

# Stroke Report

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## INTRODUCTION TO STROKE

Stroke is one of the leading causes of death globally. Sometimes it is also called a brain attack. A stroke happens when something is blocking the blood supply to a part of the brain. Also a Stroke happens when a vessel in the brain bursts. In either case, this stops the flow of blood and due to this, part of the brain becomes damage or dies. Unfortunately when this happens it can cause lasting brain damage, long-term disability and even in some cases the death. Our brain controls our movements, stores our memories, and it is the source of our thoughts, emotions and our language. Besides these functions also the brain controls functions like breathing and controls our digestion.

Our brain uses 20% of the oxygen we breathe and the arteries deliver our oxygen-rich blood to all the sections of our brain.

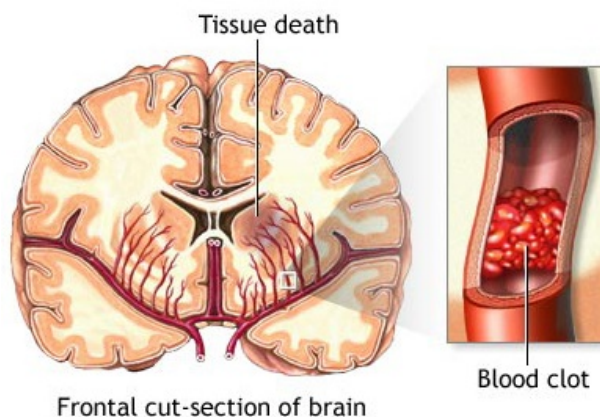


Image taken from CDC.gov

A stroke happens when a blood clot blocks blood flow to the brain or when there is a bursts that prevents the flow of blood

The stroke is the third major cause of disability. Long term disability affects people severely, in terms of their productive life. The aim of this report is to identify the risk factors and with them be able to predict if someone has high risk of having a Stroke.

The patient dataset was obtain from **Kaggle** the process and methods to ascertain whether a variable is a risk factor will be evaluated and described. We will visualized and discovered insights of the dataset, ending with a conclusion and some ideas and suggestions for future work on the reserach for early symptions that could help prevent an actual Stroke.

From Kaggle we get the description of the columns in our dataset:

- 1) id: unique identifier
- 2) gender: Male, Female or Other
- 3) age: age of the patient
- 4) hypertension: 0 if the patient doesn't have hypertension, 1 if the patient has hypertension
- 5) heart\_disease: 0 if the patient doesn't have any heart diseases, 1 if the patient has a heart disease
- 6) ever\_married: "No" or "Yes"
- 7) work\_type: "children", "Govt\_jov", "Never\_worked", "Private" or "Self-employed"
- 8) Residence\_type: "Rural" or "Urban"
- 9) avg\_glucose\_level: average glucose level in blood
- 10) bmi: body mass index
- 11) smoking\_status: "formerly smoked", "never smoked", "smokes" or "Unknown"\*
- 12) stroke: 1 if the patient had a stroke or 0 if not

\*Note: "Unknown" in smoking\_status means that the information is unavailable for this patient

In the next section we will first do a data preprocessing and then we will execute the exploratory data analysis and then work on the models.

## DATA PREPROCESSING ANALYSIS:

The Dataset consists of:

```
stroke_data <- read.csv("stroke.csv", header = TRUE)
dim(stroke_data)
```

```
## [1] 5110 12
```

We have 5110 records and 12 columns, 11 potential predictors and the column that indicates if the patient got actually a stroke or not.

Now we will be exploring one by one the potential predictors:

### 1) ID : Unique Identifier

This is a number to identify the patient but it is irrelevant because does not provide any meaningful information for our future models so we will delete this column from our dataset by applying this code:

```
stroke_data <- subset( stroke_data, select = -id )
```

### 2) Gender: The specific gender of the patients

With the following will generate the actual distribution of the gender within the dataset:

```
stroke_data %>%
  group_by(gender) %>%
  summarise(total = n())
```

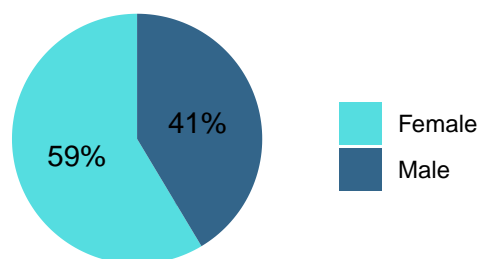
```
## # A tibble: 3 x 2
##   gender total
##   <chr>   <int>
## 1 Female  2994
## 2 Male   2115
## 3 Other    1
```

We see that there is just one record of an “Other” gender, having just one record is insignificant to the dataset and the future prediction models so we will eliminate it from the dataset using this code:

```
stroke_data <- subset( stroke_data, stroke_data$gender != "Other" )
```

Now the dataset has the following distribution of Gender of Patients:

PATIENT GENDER DISTRIBUTION



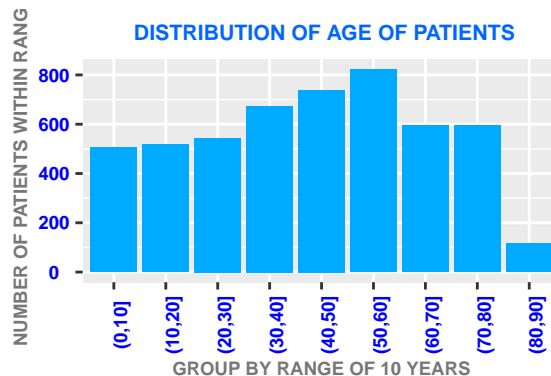
### 3) Age: Distribution of the age of the patients

Generating the summary of how the age is distributed within our patients

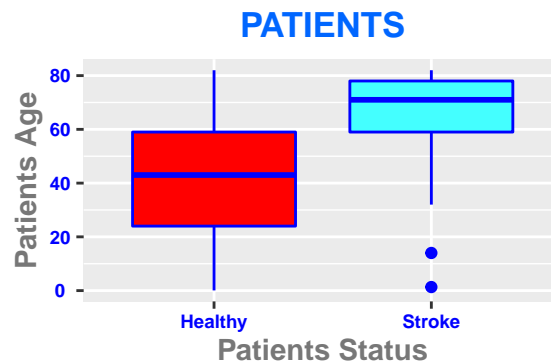
```
summary(stroke_data$age)
```

```
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##      0.08  25.00   45.00   43.23  61.00   82.00
```

The next chart shows how the patients are distribute by grouping them in ranges of 10 years of age



With the following BoxPlot we can see very clear that there is a tendency for older patient to have a Stroke:



#### 4) Hypertension: Information if the patient had hypertension or not

With the following code we visualized the total patients that have hypertension and the ones without hypertension

```
stroke_data %>%
  mutate(text = ifelse(hypertension==0,"Without Hypertension","With Hypertension")) %>%
  group_by(text) %>%
  summarise(total = n())
```

```
## # A tibble: 2 x 2
##   text          total
##   <chr>         <int>
## 1 With Hypertension    498
## 2 Without Hypertension 4611
```

Showing in a pie chart the hypertension distribution within our set:

#### HYPERTENSION DISTRIBUTION



#### 5) Heart Disease: Information if the patient had a problem in his heart or not

With the following code we visualized the total patients that have heart problems and the ones without any problem in their heart

```
stroke_data %>%
  mutate(text = ifelse(heart_disease==0,"Without Heart Problem","With Heart Problem")) %>%
  group_by(text) %>%
  summarise(total = n())
```

```
## # A tibble: 2 x 2
##   text          total
##   <chr>         <int>
## 1 With Heart Problem    276
## 2 Without Heart Problem 4833
```

The following pie chart shows the distribution of the patients with problems in their heart:

#### HEART DISEASE DISTRIBUTION



#### 6) ever\_married: Information if the patient had been married or not

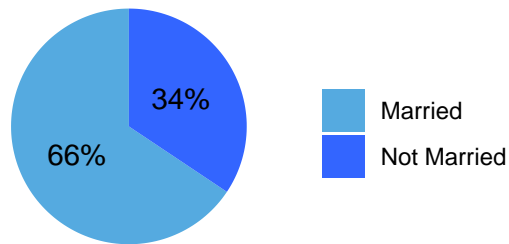
With the following code we are able to visualize how many patients were married and how many were never married:

```
stroke_data %>%
  mutate(text = ifelse(ever_married=="Yes","Married","Not Married")) %>%
  group_by(text) %>%
  summarise(total = n())
```

```
## # A tibble: 2 x 2
##   text          total
##   <chr>         <int>
## 1 Married    3353
## 2 Not Married 1756
```

The following pie chart shows the distribution of the Patients that were Married against the ones that were never married:

PATIENT MARRIED DISTRIBUTION



## 7) work\_type: We will show the information if the patient have work and what type of work

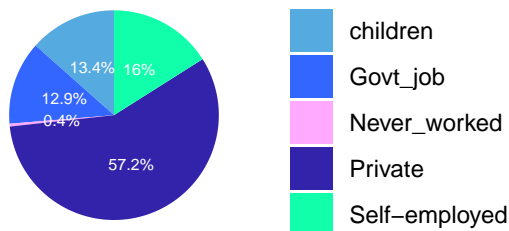
With the following code shows the amount of the patients by their work situation unless they are children:

```
stroke_data %>%
  group_by(work_type) %>%
  summarise(total = n())
```

```
## # A tibble: 5 x 2
##   work_type    total
##   <chr>      <int>
## 1 children     687
## 2 Govt_job     657
## 3 Never_worked   22
## 4 Private    2924
## 5 Self-employed  819
```

With the following code we will show a pie chart with the work distribution of the patients:

PATIENT WORK DISTRIBUTION



## 8) Residence\_type: defines where the patients life in urban area or rural area

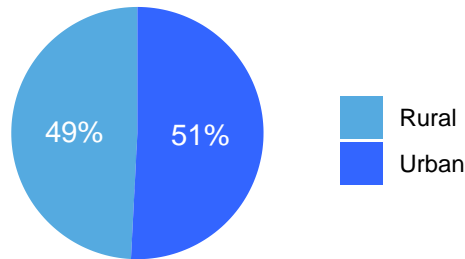
With the following code summarizes where patients residence is:

```
stroke_data %>%
  group_by(Residence_type) %>%
  summarise(total = n())
```

```
## # A tibble: 2 x 2
##   Residence_type total
##   <chr>      <int>
## 1 Rural      2513
## 2 Urban      2596
```

The following is a pie chart showing the distribution of the patients residence:

PATIENT RESIDENCE DISTRIBUTION



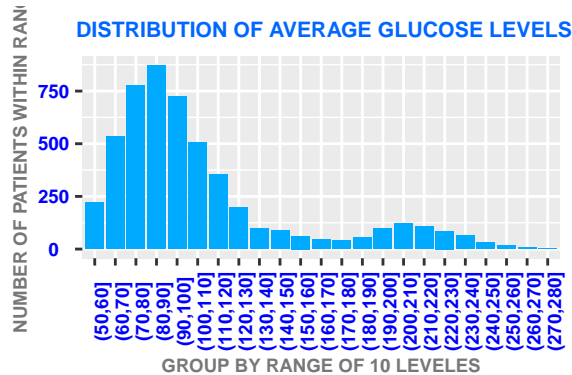
### 9) avg\_glucose\_level: defines the glucose levels of the patients in the set

With the following code we generate the summary of the statistics of the average glucose level with the dataset:

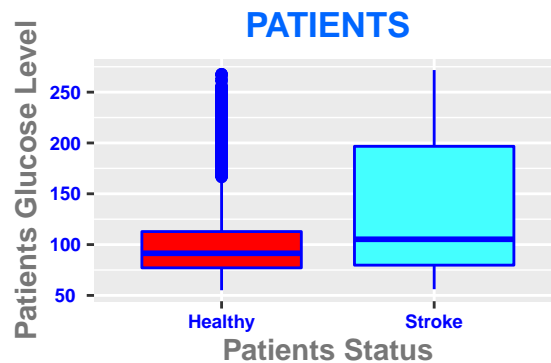
```
summary(stroke_data$avg_glucose_level)
```

```
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   55.12   77.24   91.88  106.14  114.09  271.74
```

The following chart shows the distribution in ranges from the lower limit to the higher limit with increments of 10 units:



We show a box plot of the patients that had a stroke as well as the ones healthy:



The patients with high level of glucose tend to be more prone to have a Stroke.

### 10) bmi: defines the Body Mass Index of the patients in the set

Reviewing the information of the Body Mass Index (bmi) levels, there are patients without this information with an N/A in these row and also we identify that the values of the bmi are strings within the dataset instead of numbers, with the following code we are showing the summary of bmi

```
# To avoid warning due to N/A will disable them during this code execution
options(warn = -1) # To avoid Warning due to N/A
summary(as.numeric(stroke_data$bmi), na.rm=TRUE)
```

```
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.     NA's
##    10.30   23.50   28.10   28.89   33.10   97.60     201
```

With the following code we will review what patients do not have bmi information and had not had any stroke:

```
# How many records we have without bmi information and that have not had any stroke
sum(stroke_data$bmi=="N/A" & stroke_data$stroke==0)
```

```
## [1] 161
```

With the following code we will review what patients that do not have bmi information and had a stroke:

```
# How many records we have without bmi information and that had a stroke
sum(stroke_data$bmi=="N/A" & stroke_data$stroke==1)
```

```
## [1] 40
```

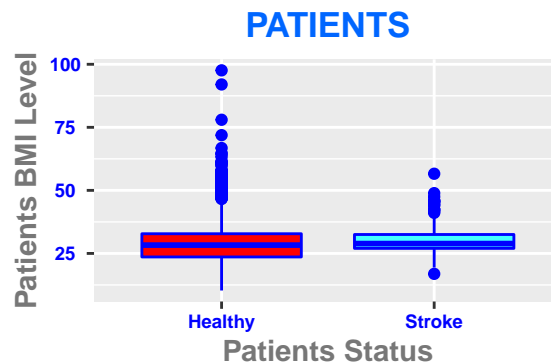
Due that these 201 registries ( 161 that have not suffer a stroke and 40 that suffer a stroke ) we consider this relevant for our study and predictions of Stroke, so we will be calculate the average bmi of the dataset using this code:

```
# Calculate the mean of bmi
bmimean <- mean(as.numeric(stroke_data$bmi), na.rm = TRUE)
```

Adding a new column in our dataset with the patients bmi number, instead of the string and also for the patients without bmi information the mean of bmi will be assigned to them. The following code achieves this:

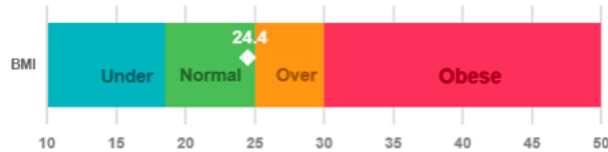
```
stroke_data <- stroke_data %>%
  mutate( bmi_num = ifelse(bmi=="N/A",bmimean,as.numeric(bmi)))
# Return to normal warnings
options(warn = 0L)
# Clearing the temporary variable bmimean to keep the environment clean
rm(bmimean)
```

The following boxplot shows the distribution of the patients that had a stroke and the healthy ones:



In a research of the BMI information we see the following pictures:



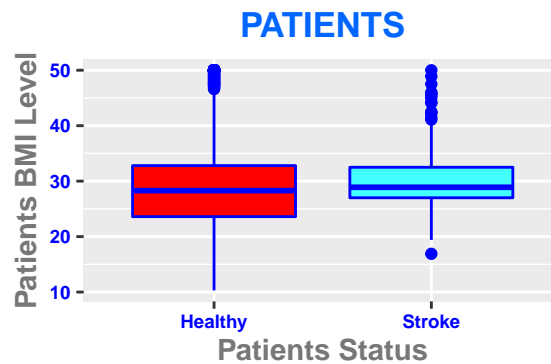


As seen here, anyone above 50 is extremely obese, so values on top of 56 of BMI seem out of range. All the outliers of patients above 50 will be adjusted to 56 to avoid distortion in the models.

With the following code we will adjust this:

```
stroke_data <- stroke_data %>%
  mutate(bmi_num = ifelse(bmi_num >=50,50, bmi_num))
```

Showing the boxplot after the adjustment:



We do not see any specific trend with the BMI distribution between healthy patients and patients that had a stroke.

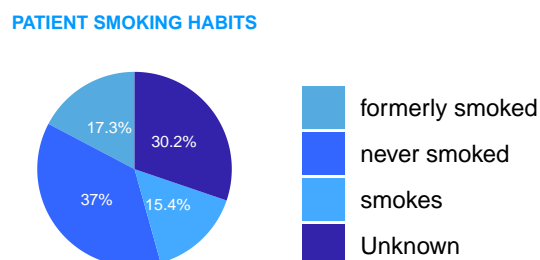
## 11) smoking\_status: defines the patient relation to smoking

With the following code we show the distribution of the patients based on their smoking status:

```
stroke_data %>%
  group_by(smoking_status) %>%
  summarise(total = n())
```

```
## # A tibble: 4 x 2
##   smoking_status total
##   <chr>          <int>
## 1 formerly smoked  884
## 2 never smoked    1892
## 3 smokes          789
## 4 Unknown        1544
```

In the following pie chart we observe the distribution of the smoking habits of the patients:



Note: "Unknown" in smoking\_status means that the information is unavailable for this patient

### Stroke Patient in the Dataset:

With the following code we visualize the amount of stroke patients against the health patients in the dataset:

```
stroke_data %>%  
  mutate(text = ifelse(stroke==0,"Healthy Patients","Stroke Patients")) %>%  
  group_by(text) %>%  
  summarise(total = n())
```

```
## # A tibble: 2 x 2  
##   text          total  
##   <chr>         <int>  
## 1 Healthy Patients 4860  
## 2 Stroke Patients  249
```

The following Pie chart show the distribution between Stroke Patients and Healthy Patients

TOKE PATIENTS VS. HEALTH PATIENTS



### General and preparation for models

For a correlation check it only accepts numerical variables and also for fitting models, so we are preprocessing all categorical variables to numbers, encoding them. Also we will scale age, avg\_glucose\_level and bmi because if we keep predictors that are measured at different scales they will not contribute equally to our fitting models and could create a bias. To deal with this possible problem we will standardized the age, avg\_glucose\_level and bmi to have a ( $\mu = 0, \sigma = 1$ ) before we start the fitting of the models

The following code achieves all the transformation:

```
# mean of age  
age_mean <- mean(stroke_data$age)  
# sd of age  
age_sd <- sd(stroke_data$age)  
# mean of glucose  
glucose_mean <- mean(stroke_data$avg_glucose_level)  
# sd of glucose  
glucose_sd <- sd(stroke_data$avg_glucose_level)  
# mean of bmi  
bmi_mean <- mean(stroke_data$bmi_num)  
# sd of bmi  
bmi_sd <- sd(stroke_data$bmi_num)  
  
# We need to change our categorical variables to  
stroke_data_num <- stroke_data %>%  
  # Gender: Female 0, Male 1  
  mutate(gender_num=ifelse(gender=="Female",0,1)) %>%
```

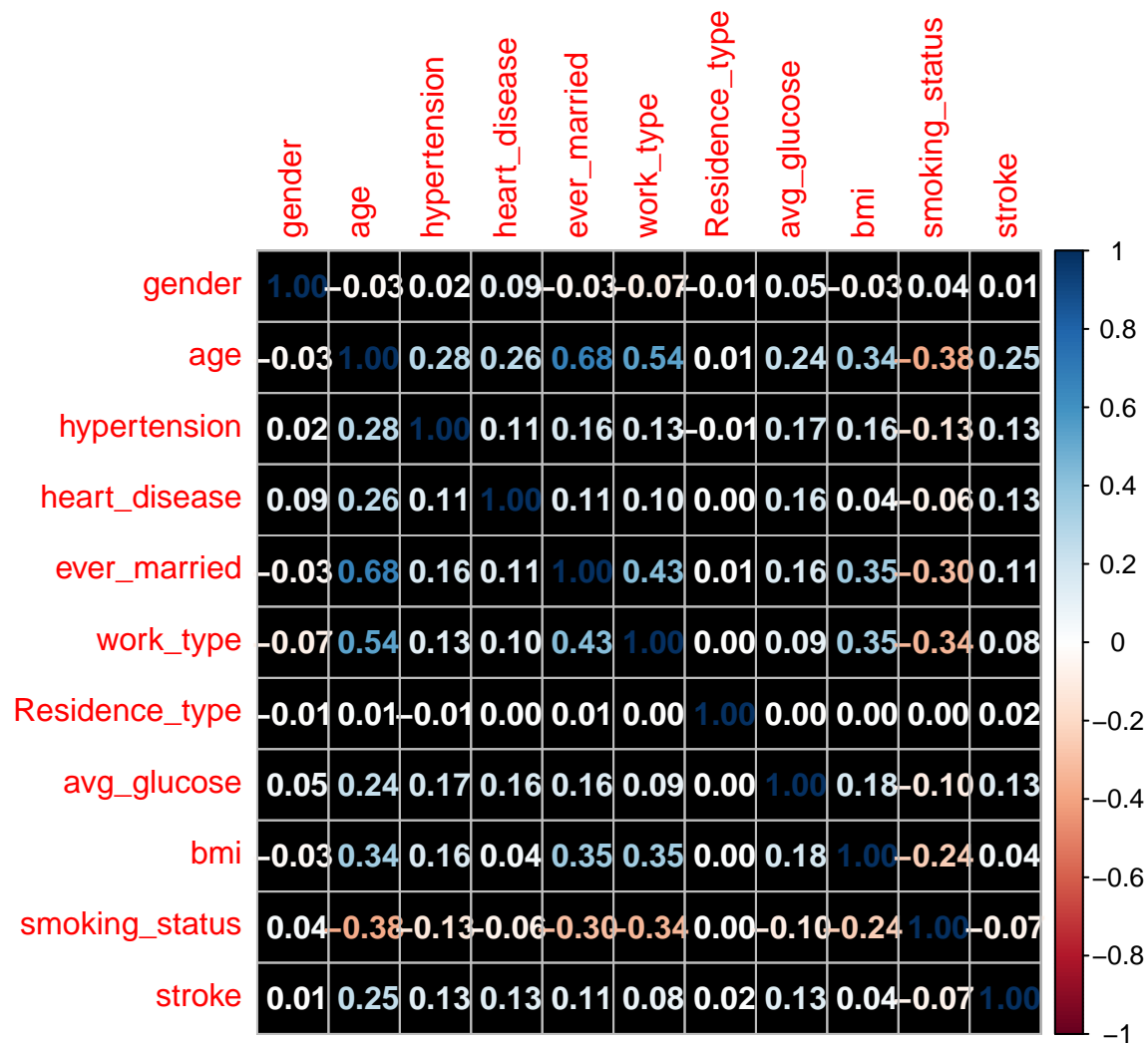
```

# Married: Not_Married 0, Married 1
mutate(married_num=ifelse(ever_married=="Yes",1,0)) %>%
# In the following section we will be passing from text to numbers of work type
# children 0, Govt_job 1, Never_worked2, Private 3, Self-employed 4
mutate(work_type_num=sapply(work_type, function(x)
  switch(x,"children"= 0,"Govt_job"= 1,"Never_worked"= 2,"Private"= 3,
    "Self-employed"= 4))) %>%
# Residence_type: Rural 0, Urban 1
mutate(Residence_type_num=ifelse(Residence_type=="Urban",1,0)) %>%
# In the following section we will be passing from text to numbers of smoking status
# formerly smoked 0, never smoked 1, smokes 2, Unknown 3
mutate(smoking_status_num=sapply(smoking_status, function(x)
  switch(x,"formerly smoked"= 0,"never smoked"= 1,"smokes"= 2,"Unknown"= 3))) %>%
# Adjust/Fit the values of age
mutate(age_fit=((age - age_mean)/age_sd)) %>%
# Adjust/Fit the values of glucose
mutate(glucose_fit=((avg_glucose_level - glucose_mean)/glucose_sd)) %>%
# Adjust/Fit the values of bmi
mutate(bmi_fit=((bmi_num - bmi_mean)/bmi_sd)) %>%
dplyr::select(gender=gender_num, age=age_fit, hypertension,
  heart_disease, ever_married=married_num,
  work_type=work_type_num, Residence_type=Residence_type_num,
  avg_glucose= glucose_fit, bmi = bmi_fit,
  smoking_status=smoking_status_num, stroke )

# We remove the temporary values to keep as clean as possible the environment
rm(age_mean,age_sd,bmi_mean,bmi_sd,glucose_mean,glucose_sd)

```

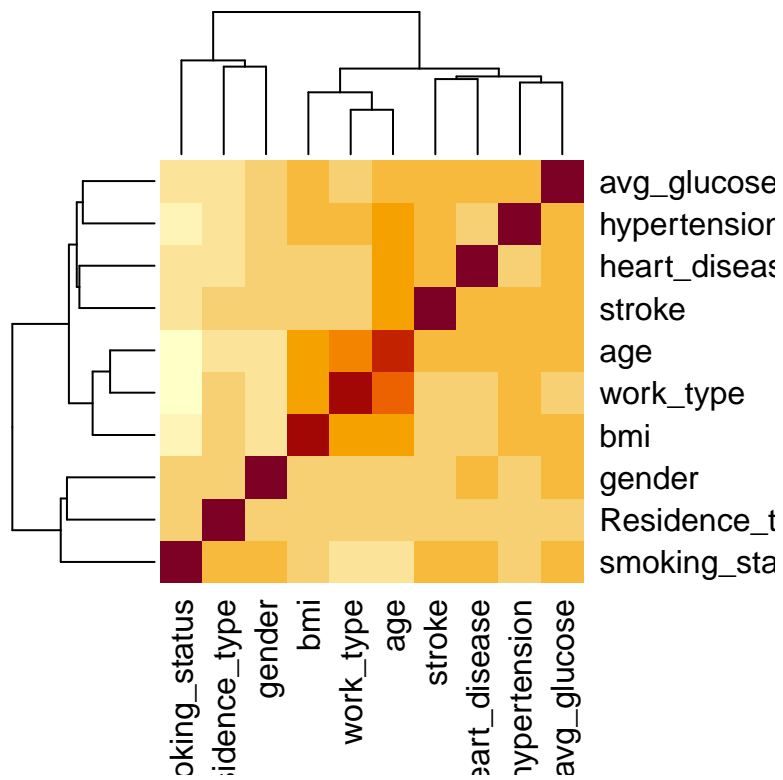
This is the correlation matrix:



There seems to be Multicollinearity between age and ever\_married because we have a high correlation of 0.68 in principle age contains more information if a patient is susceptible to a stroke and we will discard ever\_married from our predictors, the following code will execute this:

```
stroke_data_num <- subset( stroke_data_num, select = -ever_married )
```

The following is the Headmap of the predictors:



## MODELS

## CONCLUSION