209041841_GY7702_CW2

209041841

04/01/2021

GY7702-R-for-Data-Science

Datascience-Project

##*The University of Leicester* **Coursework 2 This document is created from R - Markdown and linked to the GitHub repository** The link to the GitHub Repository

Repository link : https://github.com/gowthamnallathambi/Datascience_project.git

This repository / document contains public sector information licensed under the Open Government Licence v3.0 (http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/): [list the files here]. See also [add relevant links to sources of data, see assignment document] and Office for National Statistics (https://geoportal.statistics.gov.uk/).

Option A

Option A.1

Exploratory Data Analysis

```r
rm(list=ls())       # To clear environment
library(tidyverse)
library(knitr)
library(pastecs)
library(magrittr)
```

```r
# Read OAC_2011 data
OAC_2011 <-
  readr::read_csv("Data/2011_OAC_Raw_kVariables.csv")
```

```r
# Creating new table for assigned LAD - Wolverhampton

Wolverhampton_LAD <-
  readr::read_csv("Data/OA11_LSOA11_MSOA11_LAD11_EW_LUv2.csv") %>%
  dplyr::filter(LAD11CD == "E08000031") %>%
  dplyr::select(-LAD11NMW) %>%
  readr::write_csv("Data/Wolverhampton_LAD.csv")
```

```
# Read_LAD data

Wolverhampton_LAD <-
  readr::read_csv("Data/Wolverhampton_LAD.csv")
```

```
# Tibble joining

OAC_2011 %>%

dplyr::inner_join(

  Wolverhampton_LAD,
  by = c("OA" = "OA11CD")
) %>%
  dplyr::select(OA, Total_Population, Total_Households, Total_Dwellings,
                Total_Household_Spaces, Total_Population_16_and_over,
                Total_Population_16_to_74, Total_Employment_16_to_74,
                Total_Pop_in_Housesholds_16_and_over,
                k004, k009, k010, k027, k031, k041, k046
  ) %>%
  readr::write_csv("Data/Wolverhampton_OAC2011.csv")
```

```
# Read_Wolverhampton_data

Wolverhampton_2011OAC <-
  readr::read_csv("Data/Wolverhampton_OAC2011.csv")
```

Data Visualisation

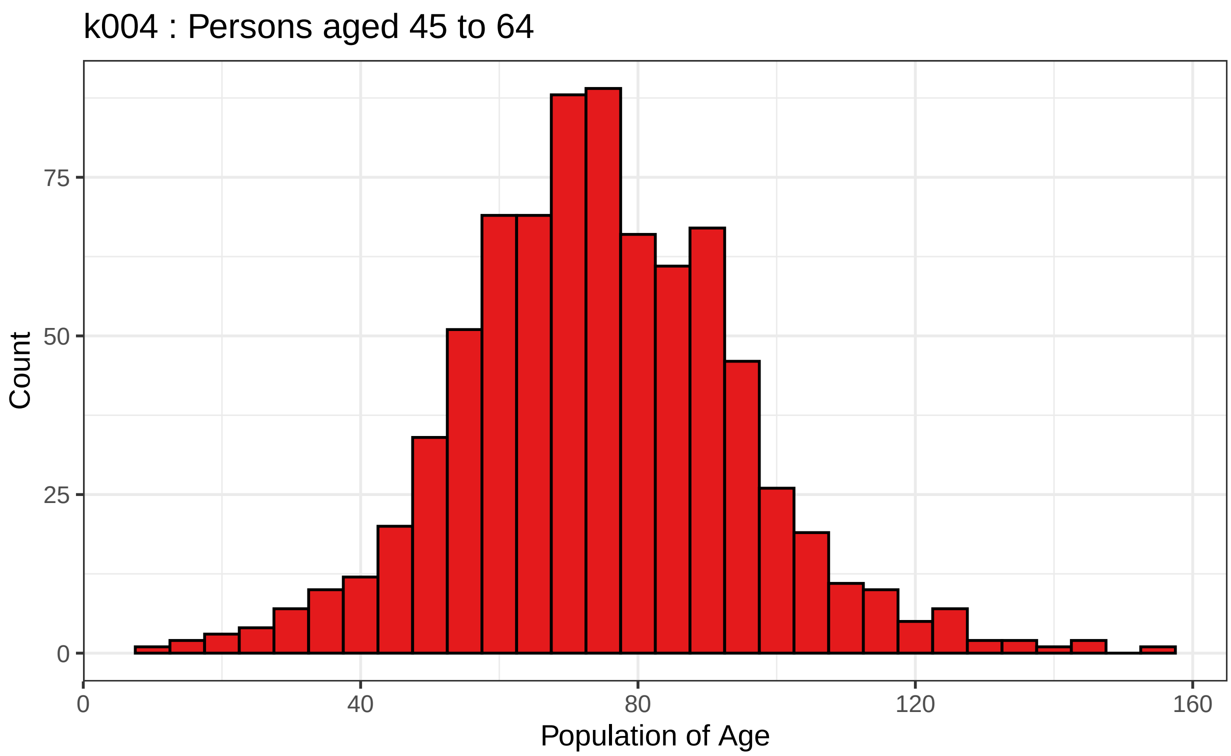
Distribution of variables

k004 - Persons aged 45 to 64

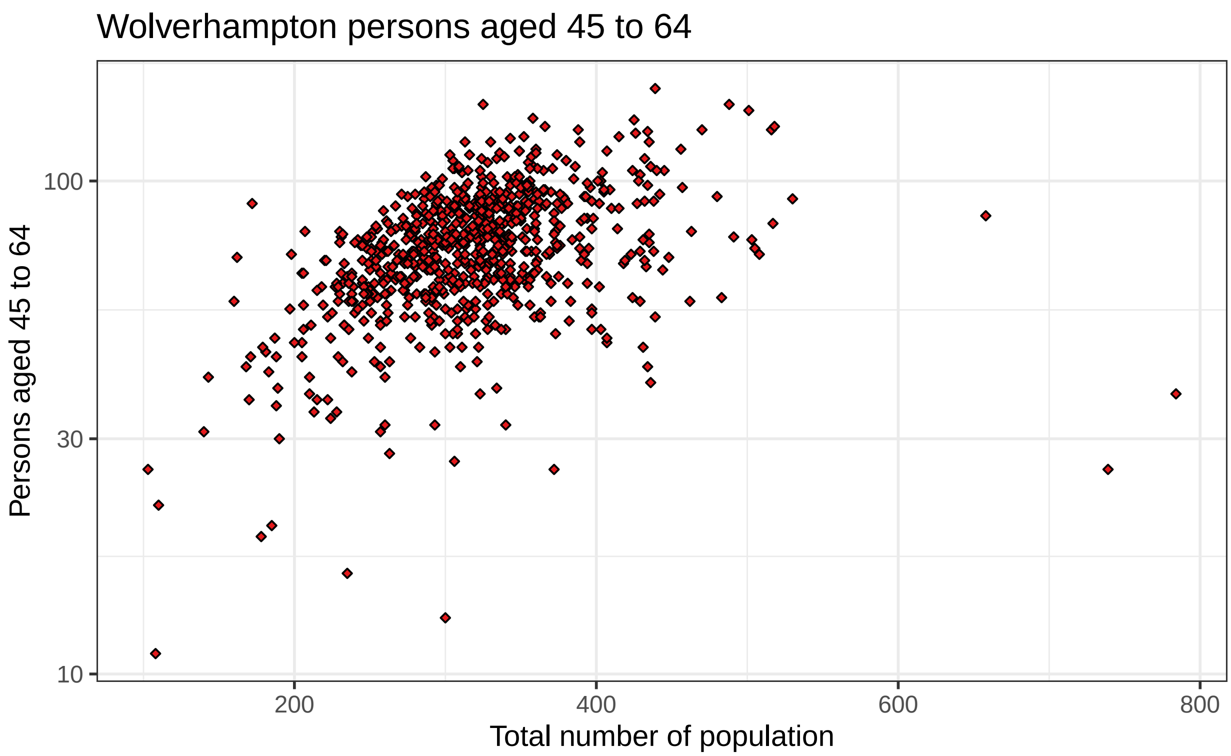
```
summary(Wolverhampton_2011OAC$k004)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   11.00   62.00   74.00   74.59   88.00  154.00
```

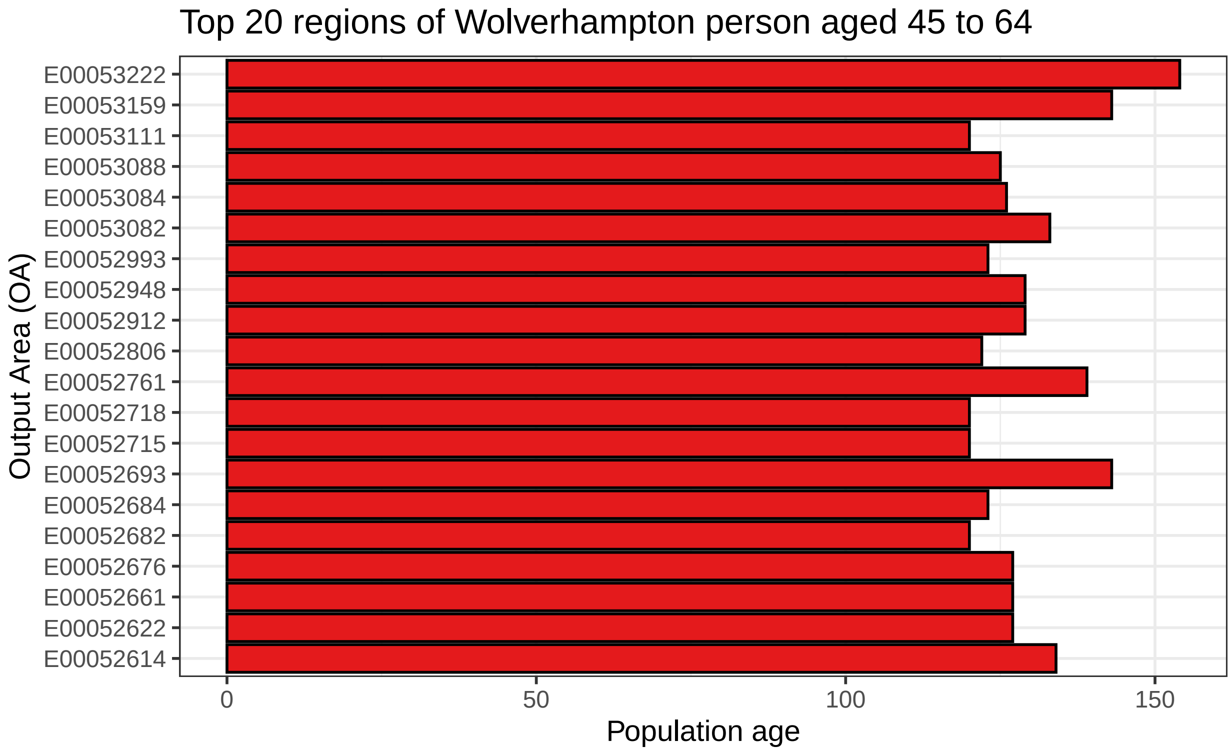
```
# Histogram

Wolverhampton_2011OAC %>%
  ggplot2::ggplot (
    aes(
      x = k004
    )
  ) +
  ggplot2::geom_histogram(binwidth = 5, fill="#e41a1c", colour="black") +
  ggplot2::ggtitle("k004 : Persons aged 45 to 64") +
  ggplot2::xlab("Population of Age") +
  ggplot2::ylab("Count") +
  ggplot2::theme_bw()
```



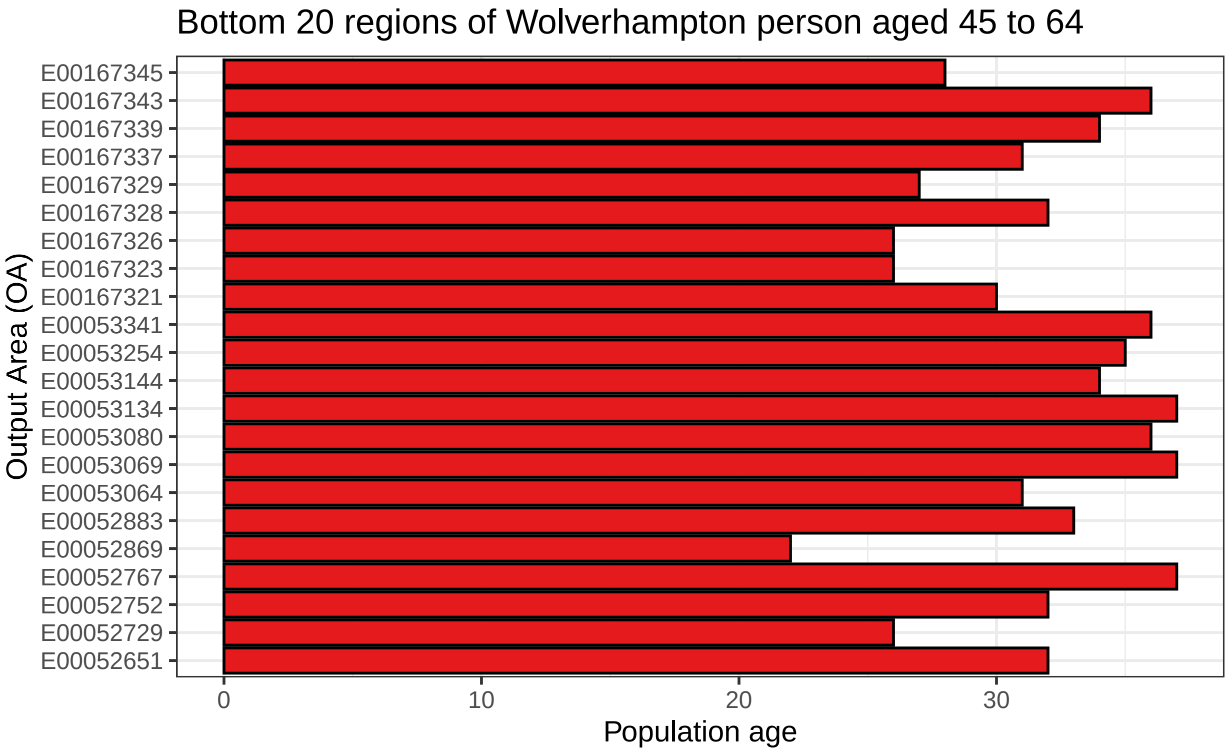
```
# Scatterplot

Wolverhampton_2011OAC %>%
  ggplot2::ggplot(
    aes(
      x = Total_Population,
      y = k004
    )
  )+
  ggplot2::geom_point(color= "black", shape = 23, size = 1, fill = "#e41a1c") +
  ggplot2::ggtitle("Wolverhampton persons aged 45 to 64") +
  ggplot2::xlab("Total number of population") +
  ggplot2::ylab("Persons aged 45 to 64") +
  ggplot2::scale_y_log10() +
  ggplot2::theme_bw()
```



```
# Top 20 regions of Wolverhampton person aged 45 to 64

k004_max <-
Wolverhampton_2011OAC %>%
dplyr::filter(k004>20) %>%
  dplyr::select(OA, k004) %>%
  dplyr::slice_max(k004, n=20)

ggplot2::ggplot(k004_max,
       aes(
         x = k004,
         y = OA,
         )
       )+
ggplot2::geom_bar(position = "stack", stat = "identity", fill="#e41a1c", colour="black") +
ggplot2::ggtitle("Top 20 regions of Wolverhampton person aged 45 to 64")+
ggplot2::xlab("Population age")+
ggplot2::ylab("Output Area (OA)")+
ggplot2::theme_bw()
```



```
# Bottom 20 regions of Wolverhampton person aged 45 to 64

k004_min <-
  Wolverhampton_2011OAC %>%
  dplyr::filter(k004>20) %>%
  dplyr::select(OA, k004) %>%
  dplyr::slice_min(k004, n=20)

ggplot2::ggplot(k004_min,
                aes(
                  x = k004,
                  y = OA,
                )
)+
  ggplot2::geom_bar(position = "stack", stat = "identity", fill="#e41a1c", colour="black") +
  ggplot2::ggtitle("Bottom 20 regions of Wolverhampton person aged 45 to 64")+
  ggplot2::xlab("Population age")+
  ggplot2::ylab("Output Area (OA)")+
  ggplot2::theme_bw()
```

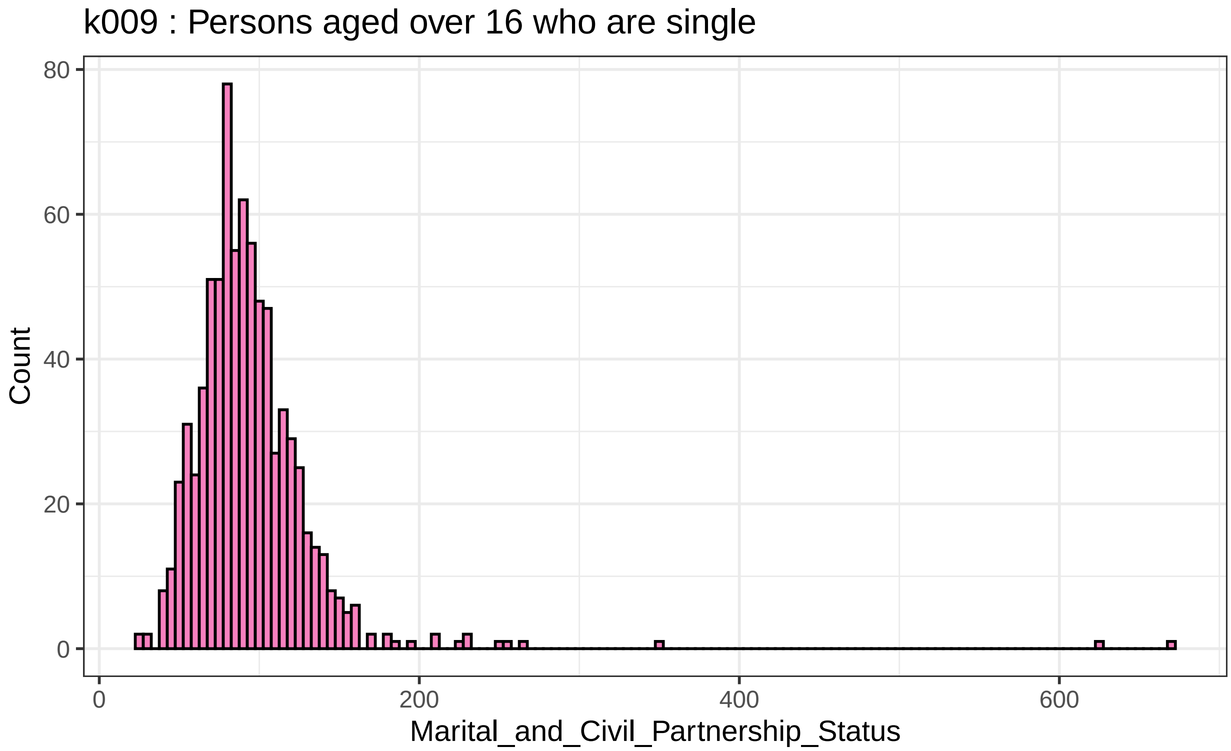


k009-Persons aged over 16 who are single

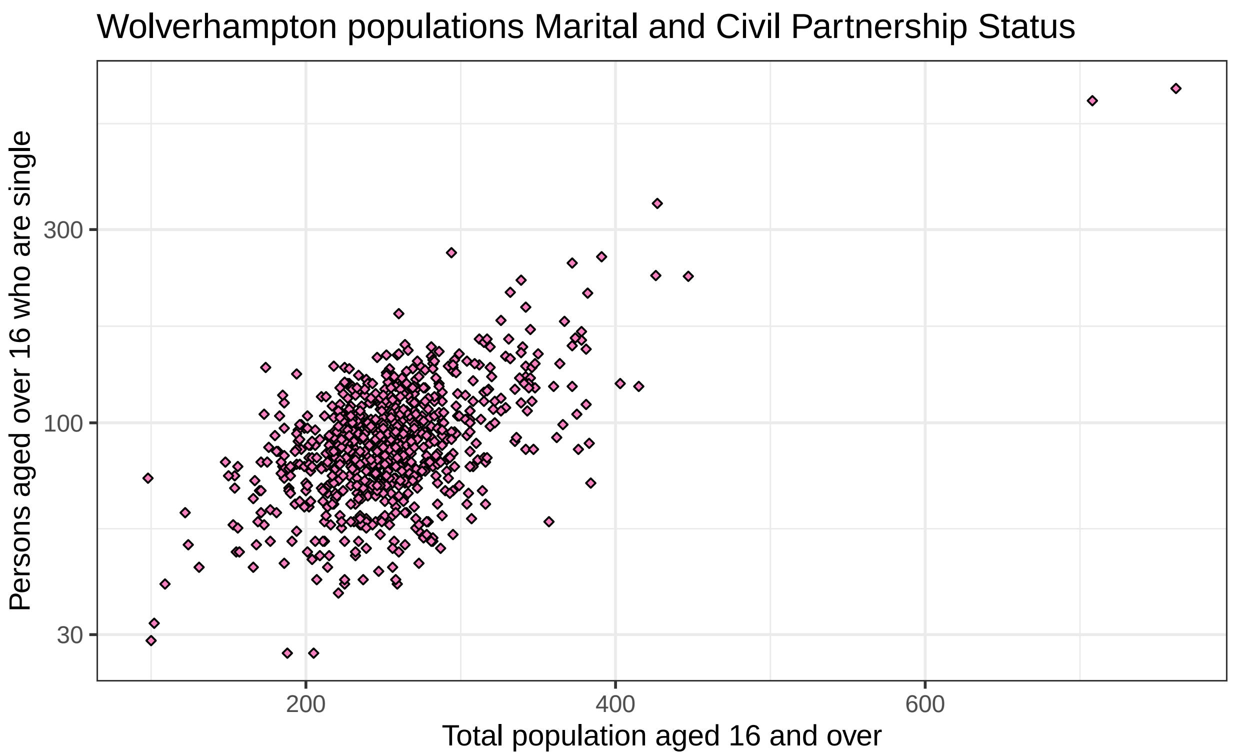
```
summary(Wolverhampton_2011OAC$k009)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   27.00   73.00   89.00   94.56  108.00  669.00
```

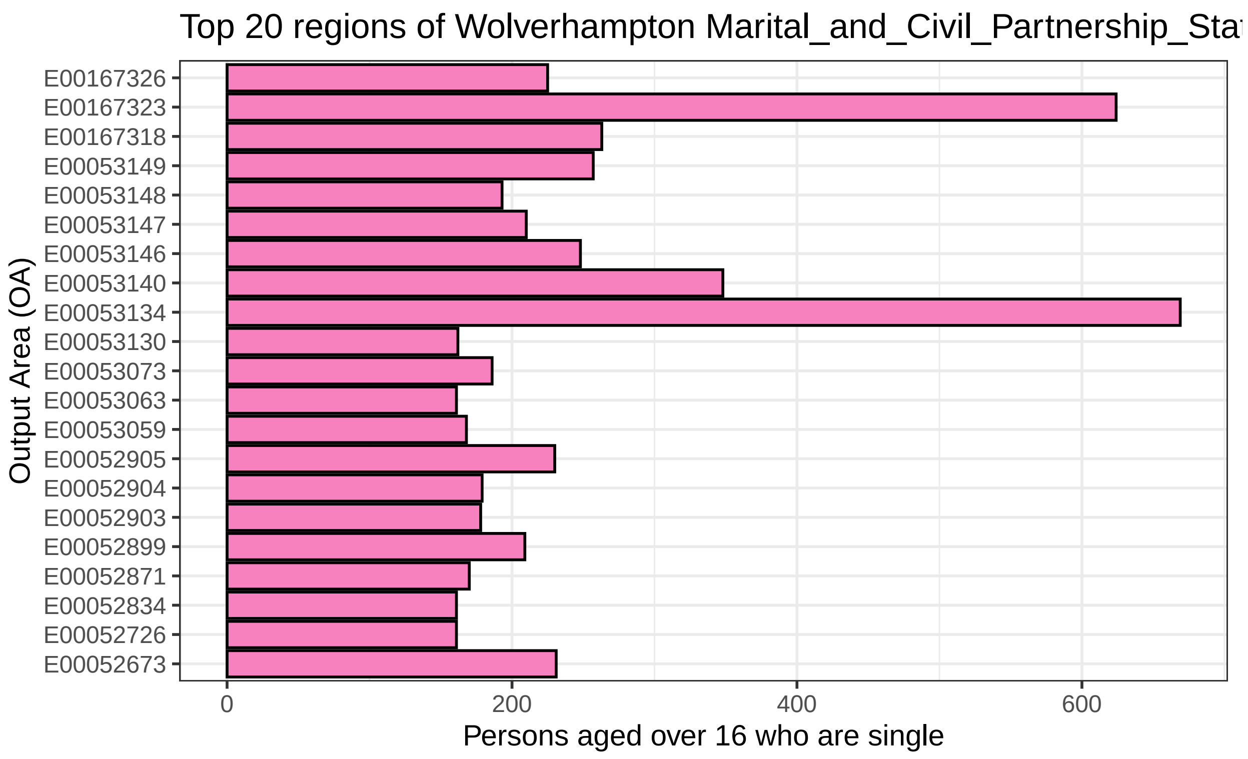
```
# Histogram

Wolverhampton_2011OAC %>%
  ggplot2::ggplot (
    aes(
      x = k009
    )
  ) +
  ggplot2::geom_histogram(binwidth = 5, fill="#f781bf", colour="black") +
  ggplot2::ggtitle("k009 : Persons aged over 16 who are single") +
  ggplot2::xlab("Marital_and_Civil_Partnership_Status") +
  ggplot2::ylab("Count") +
  ggplot2::theme_bw()
```



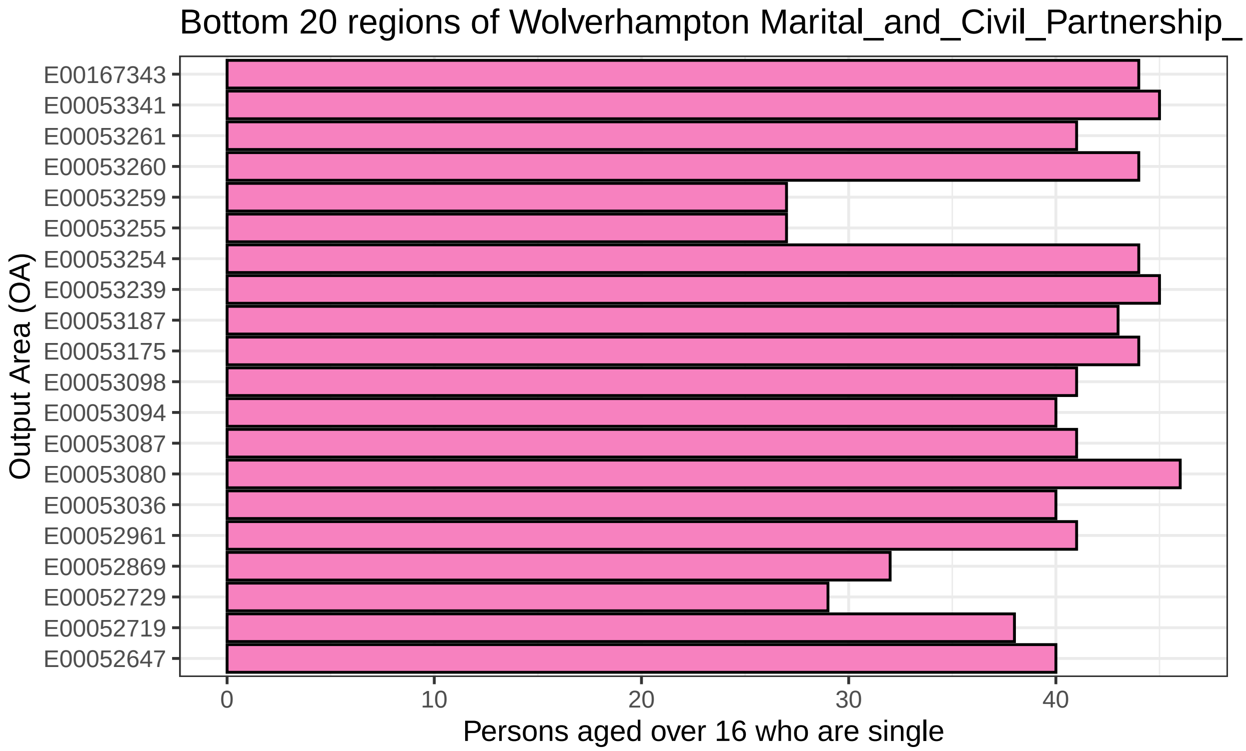
```
# Scatterplot

Wolverhampton_2011OAC %>%
  ggplot2::ggplot(
    aes(
      x = Total_Population_16_and_over,
      y = k009
    )
  )+
  ggplot2::geom_point(color= "black", shape = 23, size = 1, fill = "#f781bf") +
  ggplot2::ggtitle("Wolverhampton populations Marital and Civil Partnership Status") +
  ggplot2::xlab("Total population aged 16 and over") +
  ggplot2::ylab("Persons aged over 16 who are single") +
  ggplot2::scale_y_log10() +
  ggplot2::theme_bw()
```



```r
# Top 20 regions of Wolverhampton Marital_and_Civil_Partnership_Status

k009_max <-
  Wolverhampton_2011OAC %>%
  dplyr::select(OA, k009) %>%
  dplyr::slice_max(k009, n=20)

ggplot2::ggplot(k009_max,
                aes(
                  x = k009,
                  y = OA,
                )
)+
  ggplot2::geom_bar(position = "stack", stat = "identity", fill="#f781bf", colour="black") +
  ggplot2::ggtitle("Top 20 regions of Wolverhampton Marital_and_Civil_Partnership_Status")+
  ggplot2::xlab("Persons aged over 16 who are single")+
  ggplot2::ylab("Output Area (OA)")+
  ggplot2::theme_bw()
```



```
# Bottom 20 regions of Wolverhampton Marital_and_Civil_Partnership_Status

k009_min <-
  Wolverhampton_2011OAC %>%
  dplyr::select(OA, k009) %>%
  dplyr::slice_min(k009, n=20)

ggplot2::ggplot(k009_min,
                aes(
                  x = k009,
                  y = OA,
                )
)+
  ggplot2::geom_bar(position = "stack", stat = "identity", fill="#f781bf", colour="black") +
  ggplot2::ggtitle("Bottom 20 regions of Wolverhampton Marital_and_Civil_Partnership_Status")+
  ggplot2::xlab("Persons aged over 16 who are single")+
  ggplot2::ylab("Output Area (OA)")+
  ggplot2::theme_bw()
```

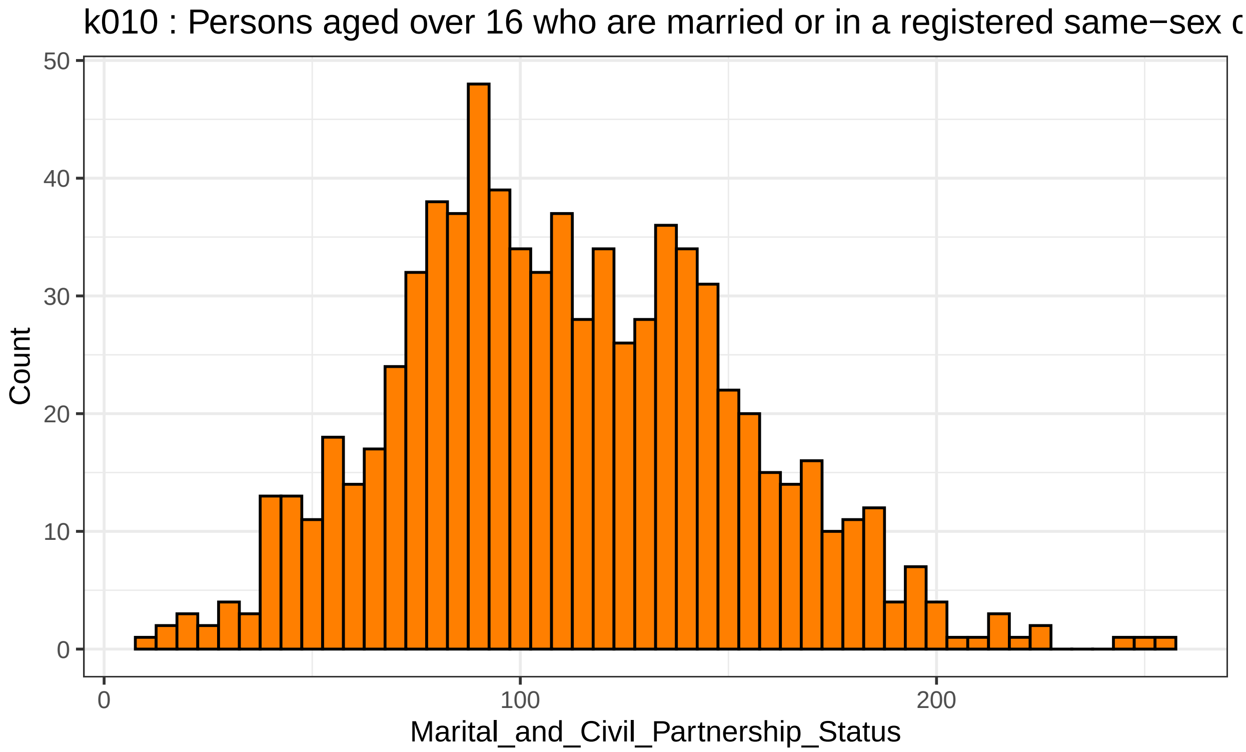


k010 - Persons aged over 16 who are married or in a registered same-sex civil partnership

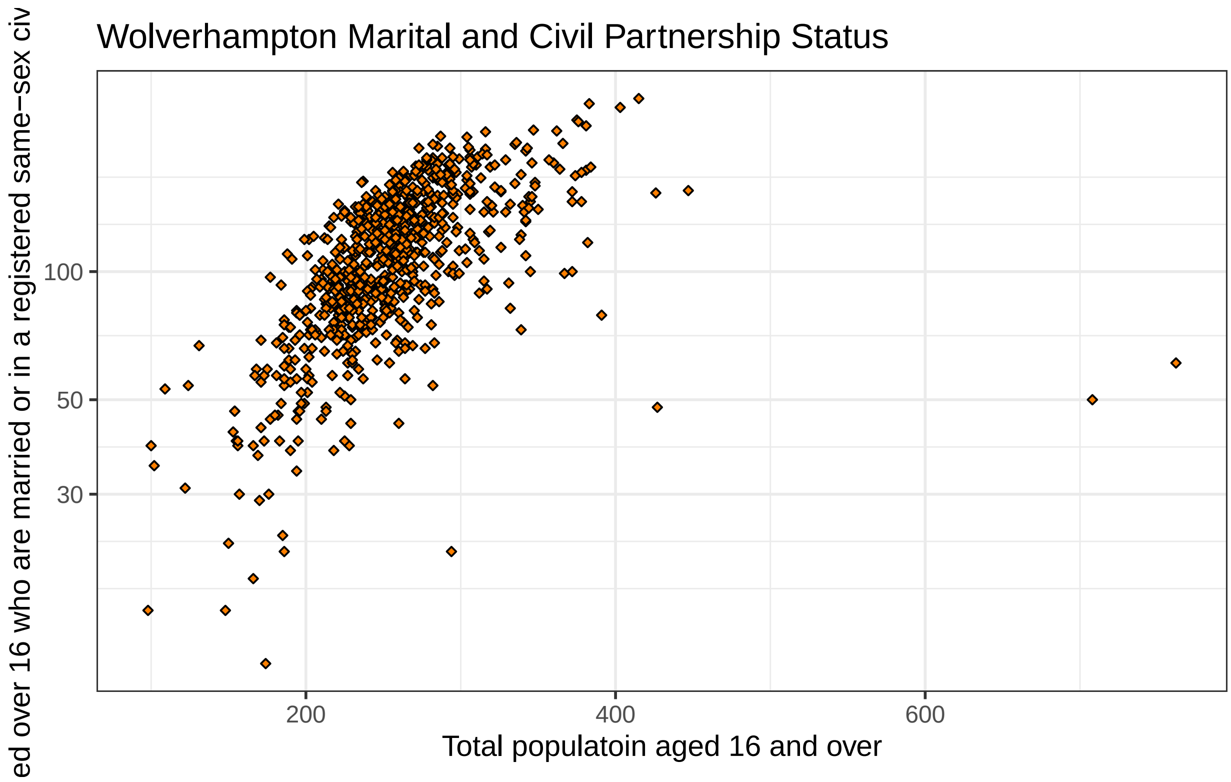
```
summary(Wolverhampton_2011OAC$k010)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    12.0    83.0   109.0   111.6   139.0   255.0
```

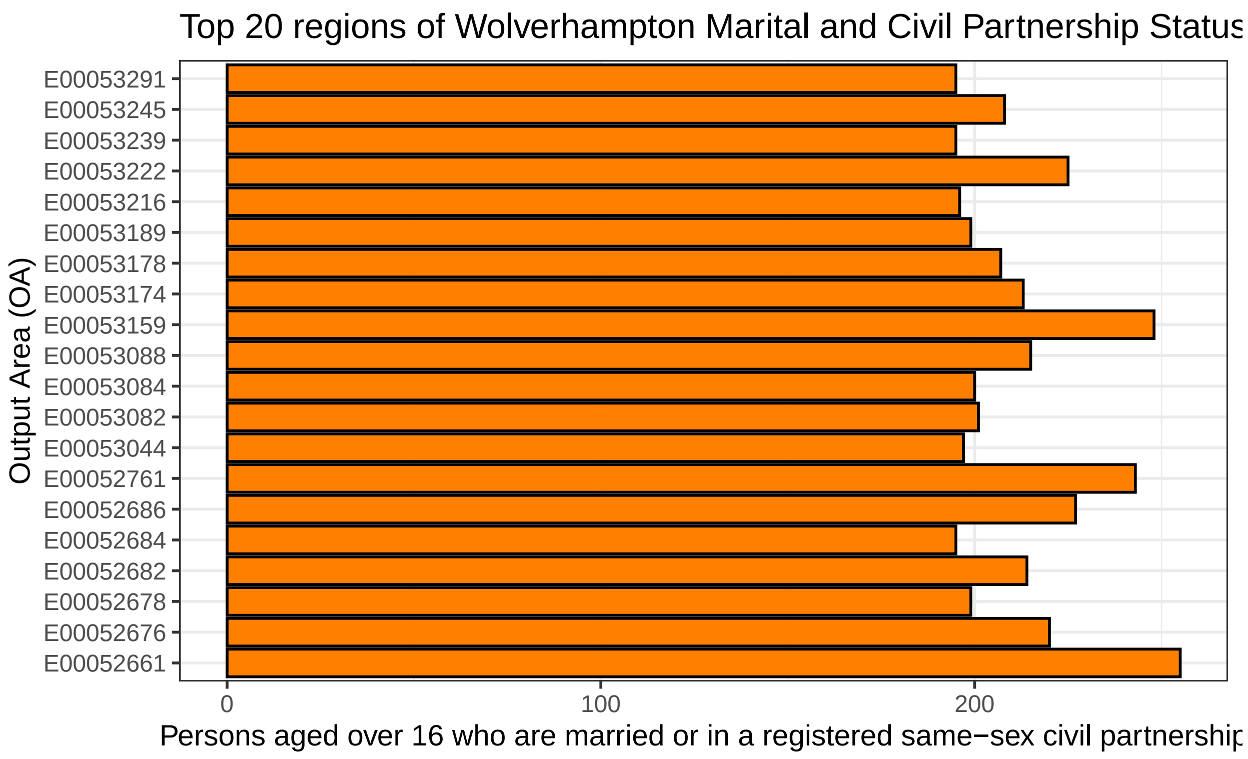
```
# Histogram

Wolverhampton_2011OAC %>%
  ggplot2::ggplot (
    aes(
      x = k010
    )
  ) +
  ggplot2::geom_histogram(binwidth = 5, fill="#ff7f00", colour="black") +
  ggplot2::ggtitle("k010 : Persons aged over 16 who are married or in a registered same-sex civil partn
  ggplot2::xlab("Marital_and_Civil_Partnership_Status") +
  ggplot2::ylab("Count") +
  ggplot2::theme_bw()
```



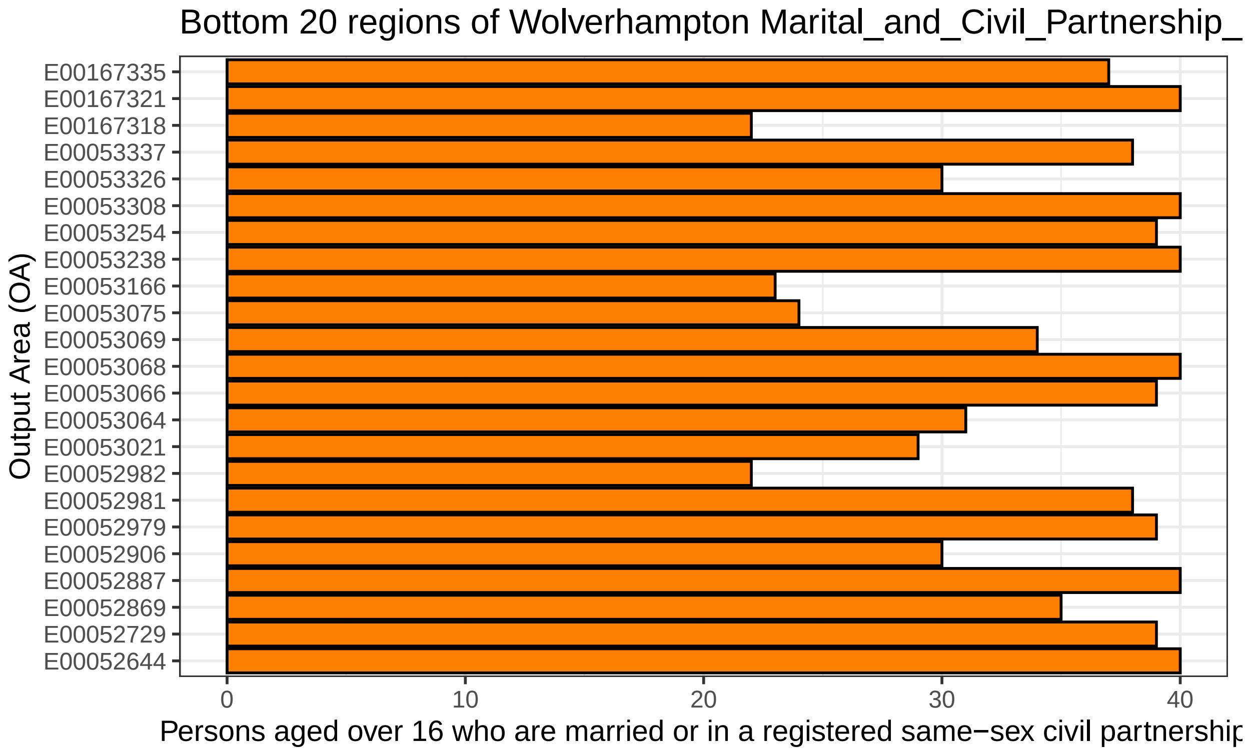
```
# Scatterplot

Wolverhampton_2011OAC %>%
  ggplot2::ggplot(
    aes(
      x = Total_Population_16_and_over,
      y = k010
    )
  )+
  ggplot2::geom_point(color= "black", shape = 23, size = 1, fill = "#ff7f00") +
  ggplot2::ggtitle("Wolverhampton Marital and Civil Partnership Status") +
  ggplot2::xlab("Total populatoin aged 16 and over") +
  ggplot2::ylab("Persons aged over 16 who are married or in a registered same-sex civil partnership") +
  ggplot2::scale_y_log10() +
  ggplot2::theme_bw()
```



```
# Top 20 regions of Wolverhampton Marital and Civil Partnership Status

k010_max <-
  Wolverhampton_2011OAC %>%
  dplyr::select(OA, k010) %>%
  dplyr::filter(k010>20) %>%
  dplyr::slice_max(k010, n=20)

ggplot2::ggplot(k010_max,
                aes(
                  x = k010,
                  y = OA,
                )
)+
  ggplot2::geom_bar(position = "stack", stat = "identity", fill="#ff7f00", colour="black") +
  ggplot2::ggtitle("Top 20 regions of Wolverhampton Marital and Civil Partnership Status")+
  ggplot2::xlab("Persons aged over 16 who are married or in a registered same-sex civil partnership")+
  ggplot2::ylab("Output Area (OA)")+
  ggplot2::theme_bw()
```



```
# Bottom 20 regions of Wolverhampton Marital_and_Civil_Partnership_Status

k010_min <-
  Wolverhampton_2011OAC %>%
  dplyr::filter(k010>20) %>%
  dplyr::select(OA, k010) %>%
  dplyr::slice_min(k010, n=20)

ggplot2::ggplot(k010_min,
                aes(
                  x = k010,
                  y = OA,
                )
)+
  ggplot2::geom_bar(position = "stack", stat = "identity", fill="#ff7f00", colour="black") +
  ggplot2::ggtitle("Bottom 20 regions of Wolverhampton Marital_and_Civil_Partnership_Status")+
  ggplot2::xlab("Persons aged over 16 who are married or in a registered same-sex civil partnership")+
  ggplot2::ylab("Output Area (OA)")+
  ggplot2::theme_bw()
```

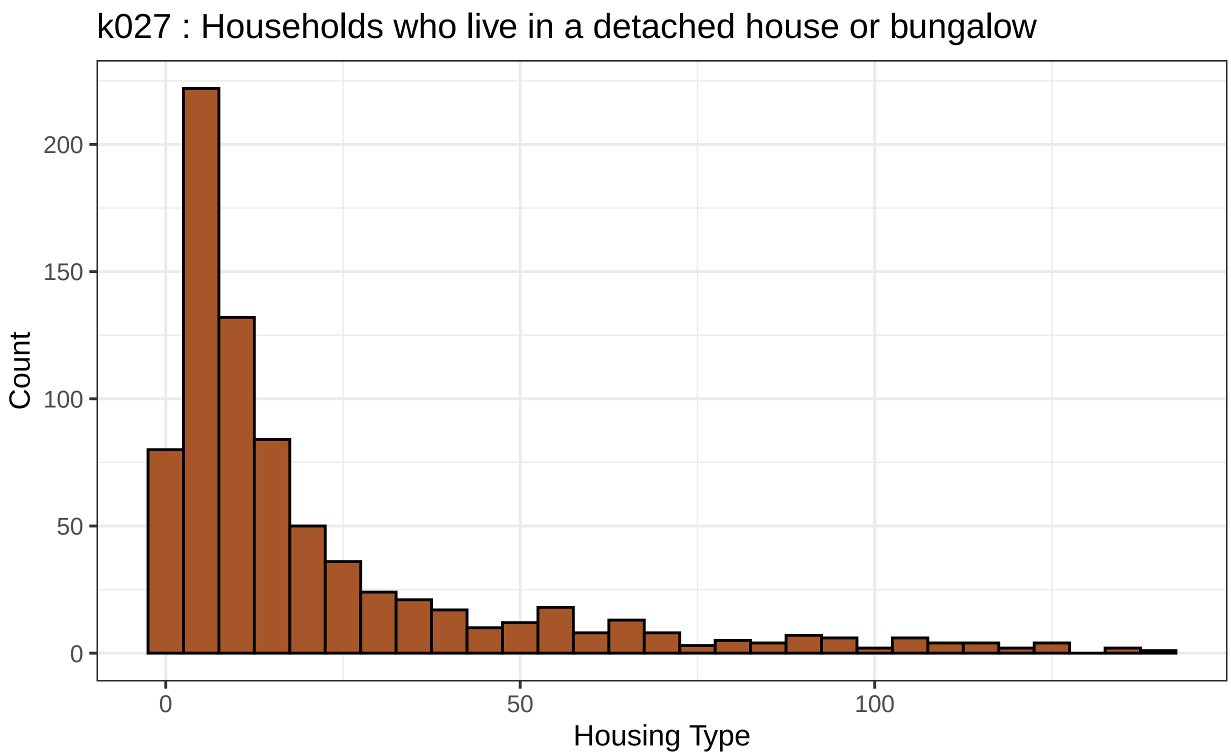


k027-Households who live in a detached house or bungalow

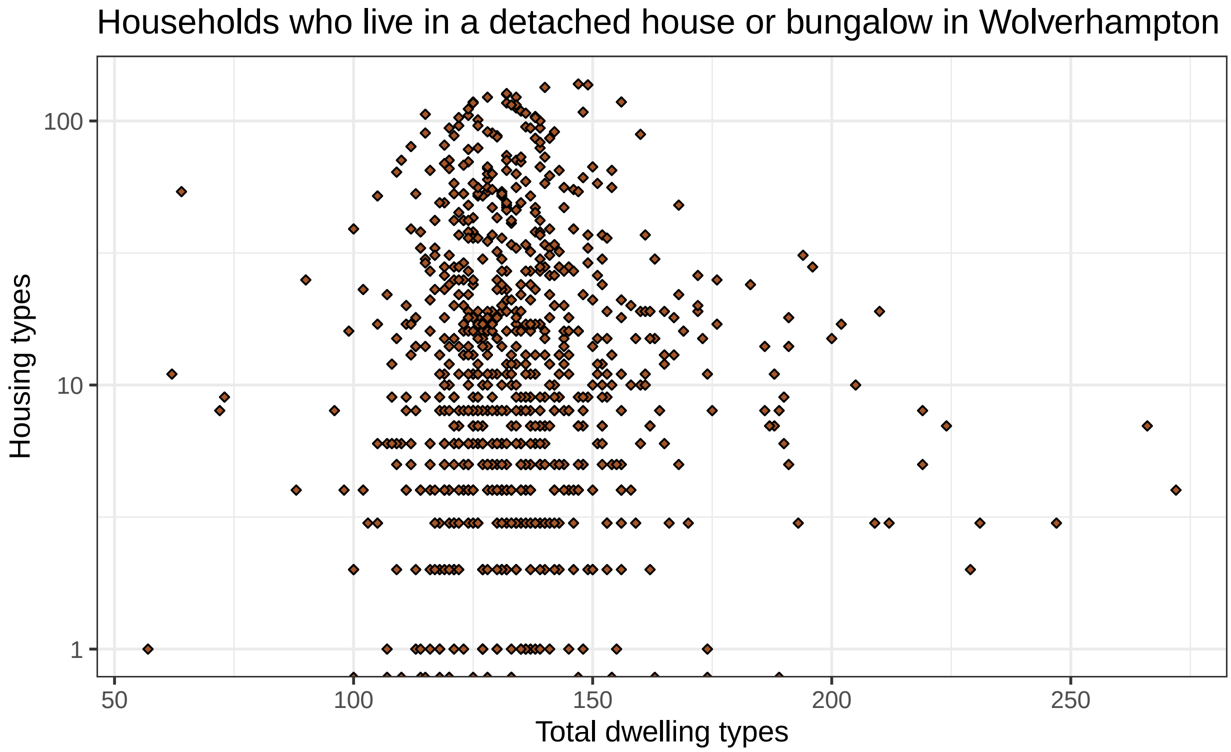
```
summary(Wolverhampton_2011OAC$k027)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##    0.00    5.00   10.00   21.22   25.00  138.00
```

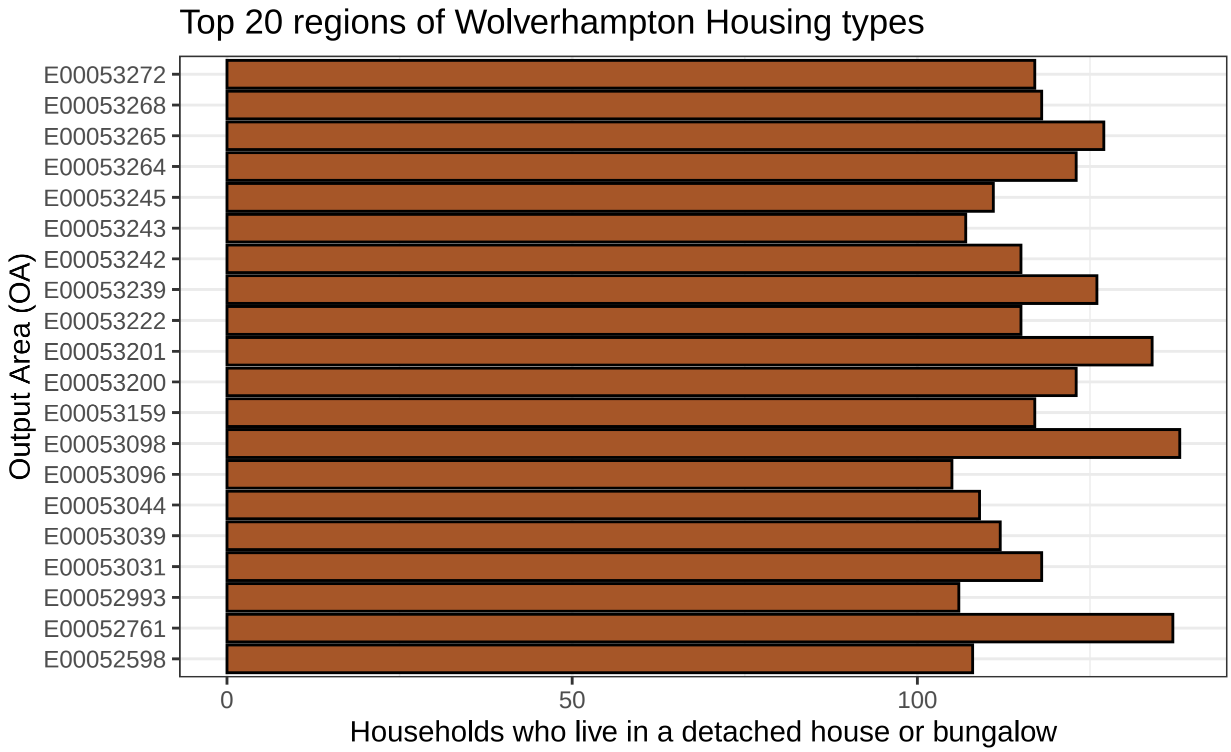
```
# Histogram

Wolverhampton_2011OAC %>%
  ggplot2::ggplot (
    aes(
      x = k027
    )
  ) +
  ggplot2::geom_histogram(binwidth = 5, fill="#a65628", colour="black") +
  ggplot2::ggtitle("k027 : Households who live in a detached house or bungalow") +
  ggplot2::xlab("Housing Type") +
  ggplot2::ylab("Count") +
  ggplot2::theme_bw()
```



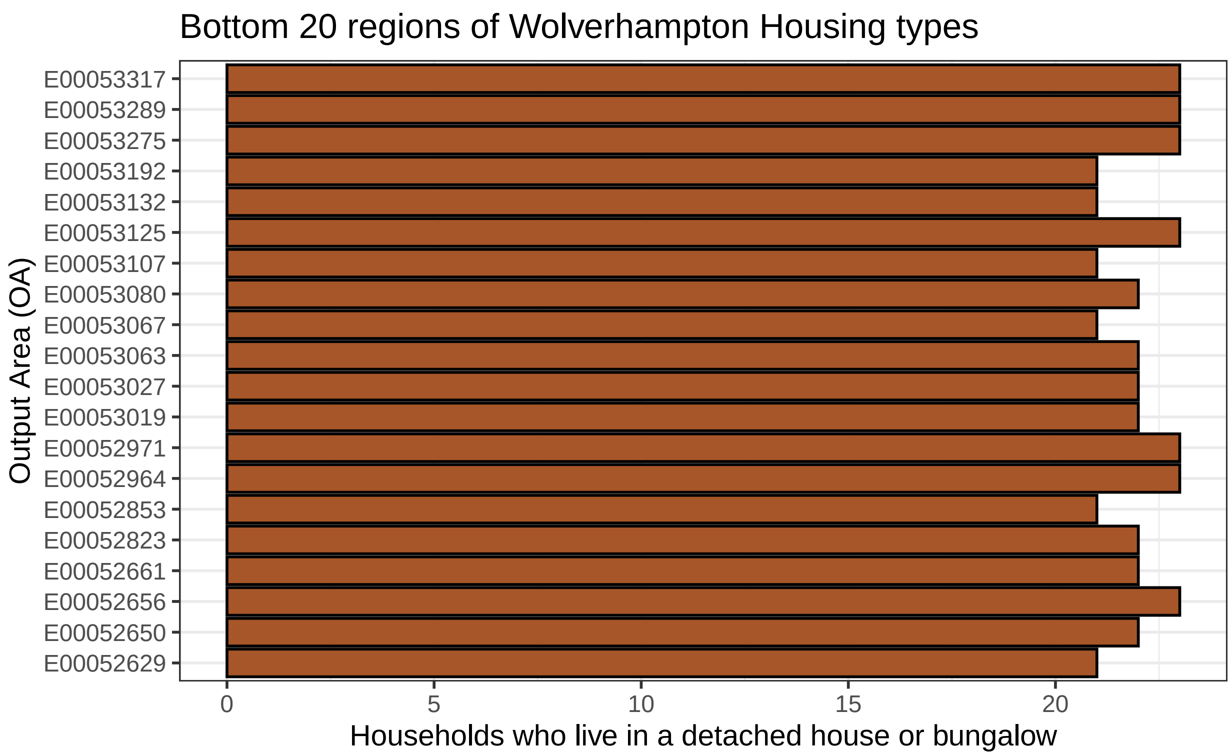
```
# Scatterplot

Wolverhampton_2011OAC %>%
  ggplot2::ggplot(
    aes(
      x = Total_Household_Spaces,
      y = k027
    )
  )+
  ggplot2::geom_point(color= "black", shape = 23, size = 1, fill = "#a65628") +
  ggplot2::ggtitle("Households who live in a detached house or bungalow in Wolverhampton") +
  ggplot2::xlab("Total dwelling types") +
  ggplot2::ylab("Housing types") +
  ggplot2::scale_y_log10() +
  ggplot2::theme_bw()
```



```
# Top 20 regions of Wolverhampton Housing types

k027_max <-
  Wolverhampton_2011OAC %>%
  dplyr::select(OA, k027) %>%
  dplyr::slice_max(k027, n=20)

ggplot2::ggplot(k027_max,
                aes(
                  x = k027,
                  y = OA,
                )
)+
  ggplot2::geom_bar(position = "stack", stat = "identity", fill="#a65628", colour="black") +
  ggplot2::ggtitle("Top 20 regions of Wolverhampton Housing types")+
  ggplot2::xlab("Households who live in a detached house or bungalow")+
  ggplot2::ylab("Output Area (OA)")+
  ggplot2::theme_bw()
```



```
# Bottom 20 regions of Wolverhampton Housing types

k027_min <-
  Wolverhampton_2011OAC %>%
  dplyr::select(OA, k027) %>%
  dplyr::filter(k027>20) %>%
  dplyr::slice_min(k027, n=20)

ggplot2::ggplot(k027_min,
                aes(
                  x = k027,
                  y = OA,
                )
)+
  ggplot2::geom_bar(position = "stack", stat = "identity", fill="#a65628", colour="black") +
  ggplot2::ggtitle("Bottom 20 regions of Wolverhampton Housing types")+
  ggplot2::xlab("Households who live in a detached house or bungalow")+
  ggplot2::ylab("Output Area (OA)")+
  ggplot2::theme_bw()
```

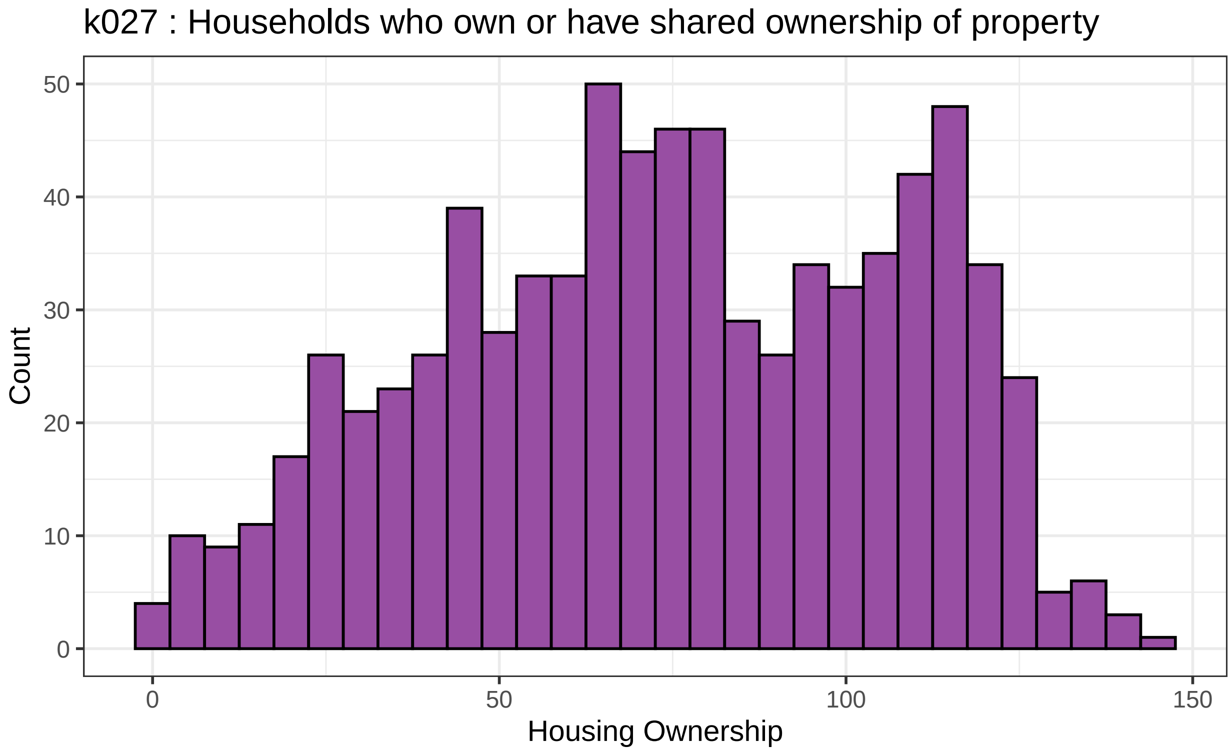


k031-Households who own or have shared ownership of property

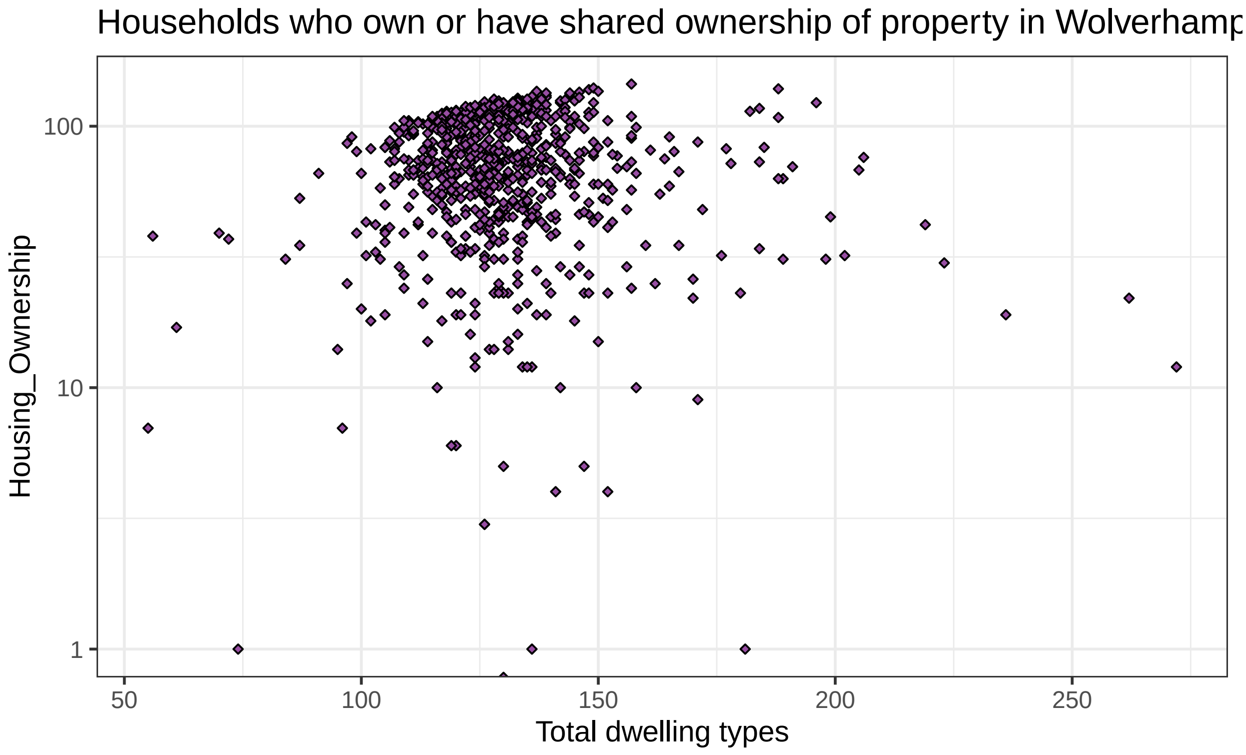
```
summary(Wolverhampton_2011OAC$k031)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    0.00   49.00   74.00   74.18  103.00  145.00
```

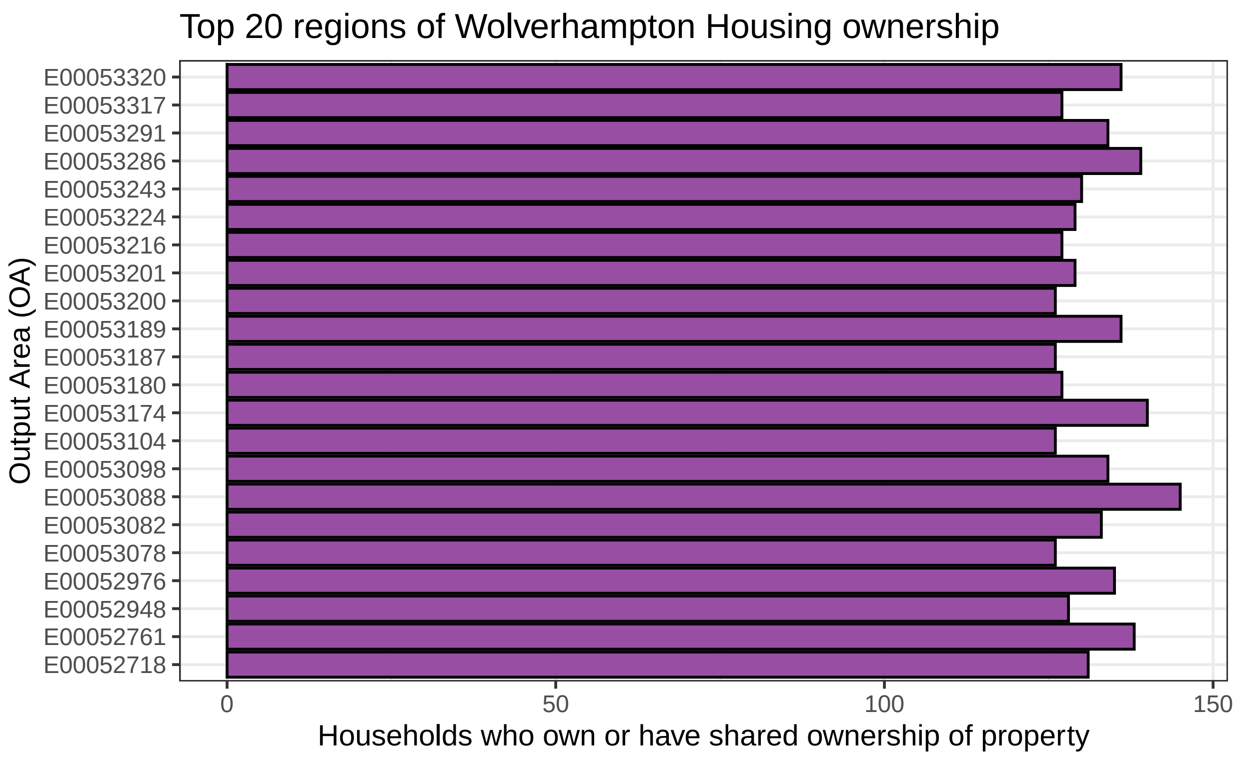
```
# Histogram

Wolverhampton_2011OAC %>%
  ggplot2::ggplot (
    aes(
      x = k031
    )
  ) +
  ggplot2::geom_histogram(binwidth = 5, fill="#984ea3", colour="black") +
  ggplot2::ggtitle("k027 : Households who own or have shared ownership of property") +
  ggplot2::xlab("Housing Ownership") +
  ggplot2::ylab("Count") +
  ggplot2::theme_bw()
```



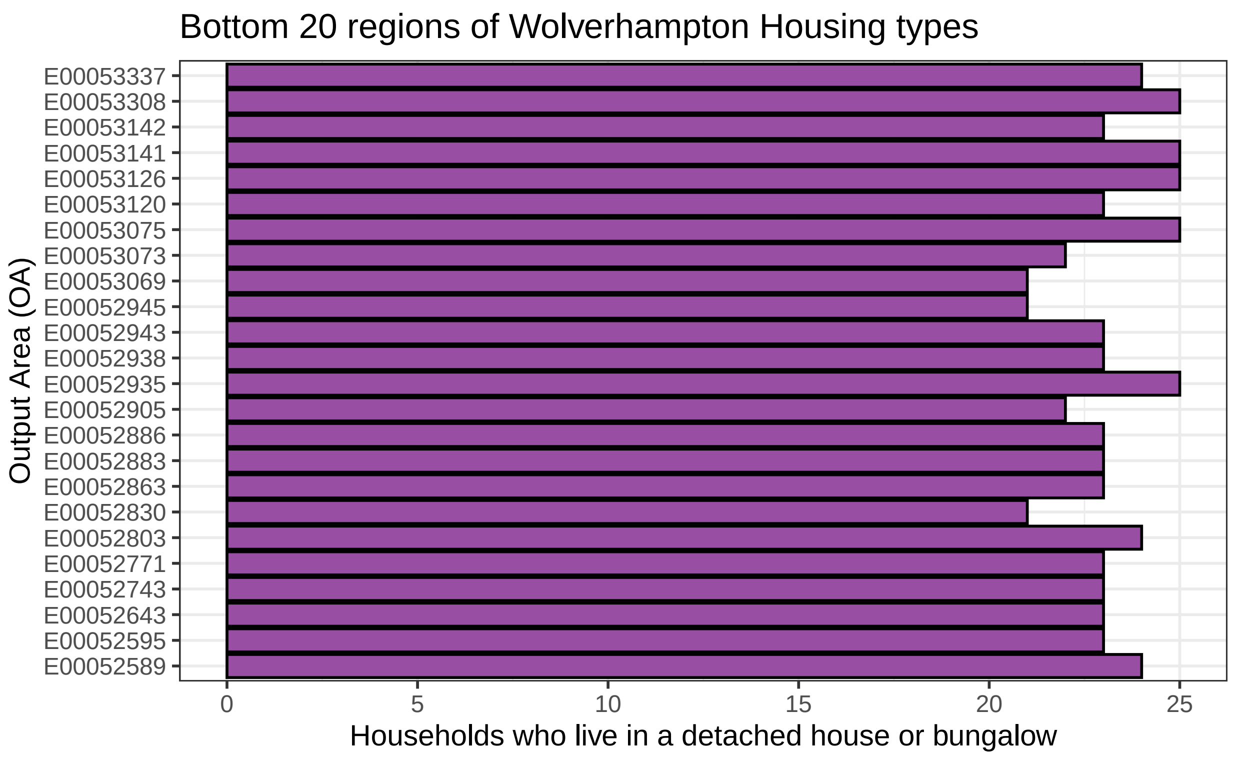
```
# Scatterplot

Wolverhampton_2011OAC %>%
  ggplot2::ggplot(
    aes(
      x = Total_Households,
      y = k031
    )
  )+
  ggplot2::geom_point(color= "black", shape = 23, size = 1, fill = "#984ea3") +
  ggplot2::ggtitle("Households who own or have shared ownership of property in Wolverhampton") +
  ggplot2::xlab("Total dwelling types") +
  ggplot2::ylab("Housing_Ownership") +
  ggplot2::scale_y_log10() +
  ggplot2::theme_bw()
```



```
# Top 20 regions of Wolverhampton Housing ownership

k031_max <-
  Wolverhampton_2011OAC %>%
  dplyr::select(OA, k031) %>%
  dplyr::filter(k031>20) %>%
  dplyr::slice_max(k031, n=20)

ggplot2::ggplot(k031_max,
                aes(
                  x = k031,
                  y = OA,
                )
)+
  ggplot2::geom_bar(position = "stack", stat = "identity", fill="#984ea3", colour="black") +
  ggplot2::ggtitle("Top 20 regions of Wolverhampton Housing ownership")+
  ggplot2::xlab("Households who own or have shared ownership of property")+
  ggplot2::ylab("Output Area (OA)")+
  ggplot2::theme_bw()
```



```
# Bottom 20 regions of Wolverhampton Housing types

k031_min <-
  Wolverhampton_2011OAC %>%
  dplyr::select(OA, k031) %>%
  dplyr::filter(k031>20) %>%
  dplyr::slice_min(k031, n=20)

ggplot2::ggplot(k031_min,
                aes(
                  x = k031,
                  y = OA,
                )
)+
  ggplot2::geom_bar(position = "stack", stat = "identity", fill="#984ea3", colour="black") +
  ggplot2::ggtitle("Bottom 20 regions of Wolverhampton Housing types")+
  ggplot2::xlab("Households who live in a detached house or bungalow")+
  ggplot2::ylab("Output Area (OA)")+
  ggplot2::theme_bw()
```

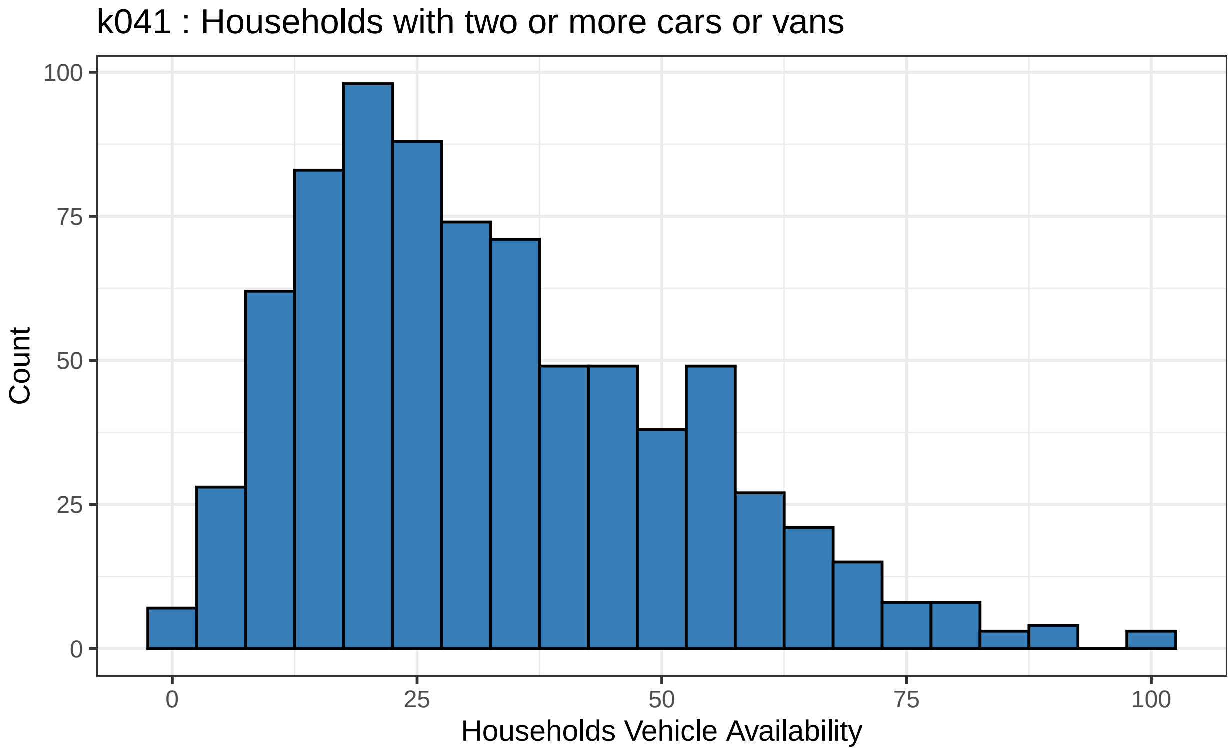


k041-Households with two or more cars or vans

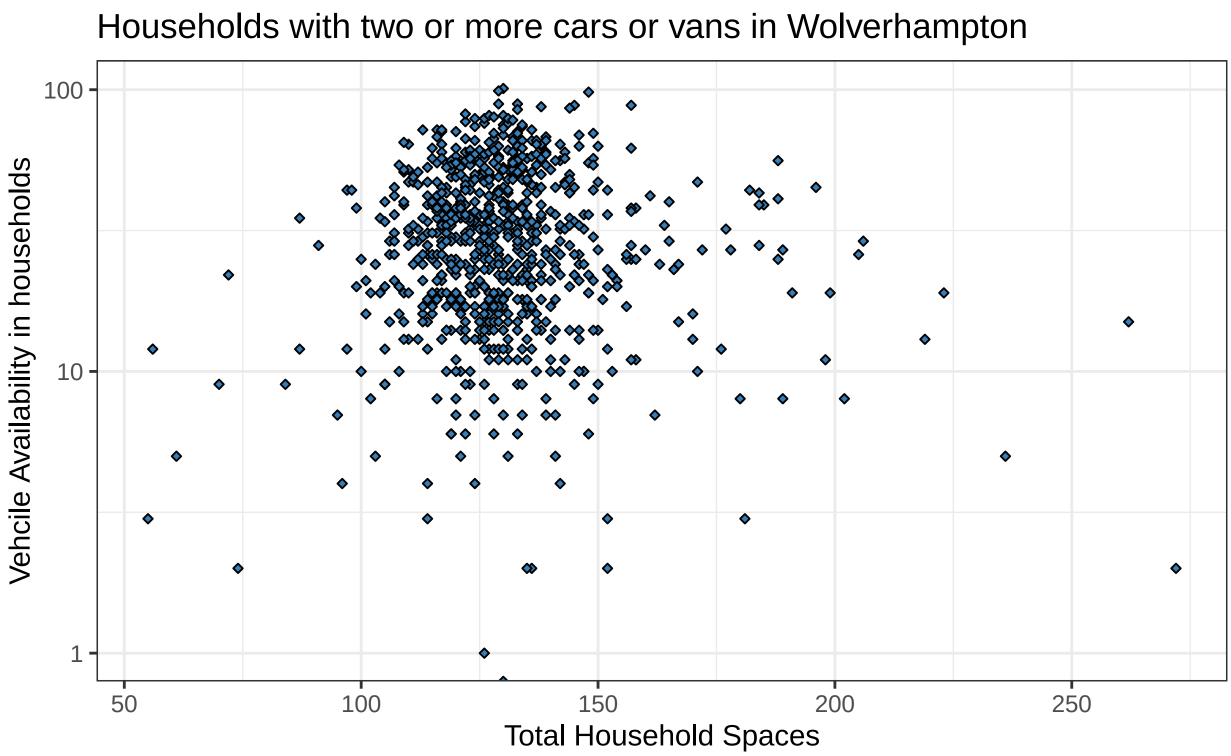
```
summary(Wolverhampton_2011OAC$k041)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    0.00   18.00   29.00   32.87   45.00  101.00
```

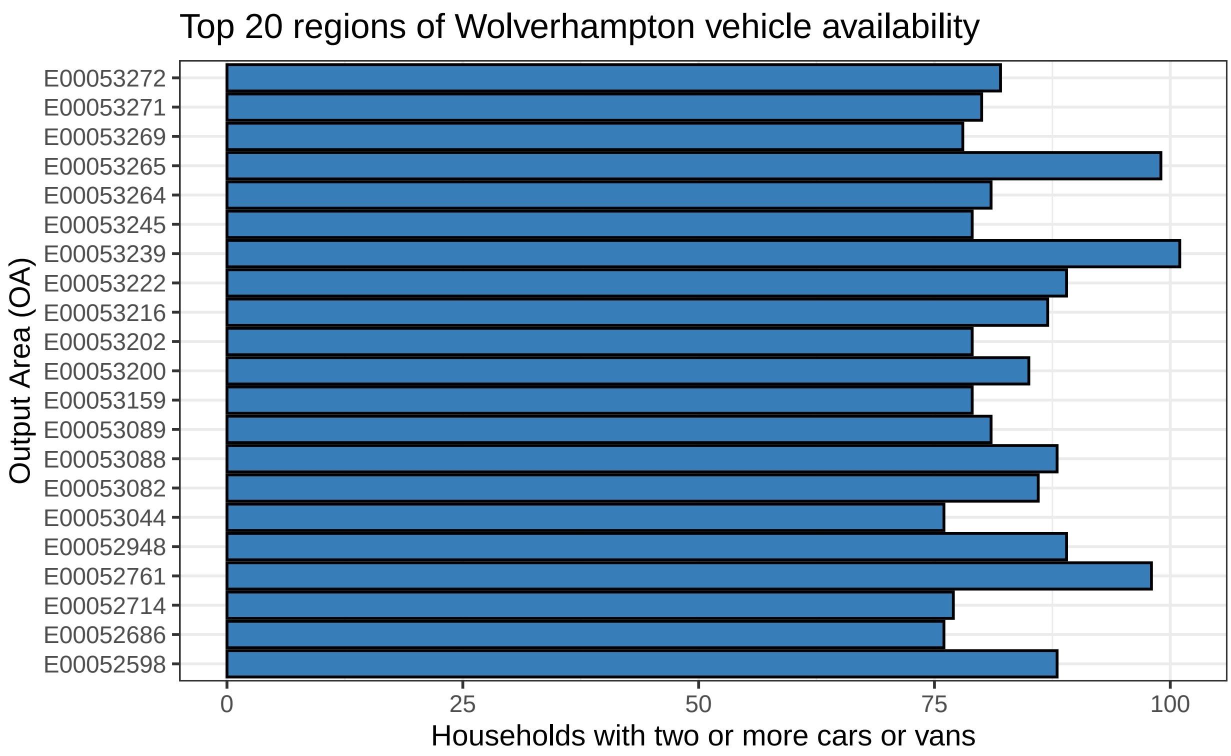
```
# Histogram

Wolverhampton_2011OAC %>%
  ggplot2::ggplot (
    aes(
      x = k041
    )
  ) +
  ggplot2::geom_histogram(binwidth = 5, fill="#377eb8", colour="black") +
  ggplot2::ggtitle("k041 : Households with two or more cars or vans") +
  ggplot2::xlab("Households Vehicle Availability") +
  ggplot2::ylab("Count") +
  ggplot2::theme_bw()
```



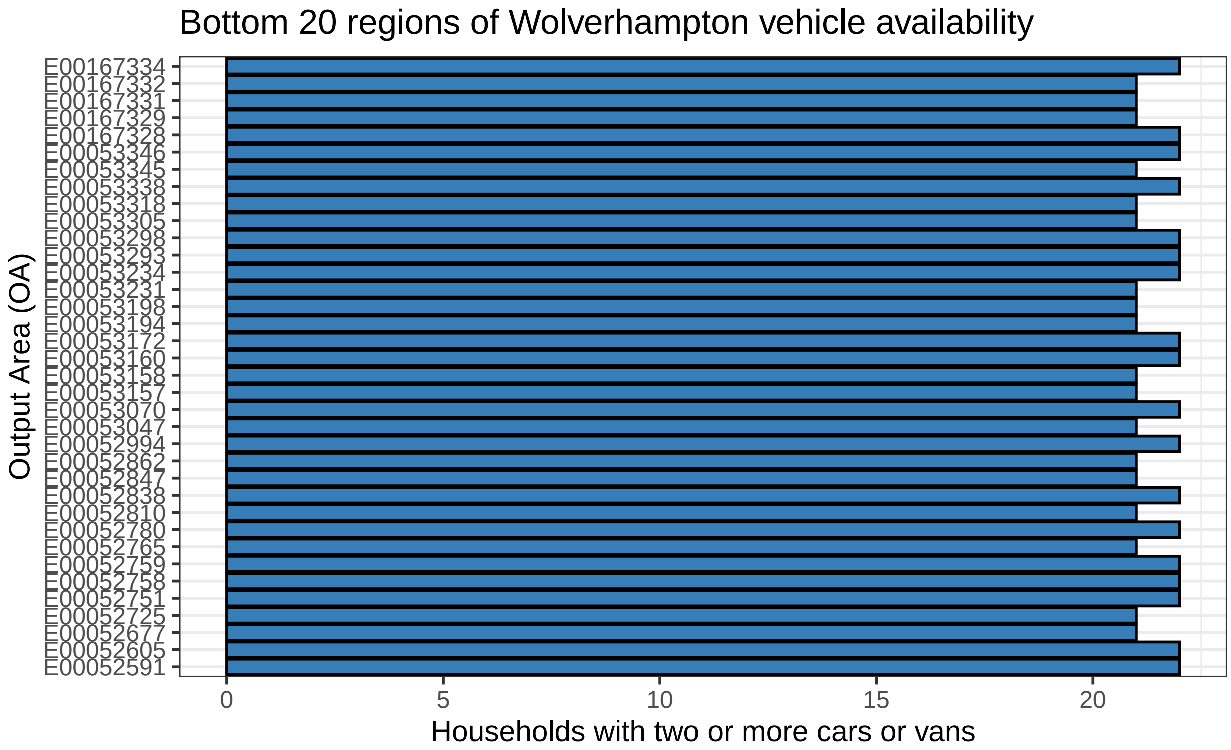
```
# Scatterplot

Wolverhampton_2011OAC %>%
  ggplot2::ggplot(
    aes(
      x = Total_Households,
      y = k041
    )
  )+
  ggplot2::geom_point(color= "black", shape = 23, size = 1, fill = "#377eb8") +
  ggplot2::ggtitle("Households with two or more cars or vans in Wolverhampton") +
  ggplot2::xlab("Total Household Spaces") +
  ggplot2::ylab("Vehcile Availability in households") +
  ggplot2::scale_y_log10() +
  ggplot2::theme_bw()
```



```
# Top 20 regions of Wolverhampton vehicle availability

k041_max <-
  Wolverhampton_2011OAC %>%
  dplyr::select(OA, k041) %>%
  dplyr::filter(k041>20) %>%
  dplyr::slice_max(k041, n=20)

ggplot2::ggplot(k041_max,
                aes(
                  x = k041,
                  y = OA,
                )
)+
  ggplot2::geom_bar(position = "stack", stat = "identity", fill="#377eb8", colour="black") +
  ggplot2::ggtitle("Top 20 regions of Wolverhampton vehicle availability")+
  ggplot2::xlab("Households with two or more cars or vans")+
  ggplot2::ylab("Output Area (OA)")+
  ggplot2::theme_bw()
```



```
# Bottom 20 regions of Wolverhampton vehicle availability

k041_min <-
  Wolverhampton_2011OAC %>%
  dplyr::select(OA, k041) %>%
  dplyr::filter(k041>20) %>%
  dplyr::slice_min(k041, n=20)

ggplot2::ggplot(k041_min,
                aes(
                  x = k041,
                  y = OA,
                )
)+
  ggplot2::geom_bar(position = "stack", stat = "identity", fill="#377eb8", colour="black") +
  ggplot2::ggtitle("Bottom 20 regions of Wolverhampton vehicle availability")+
  ggplot2::xlab("Households with two or more cars or vans")+
  ggplot2::ylab("Output Area (OA)")+
  ggplot2::theme_bw()
```

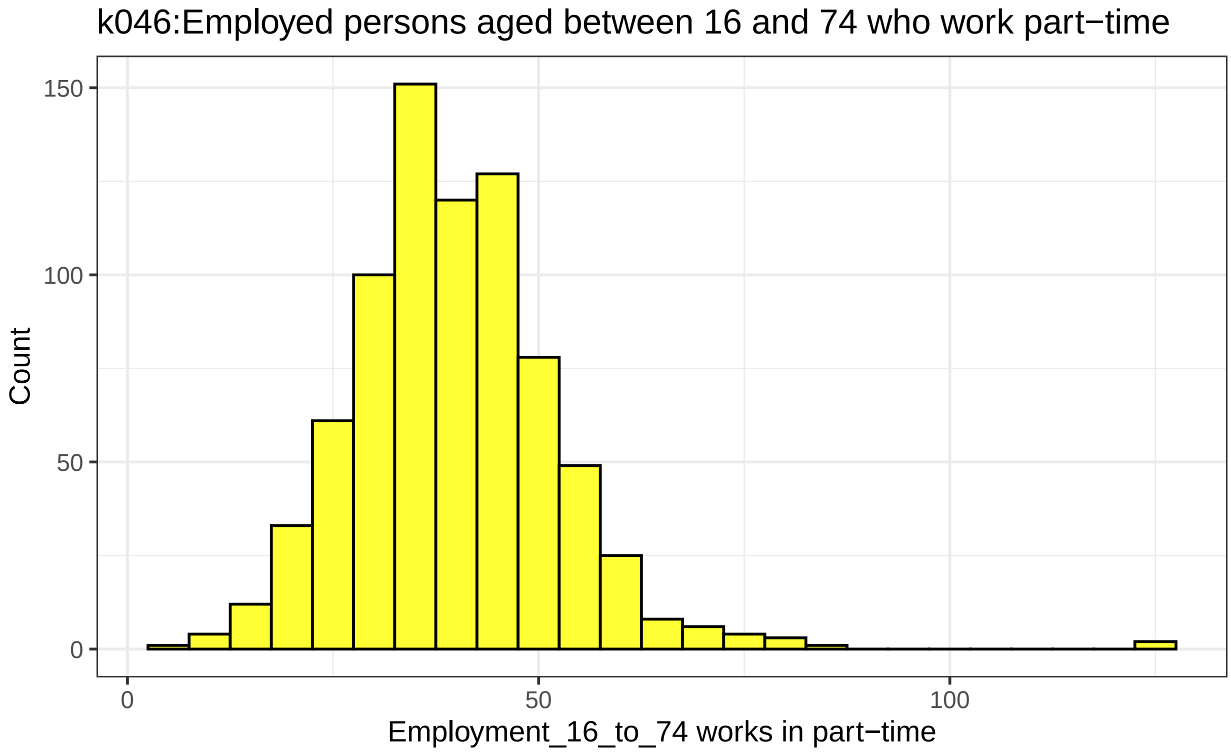


k046-Employed persons aged between 16 and 74 who work part-time

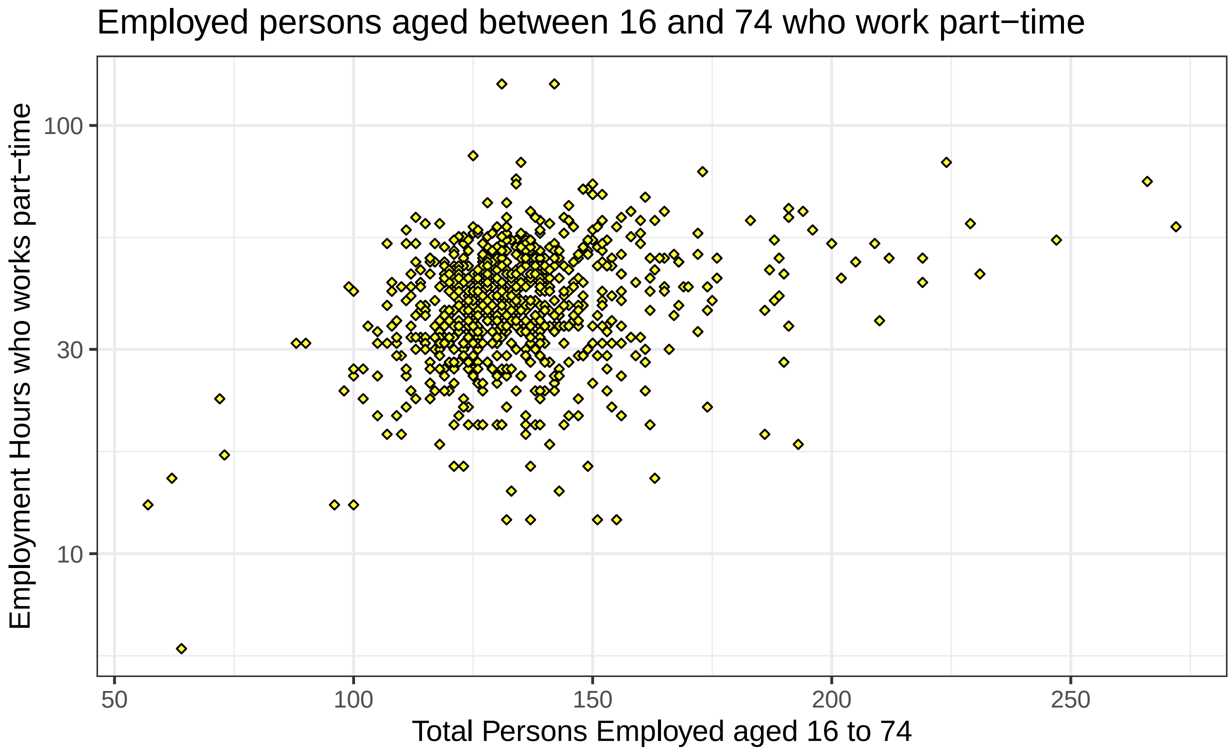
```
summary(Wolverhampton_2011OAC$k046)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    6.00   32.00   39.00   39.62   47.00  125.00
```

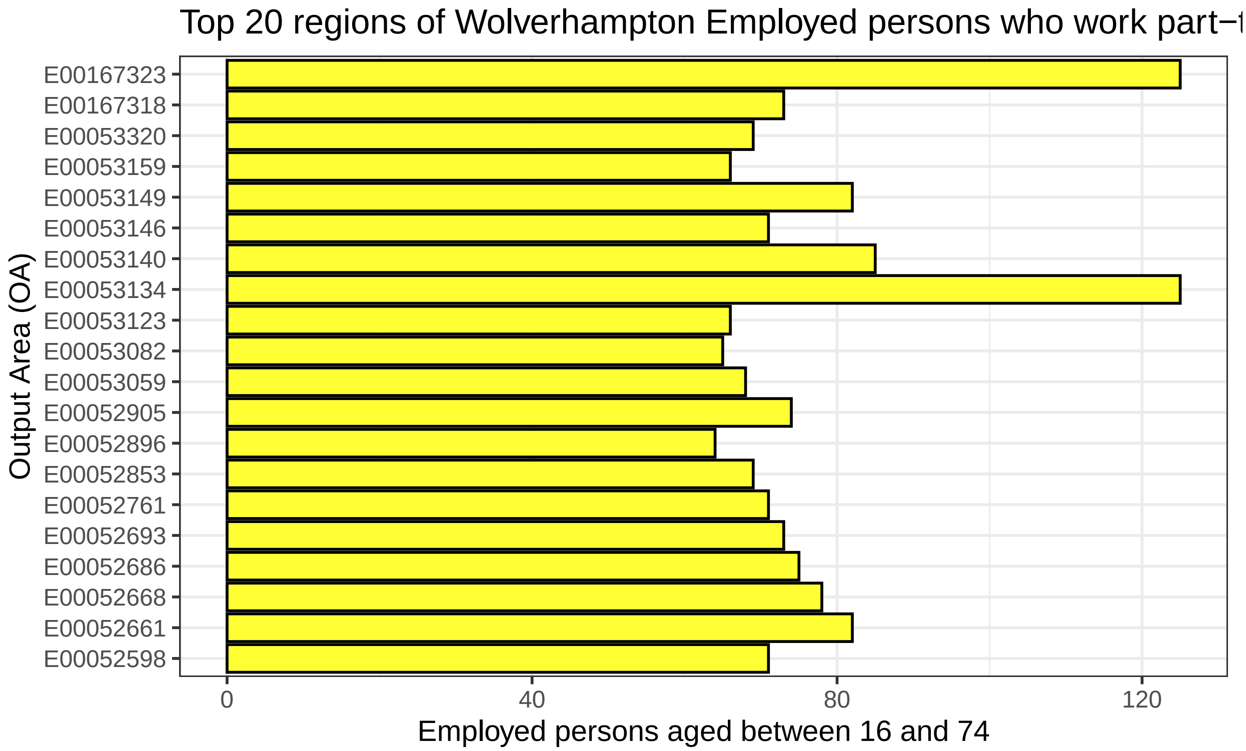
```
# Histogram

Wolverhampton_2011OAC %>%
  ggplot2::ggplot (
    aes(
      x = k046
    )
  ) +
  ggplot2::geom_histogram(binwidth = 5, fill="#ffff33", colour="black") +
  ggplot2::ggtitle("k046:Employed persons aged between 16 and 74 who work part-time") +
  ggplot2::xlab("Employment_16_to_74 works in part-time") +
  ggplot2::ylab("Count") +
  ggplot2::theme_bw()
```



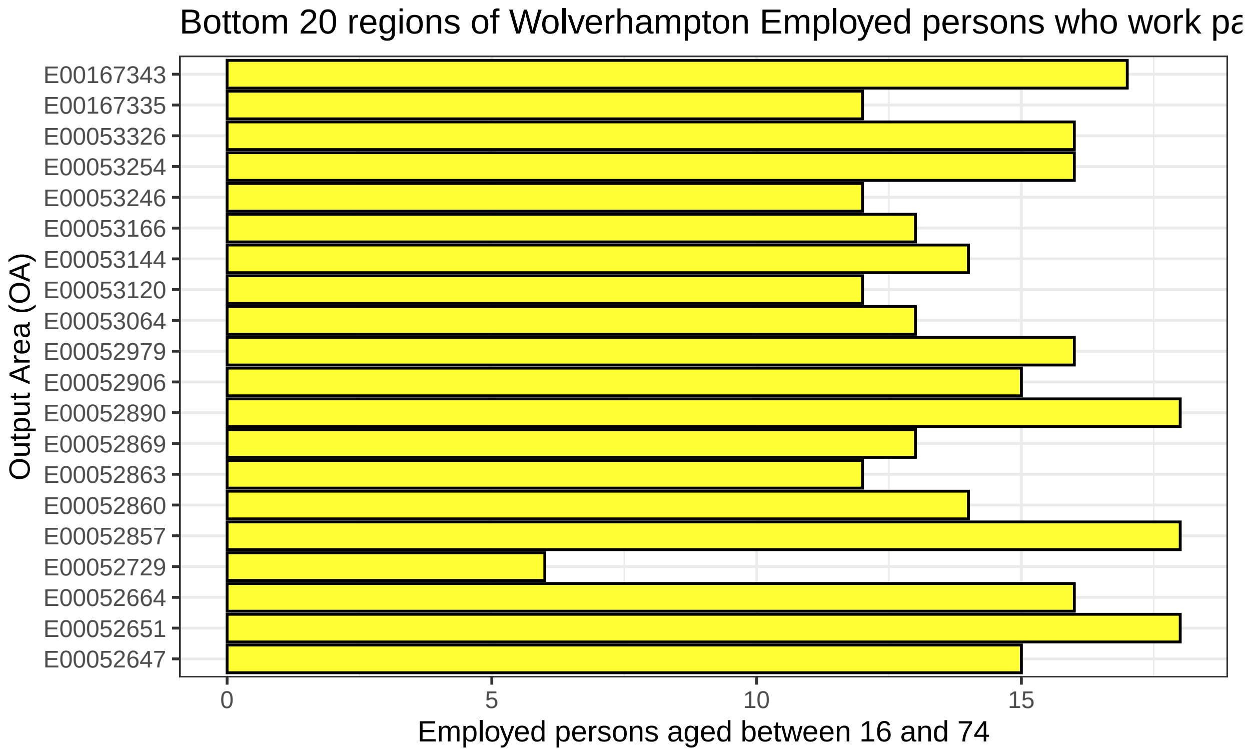
```
# Scatterplot

Wolverhampton_2011OAC %>%
  ggplot2::ggplot(
    aes(
      x = Total_Household_Spaces,
      y = k046
    )
  )+
  ggplot2::geom_point(color= "black", shape = 23, size = 1, fill = "#ffff33") +
  ggplot2::ggtitle("Employed persons aged between 16 and 74 who work part-time") +
  ggplot2::xlab("Total Persons Employed aged 16 to 74") +
  ggplot2::ylab("Employment Hours who works part-time") +
  ggplot2::scale_y_log10() +
  ggplot2::theme_bw()
```



```
# Top 20 regions of Wolverhampton Employed persons who work part-time

k046_max <-
  Wolverhampton_2011OAC %>%
  dplyr::select(OA, k046) %>%
  dplyr::slice_max(k046, n=20)

ggplot2::ggplot(k046_max,
                aes(
                  x = k046,
                  y = OA,
                )
)+
  ggplot2::geom_bar(position = "stack", stat = "identity", fill="#ffff33", colour="black") +
  ggplot2::ggtitle("Top 20 regions of Wolverhampton Employed persons who work part-time")+
  ggplot2::xlab("Employed persons aged between 16 and 74")+
  ggplot2::ylab("Output Area (OA)")+
  ggplot2::theme_bw()
```



```
# Bottom 20 regions of Wolverhampton Employed persons who work part-time

k046_min <-
  Wolverhampton_2011OAC %>%
  dplyr::select(OA, k046) %>%
  dplyr::slice_min(k046, n=20)

ggplot2::ggplot(k046_min,
                aes(
                  x = k046,
                  y = OA,
                )
)+
  ggplot2::geom_bar(position = "stack", stat = "identity", fill="#ffff33", colour="black") +
  ggplot2::ggtitle("Bottom 20 regions of Wolverhampton Employed persons who work part-time")+
  ggplot2::xlab("Employed persons aged between 16 and 74")+
  ggplot2::ylab("Output Area (OA)")+
  ggplot2::theme_bw()
```



Exploratory statistics

The graphics above provide preliminary evidence that the distribution of variables.

The code below calculates the percentage of assigned variables over total population, households, total population aged 16 to 74, total person employed aged 16 to 74.

Calculate percentage for the each variables

```
Percentage <-
  Wolverhampton_2011OAC %>%
  dplyr::mutate(
    Perc_k004 = (k004 / Total_Population) * 100,
    Perc_k009 = (k009 / Total_Population_16_and_over) * 100,
    Perc_k010 = (k010 / Total_Population_16_and_over) * 100,
    Perc_k027 = (k027 / Total_Household_Spaces) * 100,
    Perc_k031 = (k031 / Total_Households) * 100,
    Perc_k041 = (k041 / Total_Households) * 100,
    Perc_k046 = (k046 / Total_Employment_16_to_74) * 100
  ) %>%
  dplyr::select(OA, Perc_k004, Perc_k009, Perc_k010,
                Perc_k027, Perc_k031, Perc_k041, Perc_k046
                )
```

Descriptive statistics

```r
# Calculating descriptive statistics

wolverhampton_stat_desc <-
  Percentage %>%
  dplyr::select(Perc_k004, Perc_k009, Perc_k010,
                Perc_k027, Perc_k031, Perc_k041, Perc_k046) %>%
  pastecs::stat.desc(norm =TRUE)

wolverhampton_stat_desc %>%
  knitr::kable(digits = 5)
```

	Perc_k004	Perc_k009	Perc_k010	Perc_k027	Perc_k031	Perc_k041	Perc_k046
nbr.val	785.00000	785.00000	785.00000	785.00000	785.00000	785.00000	785.00000
nbr.null	0.00000	0.00000	0.00000	17.00000	1.00000	1.00000	0.00000
nbr.na	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
min	3.51827	13.17073	6.89655	0.00000	0.00000	0.00000	12.37113
max	52.32558	89.45578	72.47387	96.21212	99.27007	77.69231	64.10256
range	48.80731	76.28505	65.57732	96.21212	99.27007	77.69231	51.73143
sum	18691.32819	29049.88200	33988.64147	12658.03389	45435.69382	20146.86762	23688.50896
median	24.13793	36.28319	42.91498	7.62712	58.20896	23.00885	29.50820
mean	23.81061	37.00622	43.29763	16.12488	57.87986	25.66480	30.17644
SE.mean	0.20505	0.37399	0.42974	0.72517	0.91407	0.53335	0.21622
CI.mean.0.95	0.40251	0.73414	0.84358	1.42351	1.79432	1.04696	0.42444
var	33.00465	109.79665	144.97175	412.81289	655.88755	223.30052	36.70061
std.dev	5.74497	10.47839	12.04042	20.31780	25.61030	14.94324	6.05810
coef.var	0.24128	0.28315	0.27808	1.26003	0.44247	0.58225	0.20076
skewness	-0.05498	0.83897	-0.16098	2.06691	-0.24200	0.68742	0.99092
skew.2SE	-0.31502	4.80731	-0.92245	11.84346	-1.38664	3.93891	5.67801
kurtosis	1.02426	2.32522	-0.32131	3.86446	-0.97436	-0.11994	3.00249
kurt.2SE	2.93822	6.67018	-0.92172	11.08572	-2.79509	-0.34407	8.61303
normtest.W	0.99115	0.96405	0.99216	0.71265	0.95823	0.95469	0.95548
normtest.p	0.00012	0.00000	0.00037	0.00000	0.00000	0.00000	0.00000

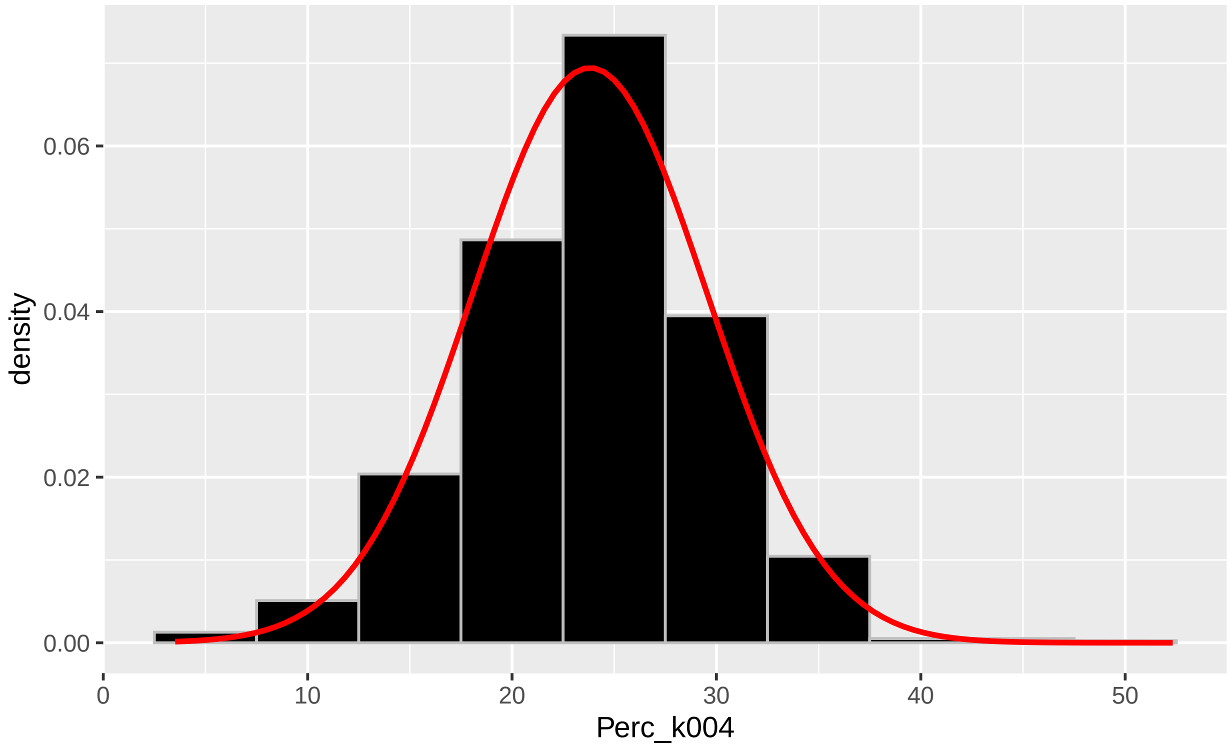
Shapiro test, Density histogram and QQ plot

k004 - Persons aged 45 to 64

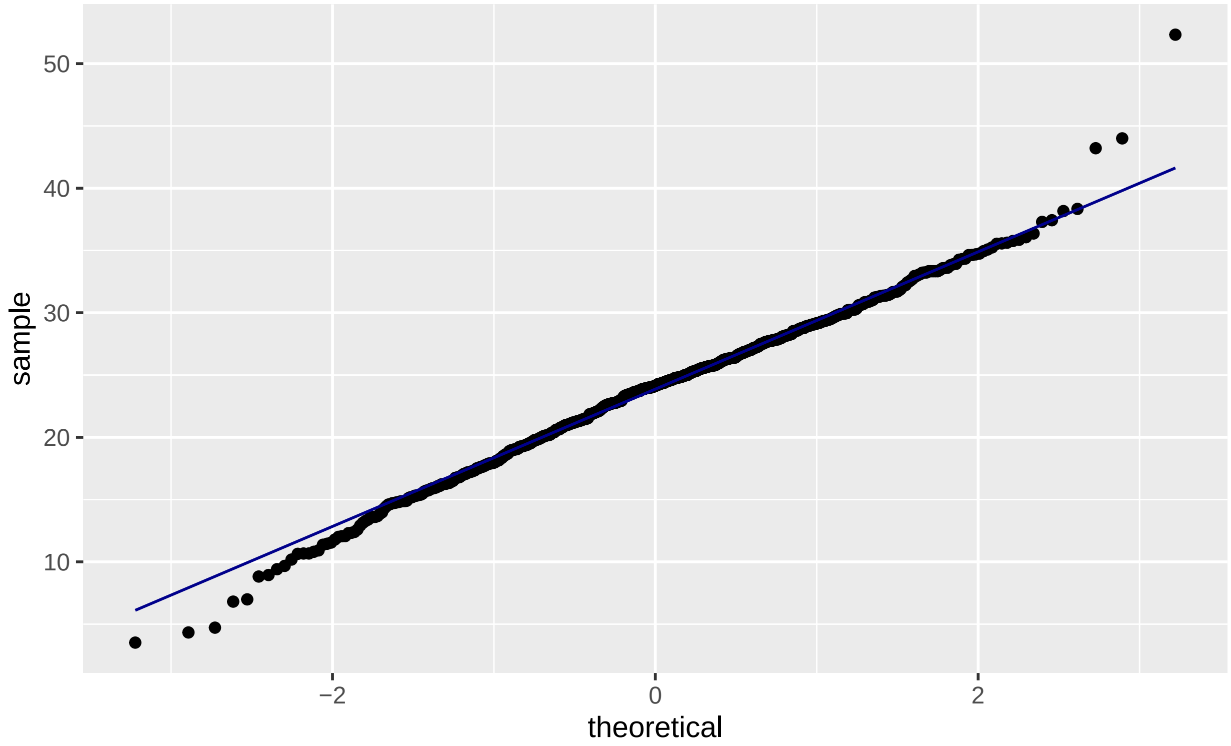
```r
# Shapiro_Test

Percentage %>%
  dplyr::pull(Perc_k004) %>%
  stats::shapiro.test()
```

```
##
##  Shapiro-Wilk normality test
##
## data:  .
## W = 0.99115, p-value = 0.0001186
```

```
# Density_Histogram

Percentage %>%
  ggplot2::ggplot(
    aes(
      x = Perc_k004
    )
  ) +
  ggplot2::geom_histogram(
    aes(
      y =..density..
    ),
    binwidth = 5,
    fill = "black",
    colour = "grey"
  ) +
  ggplot2::stat_function(
    fun = dnorm,
    args = list(
      mean = Percentage %>% pull(Perc_k004) %>% mean(),
      sd = Percentage %>% pull(Perc_k004) %>% sd()
    ),
    colour = "red", size = 1
  )
```



```
# QQ-Plot

Percentage %>%
  ggplot2::ggplot(
    aes(
      sample = Perc_k004
    )
  ) +
  ggplot2::stat_qq() +
  ggplot2::stat_qq_line(col = "darkblue")
```

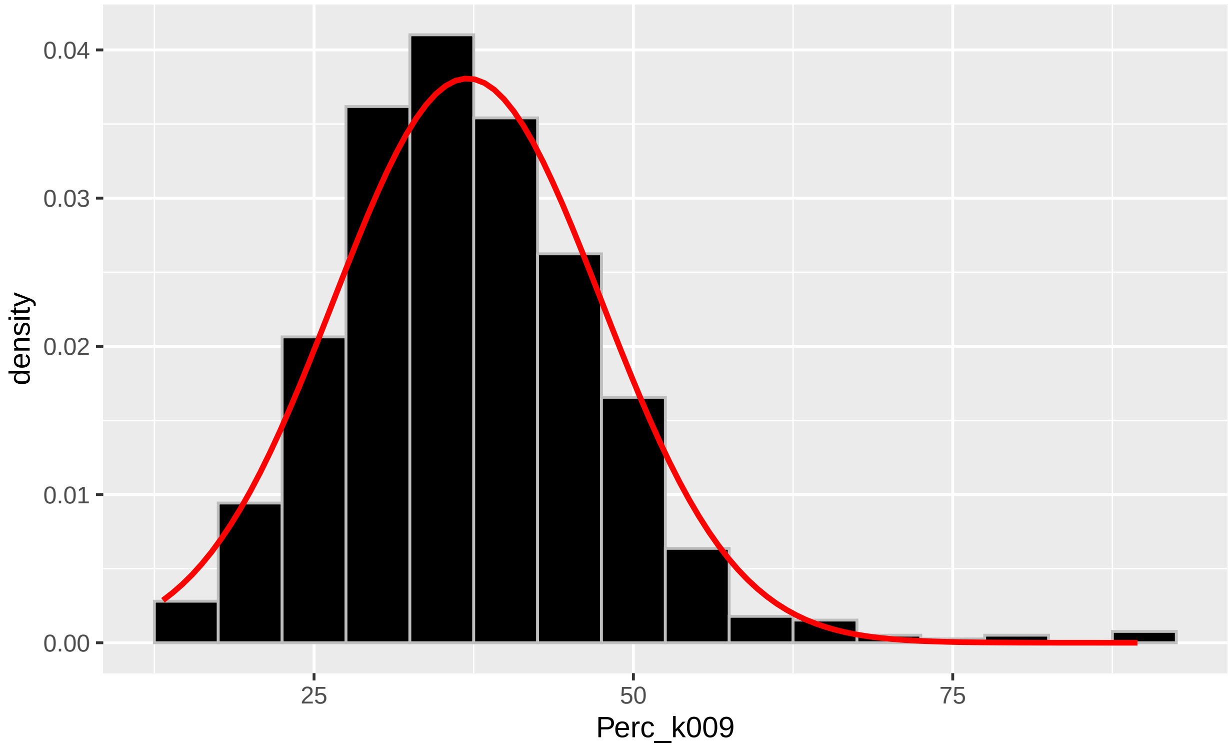


k009 - Persons aged over 16 who are single

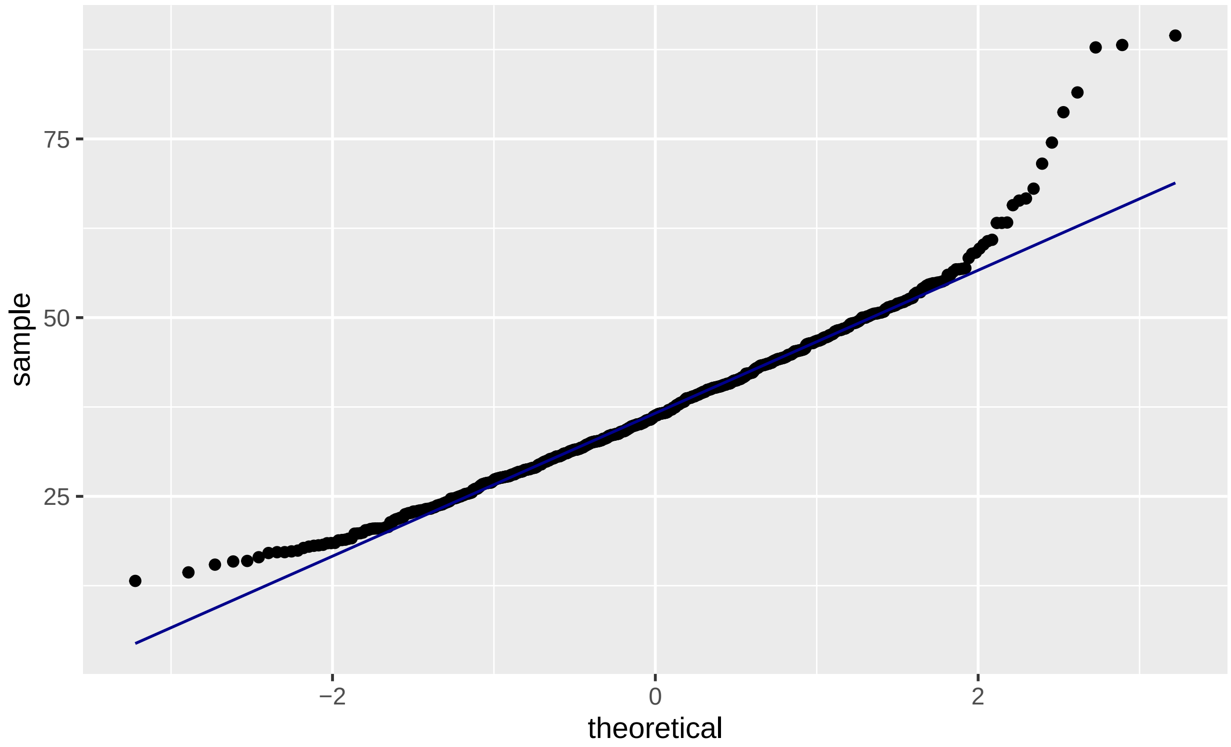
```
# Shapiro-Test

Percentage %>%
  dplyr::pull(Perc_k009) %>%
  stats::shapiro.test()
```

```
##
##  Shapiro-Wilk normality test
##
## data:  .
## W = 0.96405, p-value = 5.709e-13
```

```
# Density-Histogram

Percentage %>%
  ggplot2::ggplot(
    aes(
      x = Perc_k009
    )
  ) +
  ggplot2::geom_histogram(
    aes(
      y =..density..
    ),
    binwidth = 5,
    fill = "black",
    colour = "grey"
  ) +
  ggplot2::stat_function(
    fun = dnorm,
    args = list(
      mean = Percentage %>% pull(Perc_k009) %>% mean(),
      sd = Percentage %>% pull(Perc_k009) %>% sd()
    ),
    colour = "red", size = 1
  )
```



```
# QQ-plot

Percentage %>%
  ggplot2::ggplot(
    aes(
      sample = Perc_k009
    )
  ) +
  ggplot2::stat_qq() +
  ggplot2::stat_qq_line(col = "darkblue")
```



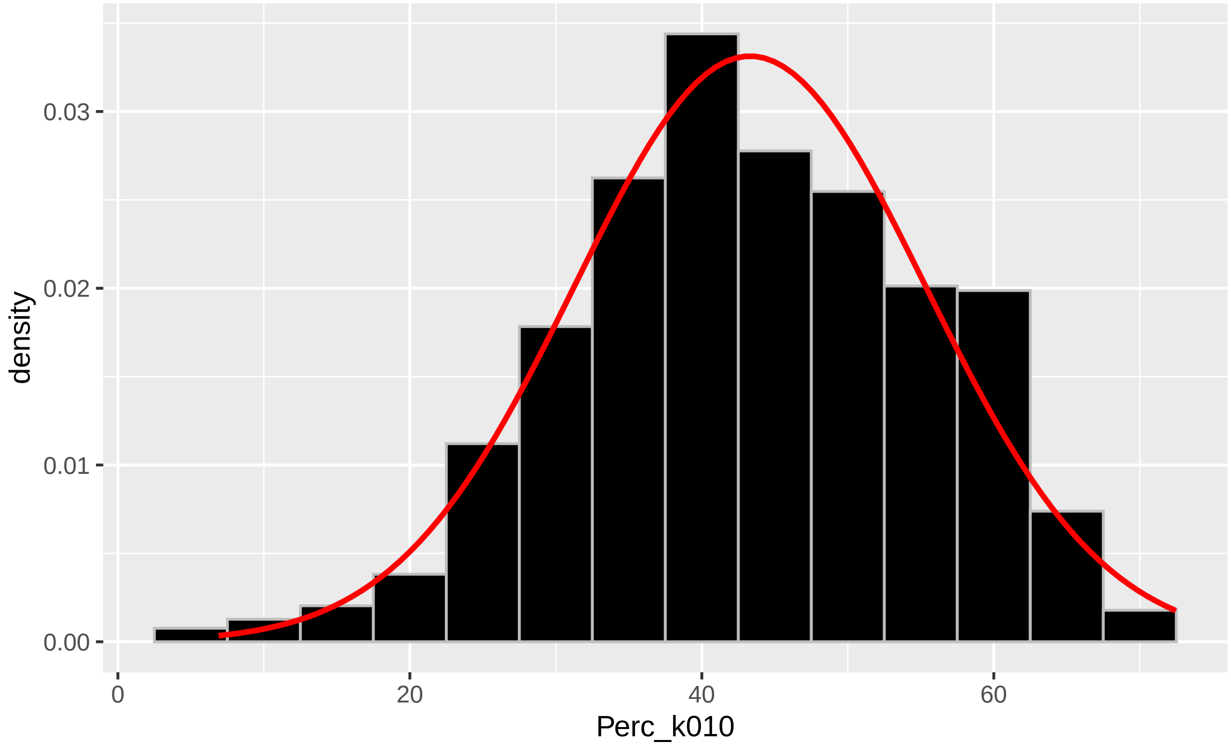
k010 - Persons aged over 16 who are married or in a registered same-sex civil partnership

```
# Shapiro-test

Percentage %>%
  dplyr::pull(Perc_k010) %>%
  stats::shapiro.test()
```

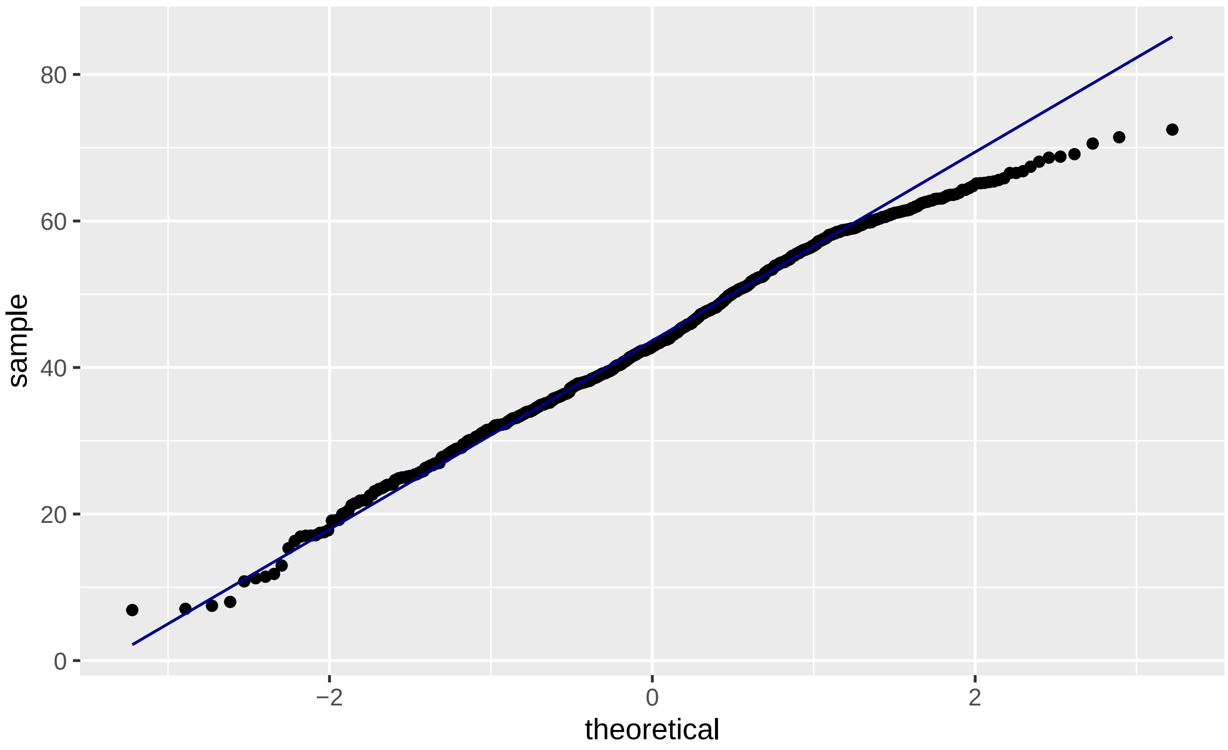
```
##
##  Shapiro-Wilk normality test
##
## data:  .
## W = 0.99216, p-value = 0.0003657
```

```
# Density-Histogram
```

```
Percentage %>%
  ggplot2::ggplot(
    aes(
      x = Perc_k010
    )
  ) +
  ggplot2::geom_histogram(
    aes(
      y =..density..
    ),
    binwidth = 5,
    fill = "black",
    colour = "grey"
  ) +
  ggplot2::stat_function(
    fun = dnorm,
    args = list(
      mean = Percentage %>% pull(Perc_k010) %>% mean(),
      sd = Percentage %>% pull(Perc_k010) %>% sd()
    ),
    colour = "red", size = 1
  )
```



```
# QQ-plot

Percentage %>%
  ggplot2::ggplot(
    aes(
      sample = Perc_k010
    )
  ) +
  ggplot2::stat_qq() +
  ggplot2::stat_qq_line(col = "darkblue")
```

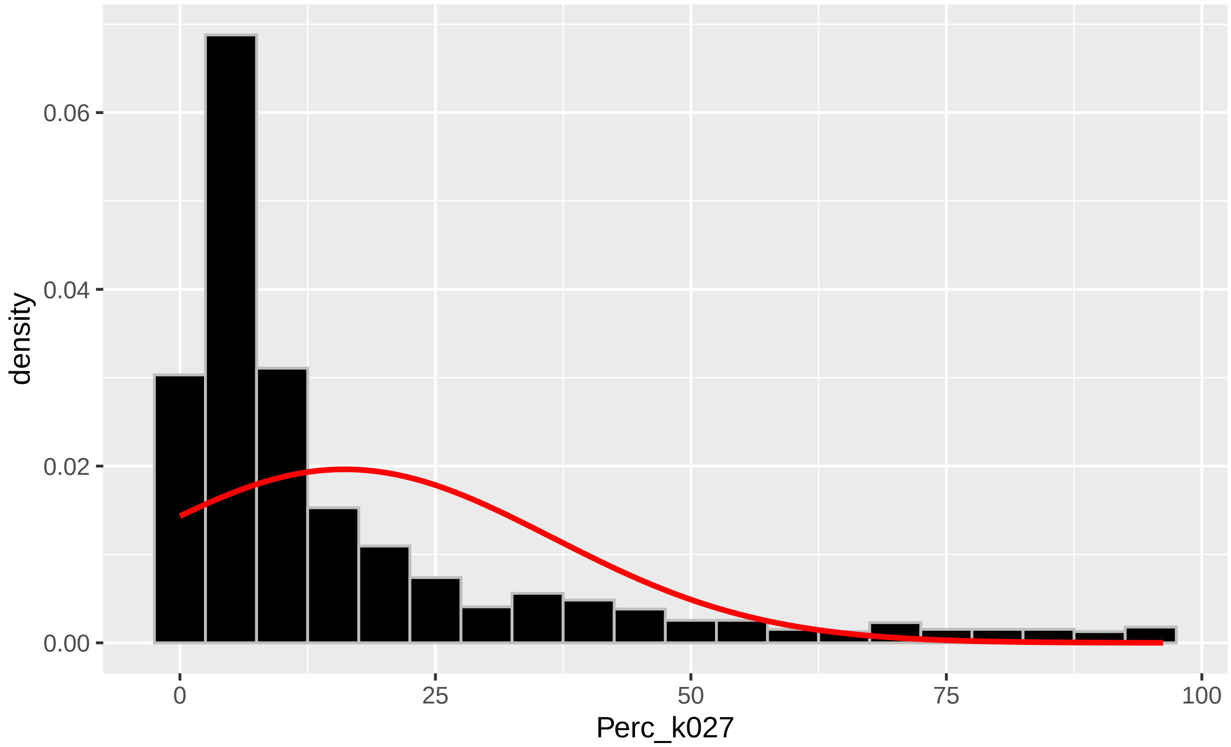


k027 - Households who live in a detached house or bungalow

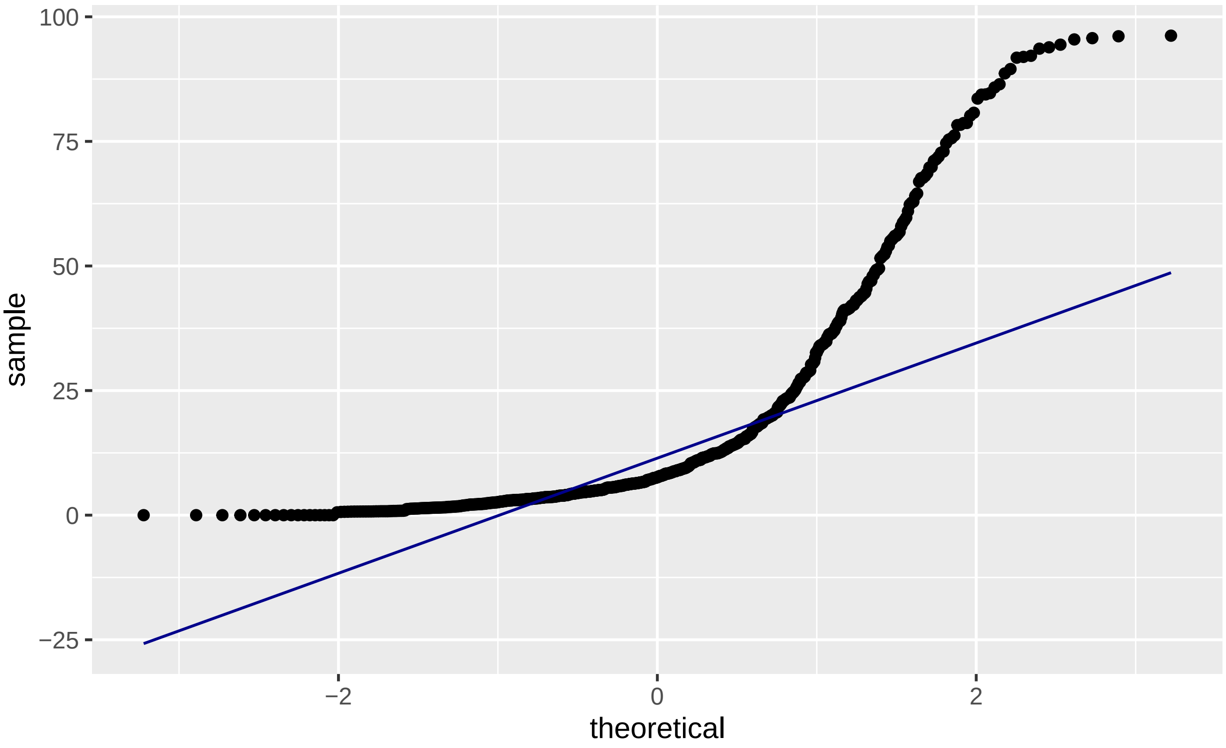
```
# Shapiro-Test

Percentage %>%
  dplyr::pull(Perc_k027) %>%
  stats::shapiro.test()
```

```
##
##  Shapiro-Wilk normality test
##
## data:  .
## W = 0.71265, p-value < 2.2e-16
```

```
# Density-Histogram

Percentage %>%
  ggplot2::ggplot(
    aes(
      x = Perc_k027
    )
  ) +
  ggplot2::geom_histogram(
    aes(
      y =..density..
    ),
    binwidth = 5,
    fill = "black",
    colour = "grey"
  ) +
  ggplot2::stat_function(
    fun = dnorm,
    args = list(
      mean = Percentage %>% pull(Perc_k027) %>% mean(),
      sd = Percentage %>% pull(Perc_k027) %>% sd()
    ),
    colour = "red", size = 1
  )
```



```
# QQ-plot

Percentage %>%
  ggplot2::ggplot(
    aes(
      sample = Perc_k027
    )
  ) +
  ggplot2::stat_qq() +
  ggplot2::stat_qq_line(col = "darkblue")
```

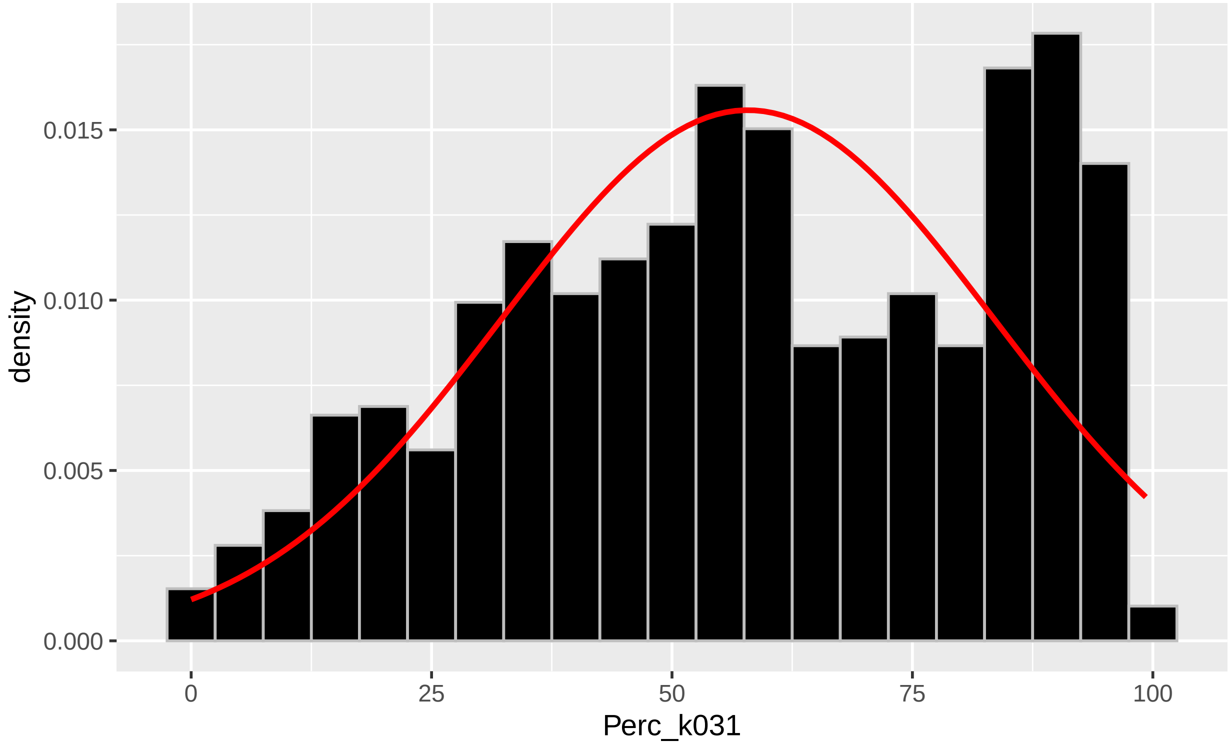


k031 - Households who own or have shared ownership of property

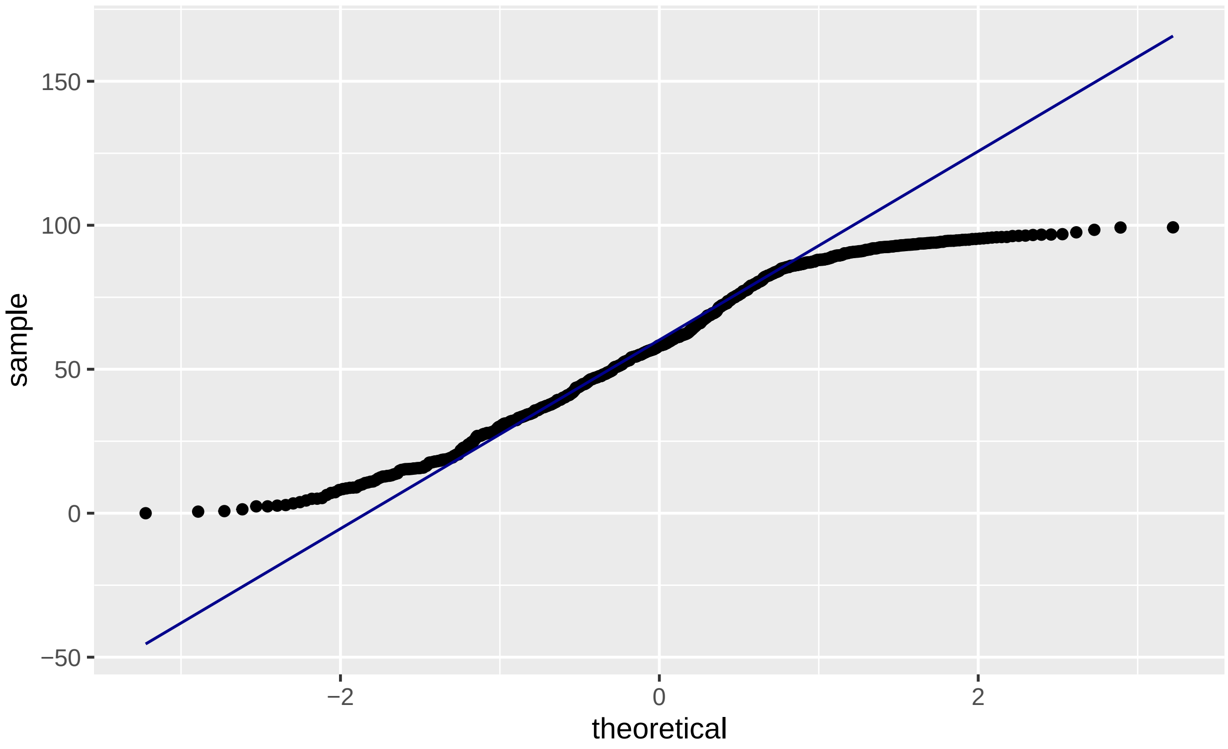
```
# Shapiro-Test

Percentage %>%
  dplyr::pull(Perc_k031) %>%
  stats::shapiro.test()
```

```
##
##  Shapiro-Wilk normality test
##
## data:  .
## W = 0.95823, p-value = 3.72e-14
```

```
# Density-Histogram

Percentage %>%
  ggplot2::ggplot(
    aes(
      x = Perc_k031
    )
  ) +
  ggplot2::geom_histogram(
    aes(
      y =..density..
    ),
    binwidth = 5,
    fill = "black",
    colour = "grey"
  ) +
  ggplot2::stat_function(
    fun = dnorm,
    args = list(
      mean = Percentage %>% pull(Perc_k031) %>% mean(),
      sd = Percentage %>% pull(Perc_k031) %>% sd()
    ),
    colour = "red", size = 1
  )
```



```
# QQ-plot

Percentage %>%
  ggplot2::ggplot(
    aes(
      sample = Perc_k031
    )
  ) +
  ggplot2::stat_qq() +
  ggplot2::stat_qq_line(col = "darkblue")
```

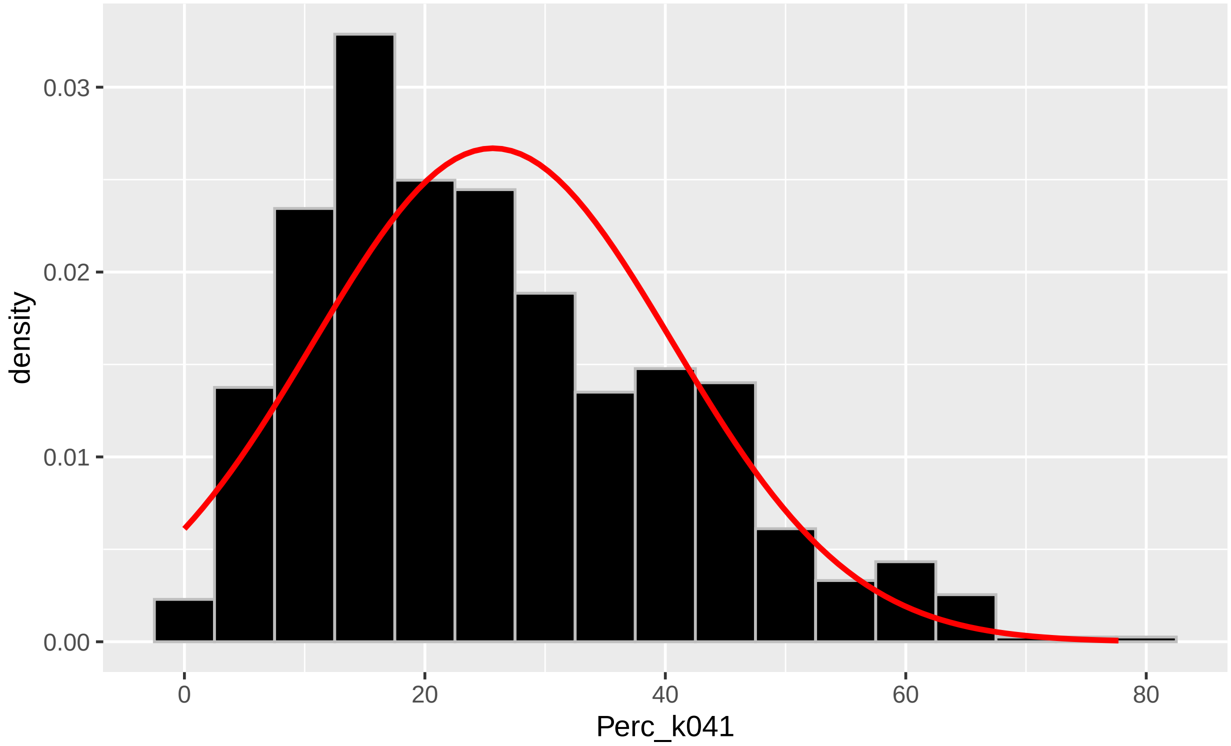


k041 - Households with two or more cars or vans

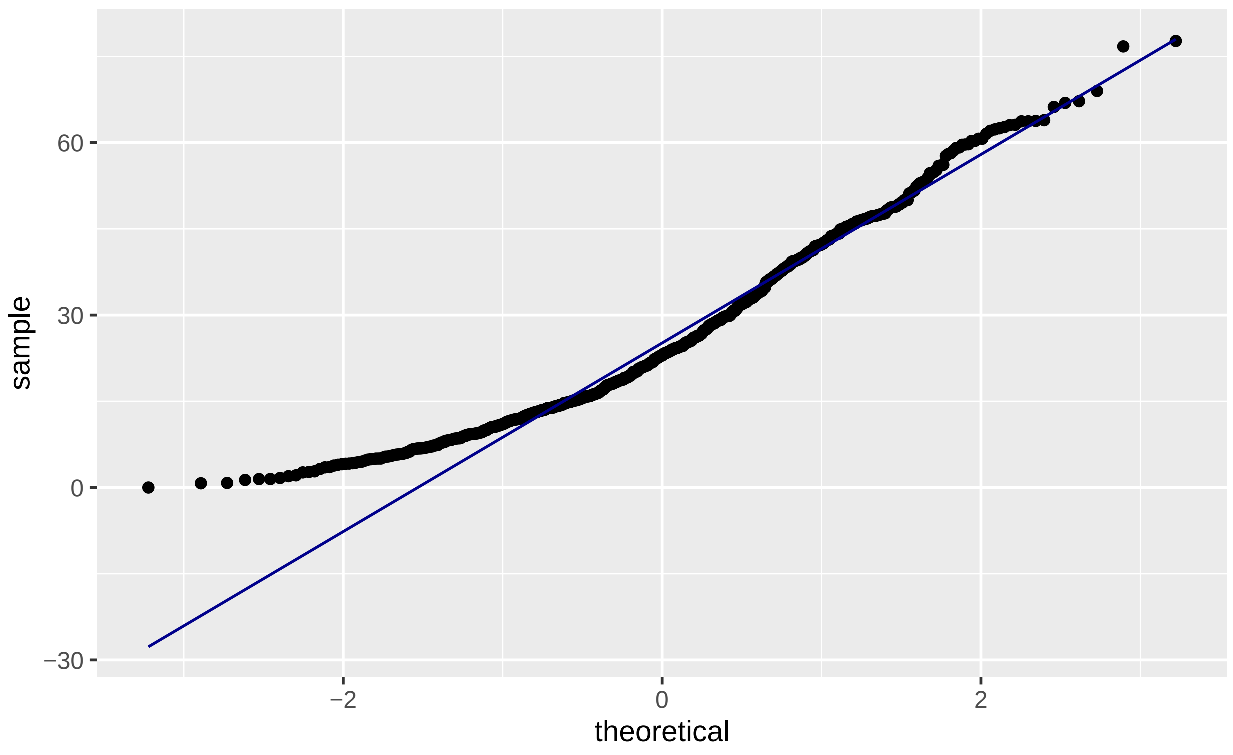
```
# Shapiro-Test

Percentage %>%
  dplyr::pull(Perc_k041) %>%
  stats::shapiro.test()
```

```
##
##  Shapiro-Wilk normality test
##
## data:  .
## W = 0.95469, p-value = 7.991e-15
```

```
# Density-Histogram

Percentage %>%
  ggplot2::ggplot(
    aes(
      x = Perc_k041
    )
  ) +
  ggplot2::geom_histogram(
    aes(
      y =..density..
    ),
    binwidth = 5,
    fill = "black",
    colour = "grey"
  ) +
  ggplot2::stat_function(
    fun = dnorm,
    args = list(
      mean = Percentage %>% pull(Perc_k041) %>% mean(),
      sd = Percentage %>% pull(Perc_k041) %>% sd()
    ),
    colour = "red", size = 1
  )
```



```
# QQ-plot

Percentage %>%
  ggplot2::ggplot(
    aes(
      sample = Perc_k041
    )
  ) +
  ggplot2::stat_qq() +
  ggplot2::stat_qq_line(col = "darkblue")
```

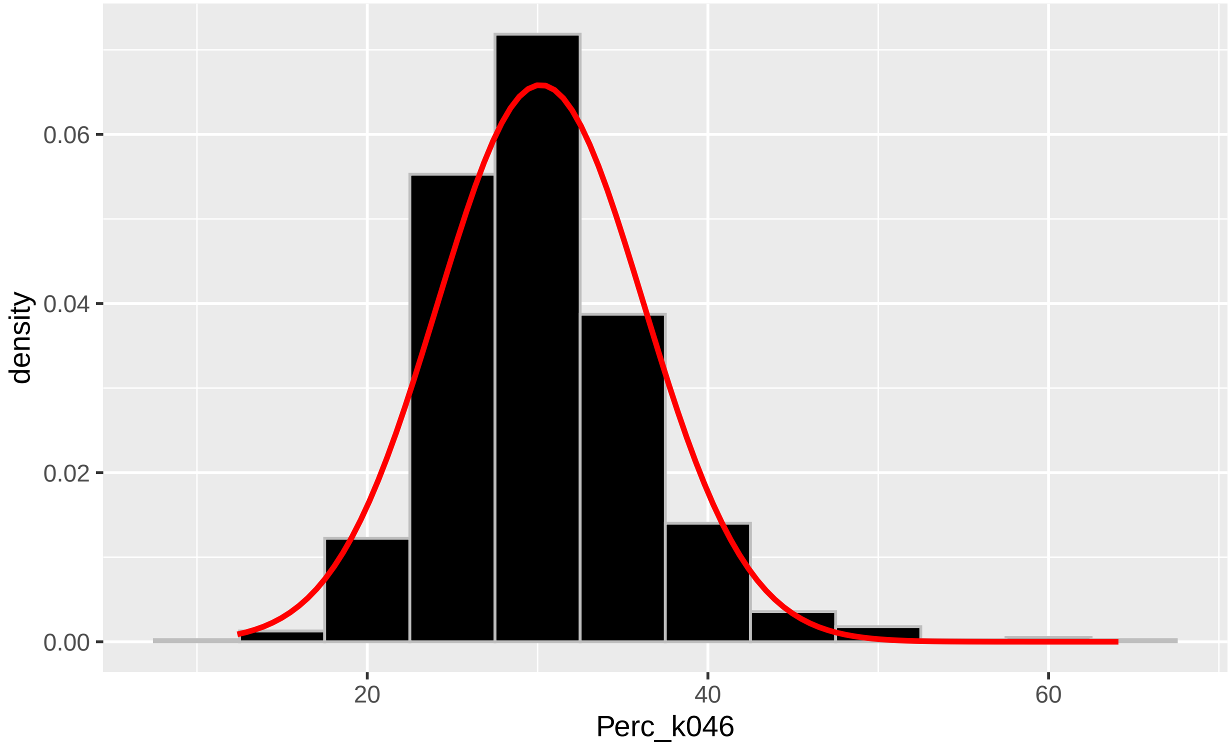


k046 - Employed persons aged between 16 and 74 who work part-time

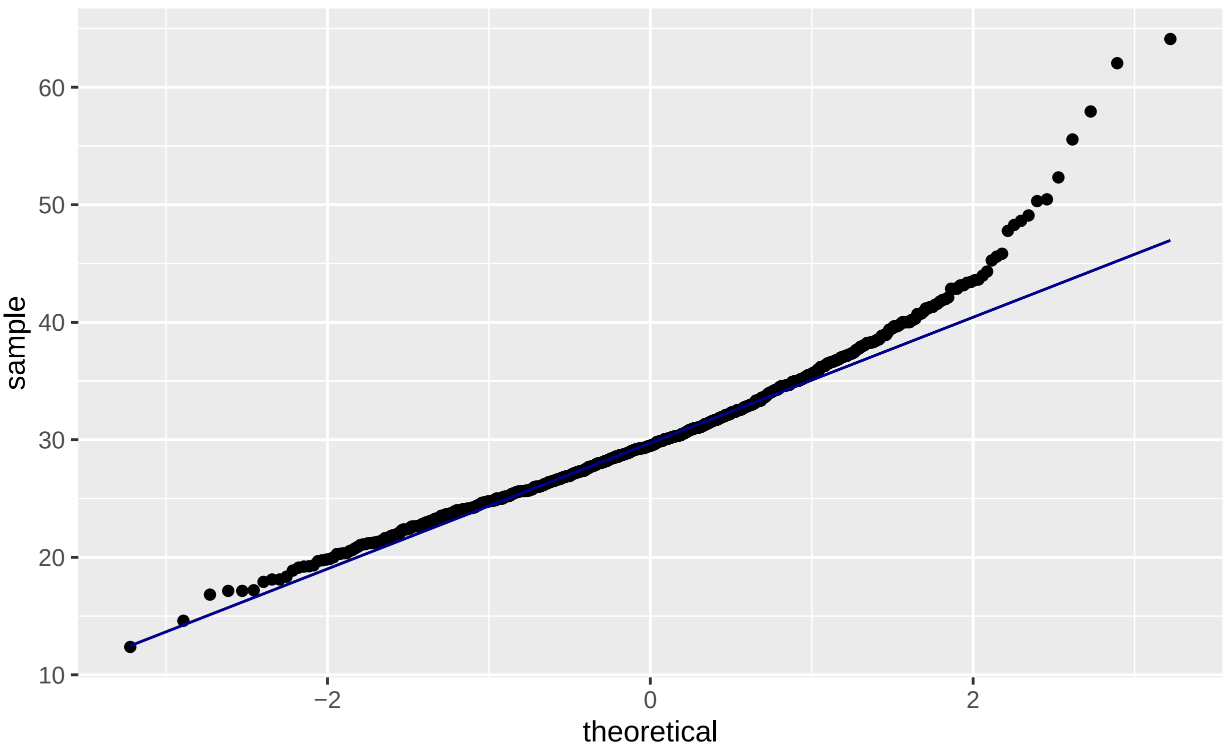
```
# Shapiro-Test

Percentage %>%
  dplyr::pull(Perc_k046) %>%
  stats::shapiro.test()
```

```
##
##  Shapiro-Wilk normality test
##
## data:  .
## W = 0.95548, p-value = 1.117e-14
```

```
# Density-Histogram

Percentage %>%
  ggplot2::ggplot(
    aes(
      x = Perc_k046
    )
  ) +
  ggplot2::geom_histogram(
    aes(
      y =..density..
    ),
    binwidth = 5,
    fill = "black",
    colour = "grey"
  ) +
  ggplot2::stat_function(
    fun = dnorm,
    args = list(
      mean = Percentage %>% pull(Perc_k046) %>% mean(),
      sd = Percentage %>% pull(Perc_k046) %>% sd()
    ),
    colour = "red", size = 1
  )
```



```
# QQ-plot

Percentage %>%
  ggplot2::ggplot(
    aes(
      sample = Perc_k046
    )
  ) +
  ggplot2::stat_qq() +
  ggplot2::stat_qq_line(col = "darkblue")
```



Results and Discussion

Initial analysis of the variables with simple histogram, scatterplot, highest and lowest also summarized each variable to explore the distribution of the variables with GGplot2.Which shows some variables are equally distributed among the other Kvariables from the 2011- Output Area Classification. Exploratory Data Analysis (EDA) s essentially a creative operation. And like most innovative processes, the trick to asking quality questions is to produce a large quantity of questions. It's used to investigate the distribution of the data, relationships and patterns and to conduct the hypothesis tests and statistical calculation with various statistical tools methods via summary statistics and graphical representation, EDA helps to understand the data first.

An EDA of the variables allocated from LAD data and compared with the 2011OAC data is analyzed in this project paper. The variables include a plethora of statistical units, such as population age, marital and civil partnership status, ownership of housing, availability of vehicles in regions of Wolverhampton, and part-time work hours. The data visualized by Histograms shows the distribution of data being normal or skewed. It seems the data are distributed normally for all the variables some had outliers which has been skimmed from the table. Then, to determine the relationship between variables we have plotted scatterplot with the same unit statistical measure which distributed normally. Finally, Top and bottom 20 variables for the variable have been generated by the OA. It helps to understand the regions with higher and lower variables. EDA was carried out where the percentage of the variable was measured over the totals per OA. It helps to normalize the data better than numerical values. Therefore, measurement of descriptive statistics was performed for these results.

Descriptive statistics help to explore the form or distribution of the data used for modeling or analysis. There are different measures that help to understand the curves' meaning. To check the normality of the data Shapiro-Wilk test which provides the significance data. A normtest.p is a measure whose importance for the Shapiro test is indicated by its value. To visually validate the fact that the variable is typically distributed or not, a density-based histogram including the form of the normal distribution with the same mean and standard deviation is also plotted for the visualization and the QQ plot. The positive kurtosis indicates the distribution of the heavily-tailed and the negative value indicates the flat distribution. Where the distribution of Perc_k004, Perc_k009, Perc_k027 and Perc_k046 is heavily tailed, the distribution of Perc_k010, Perc_k031 and Per_k041 is smooth. The mean value, minimum and maximum, is the measure of the value of the variable that differs with and from the mean value of the variable in OA. The vector Perc k004, Perc_k009, Perc_k010, Perc_k031, Perc_k046 is typically distributed where there is large distribution of Perc_k027, Per_k041. Positive skew values reflect the skew to the left and the negative value reveals the skew to the right. Thus, ends the discussion on the variables, we will create the Household modelling further.

Option A.2

Multiple Linear regression

###Select and normalize variables

```r
library(stargazer)
library(lmtest)
library(car)
library(lm.beta)
```

```r
# Selecting the dependent and independent variables

Wolverhampton_Household <-
  Wolverhampton_2011OAC %>%
  dplyr::select(
    OA, Total_Population, Total_Population_16_and_over, Total_Household_Spaces,
    Total_Households, Total_Employment_16_to_74,
    k004, k009, k010, k027, k031, k041, k046
  ) %>%

# percentage of dependent and independent variables

dplyr::mutate (
  k004 = ( k004 / Total_Population) * 100,
  k009 = ( k009 / Total_Population_16_and_over) * 100,
  k010 = ( k010 / Total_Population_16_and_over) * 100,
  k027 = ( k027 / Total_Household_Spaces) * 100,
  k031 = ( k031 / Total_Households) * 100,
  k041 = ( k041 / Total_Households) * 100,
  k046 = ( k046 / Total_Employment_16_to_74) * 100
  ) %>%

#  rename columns

  dplyr::rename_with(
    function(x) {(paste0("Perc_", x))},
    c(k004, k009, k010, k027, k031, k041, k046)
  )
```

```r
# Selected variables

#Perc_k004 : Persons aged 45 to 64
#Perc_k009 : Persons aged over 16 who are single
#Perc_k010 : Persons aged over 16 who are married or in a registered same-sex civil partnership
#Perc_k027 : Households who live in a detached house or bungalow
#Perc_k041 : Households with two or more cars or vans
#Perc_k046 : Employed persons aged between 16 and 74 who work part-time

# create household model

Household_model <-
  Wolverhampton_Household %$%
  lm(
    Perc_k031 ~
      Perc_k004 + Perc_k009 + Perc_k010 + Perc_k027 + Perc_k041 + Perc_k046
    )
```

```r
#print summary
Household_model %>%
  summary()
```

```
##
## Call:
## lm(formula = Perc_k031 ~ Perc_k004 + Perc_k009 + Perc_k010 +
##     Perc_k027 + Perc_k041 + Perc_k046)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -31.758  -6.096   0.545   6.160  46.007
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  8.62323    6.02163   1.432 0.152533
## Perc_k004    0.30026    0.08081   3.716 0.000217 ***
## Perc_k009   -0.16804    0.07011  -2.397 0.016771 *
## Perc_k010    0.85996    0.07447  11.548  < 2e-16 ***
## Perc_k027   -0.15791    0.02447  -6.453 1.93e-10 ***
## Perc_k041    0.89511    0.05118  17.491  < 2e-16 ***
## Perc_k046   -0.30935    0.06346  -4.875 1.32e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.805 on 778 degrees of freedom
## Multiple R-squared:  0.8545, Adjusted R-squared:  0.8534
## F-statistic: 761.7 on 6 and 778 DF,  p-value: < 2.2e-16
```

```r
# Not rendered in bookdown
stargazer(Household_model, header=FALSE)
```

```
##
## \begin{table}[!htbp] \centering
##   \caption{}
##   \label{}
## \begin{tabular}{@{\extracolsep{5pt}}lc}
## \\[-1.8ex]\hline
## \hline \\[-1.8ex]
##  & \multicolumn{1}{c}{\textit{Dependent variable:}} \\
## \cline{2-2}
## \\[-1.8ex] & Perc\_k031 \\
## \hline \\[-1.8ex]
##  Perc\_k004 & 0.300$^{***}$ \\
##   & (0.081) \\
##   & \\
##  Perc\_k009 & $-$0.168$^{**}$ \\
##   & (0.070) \\
##   & \\
##  Perc\_k010 & 0.860$^{***}$ \\
##   & (0.074) \\
##   & \\
##  Perc\_k027 & $-$0.158$^{***}$ \\
##   & (0.024) \\
##   & \\
##  Perc\_k041 & 0.895$^{***}$ \\
##   & (0.051) \\
##   & \\
##  Perc\_k046 & $-$0.309$^{***}$ \\
##   & (0.063) \\
##   & \\
##  Constant & 8.623 \\
##   & (6.022) \\
##   & \\
## \hline \\[-1.8ex]
## Observations & 785 \\
## R$^{2}$ & 0.855 \\
## Adjusted R$^{2}$ & 0.853 \\
## Residual Std. Error & 9.805 (df = 778) \\
## F Statistic & 761.719$^{***}$ (df = 6; 778) \\
## \hline
## \hline \\[-1.8ex]
## \textit{Note:}  & \multicolumn{1}{r}{$^{*}$p$<$0.1; $^{**}$p$<$0.05; $^{***}$p$<$0.01} \\
## \end{tabular}
## \end{table}
```

```
# Conduct shapiro-test for Households.
# Normality

Household_model %>%
  rstandard() %>%
  shapiro.test()
```

```
##
##  Shapiro-Wilk normality test
##
## data:  .
## W = 0.99156, p-value = 0.0001853
```

```r
# Homoscedasticity
# Breusch-Pagan test

Household_model %>%
  bptest()
```

```
##
##  studentized Breusch-Pagan test
##
## data:  .
## BP = 32.155, df = 6, p-value = 1.524e-05
```

```r
# Independence
# Durbin-Watson test

Household_model %>%
  dwtest()
```

```
##
##  Durbin-Watson test
##
## data:  .
## DW = 1.7526, p-value = 0.0002195
## alternative hypothesis: true autocorrelation is greater than 0
```

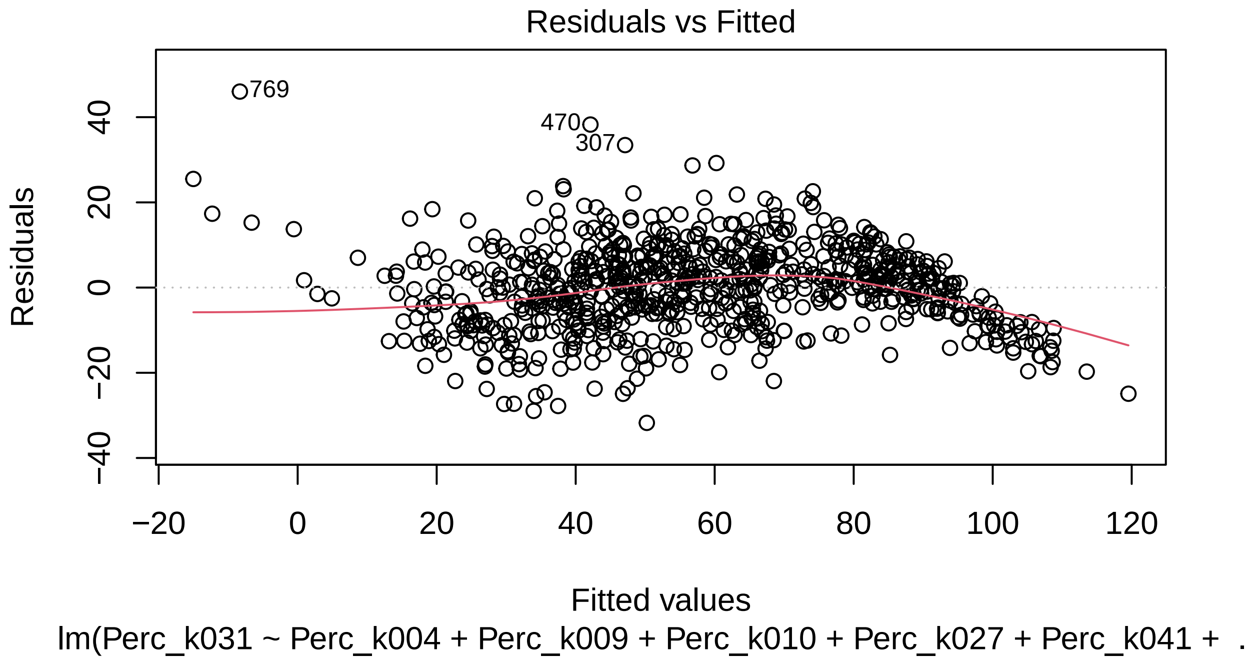
```r
# Conduct vif model

Household_model %>%
  vif()
```

```
## Perc_k004 Perc_k009 Perc_k010 Perc_k027 Perc_k041 Perc_k046
##  1.757381  4.400610  6.555691  2.016023  4.768866  1.205221
```

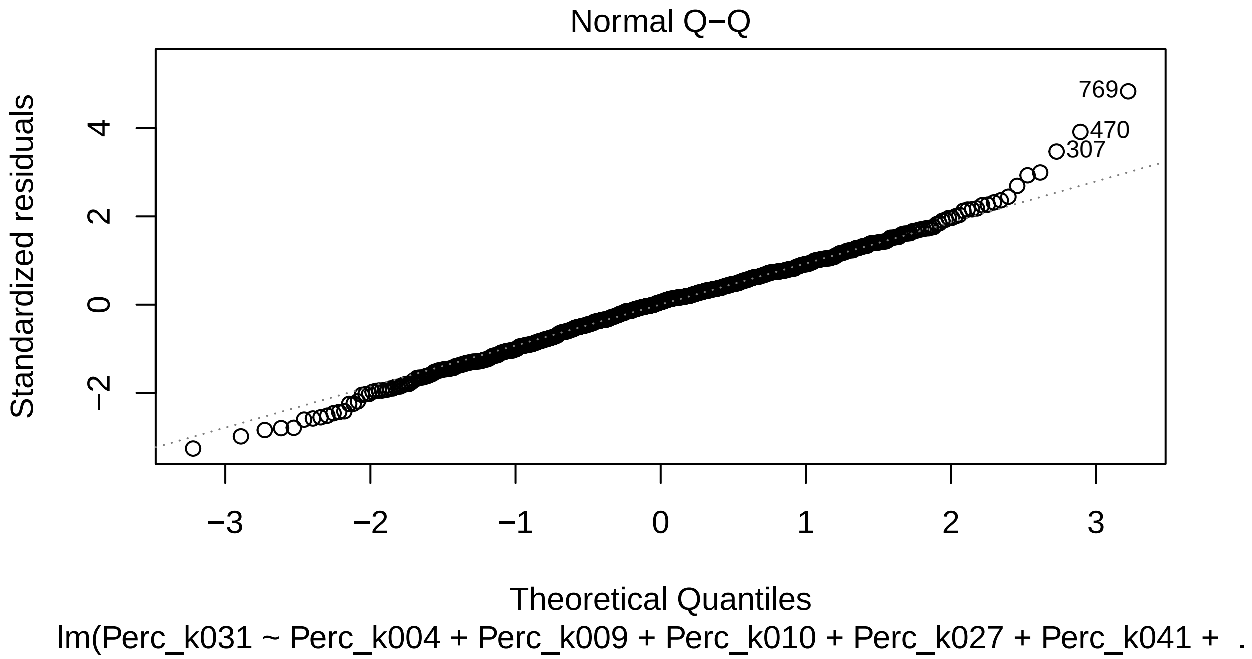
```r
# Conduct lm.beta

lm.beta(Household_model)
```

```
##
## Call:
## lm(formula = Perc_k031 ~ Perc_k004 + Perc_k009 + Perc_k010 +
##     Perc_k027 + Perc_k041 + Perc_k046)
##
## Standardized Coefficients::
## (Intercept)   Perc_k004   Perc_k009   Perc_k010   Perc_k027   Perc_k041
##  0.00000000  0.06735401 -0.06875274  0.40430088 -0.12527696  0.52228662
##   Perc_k046
## -0.07317581
```

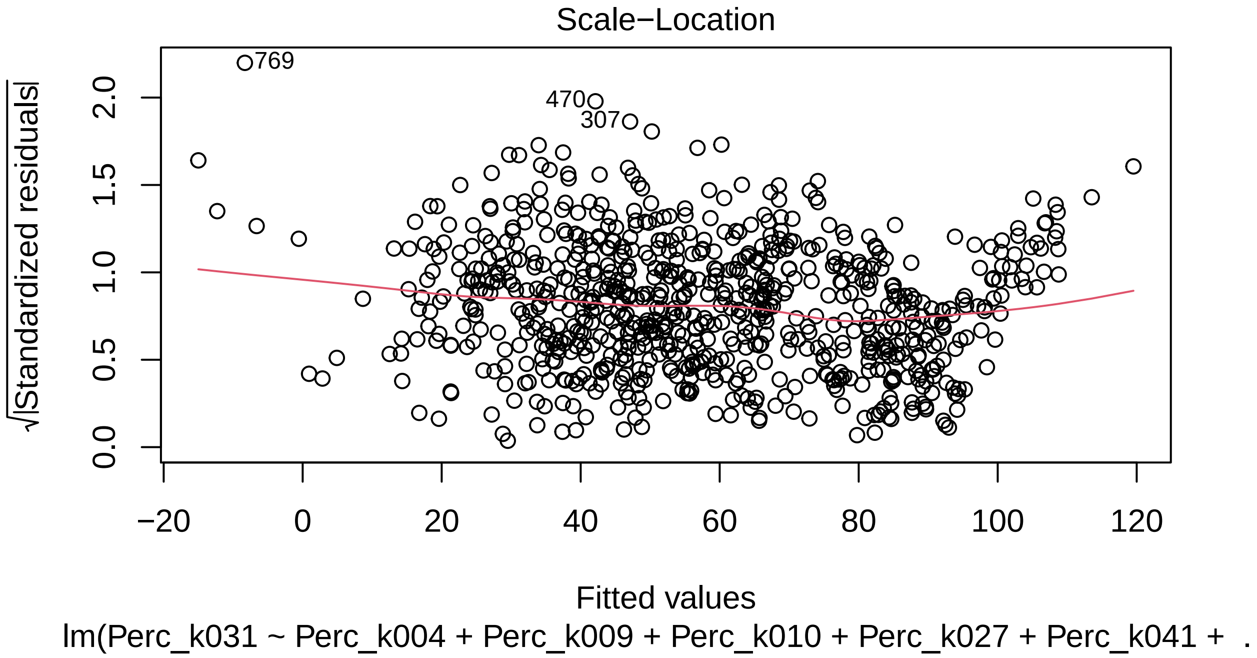
```r
# Plotting residual to better understanding the variables
# Explore the residuals visually

# cook's distance c = 1

Household_model %>%
  plot(which = c(1))
```



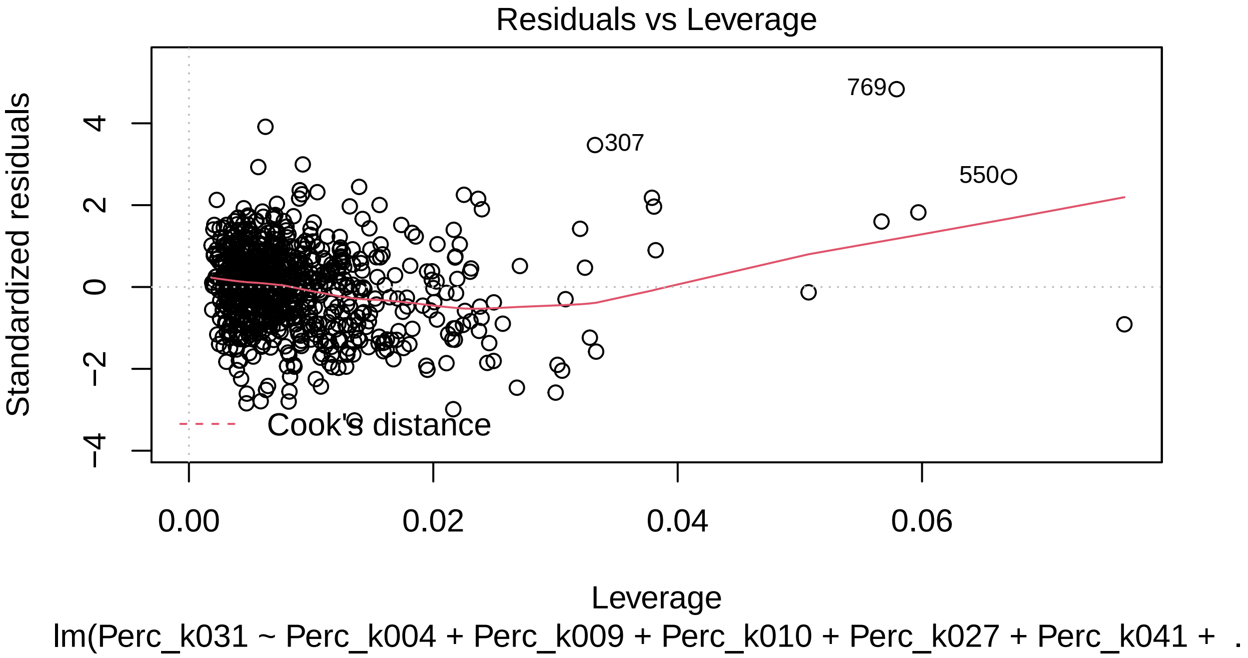
```
# cook's distance c = 2

Household_model %>%
  plot(which = c(2))
```



```r
# cook's distance c = 3

Household_model %>%
  plot(which = c(3))
```



```r
# cook's distance c = 5

Household_model %>%
  plot(which = c(5))
```



# Results and Discussion

In order to find the relationship between dependent and independent variables, regression analysis is a statistical process. Multiple linear regression, which is a supervised machine learning technique, was used in this exercise to construct a model that predicts the value of the outcome variable k031 (house holding owned or shared ownership of property) based on the other variables used in question A.1 of the exploratory study. As follows, the simple multiple linear regression equation can be seen:

This project the household model will

property ownershipi = (model) + errori

property ownershipi - Outcome variable

All the remaining variables with different variable statistical units are used to construct a robust model for the existence of households that own or have shared land. k004 – Persons aged 45 to 64 per Output Area (OA). Persons is the statistical unit for this variable. Since OAs differ in size and composition, the % of people aged 45 to 64 per OA can be estimated using the Total_Population, which is more stable as it normalizes the data. k009 – Persons aged over 16 who are all single per OA. Person_16_Over is the statistical unit for this variable. Since OAs differ in size and composition, the % per OA can be estimated using the Total_Population_16_ and_Over. k010 – Persons aged over 16 who are all married or in a registered same-sex civil relationship. Person_16_Over is the statistical unit for this variable. Since OAs differ in size and composition, the % per OA can be estimated using the Total_Population_16_ and_Over. k027 – Households who live in individual house bungalow and house. Household_Spaces is the statistical unit for this variable. Since OA's differ in size and composition, the % of households per OA can be estimated using the Total_Household_Spaces. k041 – Households count with 2 or more vans or cars per OA. Household is the statistical unit for this variable. Since OA's differ in size and composition, the %

of households per OA with 2 or more vans or cars can be estimated using the Total_Household. k046 – Employed persons aged between 16 and 74 works part-time. Employment_16_to_74 is the statistical unit for this variable. Since OA's differ in size and composition, the % of households per OA can be estimated using the Total_Employment_16_to_74.

The hypothesis for multiple regression analysis is – 1.Normality – To check the normality of standard residuals, the Shapiro-Wilk test is used. For the model to be stable, the test should not be relevant. 2.Homoscedacity – To check the homoscedasticity of standard residuals, the Breusch-Pagan test is used. For the model to be stable, the test should not be relevant. 3.Independence – To check the independence of residuals, the Durbin-Watson test is used. 4.Multicollinearity – The Variance Inflation Factor (VIF) test is performed where there might be non-multicollinearity if the largest VIF value is greater than 10 or the average VIF is greater than 1.

The model output produced for the variable k031 indicates that the model is not fit, indicating the percent of households owning or having joint ownership of property can account for the model based on the different variable Individual count, household and jobs. However, the model is not stable. The residuals are not normally distributed, but the residuals do not fulfill the assumption of homoscedasticity (Breusch-Pagan test, BP = 32.155, p<0.001), nor the assumption of independence (Durbin-Watson test, DW = 1.7526, p<0.01).

The residuals are also visually analysed by plotting different plots such as the Residuals Vs Fitted and the scale-location plot provides an insight into the residuals' homoscedasticity, the standard Q-Q plot provides an example of the residuals' normality, and the Vs leverage residuals can be useful to distinguish unusual cases.