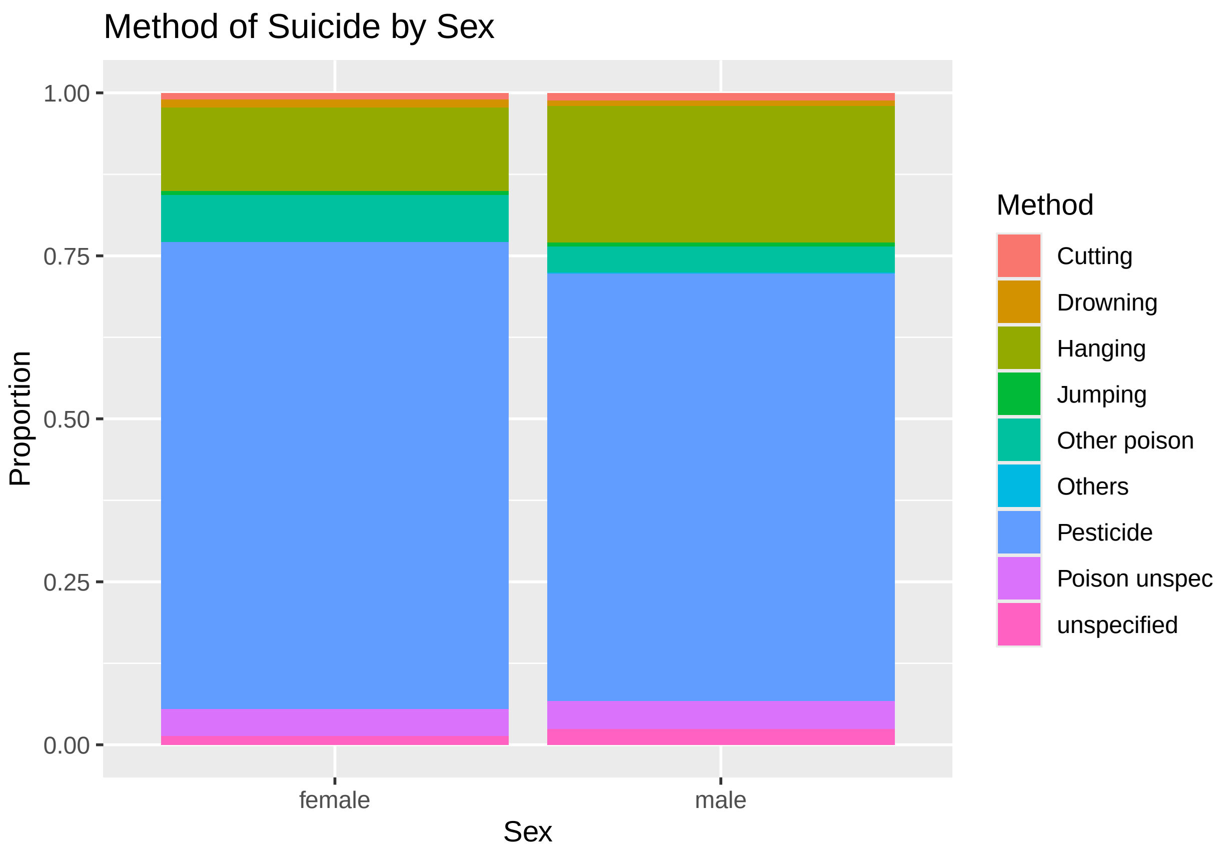
```
ggplot(suicide_data, aes(x = method, fill = Died)) +
  geom_bar(position = "fill") +
  coord_flip() +
  labs(title = "Proportion of Deaths by Method", x = "Method", y = "Proportion", fill = "Died")
```



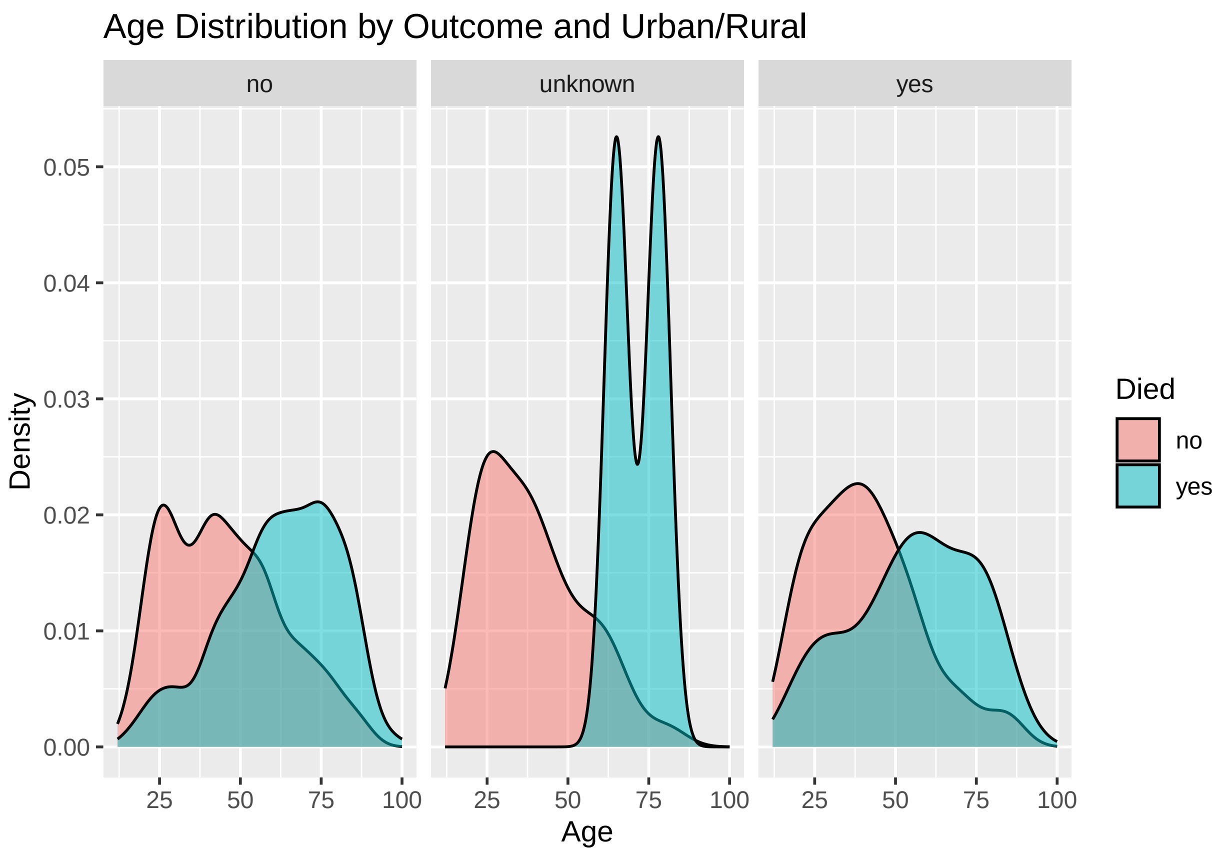
```r
ggplot(suicide_data, aes(x = Age, fill = Died)) +
  geom_density(alpha = 0.5) +
  labs(title = "Age Distribution by Outcome", x = "Age", y = "Density", fill = "Died")
```



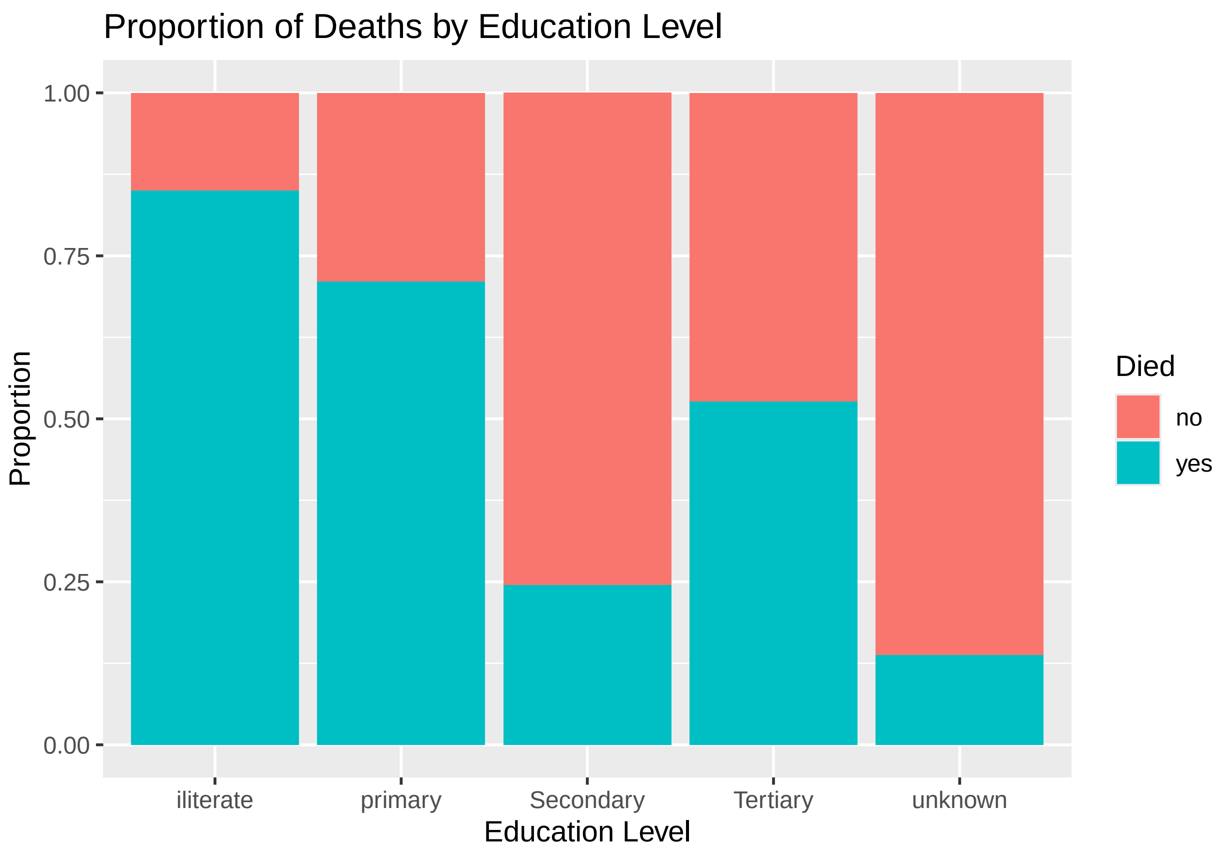
```r
ggplot(suicide_data, aes(x = Sex, fill = method)) +
  geom_bar(position = "fill") +
  labs(title = "Method of Suicide by Sex", x = "Sex", y = "Proportion", fill = "Method")
```



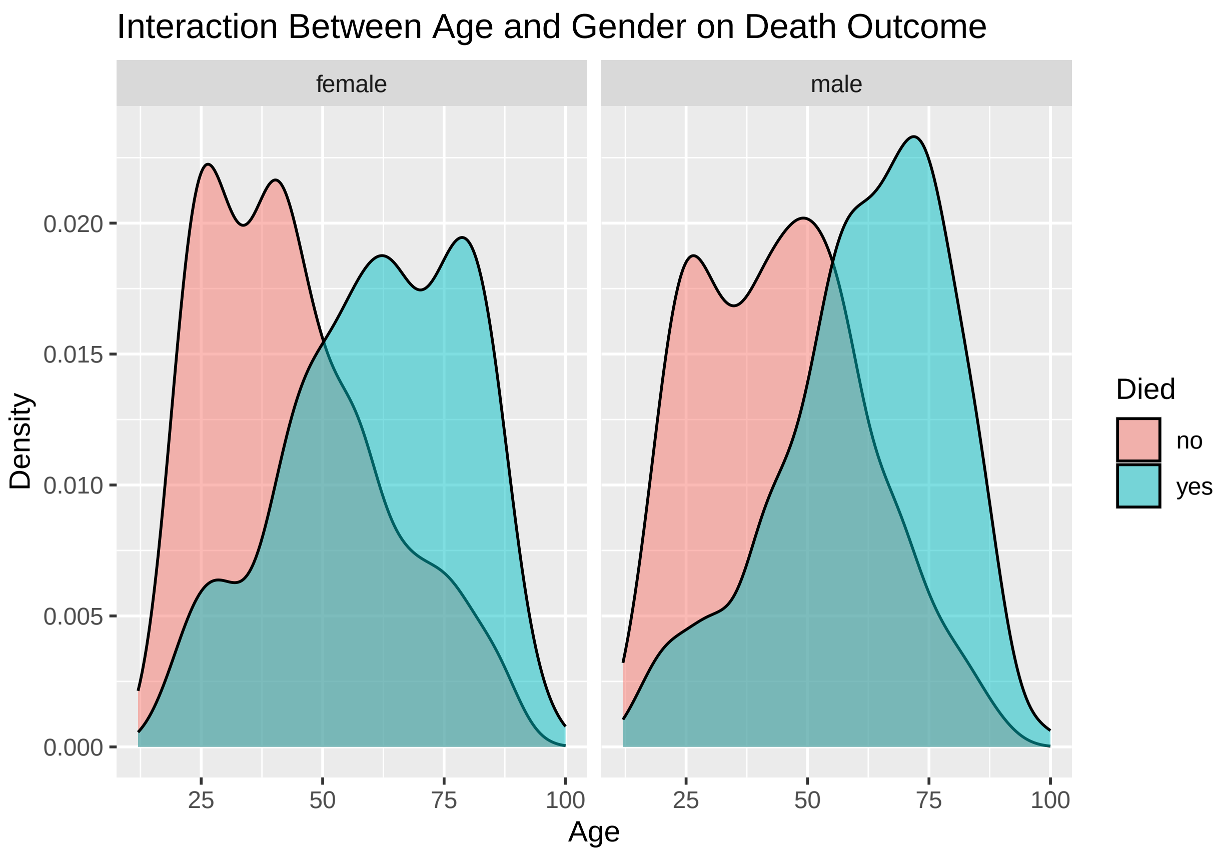
```
ggplot(suicide_data, aes(x = Age, fill = Died)) +
  geom_density(alpha = 0.5) +
  facet_wrap(~Urban) +
  labs(title = "Age Distribution by Outcome and Urban/Rural", x = "Age", y = "Density", fill = "Died")
```



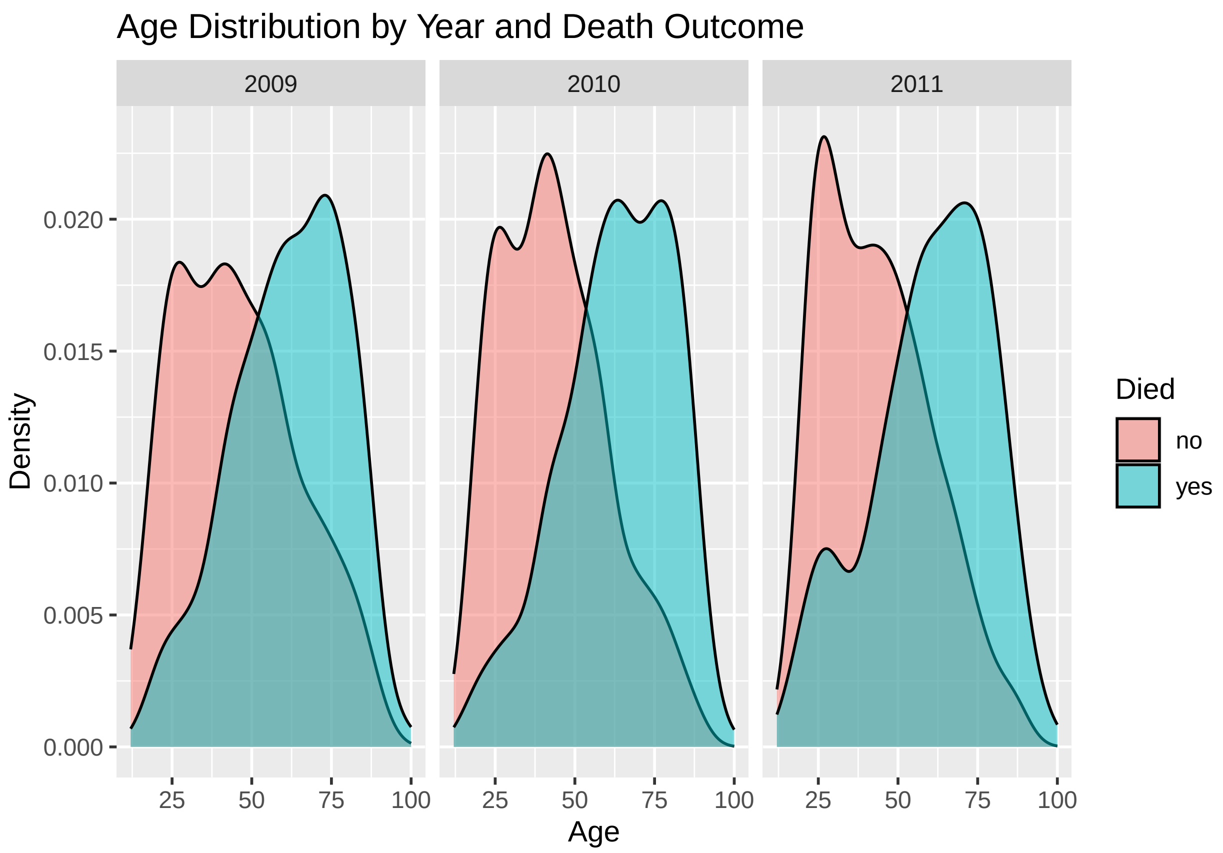
```
ggplot(suicide_data, aes(x = Education, fill = Died)) +
  geom_bar(position = "fill") +
  labs(title = "Proportion of Deaths by Education Level", x = "Education Level", y = "Proportion", fill
```



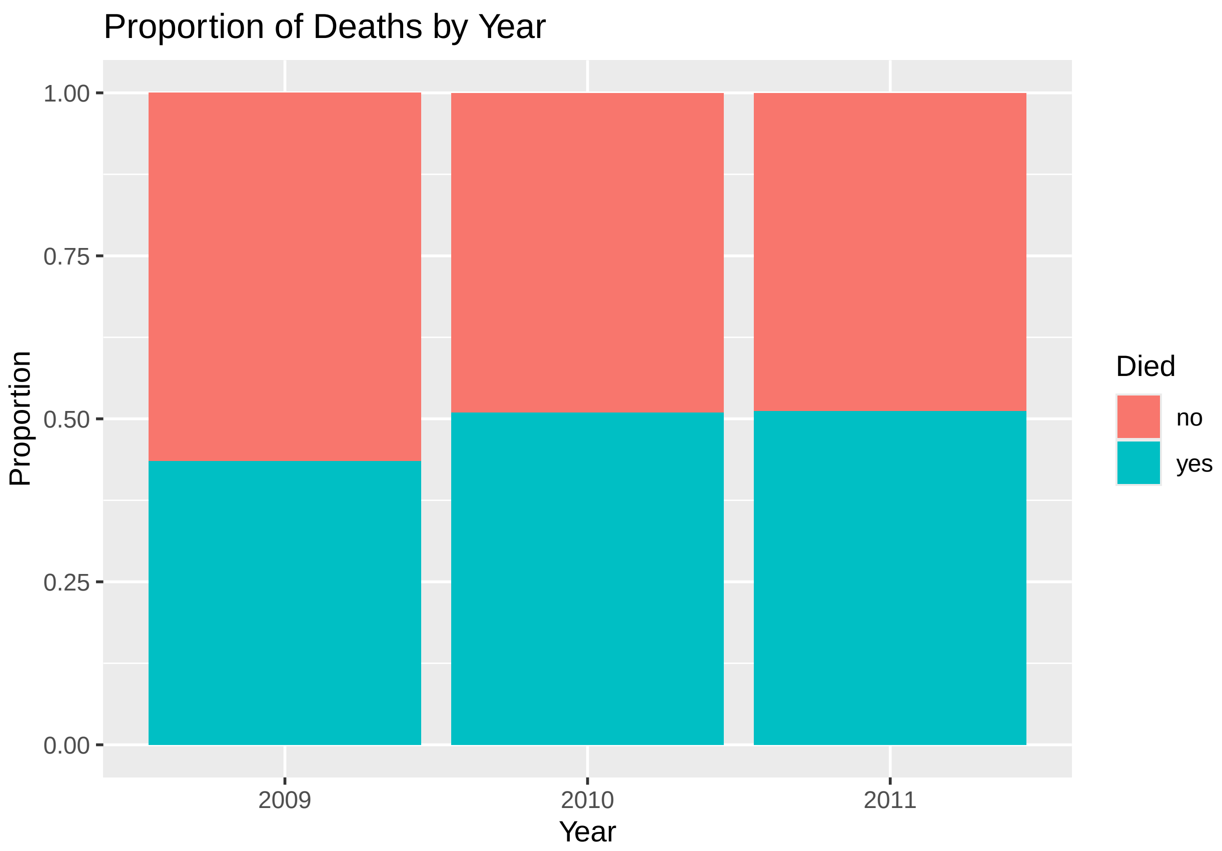
```r
# Interaction between Age and Gender on Death Outcome
ggplot(suicide_data, aes(x = Age, fill = Died)) +
  geom_density(alpha = 0.5) +
  facet_wrap(~Sex) +
  labs(
    title = "Interaction Between Age and Gender on Death Outcome",
    x = "Age",
    y = "Density",
    fill = "Died"
  )
```



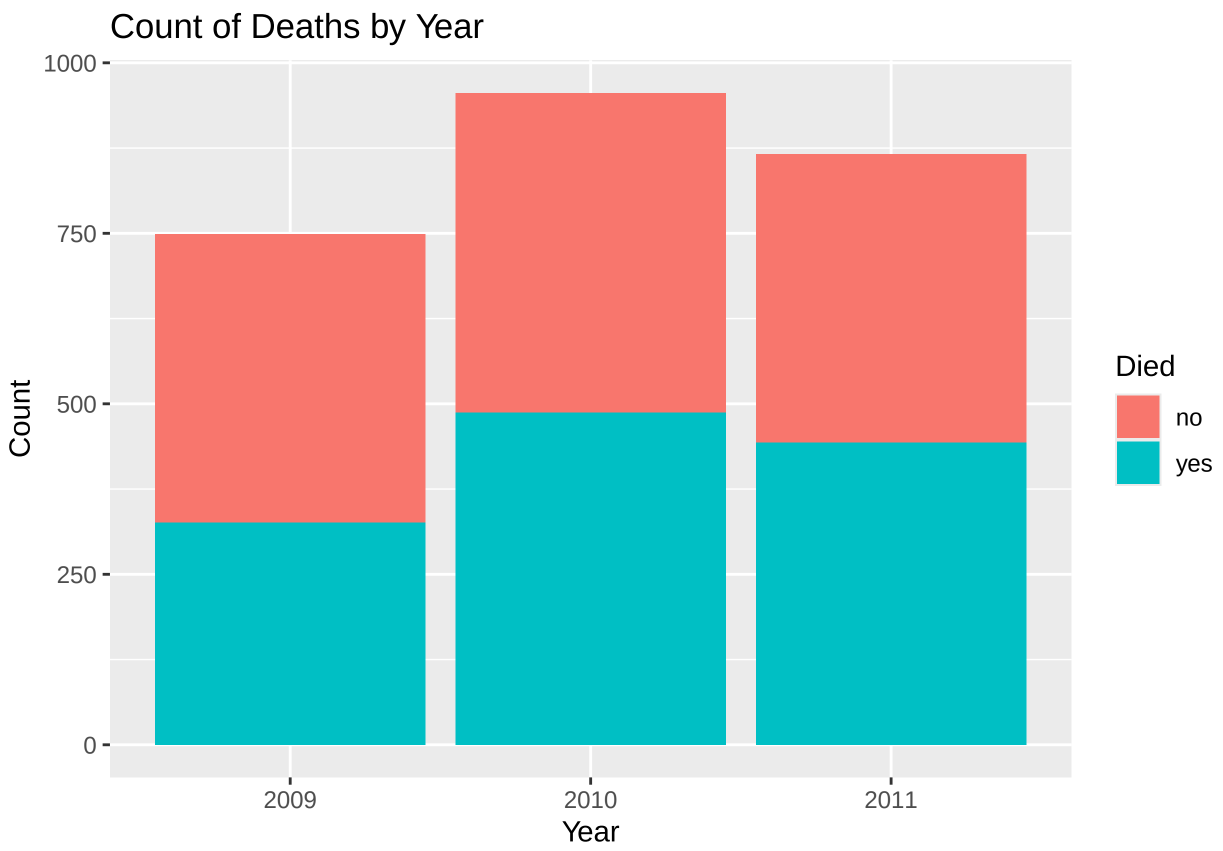
```
ggplot(suicide_data, aes(x = Age, fill = Died)) +
  geom_density(alpha = 0.5) +
  facet_wrap(~Year) +
  labs(
    title = "Age Distribution by Year and Death Outcome",
    x = "Age",
    y = "Density",
    fill = "Died"
  )
```



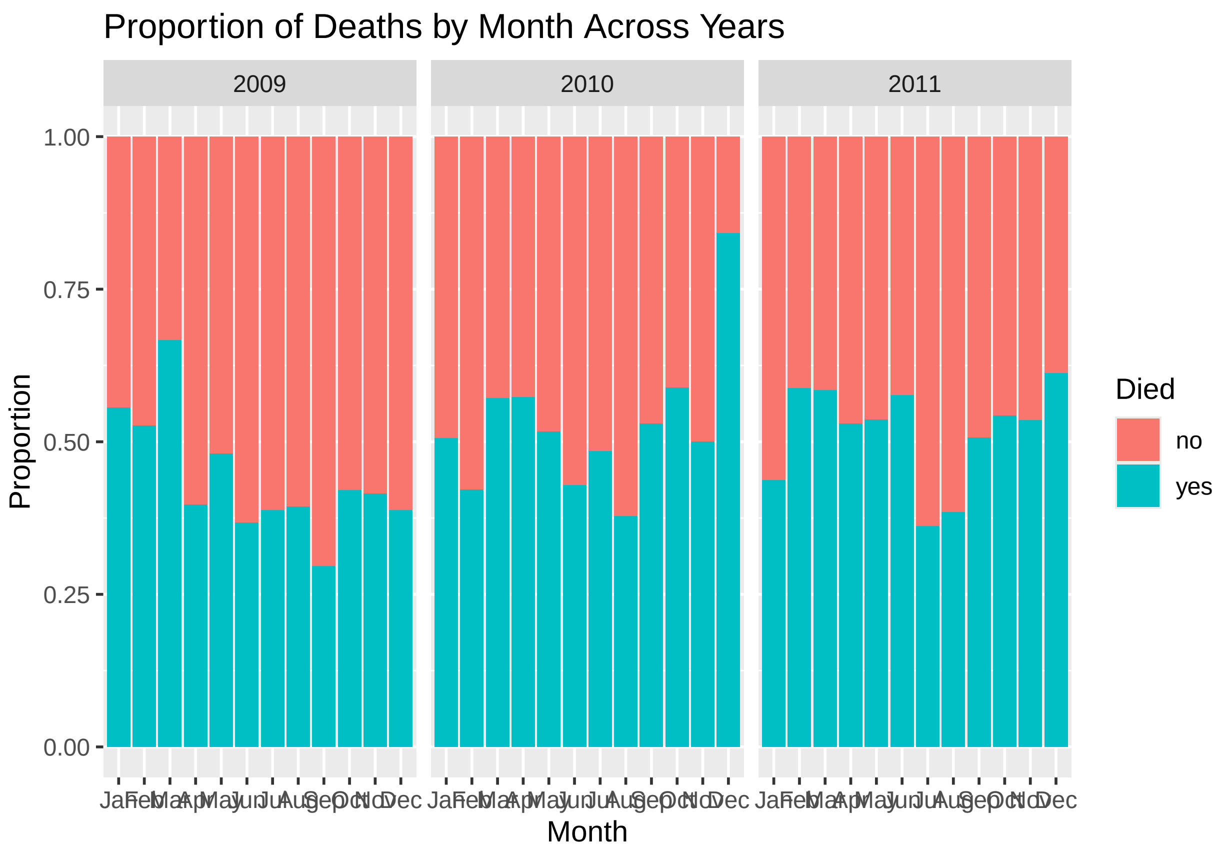
```r
ggplot(suicide_data, aes(x = as.factor(Year), fill = Died)) +
  geom_bar(position = "fill") +
  labs(
    title = "Proportion of Deaths by Year",
    x = "Year",
    y = "Proportion",
    fill = "Died"
  )
```



```
ggplot(suicide_data, aes(x = as.factor(Year), fill = Died)) +
  geom_bar() +
  labs(
    title = "Count of Deaths by Year",
    x = "Year",
    y = "Count",
    fill = "Died"
  )
```



```r
library(ggplot2)

ggplot(suicide_data, aes(x = as.factor(Month), fill = Died)) +
  geom_bar(position = "fill") +
  facet_wrap(~ Year) +
  labs(
    title = "Proportion of Deaths by Month Across Years",
    x = "Month",
    y = "Proportion",
    fill = "Died"
  ) +
  scale_x_discrete(labels = c("1" = "Jan", "2" = "Feb", "3" = "Mar", "4" = "Apr",
                              "5" = "May", "6" = "Jun", "7" = "Jul", "8" = "Aug",
                              "9" = "Sep", "10" = "Oct", "11" = "Nov", "12" = "Dec"))
```



```
# Convert 'Died' to a factor variable
suicide_data$Died <- factor(suicide_data$Died, levels = c("no", "yes"))


logistic_model <- glm(Died ~ Age + Sex + Education + Occupation + method + Urban + Year + Month,
                      data = suicide_data,
                      family = binomial)

# Summary of the model
summary(logistic_model)
```

```
##
## Call:
## glm(formula = Died ~ Age + Sex + Education + Occupation + method +
##     Urban + Year + Month, family = binomial, data = suicide_data)
##
## Coefficients:
##                            Estimate Std. Error z value Pr(>|z|)
## (Intercept)              -7.440e+02  1.465e+02  -5.077 3.84e-07 ***
## Age                       1.922e-02  3.807e-03   5.050 4.43e-07 ***
## Sexmale                   2.091e-01  1.153e-01   1.814 0.069718 .
## Educationprimary         -7.085e-01  1.799e-01  -3.938 8.22e-05 ***
## EducationSecondary       -2.381e+00  1.881e-01 -12.658  < 2e-16 ***
## EducationTertiary        -1.429e+00  7.591e-01  -1.883 0.059736 .
## Educationunknown         -2.317e+00  6.461e-01  -3.586 0.000336 ***
## Occupationfarming        -7.934e-01  6.082e-01  -1.305 0.192040
## Occupationhousehold      -1.983e+00  6.385e-01  -3.106 0.001898 **
## Occupationothers          1.478e+01  1.164e+03   0.013 0.989867
## Occupationothers/unknown -2.106e+00  7.875e-01  -2.674 0.007493 **
## Occupationprofessional    8.011e-01  7.713e-01   1.039 0.298946
## Occupationretiree        -1.472e+01  1.250e+03  -0.012 0.990603
## Occupationstudent        -5.037e-01  7.648e-01  -0.659 0.510157
## Occupationunemployed     -1.184e+00  9.745e-01  -1.215 0.224225
## Occupationworker          1.552e+01  7.445e+02   0.021 0.983367
## methodDrowning            1.738e+01  4.064e+02   0.043 0.965889
## methodHanging             4.310e+00  6.010e-01   7.172 7.41e-13 ***
## methodJumping             4.227e+00  1.044e+00   4.051 5.11e-05 ***
## methodOther poison       -1.099e+00  5.947e-01  -1.848 0.064613 .
## methodOthers             -1.350e+01  2.400e+03  -0.006 0.995513
## methodPesticide           8.448e-01  5.079e-01   1.663 0.096219 .
## methodPoison unspec      -2.464e+00  7.991e-01  -3.083 0.002051 **
## methodunspecified        -2.064e+00  8.224e-01  -2.510 0.012089 *
## Urbanunknown             -4.064e+00  8.807e-01  -4.614 3.95e-06 ***
## Urbanyes                  1.367e-02  1.926e-01   0.071 0.943437
## Year                      3.703e-01  7.293e-02   5.078 3.81e-07 ***
## Month                    -1.905e-02  1.783e-02  -1.069 0.285205
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3562.8  on 2570  degrees of freedom
## Residual deviance: 1988.0  on 2543  degrees of freedom
## AIC: 2044
##
## Number of Fisher Scoring iterations: 15
```

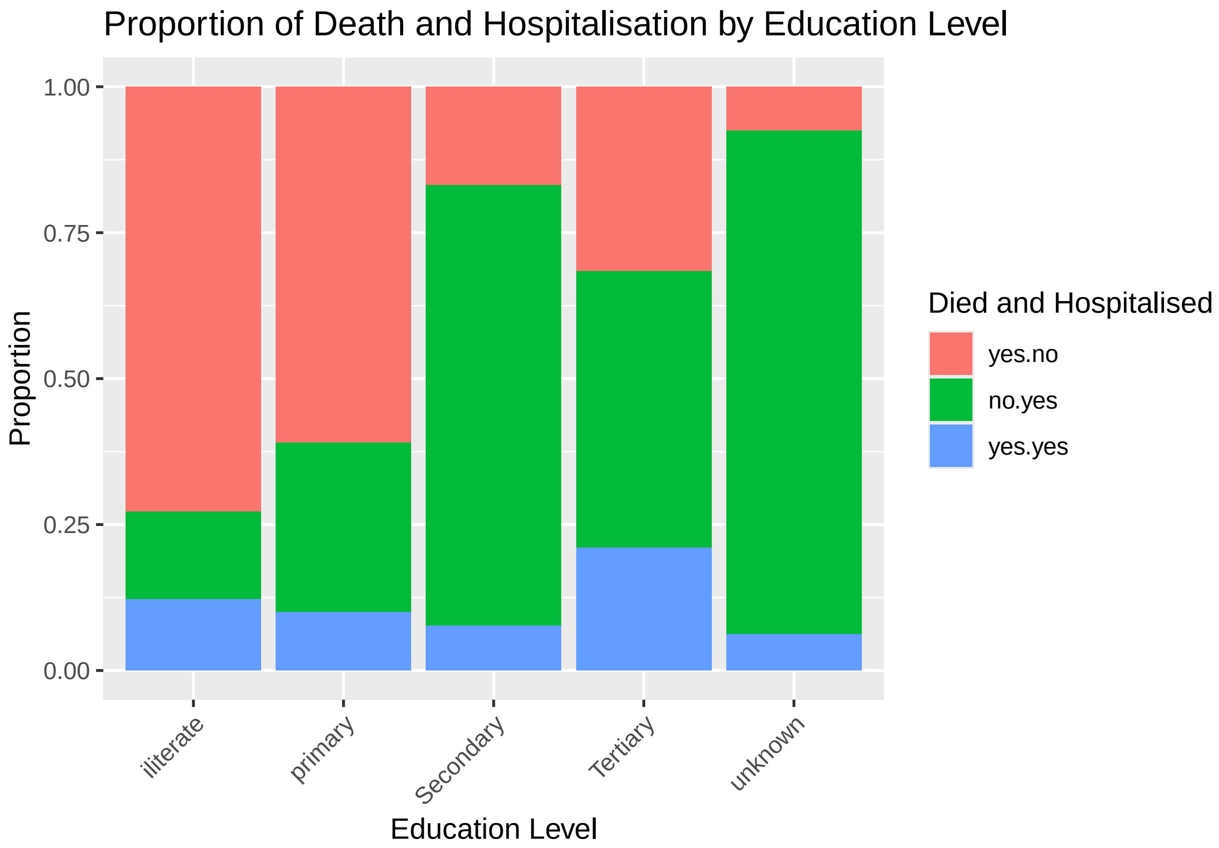
```
# Odds Ratios
exp(coef(logistic_model))
```

```
##              (Intercept)                      Age                  Sexmale
##             9.881313e-324             1.019411e+00             1.232597e+00
##         Educationprimary       EducationSecondary        EducationTertiary
##             4.923818e-01             9.245794e-02             2.395159e-01
##         Educationunknown        Occupationfarming      Occupationhousehold
##             9.860135e-02             4.522864e-01             1.376728e-01
##         Occupationothers Occupationothers/unknown   Occupationprofessional
##             2.619076e+06             1.217369e-01             2.228024e+00
##        Occupationretiree        Occupationstudent     Occupationunemployed
##             4.039341e-07             6.042897e-01             3.059355e-01
##         Occupationworker           methodDrowning            methodHanging
##             5.504952e+06             3.530801e+07             7.446246e+01
##            methodJumping       methodOther poison             methodOthers
##             6.852308e+01             3.331906e-01             1.376897e-06
##          methodPesticide      methodPoison unspec        methodunspecified
##             2.327507e+00             8.513527e-02             1.269561e-01
##             Urbanunknown                 Urbanyes                     Year
##             1.718620e-02             1.013761e+00             1.448229e+00
##                    Month
##             9.811273e-01
```

```
# Count the frequency of each occupation
occupation_counts <- table(suicide_data$Occupation)
print(occupation_counts)
```

```
## 
## business/service          farming        household           others 
##               21             2032              248                3 
##   others/unknown     professional          retiree          student 
##              156               37                3               35 
##       unemployed           worker 
##               30                6 
```

```
# Create a stacked bar plot for Died and Hospitalised by Education
ggplot(suicide_data, aes(x = Education, fill = interaction(Died, Hospitalised))) +
  geom_bar(position = "fill") +
  labs(
    title = "Proportion of Death and Hospitalisation by Education Level",
    x = "Education Level",
    y = "Proportion",
    fill = "Died and Hospitalised"
  ) +
  theme(axis.text.x = element_text(angle = 45, hjust = 1))
```



```r
# Count the frequency of each occupation
educationlevels_counts <- table(suicide_data$Education)
print(educationlevels_counts)
```

```
##
## iliterate   primary Secondary  Tertiary   unknown
##       533       659      1280        19        80
```

```r
# Count the frequency of each occupation
month_counts <- table(suicide_data$Month)
print(month_counts)
```

```
##
##   1   2   3   4   5   6   7   8   9  10  11  12
## 201 208 190 208 263 284 247 229 241 211 153 136
```

```r
# Count the frequency of each occupation
age_counts <- table(suicide_data$Age)
print(age_counts)
```

```
##
##   12   13   14   15   16   17   18   19   20   21   22   23   24   25   26   27   28   29   30   31
##    1    3    5    5    9   12    9   21   29   32   34   39   40   42   40   34   37   29   38   31
##   32   33   34   35   36   37   38   39   40   41   42   43   44   45   46   47   48   49   50   51
##   33   29   23   29   18   28   32   37   58   45   45   52   28   34   38   42   53   36   47   35
##   52   53   54   55   56   57   58   59   60   61   62   63   64   65   66   67   68   69   70   71
##   39   33   48   38   53   54   52   40   45   34   29   43   30   44   39   35   38   35   37   27
##   72   73   74   75   76   77   78   79   80   81   82   83   84   85   86   87   88   89   90   91
##   37   30   39   45   37   33   29   31   30   30   28   27   29   24   25   15   23    8    9    2
##   92   94   95   96   97   98  100
##    6    1    2    1    1    3    1
```

```r
hos <- table(suicide_data$Hospitalised)
print(hos)
```

```
##
##   no  yes
## 1018 1553
```

```r
urban <- table(suicide_data$Urban)
print(urban)
```

```
##
##      no unknown     yes
##    2213      81     277
```

```r
# Filter dataset to include only farming and household occupations
suicide_data <- suicide_data %>%
  filter(Occupation %in% c("farming", "household"))
```

```
# Filter for farming and household occupations and remove "unknown" values
cleaned_data <- suicide_data %>%
  filter(Occupation %in% c("farming", "household")) %>%   # Keep only farming and household
  filter(!Education %in% c("unknown"),                   # Remove "unknown" in Education
         !Died %in% c("unknown"),                        # Remove "unknown" in Died
         !Hospitalised %in% c("unknown"),                # Remove "unknown" in Hospitalised
         !method %in% c("unknown"),                      # Remove "unknown" in method
         !Urban %in% c("unknown"))                       # Remove "unknown" in Urban

# Check the size of the cleaned dataset
nrow(cleaned_data)
```

```
## [1] 2211
```

```
cleaned_data <- cleaned_data %>%
  mutate(method = case_when(
    method %in% c("Poison", "Poison unspec", "Other poison") ~ "Poison",
    TRUE ~ method  # Keep other categories unchanged
  ))

# Check the updated counts for the 'method' column
table(cleaned_data$method)
```

```
## 
##     Cutting    Drowning     Hanging     Jumping   Pesticide      Poison 
##          22          24         405           7        1576         139 
## unspecified 
##          38 
```

```
# Ensure 'Died' is a binary factor with levels "no" and "yes"
cleaned_data$Died <- factor(cleaned_data$Died, levels = c("no", "yes"))

# Build the logistic regression model
death_model <- glm(Died ~ Age + Sex + Education + method + Urban + Year + Month,
                   data = cleaned_data,
                   family = binomial)

# View model summary
summary(death_model)
```

```
## 
## Call:
## glm(formula = Died ~ Age + Sex + Education + method + Urban + 
##     Year + Month, family = binomial, data = cleaned_data)
## 
## Coefficients:
##                      Estimate Std. Error z value Pr(>|z|)    
## (Intercept)        -6.424e+02  1.471e+02  -4.366 1.27e-05 ***
## Age                 1.830e-02  3.901e-03   4.690 2.73e-06 ***
## Sexmale             3.414e-01  1.162e-01   2.937  0.00331 ** 
## Educationprimary   -8.244e-01  1.795e-01  -4.593 4.37e-06 ***
## EducationSecondary -2.450e+00  1.905e-01 -12.861  < 2e-16 ***
## EducationTertiary  -8.442e-01  1.103e+00  -0.765  0.44408    
## methodDrowning      1.756e+01  4.182e+02   0.042  0.96650    
## methodHanging       4.108e+00  6.235e-01   6.589 4.44e-11 ***
## methodJumping       3.767e+00  1.232e+00   3.058  0.00223 ** 
## methodPesticide     9.481e-01  5.403e-01   1.755  0.07932 .  
## methodPoison       -1.372e+00  6.093e-01  -2.252  0.02432 *  
## methodunspecified  -1.799e+00  8.424e-01  -2.135  0.03275 *  
## Urbanyes           -2.436e-02  2.111e-01  -0.115  0.90816    
## Year                3.193e-01  7.322e-02   4.362 1.29e-05 ***
## Month              -1.981e-02  1.842e-02  -1.075  0.28216    
## ---
## Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1
## 
## (Dispersion parameter for binomial family taken to be 1)
## 
##     Null deviance: 3055.6  on 2210  degrees of freedom
## Residual deviance: 1879.4  on 2196  degrees of freedom
## AIC: 1909.4
## 
## Number of Fisher Scoring iterations: 15
```

```r
# Calculate odds ratios for interpretation
exp(coef(death_model))
```

```
##        (Intercept)                Age            Sexmale   Educationprimary 
##      1.009225e-279       1.018466e+00       1.406968e+00       4.384955e-01 
## EducationSecondary  EducationTertiary     methodDrowning      methodHanging 
##       8.632843e-02       4.298827e-01       4.243089e+07       6.084842e+01 
##      methodJumping    methodPesticide       methodPoison  methodunspecified 
##       4.323324e+01       2.580819e+00       2.535863e-01       1.655098e-01 
##           Urbanyes               Year              Month 
##       9.759392e-01       1.376226e+00       9.803862e-01
```

```r
# Create a new column 'Season' based on the month
cleaned_data <- cleaned_data %>%
  mutate(Season = case_when(
    Month %in% c(12, 1, 2) ~ "Winter",
    Month %in% c(3, 4, 5) ~ "Spring",
    Month %in% c(6, 7, 8) ~ "Summer",
    Month %in% c(9, 10, 11) ~ "Fall"
  ))

# Check the counts for each season
table(cleaned_data$Season)
```

```
## 
##   Fall Spring Summer Winter 
##    536    570    654    451
```

```r
# Update the logistic regression model with 'Season' instead of 'Month'
death_model_season <- glm(Died ~ Age + Sex + Education + method + Urban + Year + Season,
                          data = cleaned_data,
                          family = binomial)

# View the model summary
summary(death_model_season)
```

```
##
## Call:
## glm(formula = Died ~ Age + Sex + Education + method + Urban +
##     Year + Season, family = binomial, data = cleaned_data)
##
## Coefficients:
##                       Estimate Std. Error z value Pr(>|z|)
## (Intercept)         -6.324e+02  1.476e+02  -4.286 1.82e-05 ***
## Age                  1.765e-02  3.915e-03   4.507 6.56e-06 ***
## Sexmale              3.186e-01  1.168e-01   2.727  0.00638 **
## Educationprimary    -8.200e-01  1.803e-01  -4.547 5.44e-06 ***
## EducationSecondary -2.479e+00  1.917e-01 -12.927  < 2e-16 ***
## EducationTertiary   -8.729e-01  1.094e+00  -0.798  0.42481
## methodDrowning       1.757e+01  4.169e+02   0.042  0.96637
## methodHanging        4.136e+00  6.241e-01   6.626 3.44e-11 ***
## methodJumping        3.736e+00  1.232e+00   3.033  0.00242 **
## methodPesticide      9.840e-01  5.403e-01   1.821  0.06861 .
## methodPoison        -1.396e+00  6.094e-01  -2.291  0.02199 *
## methodunspecified   -1.698e+00  8.394e-01  -2.023  0.04307 *
## Urbanyes            -6.548e-03  2.100e-01  -0.031  0.97512
## Year                 3.142e-01  7.342e-02   4.280 1.87e-05 ***
## SeasonSpring         4.197e-01  1.642e-01   2.557  0.01057 *
## SeasonSummer        -5.829e-02  1.560e-01  -0.374  0.70868
## SeasonWinter         4.031e-01  1.749e-01   2.304  0.02121 *
## ---
## Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3055.6  on 2210  degrees of freedom
## Residual deviance: 1865.8  on 2194  degrees of freedom
## AIC: 1899.8
##
## Number of Fisher Scoring iterations: 15
```

```
# Calculate odds ratios for interpretation
exp(coef(death_model_season))
```

```
##        (Intercept)                Age            Sexmale   Educationprimary
##       2.227514e-275       1.017804e+00       1.375154e+00       4.404200e-01
## EducationSecondary  EducationTertiary     methodDrowning      methodHanging
##        8.385456e-02       4.177344e-01       4.290448e+07       6.252607e+01
##      methodJumping    methodPesticide       methodPoison  methodunspecified
##        4.194650e+01       2.675025e+00       2.476527e-01       1.830092e-01
##           Urbanyes               Year       SeasonSpring       SeasonSummer
##        9.934738e-01       1.369212e+00       1.521546e+00       9.433714e-01
##       SeasonWinter
##        1.496428e+00
```

```r
# Convert Year into a categorical variable
cleaned_data$Year <- as.factor(cleaned_data$Year)

# Check the levels to confirm
levels(cleaned_data$Year)
```

```
## [1] "2009" "2010" "2011"
```

```r
# Logistic regression with Year as a categorical variable
death_model_categorical <- glm(Died ~ Age + Sex + Education + method + Urban + Season + Year,
                               data = cleaned_data,
                               family = binomial)

# View model summary
summary(death_model_categorical)
```

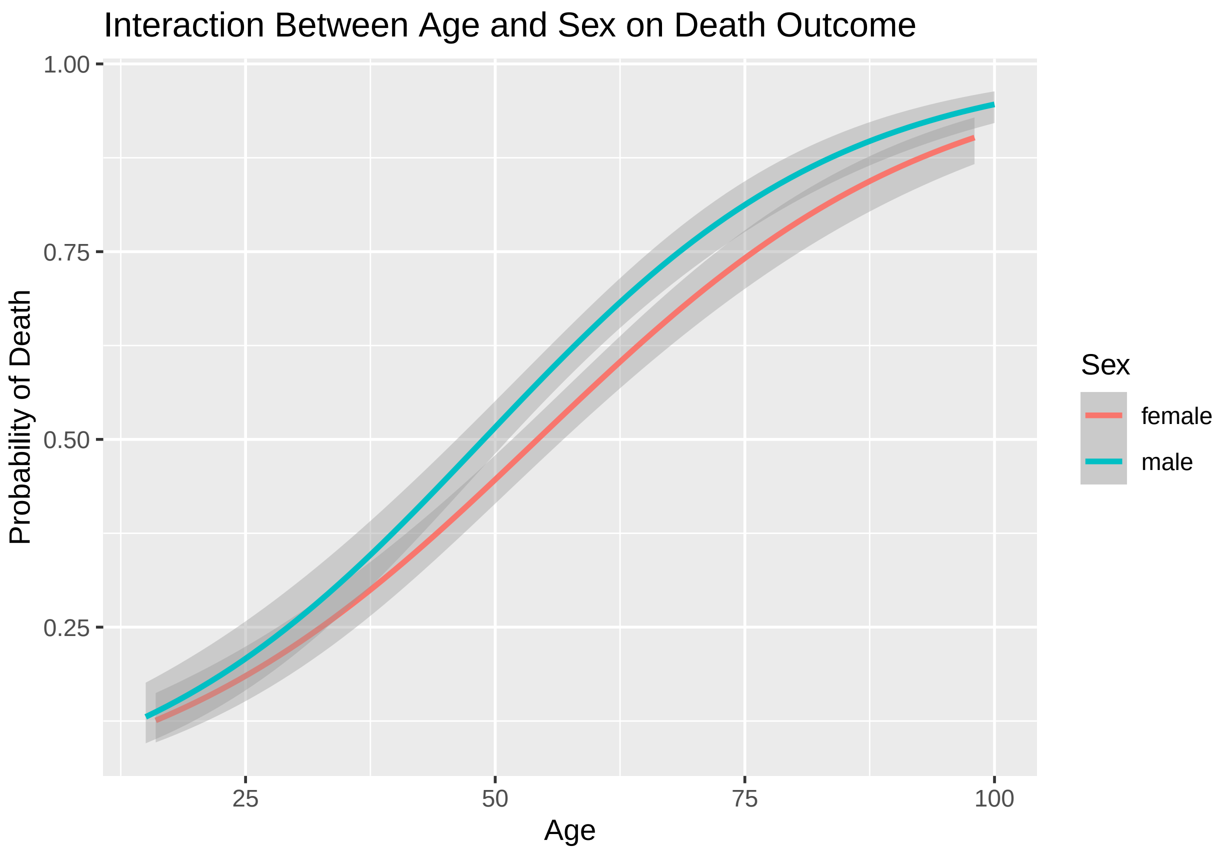
```
##
## Call:
## glm(formula = Died ~ Age + Sex + Education + method + Urban +
##     Season + Year, family = binomial, data = cleaned_data)
##
## Coefficients:
##                     Estimate Std. Error z value Pr(>|z|)
## (Intercept)        -1.122755   0.607753  -1.847  0.06469 .
## Age                 0.017616   0.003917   4.497 6.88e-06 ***
## Sexmale             0.318369   0.116802   2.726  0.00642 **
## Educationprimary   -0.822828   0.180522  -4.558 5.16e-06 ***
## EducationSecondary -2.480853   0.191859 -12.931  < 2e-16 ***
## EducationTertiary  -0.860457   1.093953  -0.787  0.43154
## methodDrowning     17.577865 416.561264   0.042  0.96634
## methodHanging       4.133303   0.624163   6.622 3.54e-11 ***
## methodJumping       3.740971   1.232428   3.035  0.00240 **
## methodPesticide     0.984014   0.540350   1.821  0.06860 .
## methodPoison       -1.389649   0.609688  -2.279  0.02265 *
## methodunspecified  -1.685206   0.840167  -2.006  0.04488 *
## Urbanyes           -0.007706   0.210086  -0.037  0.97074
## SeasonSpring        0.421035   0.164236   2.564  0.01036 *
## SeasonSummer       -0.058459   0.156024  -0.375  0.70790
## SeasonWinter        0.402815   0.174888   2.303  0.02126 *
## Year2010            0.356511   0.141806   2.514  0.01193 *
## Year2011            0.628978   0.146923   4.281 1.86e-05 ***
## ---
## Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3055.6  on 2210  degrees of freedom
## Residual deviance: 1865.7  on 2193  degrees of freedom
## AIC: 1901.7
##
## Number of Fisher Scoring iterations: 15
```

```r
# Calculate odds ratios
exp(coef(death_model_categorical))
```

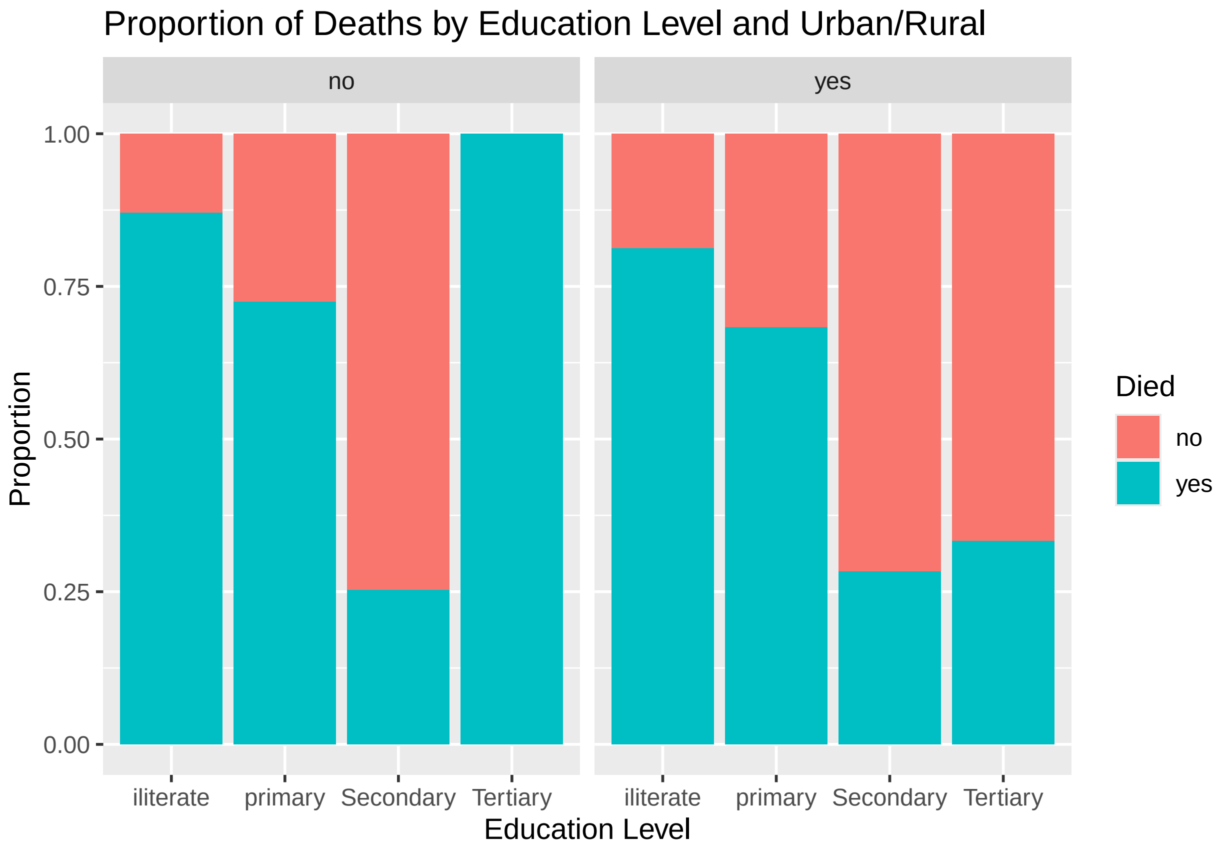
```
##         (Intercept)                 Age             Sexmale    Educationprimary 
##        3.253822e-01        1.017772e+00        1.374883e+00        4.391877e-01 
## EducationSecondary  EducationTertiary      methodDrowning       methodHanging 
##        8.367179e-02        4.229688e-01        4.304966e+07        6.238363e+01 
##       methodJumping     methodPesticide        methodPoison methodunspecified 
##        4.213887e+01        2.675174e+00        2.491627e-01        1.854062e-01 
##            Urbanyes        SeasonSpring        SeasonSummer        SeasonWinter 
##        9.923237e-01        1.523537e+00        9.432171e-01        1.496029e+00 
##            Year2010            Year2011 
##        1.428337e+00        1.875693e+00
```

```r
# Plot Age and Sex interaction
ggplot(cleaned_data, aes(x = Age, y = as.numeric(Died == "yes"), color = Sex)) +
  geom_smooth(method = "glm", method.args = list(family = "binomial")) +
  labs(
    title = "Interaction Between Age and Sex on Death Outcome",
    x = "Age",
    y = "Probability of Death"
  )
```

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



```r
# Create a bar plot showing proportions
ggplot(cleaned_data, aes(x = Education, fill = Died)) +
  geom_bar(position = "fill") +
  facet_wrap(~ Urban) +
  labs(
    title = "Proportion of Deaths by Education Level and Urban/Rural",
    x = "Education Level",
    y = "Proportion",
    fill = "Died"
  )
```



```r
# Add Education and Urban interaction to the model
final_model <- glm(Died ~ Age + Education + method + Season + Year + Sex,
                         data = cleaned_data,
                         family = binomial)

# View the model summary
summary(final_model)
```

```
##
## Call:
## glm(formula = Died ~ Age + Education + method + Season + Year +
##     Sex, family = binomial, data = cleaned_data)
##
## Coefficients:
```

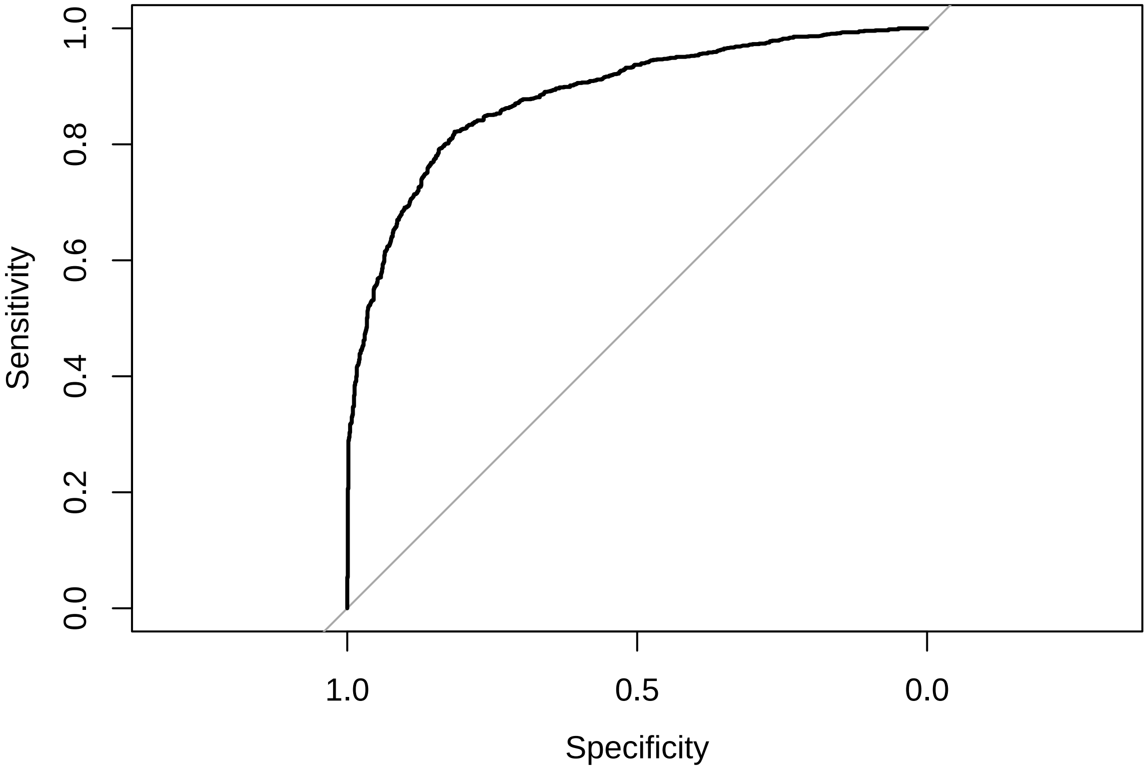
```
##                       Estimate Std. Error z value Pr(>|z|)    
## (Intercept)          -1.123417   0.607402  -1.850  0.06438 .  
## Age                   0.017616   0.003917   4.498 6.87e-06 ***
## Educationprimary     -0.822793   0.180521  -4.558 5.17e-06 ***
## EducationSecondary   -2.481094   0.191751 -12.939  < 2e-16 ***
## EducationTertiary    -0.865654   1.084484  -0.798  0.42474    
## methodDrowning       17.578842 416.613360   0.042  0.96634    
## methodHanging         4.133257   0.624076   6.623 3.52e-11 ***
## methodJumping         3.737283   1.228425   3.042  0.00235 ** 
## methodPesticide       0.984085   0.540250   1.822  0.06853 .  
## methodPoison         -1.389876   0.609575  -2.280  0.02260 *  
## methodunspecified    -1.684696   0.839992  -2.006  0.04490 *  
## SeasonSpring          0.421115   0.164219   2.564  0.01034 *  
## SeasonSummer         -0.058410   0.156023  -0.374  0.70813    
## SeasonWinter          0.402991   0.174818   2.305  0.02116 *  
## Year2010              0.356449   0.141794   2.514  0.01194 *  
## Year2011              0.628994   0.146920   4.281 1.86e-05 ***
## Sexmale               0.318367   0.116802   2.726  0.00642 ** 
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3055.6  on 2210  degrees of freedom
## Residual deviance: 1865.7  on 2194  degrees of freedom
## AIC: 1899.7
##
## Number of Fisher Scoring iterations: 15
```

```
roc_curve <- roc(cleaned_data$Died, predict(death_model_categorical, type = "response"))
```

```
## Setting levels: control = no, case = yes
```

```
## Setting direction: controls < cases
```

```
plot(roc_curve)
```



```
auc(roc_curve)
```

```
## Area under the curve: 0.884
```

```
final_model <- glm(Died ~ Hospitalised + method + Year + Education + Season + Sex + Age,
                         data = cleaned_data,
                         family = binomial)
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```
summary(final_model)
```

```
##
## Call:
## glm(formula = Died ~ Hospitalised + method + Year + Education +
##     Season + Sex + Age, family = binomial, data = cleaned_data)
##
## Coefficients:
##                        Estimate Std. Error z value Pr(>|z|)
## (Intercept)           1.493e+01  7.568e+02   0.020 0.984265
## Hospitalisedyes      -3.243e+01  1.007e+03  -0.032 0.974313
## methodDrowning        3.339e+01  4.648e+03   0.007 0.994268
## methodHanging         1.700e+01  7.558e+02   0.022 0.982055
## methodJumping         1.792e+01  7.558e+02   0.024 0.981080
## methodPesticide     1.533e+01  7.558e+02   0.020 0.983815
## methodPoison        1.387e+01  7.558e+02   0.018 0.985363
## methodunspecified   1.394e+01  7.558e+02   0.018 0.985283
## Year2010            8.576e-01  2.313e-01   3.708 0.000209 ***
## Year2011            1.178e+00  2.327e-01   5.062 4.15e-07 ***
## Educationprimary   -7.934e-01  2.502e-01  -3.171 0.001517 **
## EducationSecondary -1.823e+00  2.624e-01  -6.949 3.68e-12 ***
## EducationTertiary  -1.580e+01  1.226e+03  -0.013 0.989713
## SeasonSpring        4.662e-01  2.424e-01   1.923 0.054449 .
## SeasonSummer        7.509e-02  2.322e-01   0.323 0.746447
## SeasonWinter        3.005e-01  2.632e-01   1.142 0.253499
## Sexmale             2.495e-01  1.714e-01   1.456 0.145501
## Age                 1.731e-02  5.712e-03   3.030 0.002445 **
## ---
## Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3055.58  on 2210  degrees of freedom
## Residual deviance:  917.82  on 2193  degrees of freedom
## AIC: 953.82
##
## Number of Fisher Scoring iterations: 20
```

```r
model_no_hospital <- glm(Died ~ method + Year + Education + Season + Sex + Age,
                         data = cleaned_data, family = binomial)

# Fit model with "Hospitalised"
model_with_hospital <- glm(Died ~ Hospitalised + method + Year + Education + Season + Sex + Age,
                           data = cleaned_data, family = binomial)
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```r
vif(model_with_hospital)
```

```
##                  GVIF Df GVIF^(1/(2*Df))
## Hospitalised 1.997443  1        1.413309
## method       1.988658  6        1.058961
## Year         1.069229  2        1.016875
## Education    1.815731  3        1.104524
## Season       1.043236  3        1.007079
## Sex          1.028566  1        1.014182
## Age          1.488270  1        1.219947
```

```r
# To create a combined outcome variable
cleaned_data$Outcome <- case_when(
  cleaned_data$Died == "yes" ~ "Died",
  cleaned_data$Hospitalised == "yes" ~ "Hospitalised",
  TRUE ~ "Not_Hospitalised"
)
```

```r
cleaned_data$Outcome <- factor(cleaned_data$Outcome, levels = c("Died", "Hospitalised", "Not_Hospitalis

# Fit multinomial logistic regression
multinom_model <- multinom(Outcome ~ Age + Sex + Education + method + Urban + Year + Season,
                           data = cleaned_data)
```

```
## Warning in multinom(Outcome ~ Age + Sex + Education + method + Urban + Year + :
## group 'Not_Hospitalised' is empty

## # weights:  19 (18 variable)
## initial  value 1532.548416
## iter  10 value 1041.765204
## iter  20 value 934.689216
## iter  30 value 932.876210
## final  value 932.857566
## converged
```

```r
summary(multinom_model)
```

```
## Call:
## multinom(formula = Outcome ~ Age + Sex + Education + method +
##     Urban + Year + Season, data = cleaned_data)
##
## Coefficients:
##                           Values    Std. Err.
## (Intercept)          1.121185453 0.6076831017
## Age                 -0.017617059 0.0039168338
## Sexmale             -0.318360809 0.1168017984
## Educationprimary     0.822794401 0.1805220224
## EducationSecondary   2.480809455 0.1918588024
## EducationTertiary    0.860499851 1.0939475861
## methodDrowning     -13.576910086 0.0001168028
## methodHanging       -4.131878063 0.6241095774
## methodJumping       -3.737037597 1.2316706742
## methodPesticide     -0.982339257 0.5402683633
## methodPoison         1.391329935 0.6096188991
## methodunspecified    1.687101091 0.8401504430
## Urbanyes             0.007664267 0.2100843534
## Year2010            -0.356531399 0.1418062522
## Year2011            -0.629011036 0.1469231265
## SeasonSpring        -0.421014794 0.1642362140
## SeasonSummer         0.058490551 0.1560242625
## SeasonWinter        -0.402782230 0.1748877657
##
## Residual Deviance: 1865.715
## AIC: 1901.715
```

```r
exp(coef(multinom_model))
```

```
##        (Intercept)                Age            Sexmale   Educationprimary
##       3.068490e+00       9.825372e-01       7.273403e-01       2.276853e+00
## EducationSecondary  EducationTertiary     methodDrowning      methodHanging
##       1.195093e+01       2.364342e+00       1.269471e-06       1.605270e-02
##      methodJumping    methodPesticide       methodPoison  methodunspecified
##       2.382458e-02       3.744342e-01       4.020193e+00       5.403793e+00
##           Urbanyes           Year2010           Year2011       SeasonSpring
##       1.007694e+00       7.001005e-01       5.331188e-01       6.563804e-01
##       SeasonSummer       SeasonWinter
##       1.060235e+00       6.684577e-01
```

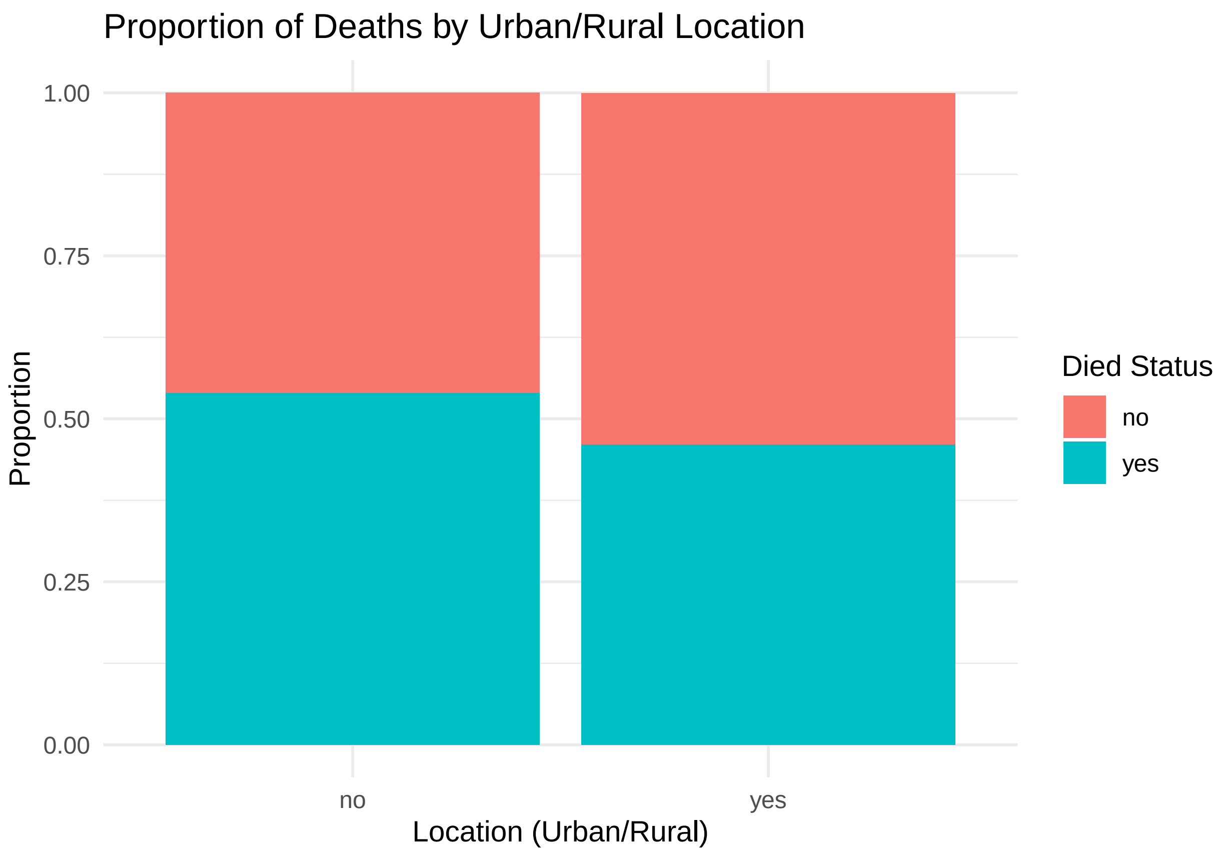
```
# fixed - fit three level
cleaned_data$Outcome <- case_when(
  cleaned_data$Died == "yes" ~ "High_Fatality",                   # Dead, regardless of hospitalization
  cleaned_data$Died == "no" & cleaned_data$Hospitalised == "yes" ~ "Medium_Fatality",   # Not dead but h
  cleaned_data$Died == "no" & cleaned_data$Hospitalised == "no" ~ "Low_Fatality"       # Not dead and no
)

cleaned_data$Outcome <- factor(cleaned_data$Outcome,
                               levels = c("High_Fatality", "Medium_Fatality", "Low_Fatality"))


table(cleaned_data$Outcome)
```

```
##
##   High_Fatality Medium_Fatality    Low_Fatality
##            1178            1033               0
```

```
#only fit the two level - medium and high?
cleaned_data$Outcome <- case_when(
  cleaned_data$Died == "yes" ~ "High_Fatality",                   # Dead (high-fatality)
  cleaned_data$Died == "no" & cleaned_data$Hospitalised == "yes" ~ "Medium_Fatality" # Survived and hos
)


cleaned_data$Outcome <- factor(cleaned_data$Outcome,
                               levels = c("High_Fatality", "Medium_Fatality"))

table(cleaned_data$Outcome)
```

```
##
##   High_Fatality Medium_Fatality
##            1178            1033
```

```
# urban? + death
ggplot(cleaned_data, aes(x = Urban, fill = Died)) +
  geom_bar(position = "fill") +
  labs(
    title = "Proportion of Deaths by Urban/Rural Location",
    x = "Location (Urban/Rural)",
    y = "Proportion",
    fill = "Died Status"
  ) +
  theme_minimal()
```



```
# % Urban/Rural
proportions <- cleaned_data %>%
  group_by(Urban, Died) %>%
  summarise(Count = n()) %>%
  mutate(Proportion = Count / sum(Count)) %>%
  arrange(Urban, Died)
```

```
## `summarise()` has grouped output by 'Urban'. You can override using the
## `.groups` argument.
```

```
print(proportions)
```

```
## # A tibble: 4 x 4
## # Groups:   Urban [2]
##   Urban Died  Count Proportion
##   <chr> <fct> <int>      <dbl>
## 1 no    no      931      0.460
## 2 no    yes    1091      0.540
## 3 yes   no      102      0.540
## 4 yes   yes      87      0.460
```

```
# final model?
binary_model <- glm(Outcome ~ Age + Sex + Education + method + Year + Season,
                    data = cleaned_data,
                     family = binomial)

summary(binary_model)
```

```
##
## Call:
## glm(formula = Outcome ~ Age + Sex + Education + method + Year +
##     Season, family = binomial, data = cleaned_data)
##
## Coefficients:
##                        Estimate Std. Error z value Pr(>|z|)
## (Intercept)            1.123417   0.607402   1.850  0.06438 .
## Age                   -0.017616   0.003917  -4.498 6.87e-06 ***
## Sexmale               -0.318367   0.116802  -2.726  0.00642 **
## Educationprimary       0.822793   0.180521   4.558 5.17e-06 ***
## EducationSecondary     2.481094   0.191751  12.939  < 2e-16 ***
## EducationTertiary      0.865654   1.084484   0.798  0.42474
## methodDrowning       -17.578842 416.613360  -0.042  0.96634
## methodHanging         -4.133257   0.624076  -6.623 3.52e-11 ***
## methodJumping         -3.737283   1.228425  -3.042  0.00235 **
## methodPesticide       -0.984085   0.540250  -1.822  0.06853 .
## methodPoison           1.389876   0.609575   2.280  0.02260 *
## methodunspecified      1.684696   0.839992   2.006  0.04490 *
## Year2010              -0.356449   0.141794  -2.514  0.01194 *
## Year2011              -0.628994   0.146920  -4.281 1.86e-05 ***
## SeasonSpring          -0.421115   0.164219  -2.564  0.01034 *
## SeasonSummer           0.058410   0.156023   0.374  0.70813
## SeasonWinter          -0.402991   0.174818  -2.305  0.02116 *
## ---
## Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3055.6  on 2210  degrees of freedom
## Residual deviance: 1865.7  on 2194  degrees of freedom
## AIC: 1899.7
##
## Number of Fisher Scoring iterations: 15
```

```
# Convert coefficients to odds ratios
exp(coef(binary_model))
```

```
##        (Intercept)                Age            Sexmale   Educationprimary
##       3.075346e+00       9.825379e-01       7.273356e-01       2.276851e+00
## EducationSecondary  EducationTertiary     methodDrowning      methodHanging
##       1.195434e+01       2.376559e+00       2.320631e-08       1.603058e-02
##      methodJumping    methodPesticide       methodPoison  methodunspecified
##       2.381874e-02       3.737810e-01       4.014352e+00       5.390812e+00
##           Year2010           Year2011       SeasonSpring       SeasonSummer
##       7.001579e-01       5.331278e-01       6.563143e-01       1.060150e+00
##       SeasonWinter
##       6.683179e-01
```

```
# new attempt - ?
cleaned_data$Outcome <- case_when(
  cleaned_data$Died == "yes" & cleaned_data$Hospitalised == "yes" ~ "Died-Hospital",
  cleaned_data$Died == "no" & cleaned_data$Hospitalised == "yes" ~ "Survived",
  cleaned_data$Died == "yes" & cleaned_data$Hospitalised == "no" ~ "ImmediateDeath"
)


cleaned_data$Outcome <- factor(cleaned_data$Outcome,
                               levels = c("Died-Hospital", "Survived", "ImmediateDeath"))

table(cleaned_data$Outcome)
```

```
##
##  Died-Hospital       Survived ImmediateDeath
##            212           1033            966
```

```
# final fianl model ? new combined model?


#?multinomial logistic regression model

multinom_model <- multinom(Outcome ~ Age + Sex + Education + method + Urban + Year + Season,
                           data = cleaned_data)
```

```
## # weights:  57 (36 variable)
## initial  value 2429.031770
## iter  10 value 1540.130188
## iter  20 value 1431.200039
## iter  30 value 1412.414984
## iter  40 value 1409.774972
## iter  50 value 1409.658761
## final  value 1409.658195
## converged
```

```
summary(multinom_model)
```

```
## Call:
## multinom(formula = Outcome ~ Age + Sex + Education + method +
##     Urban + Year + Season, data = cleaned_data)
##
## Coefficients:
##                (Intercept)          Age     Sexmale Educationprimary
## Survived          19.14277 -0.014733210 -0.26324715       0.85296270
## ImmediateDeath    18.06596  0.004393041  0.07557856       0.04443645
##                EducationSecondary EducationTertiary methodDrowning
## Survived                1.9681324          20.70484      -39.87781
## ImmediateDeath         -0.7074844          20.34890      -14.41513
##                methodHanging methodJumping methodPesticide methodPoison
## Survived           -18.76330     -19.85802       -17.20467    -15.64673
## ImmediateDeath     -14.56368     -16.29702       -16.45920    -17.74798
##                methodunspecified   Urbanyes   Year2010   Year2011 SeasonSpring
## Survived               -15.84265 -0.2368783 -0.7962393 -1.1226994   -0.5190183
## ImmediateDeath         -29.86259 -0.3563882 -0.5866742 -0.6792489   -0.1473621
##                SeasonSummer SeasonWinter
## Survived        -0.08292517  -0.34473326
## ImmediateDeath  -0.20165844   0.07733424
##
## Std. Errors:
##                (Intercept)         Age   Sexmale Educationprimary
## Survived         0.5307510 0.005571424 0.1628414        0.2416911
## ImmediateDeath   0.5271286 0.005631168 0.1610297        0.2055020
##                EducationSecondary EducationTertiary methodDrowning
## Survived                0.2616409         0.5677373   7.701903e-10
## ImmediateDeath          0.2454914         0.5677373   9.993416e-01
##                methodHanging methodJumping methodPesticide methodPoison
## Survived           0.4956731      1.166844       0.3538062    0.4701247
## ImmediateDeath     0.4096896      0.851924       0.3532652    0.5608895
##                methodunspecified  Urbanyes  Year2010  Year2011 SeasonSpring
## Survived            6.799245e-01 0.2748027 0.2193069 0.2196222     0.229438
## ImmediateDeath      4.796883e-06 0.2811515 0.2188067 0.2178180     0.225828
##                SeasonSummer SeasonWinter
## Survived          0.2235841    0.2505418
## ImmediateDeath    0.2249004    0.2463640
##
## Residual Deviance: 2819.316
## AIC: 2891.316
```

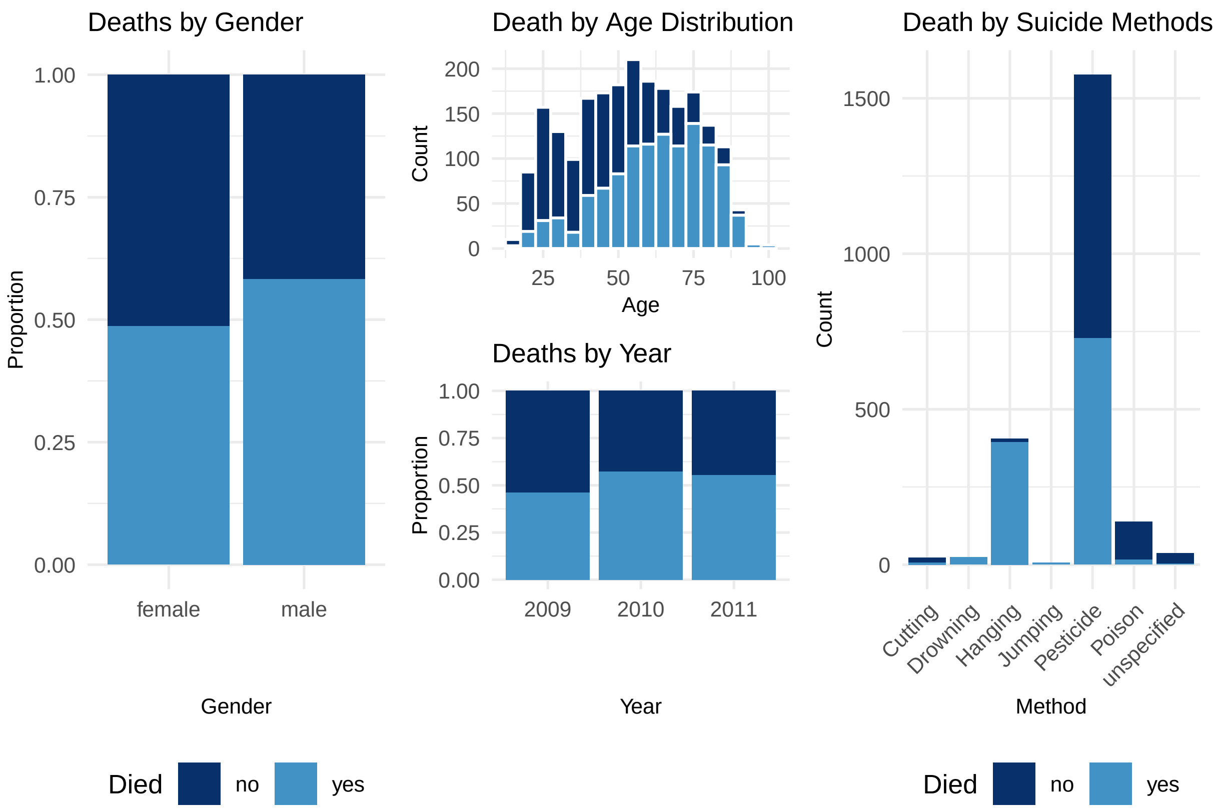
```
## cannot use this model this is wrong.
```

```
## Need to be fixed
z_values <- summary(multinom_model)$coefficients / summary(multinom_model)$standard.errors
p_values <- 2 * (1 - pnorm(abs(z_values)))
p_values
```

```
##                (Intercept)         Age   Sexmale Educationprimary
## Survived                 0 0.008182992 0.1059676     0.0004169062
## ImmediateDeath           0 0.435314617 0.6388226     0.8288056180
##                EducationSecondary EducationTertiary methodDrowning
## Survived             5.373479e-14                 0              0
## ImmediateDeath       3.952710e-03                 0              0
##                methodHanging methodJumping methodPesticide methodPoison
## Survived                   0             0               0            0
## ImmediateDeath             0             0               0            0
##                methodunspecified  Urbanyes    Year2010     Year2011
## Survived                       0 0.3886907 0.000282645 3.188376e-07
## ImmediateDeath                 0 0.2049401 0.007334895 1.818211e-03
##                SeasonSpring SeasonSummer SeasonWinter
## Survived         0.02368946    0.7107192    0.1688367
## ImmediateDeath   0.51405203    0.3699022    0.7535952
```

```
## oops something wrong...
```

```r
# Custom blue palette
blue_palette <- c("#08306B", "#4292C6", "#9ECAE1")

# Base theme for all plots
base_theme <- theme_minimal(base_size = 10) +
  theme(
    legend.position = "none",  # Suppress legends in individual plots
    plot.title = element_text(size = 10),
    axis.text = element_text(size = 8),
    axis.title = element_text(size = 8)
  )

# Plot 1: Deaths by Gender
plot1 <- ggplot(cleaned_data, aes(x = Sex, fill = Died)) +
  geom_bar(position = "fill") +
  scale_fill_manual(values = blue_palette) +
  labs(title = "Deaths by Gender", x = "Gender", y = "Proportion") +
  base_theme

# Plot 2: Death by Age Distribution
plot2 <- ggplot(cleaned_data, aes(x = Age, fill = Died)) +
  geom_histogram(binwidth = 5, color = "white", position = "stack") +
  scale_fill_manual(values = blue_palette) +
  labs(title = "Death by Age Distribution", x = "Age", y = "Count") +
  base_theme

# Plot 3: Deaths by Year
plot3 <- ggplot(cleaned_data, aes(x = factor(Year), fill = Died)) +
  geom_bar(position = "fill") +
  scale_fill_manual(values = blue_palette) +
  labs(title = "Deaths by Year", x = "Year", y = "Proportion") +
  base_theme

# Plot 4: Death by Suicide Methods
plot4 <- ggplot(cleaned_data, aes(x = method, fill = Died)) +
  geom_bar() +
  scale_fill_manual(values = blue_palette) +
  labs(title = "Death by Suicide Methods", x = "Method", y = "Count") +
  base_theme +
  theme(axis.text.x = element_text(angle = 45, hjust = 1))

# Combine the plots into a 2x2 grid with a single shared legend
combined_plot <- (plot1 + theme(legend.position = "bottom")) | plot2 /
                 plot3 | plot4 +
                 plot_layout(guides = "collect") &
                 theme(legend.position = "bottom")

# Display the combined plot
combined_plot
```


Deaths by Gender
Proportion
1.00
0.75
0.50
0.25
0.00
female
male
Gender
Death by Age Distribution
Count
200
150
100
50
0
25
50
75
100
Age
Deaths by Year
Proportion
1.00
0.75
0.50
0.25
0.00
2009
2010
2011
Year
Death by Suicide Methods
Count
1500
1000
500
0
Cutting
Drowning
Hanging
Jumping
Pesticide
Poison
unspecified
Method
Died
no
yes
Died
no
yes