

# US SChools Measles Immunization Exploration

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This R markdown explores the records of overall and MMR immunization from 46410 schools from 32 US states between 2017 and 2019. The aim of this study was to understand the vaccination reports from schools in 32 US states. The questions we would try to answer are:

1. How did the vaccination rates vary by states?
2. If the type of school affected the reported vaccination rates?
3. Where can the future efforts be focused in order to bring better awareness of the vaccination benefits?

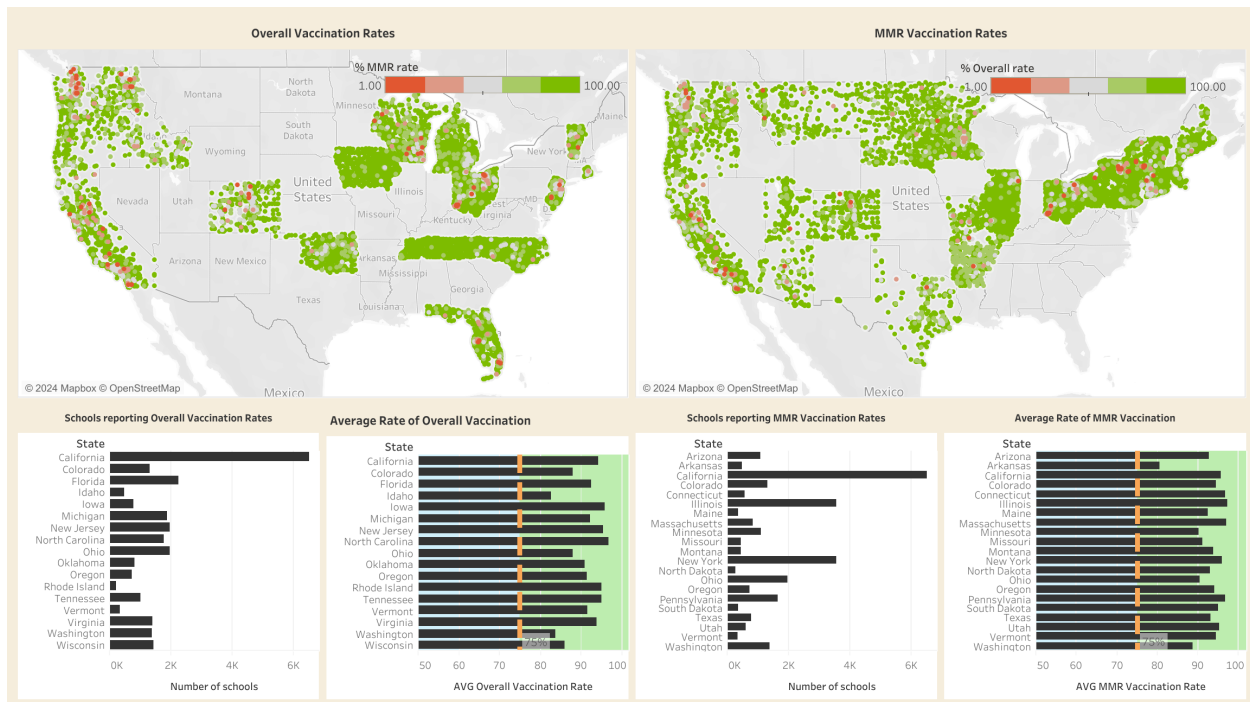


Figure 1: MMR and Overall Vaccination Rates in US schools

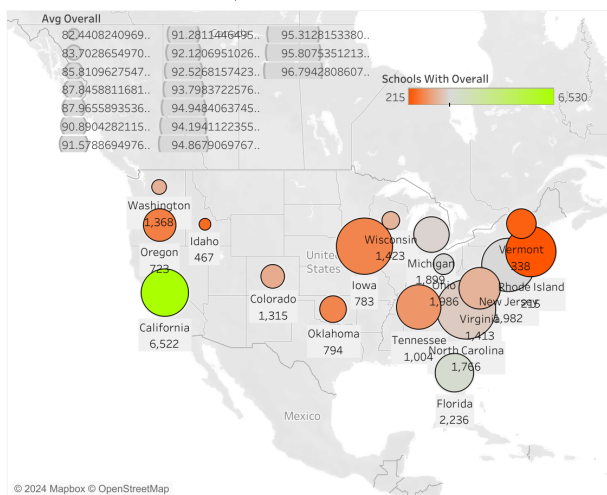
This notebook was built with R version 4.4.0

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Number of schools that reported overall vaccinations



Number of schools that reported MMR vaccinations

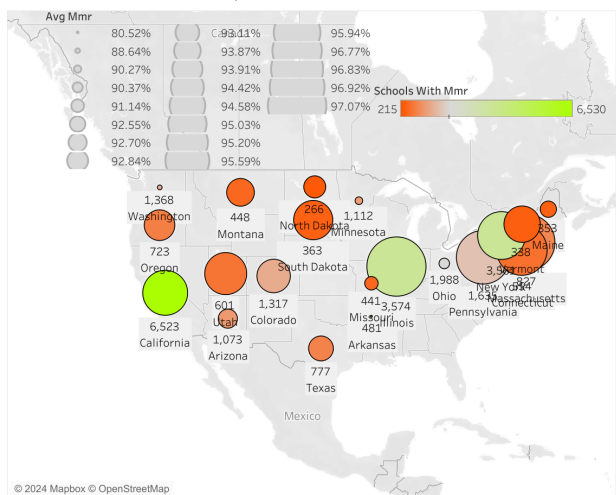


Figure 2: Statewise analysis

```
library(tidyverse)
library(rvest)
library(dplyr)
library(ggplot2)
library(pivottabler)
library(ggpattern)

`~%notin%` <- Negate(`~in%`)

##If you are downloading the code and running it locally,
##set the working directory to where the dataset is located
##setwd("C:/....../GoogleDataAnalyticsCapstoneProject")
```

“This repository contains immunization rate data for schools across the U.S., as compiled by The Wall Street Journal. The dataset includes the overall and MMR-specific vaccination rates for 46,412 schools in 32 states. As used in “What’s the Measles Vaccination Rate at Your Child’s School?”.

Vaccination rates are for the 2017-18 school year for Colorado, Connecticut, Minnesota, Montana, New Jersey, New York, North Dakota, Pennsylvania, South Dakota, Utah and Washington. Rates for other states are 2018-19.”

The cleaning process produces a .csv file with following columns:

variable	class	description
index	double	Index ID
state	character	School's state
year	character	School academic year
name	character	School name
type	character	Whether a school is public, private, charter
city	character	City
county	character	County
district	character	School district
enroll	double	Enrollment
mmr	double	School's Measles, Mumps, and Rubella (MMR) vaccination rate
overall	double	School's overall vaccination rate
xrel	double	Percentage of students exempted from vaccination for religious reasons
xmed	double	Percentage of students exempted from vaccination for medical reasons
xper	double	Percentage of students exempted from vaccination for personal reasons
lat	double	Latitude
lng	double	Longitude

## 1. Data Cleanup

**Following code adds latitude and longitude to the dataset.** The initial cleaning code from tidyTuesday had to be modified because :

- It was resulting in an error, possibly because the page where the list of URLs for individual states was coming from has changed since the code was published.
- When we were adding the latitude and longitude data from the states to the original vaccination file, it was being done only with school name and if one state had multiple schools with the same name, that was leading to a many to many matching, resulting in a Cartesian matching and duplication.)

### 1.1 Adding geolocation

```
# url_wsjsj <- "https://raw.githubusercontent.com/WSJ/measles-data/master/all-measles-rates.csv"
#
# wsjsj <- read_csv(url_wsjsj)
#
# list_of_urls <- "https://github.com/WSJ/measles-data/tree/master/individual-states"
#
# raw_states <- list_of_urls %>%
#   read_html() %>%
#   html_table() %>%
#   .[[1]] %>%
#   select(1) %>%
```

```
##changed select(Name) to select(1) because there were three columns with headers 'Name'
# mutate(Name = str_remove(Name, "\\\\.csv")) %>%
# filter(str_length(Name) > 3, str_length(Name) < 20) %>%
# pull(Name)
#
# # had to add this line of code because the first element on the list was
# #"parent directory.." and the last, 33rd element was "View all files"
# raw_states=raw_states[2:32]
#
# all_states <- glue::glue(
#   "https://raw.githubusercontent.com/WSJ/measles-data/master/individual-states/"
#   {raw_states}.csv") %>%
#   map(read_csv)
```

As it turns out, not every state had city, county, and district information included in the individual datasets. Hence in the original code was matching based on just the name of the school and state. This was leading to cross matching in states where multiple schools with same name were present

```
##Do not use this code, use the next block with updated version
## clean_states <- all_states %>%
##   map(~select(., state, name, lat, lng)) %>%
##   map(~mutate_at(., vars(lat, lng), as.numeric)) %>%
##   bind_rows() %>%
##   filter(!is.na(lat))
```

Hence added as many parameters that could have been added out of “state”, “name”, “district”, “county”, “city” for each state

```
# clean_states <- all_states %>%
#   map(~select(., tidyselect::
#     any_of(c("state", "name", "district", "county", "city", "lat", "lng")))) %>%
#   map(~mutate_at(., vars(lat, lng), as.numeric)) %>%
#   bind_rows() %>%
#   filter(!is.na(lat))
#
# wsj1 <- wsj %>%
#   left_join(clean_states, by = c("name", "state", "district", "county", "city"))
```

Creating a new identifier to remove duplications

```
#wsj1=mutate(wsj1,new_id=paste0(state,year,name,type,city,county,district,enroll,
#                               mmr,overall,xrel,xmed,xper))
#wsj1=wsj1[!duplicated(wsj1$new_id),]
```

You can save the dataset as

```
#write_csv(select(wsj1,-"new_id"),"measles_nonduplicated.csv")
```

## 1.2 Correcting incorrect longitudes

Looking at the data on Tableau revealed another problem with the data. 86 of the records, 3 from Florida and 83 from Vermont, had incorrect longitudes,



Upon checking with google maps, it was clear that in some cases the longitudes were marked as +ve where should have been -ve,

```
# tmp=wsj1[wsj1$lng>0,]
# tmp[!is.na(tmp$name),]
# rm(tmp)
```

and this problem persisted in the source files where the latitudes and longitudes were taken from.

```
# clean_states[clean_states$lng>0,]
```

However, in most cases, it looked like the latitudes were incorrectly entered as longitudes. Since it was not possible to correct each and every case manually, it was decided that for these 86 cases, the incorrect longitudes would be replaced with generated longitudes usually assigned to the respective state by Tableau. Tableau assigns -72.7678 to Vermont and -81.55 to Florida.

```
# wsj1$lng[(wsj1$state=="Vermont" & wsj1$lng>0)]= -72.7678
# wsj1$lng[(wsj1$state=="Florida" & wsj1$lng>80)]= -1* wsj1$lng[(wsj1$state=="Florida" & wsj1$lng>0)]
# wsj1$lng[(wsj1$state=="Florida" & wsj1$lng>0)]= -81.55
#
# write_csv(select(wsj1,-"new_id"),"measles_nonduplicated_ModifiedIncorrectLng.csv")
```

## 2. Data review

```
#Read your locally saved file
vacc_rec=read_csv("measles_nonduplicated_ModifiedIncorrectLng.csv")
```

```
## Rows: 46410 Columns: 16
## -- Column specification -----
## Delimiter: ","
## chr (7): state, year, name, type, city, county, district
## dbl (9): index, enroll, mmr, overall, xrel, xmed, xper, lat, lng
##
## 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.
```

### 2.1 Checking for missing values

```
length(vacc_rec$mmr[is.na(vacc_rec$mmr)])
```

Checking for any NAs in mmr and overall column

```
## [1] 0
```

```
length(vacc_rec$overall[is.na(vacc_rec$overall)])
```

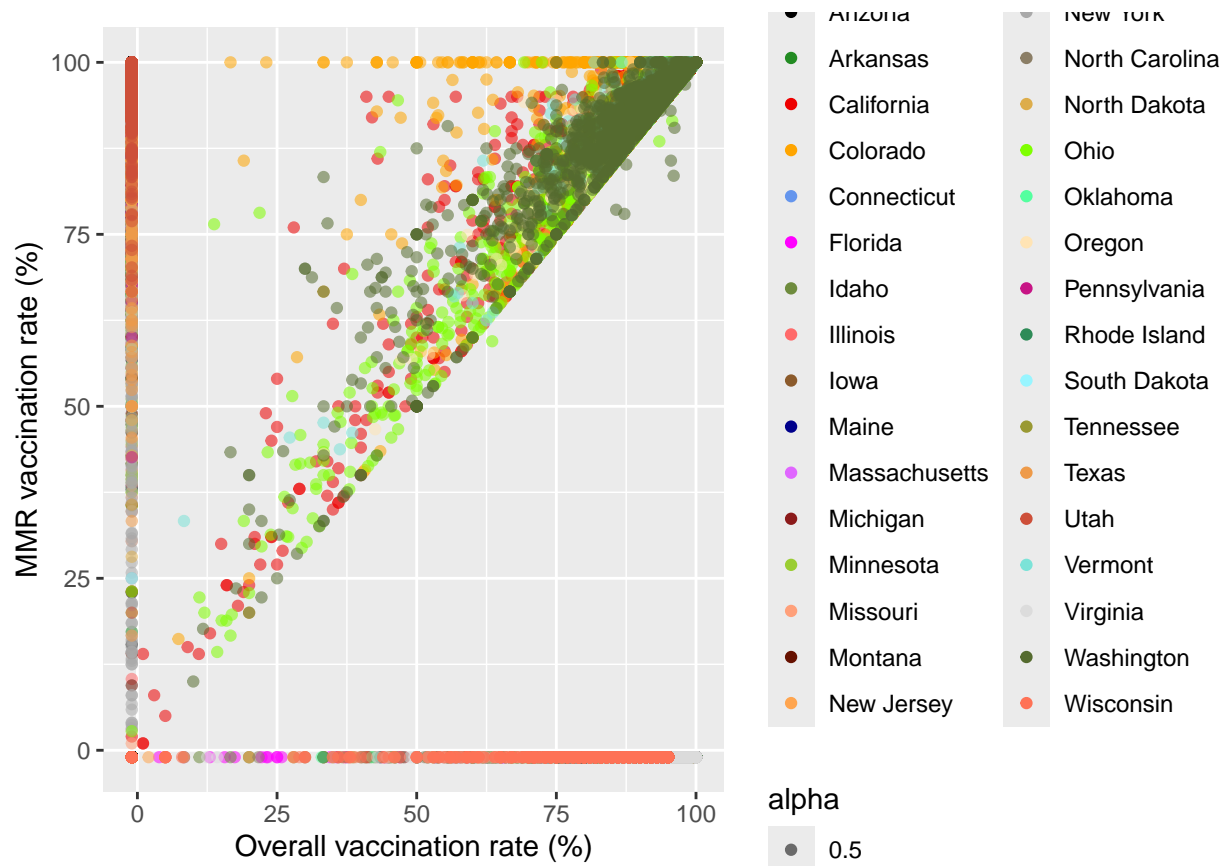
```
## [1] 0
```

Lack of report from a school is represented as -1 in this dataset.

20176 or 43.47 % of schools did not report overall vaccination rates.

18087 or 38.97 % of schools did not report mmr vaccination rates.

```
ggplot(data = vacc_rec) +  
  geom_point(mapping = aes(x = overall, y = mmr, color=state, alpha=0.5)) +  
  labs(x='Overall vaccination rate (%)',y='MMR vaccination rate (%)') +  
  scale_color_manual(values = c('black','forestgreen', 'red2', 'orange',  
                                'cornflowerblue', 'magenta', 'darkolivegreen4',  
                                'indianred1', 'tan4', 'darkblue', 'mediumorchid1',  
                                'firebrick4', 'yellowgreen', 'lightsalmon', "#661100",  
                                "tan1",'darkgray', 'wheat4', '#DDAD4B', 'chartreuse',  
                                'seagreen1', 'moccasin', 'mediumvioletred', 'seagreen',  
                                'cadetblue1', '#999933', 'tan2', 'tomato3', '#7CE3D8',  
                                'gainsboro','darkolivegreen','coral1','darkorange4'))
```



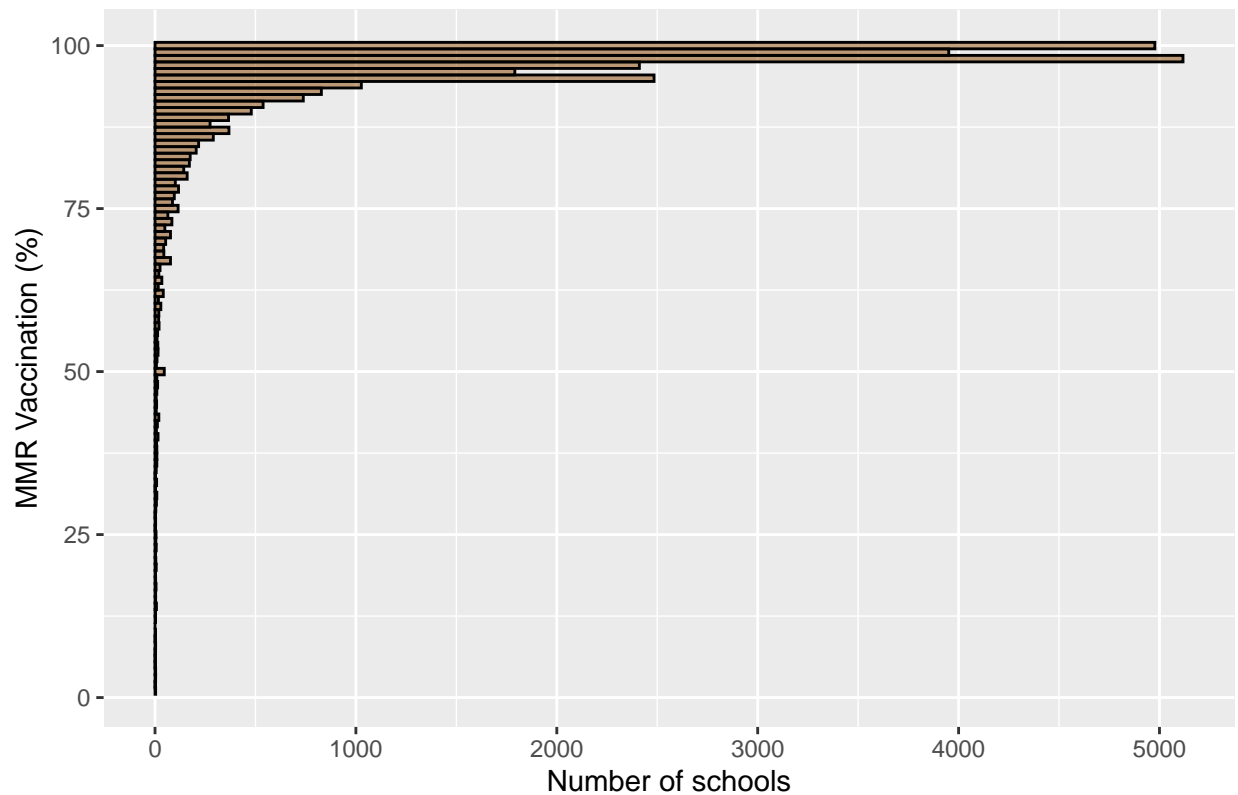
28323 or 61.03 % of the schools reported MMR vaccination rates.

94.21 % of the schools that reported MMR vaccinations had 80% or more of the kids vaccinated, and

only 0.89 % of the schools had MMR vaccination rate under 50%.

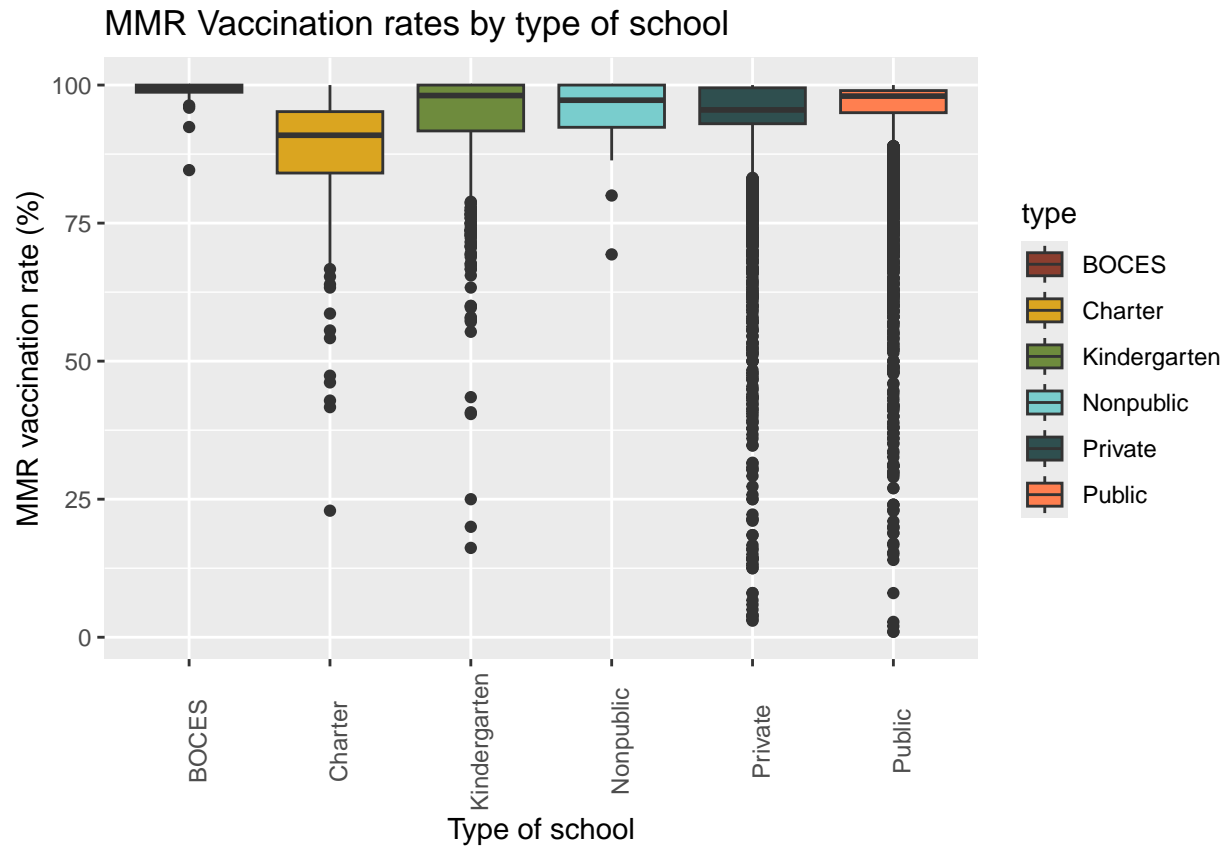
```
ggplot(data=vacc_rec[vacc_rec$mmr!=-1,],aes(y=mmr))+
  geom_histogram(binwidth=1,fill="darkorange4",alpha=0.5, color='black') +
  labs(title='Number of Schools vs % of students with MMR vaccination',
        x='Number of schools',y='MMR Vaccination (%)')
```

Number of Schools vs % of students with MMR vaccination

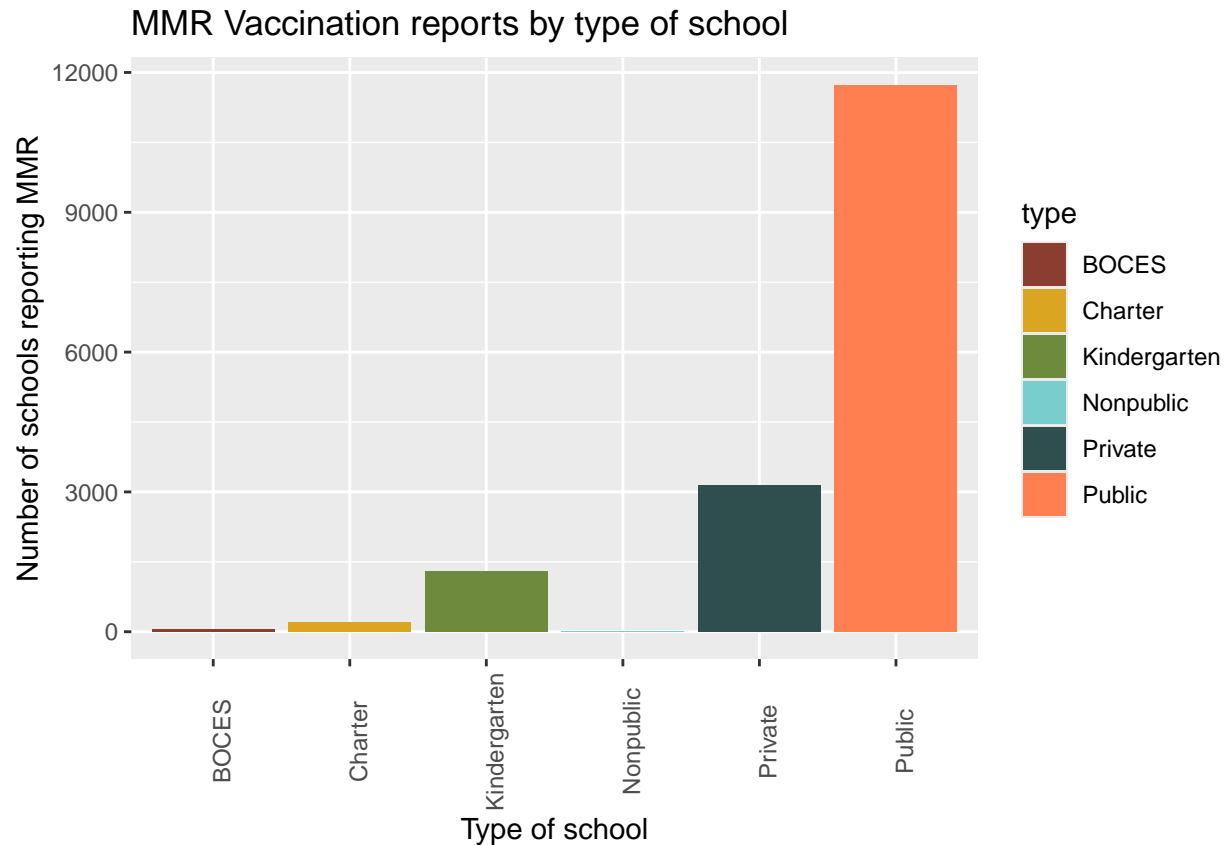


```
ggplot(data = vacc_rec[vacc_rec$mmr != -1 & !is.na(vacc_rec$type),], aes(x=type, y=mmr)) +
  geom_boxplot(aes(fill=type))+
  labs(title='MMR Vaccination rates by type of school',x=('Type of school'),
        y='MMR vaccination rate (%)') +
  scale_fill_manual(values=c('BOCES' = 'coral4', 'Charter' = 'goldenrod',
                              'Kindergarten' = 'darkolivegreen4', 'Private' = 'darkslategray',
                              'Nonpublic' = 'darkslategray3', 'Public' = 'coral'))+
  theme(axis.text.x = element_text(angle = 90))
```



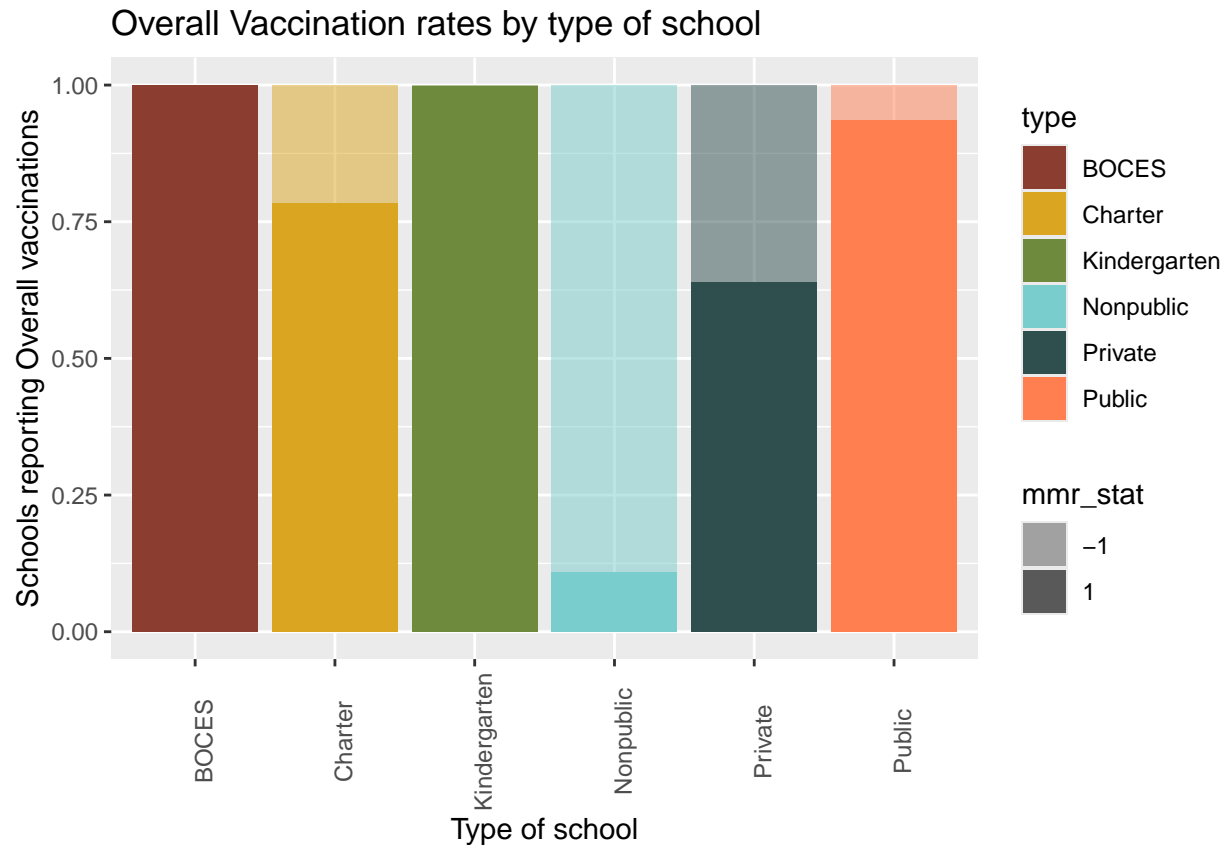


```
ggplot(data = vacc_rec[vacc_rec$mmr!=-1 & !is.na(vacc_rec$type),]) +
  geom_bar(mapping = aes(x = type, fill=type)) +
  labs(title='MMR Vaccination reports by type of school',x=('Type of school'),
        y='Number of schools reporting MMR') +
  scale_fill_manual(values=c('BOCES' = 'coral4', 'Charter' = 'goldenrod',
                             'Kindergarten' = 'darkolivegreen4','Private' = 'darkslategray',
                             'Nonpublic' = 'darkslategray3', 'Public' = 'coral'))+
  theme(axis.text.x = element_text(angle = 90))
```



```
tmp = mutate(vacc_rec, mmr_stat= ifelse(mmr!=-1, 1, -1))
tmp$mmr_stat=factor(tmp$mmr_stat)
tmp = tmp[!is.na(tmp$type),]

ggplot(data = tmp) +
  geom_bar(mapping = aes(x = type, fill= type ,alpha = mmr_stat), position="fill") +
  labs(title='Overall Vaccination rates by type of school', x=('Type of school'),
        y='Schools reporting Overall vaccinations') +
  scale_fill_manual(values=c('BOCES' = 'coral4', 'Charter' = 'goldenrod',
                             'Kindergarten' = 'darkolivegreen4', 'Private' = 'darkslategray',
                             'Nonpublic' = 'darkslategray3', 'Public' = 'coral'))+
  scale_alpha_manual(values = c("-1"=0.5, "1"=1))+
  theme(axis.text.x = element_text(angle = 90))
```

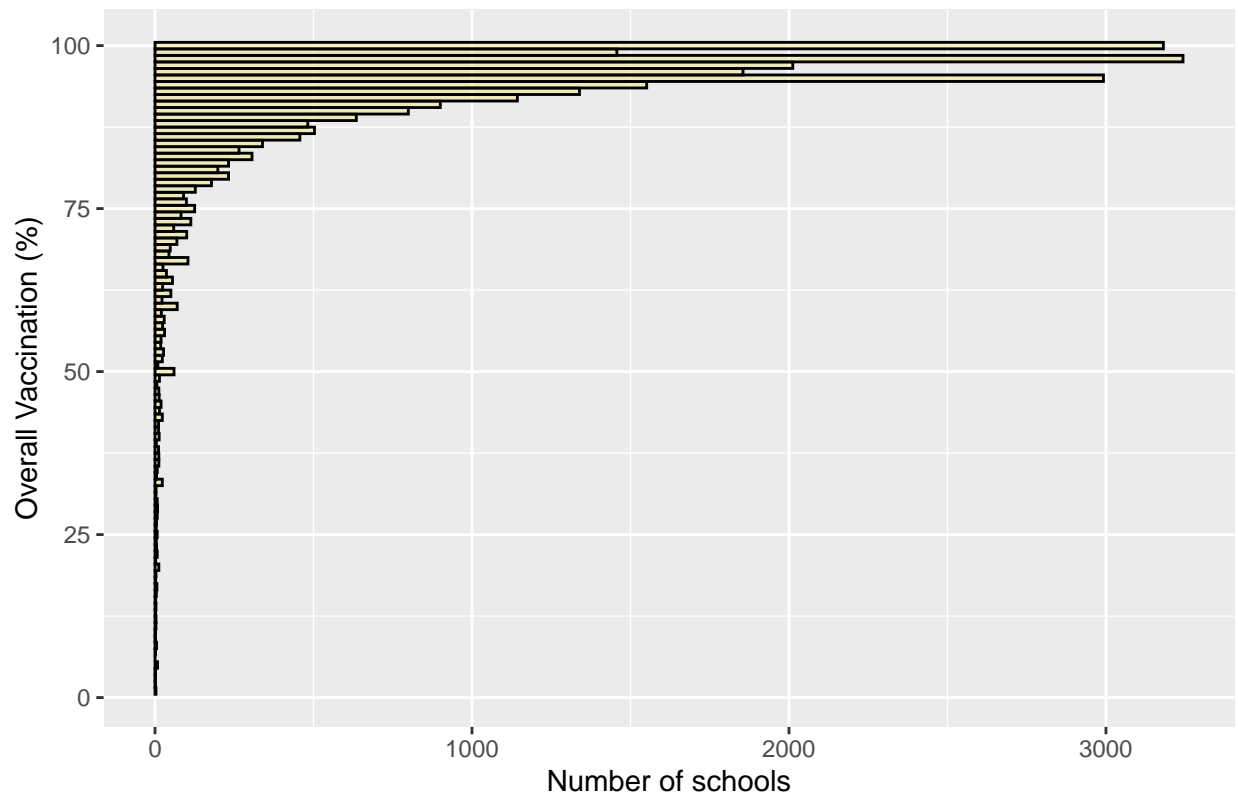


26234 or 56.53 % of the schools reported overall vaccination rates.

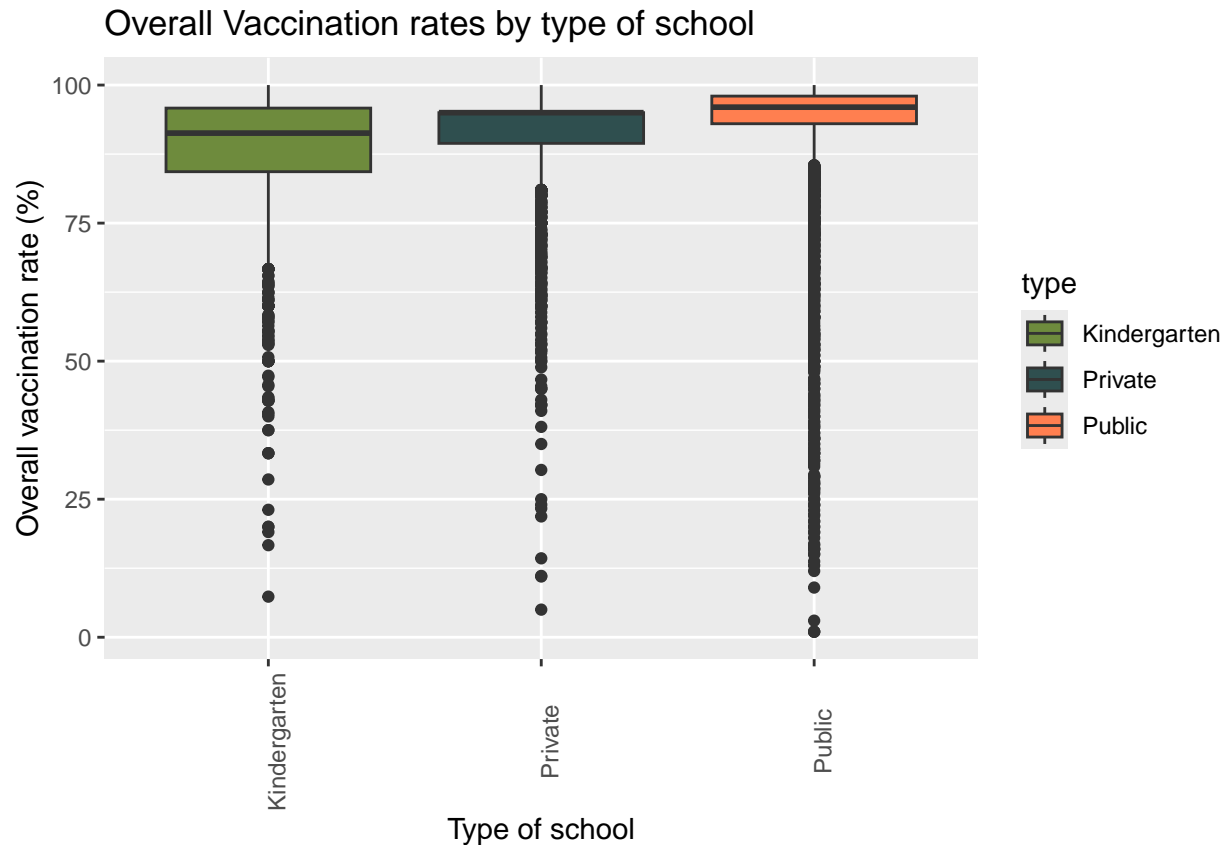
91.84 % of the schools that reported overall vaccinations had 80% or more of the kids vaccinated and Only 1.28 % of the schools had overall vaccination rate under 50%.

```
ggplot(data=vacc_rec[vacc_rec$overall!=-1,],aes(y=overall))+
  geom_histogram(binwidth=1,fill="khaki",alpha=0.5, color='black') +
  labs(title='Number of Schools vs % of students with overall vaccination',
        x='Number of schools',y='Overall Vaccination (%)')
```

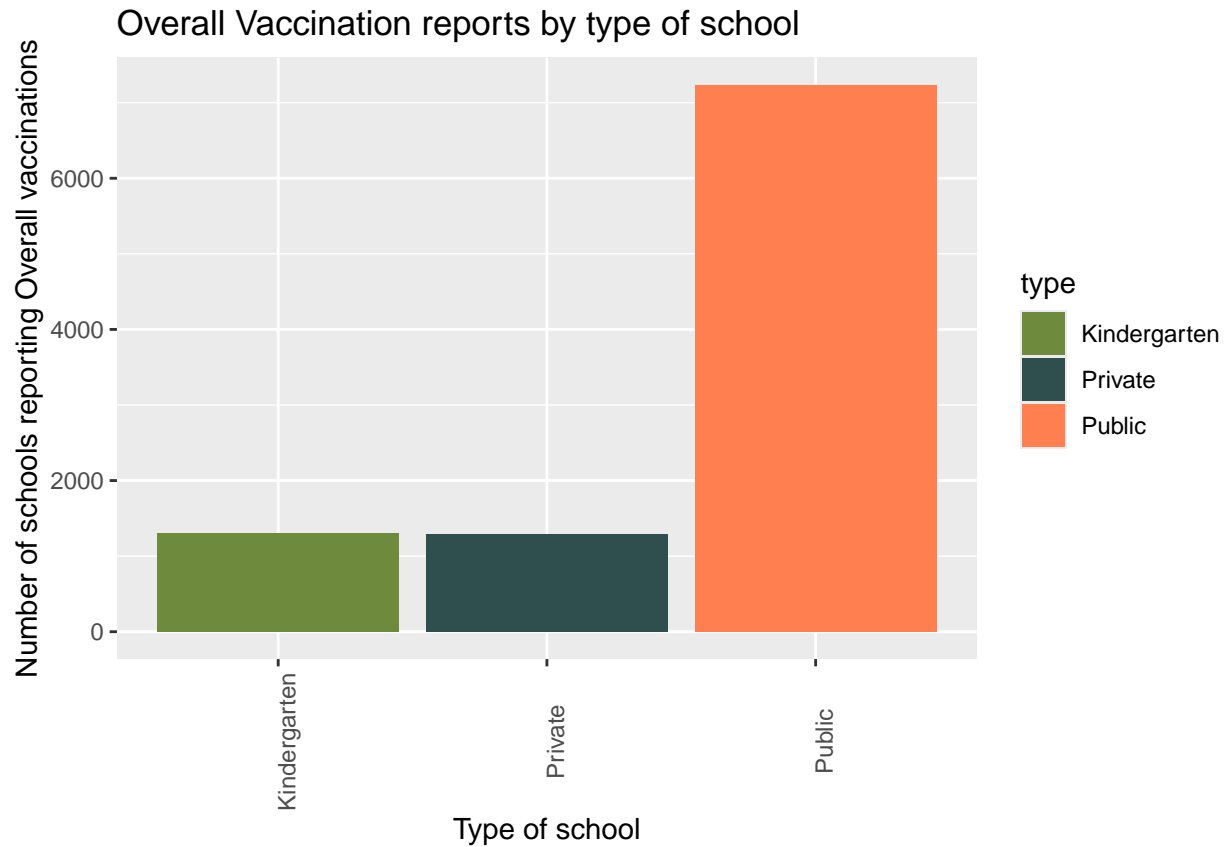
Number of Schools vs % of students with overall vaccination



```
ggplot(data = vacc_rec[vacc_rec$overall != -1 & !is.na(vacc_rec$type),], aes(x=type, y=overall)) +
  geom_boxplot(aes(fill=type))+
  labs(title='Overall Vaccination rates by type of school',x=('Type of school'),
        y='Overall vaccination rate (%)') +
  scale_fill_manual(values=c('BOCES' = 'coral4', 'Charter' = 'goldenrod',
                              'Kindergarten' = 'darkolivegreen4','Private' = 'darkslategray',
                              'Nonpublic' = 'darkslategray3', 'Public' = 'coral'))+
  theme(axis.text.x = element_text(angle = 90))
```

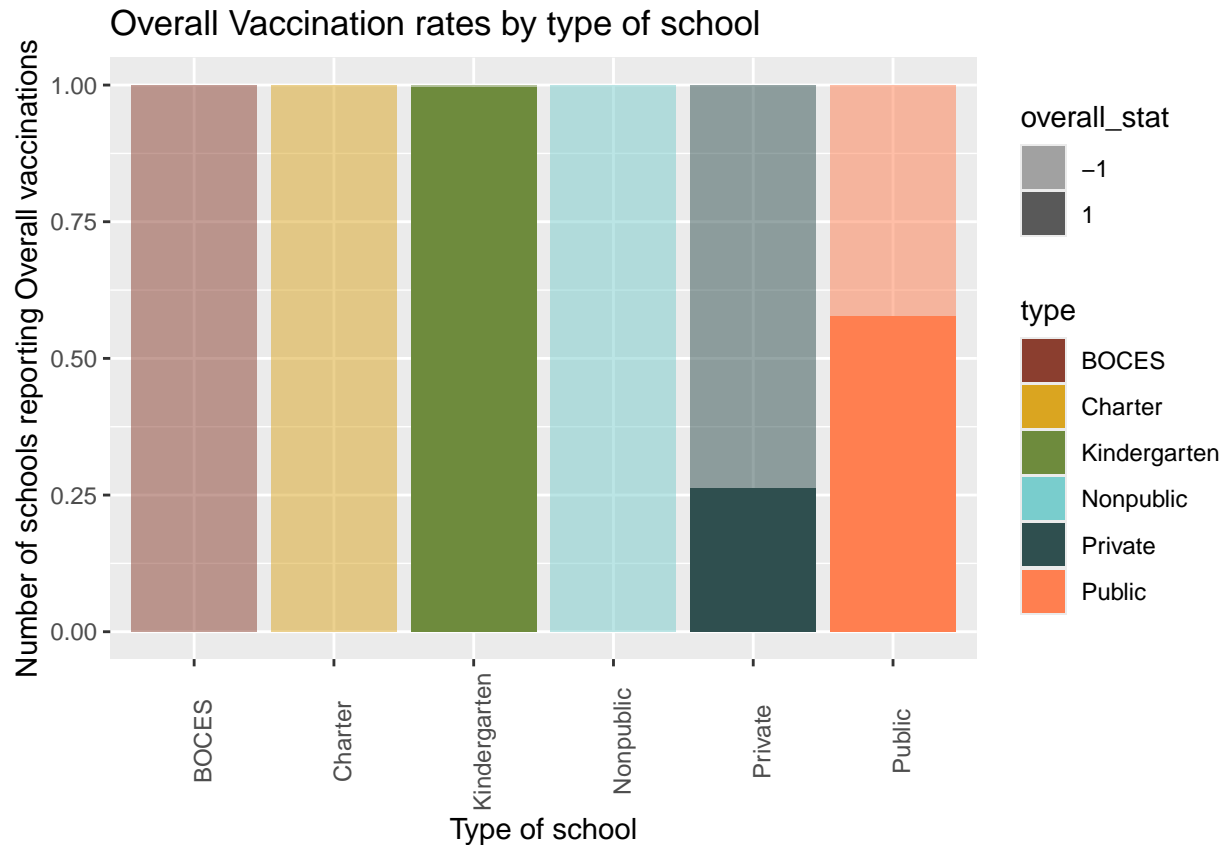


```
ggplot(data = vacc_rec[vacc_rec$overall!=-1 & !is.na(vacc_rec$type),]) +
  geom_bar(mapping = aes(x = type, fill=type)) +
  labs(title='Overall Vaccination reports by type of school',x=('Type of school'),
        y='Number of schools reporting Overall vaccinations') +
  scale_fill_manual(values=c('BOCES' = 'coral4', 'Charter' = 'goldenrod',
                             'Kindergarten' = 'darkolivegreen4','Private' = 'darkslategray',
                             'Nonpublic' = 'darkslategray3', 'Public' = 'coral'))+
  theme(axis.text.x = element_text(angle = 90))
```



```
tmp = mutate(vacc_rec, overall_stat = ifelse(overall != -1, 1, -1))
tmp$overall_stat = factor(tmp$overall_stat)
tmp = tmp[!is.na(tmp$type),]

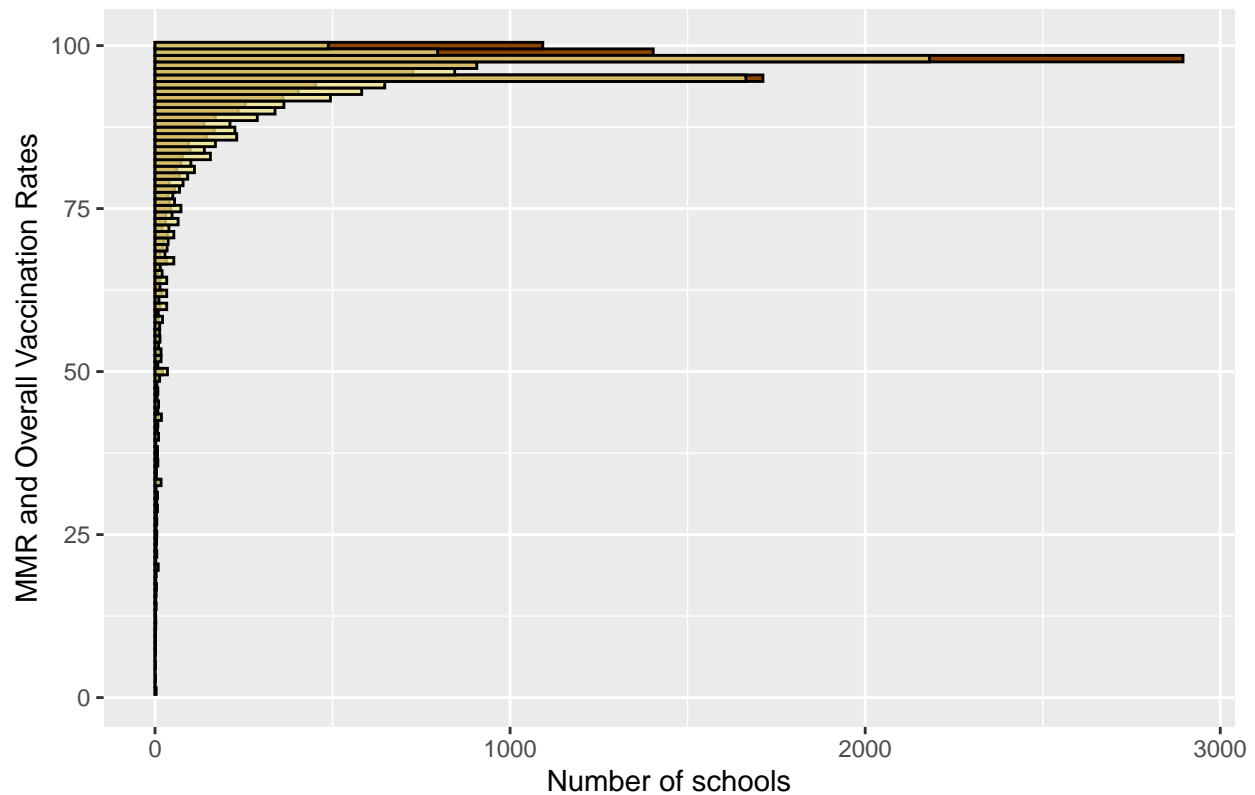
ggplot(data = tmp) +
  geom_bar(mapping = aes(x = type, fill = type, alpha = overall_stat), position = "fill") +
  labs(title = 'Overall Vaccination rates by type of school', x = ('Type of school'),
        y = 'Number of schools reporting Overall vaccinations') +
  scale_fill_manual(values = c('BOCES' = 'coral4', 'Charter' = 'goldenrod',
                              'Kindergarten' = 'darkolivegreen4', 'Private' = 'darkslategray',
                              'Nonpublic' = 'darkslategray3', 'Public' = 'coral')) +
  scale_alpha_manual(values = c("-1" = 0.5, "1" = 1)) +
  theme(axis.text.x = element_text(angle = 90))
```



12252 or 26.4 % of the schools reported both vaccination rates.

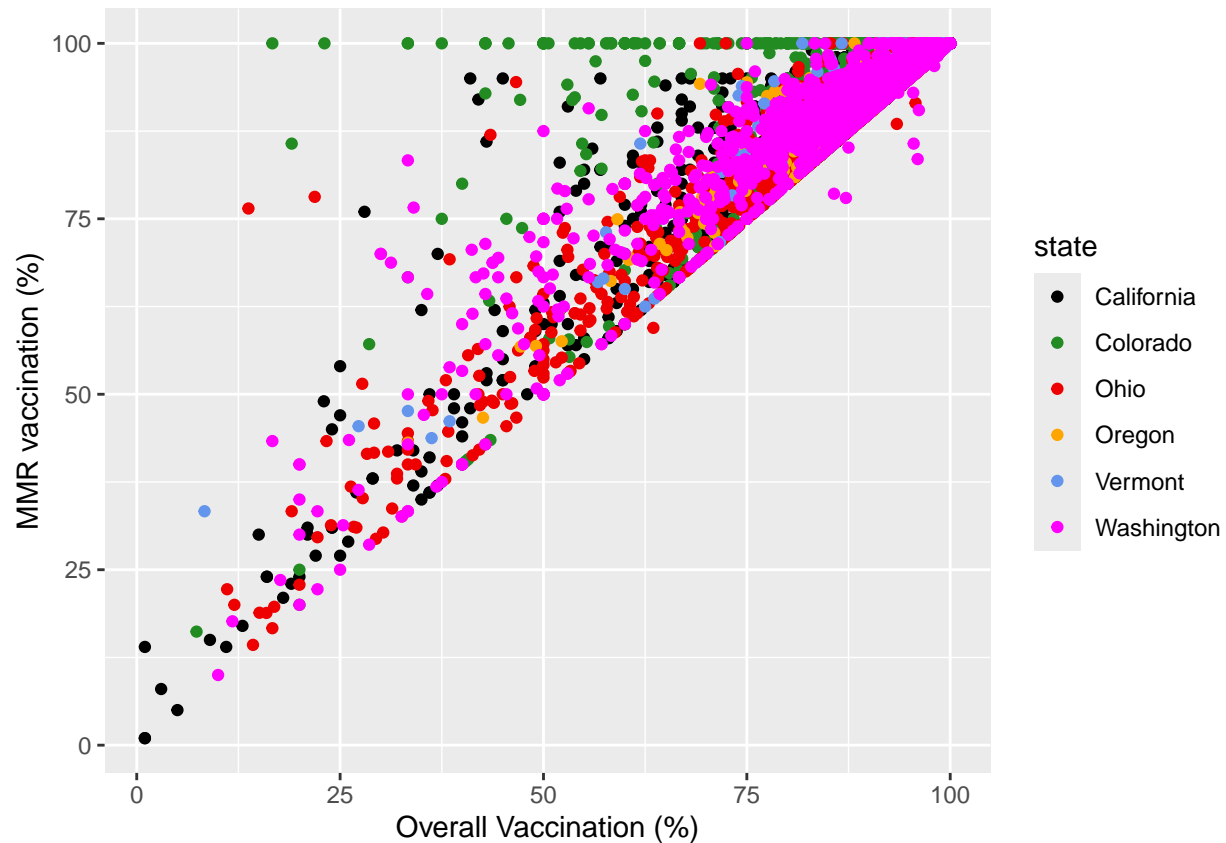
```
ggplot() +
  geom_histogram(data=vacc_rec[vacc_rec$overall!=-1 & vacc_rec$mmr!=-1,], aes(y=mmr),
    binwidth=1, fill="darkorange4", alpha=1, color='black') +
  geom_histogram(data=vacc_rec[vacc_rec$overall!=-1 & vacc_rec$mmr!=-1,], aes(y=overall),
    binwidth=1, fill="khaki", alpha=0.75, color='black') +
  labs(title="Schools that reported both vaccination rates",
    y="MMR and Overall Vaccination Rates", x='Number of schools')
```

Schools that reported both vaccination rates



```
ggplot(data = vacc_rec[vacc_rec$overall!=-1 & vacc_rec$mmr!=-1,]) +
  geom_point(mapping = aes(x = overall, y = mmr, color=state)) +
  labs(Title='MMR vs Overall vaccination percentages',
       x= 'Overall Vaccination (%)', y='MMR vaccination (%)')+
  scale_color_manual(values = c('black','forestgreen', 'red2', 'orange',
                                'cornflowerblue', 'magenta', 'darkolivegreen4',
                                'indianred1', 'tan4', 'darkblue', 'mediumorchid1',
                                'firebrick4', 'yellowgreen', 'lightsalmon', "#661100",
                                "tan1",'darkgray', 'wheat4', '#DDAD4B', 'chartreuse',
                                'seagreen1', 'moccasin', 'mediumvioletred', 'seagreen',
                                'cadetblue1', '#999933', 'tan2', 'tomato3', '#7CE3D8',
                                'gainsboro','darkolivegreen','coral1','darkorange4'))
```





### 3. Data transformation :

#### 3.1 Summarizing the data by state

```
tmpdata=vacc_rec[vacc_rec$overall!=-1 | vacc_rec$mmr!=-1,]
tmpdata$overall[tmpdata$overall==-1]<-NA
tmpdata$mmr[tmpdata$mmr==-1]<-NA
tmpdata=mutate(tmpdata,
               mmr_count=ifelse(is.na(mmr),0,1),
               overall_count=ifelse(is.na(overall),0,1))
#created separate columns in order to count number of schools with a given stat

#Creating the pivot table by state
Summary_stats<- tmpdata %>% group_by(state) %>%
  summarize(Total_schools = n(),
            schools_with_mmr = sum(mmr_count),
            avg_mmr=ifelse(sum(mmr_count)>0, mean(mmr, na.rm = TRUE), NA),
            min_mmr=ifelse(sum(mmr_count)>0, min(mmr, na.rm = TRUE), NA),
            max_mmr=ifelse(sum(mmr_count)>0, max(mmr, na.rm = TRUE), NA),
            median_mmr=median(mmr, na.rm = TRUE),
            schools_with_overall=sum(overall_count),
            avg_overall=ifelse(sum(overall_count)>0, mean(overall, na.rm = TRUE), NA),
            min_overall=ifelse(sum(overall_count)>0, min(overall, na.rm = TRUE), NA),
```

```
max_overall=ifelse(sum(overall_count)>0, max(overall, na.rm = TRUE), NA),
median_overall=median(overall, na.rm = TRUE))
```

**States with reports of MMR vaccinations** Arizona, Arkansas, California, Colorado, Connecticut, Illinois, Maine, Massachusetts, Minnesota, Missouri, Montana, New York, North Dakota, Ohio, Oregon, Pennsylvania, South Dakota, Texas, Utah, Vermont, Washington

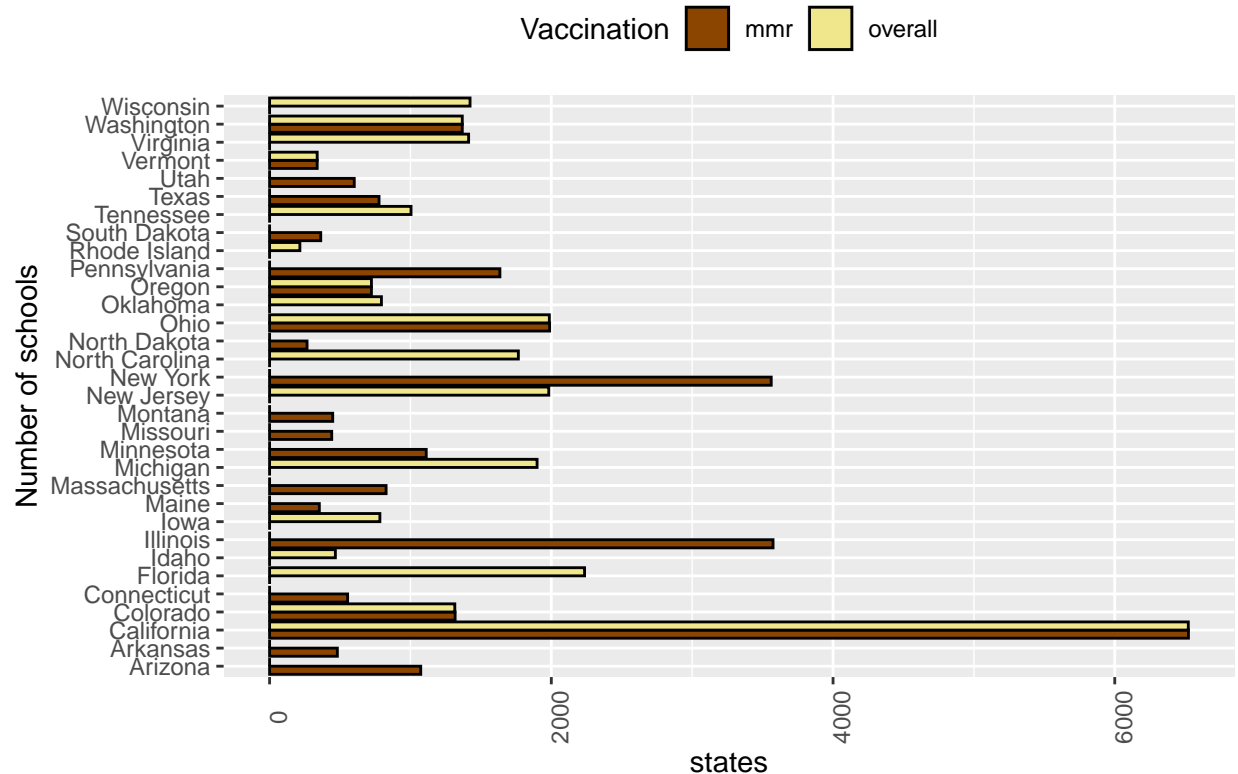
**States with reports of overall vaccinations** California, Colorado, Florida, Idaho, Iowa, Michigan, New Jersey, North Carolina, Ohio, Oklahoma, Oregon, Rhode Island, Tennessee, Vermont, Virginia, Washington, Wisconsin

**States with reports of both vaccinations** California, Colorado, Ohio, Oregon, Vermont, Washington  
Currently the write is commented out, you can uncomment it when running locally

```
School_cnt_bar_data =
  as.data.frame(rbind(rename(mutate(Summary_stats[,c("state", "schools_with_mmr")],
                                Vaccination = "mmr"),
                                "Num_of_schools"="schools_with_mmr"),
                    rename(mutate(Summary_stats[,c("state", "schools_with_overall")],
                                Vaccination = "overall"),
                                "Num_of_schools"="schools_with_overall"))))
```

```
ggplot(data=School_cnt_bar_data) +
  geom_bar(aes(y=state, x=Num_of_schools, fill=Vaccination),
           stat = "identity", position = "dodge", color='black') +
  labs(title="Number of Schools with Overall & MMR vaccination reports by state",
       y="Number of schools", x="states") +
  theme(axis.text.x = element_text(angle = 90), legend.position = 'top') +
  scale_fill_manual(values=c("mmr"="darkorange4", "overall" = "khaki"))
```

## Number of Schools with Overall & MMR vaccination reports by state



## 4. Insights and Future Steps

- From this dataset it is apparent that the higher the vaccination rates are, the schools are more likely to report those rates.
- Only about 28,323 out of 46,410 schools reported their vaccination records.
- Almost all of the kindergarten schools reported their MMR and overall vaccination rates.
- The percentage of private schools that reported the vaccination rates was significantly lower than the percentage of public schools that reported vaccinations. And this was true for both type of vaccinations. Hence, encouraging more private schools to report these would help improve the future vaccination efforts.
- Out of the 32 states, schools from only 17 states reported overall vaccination rates, and schools from 21 states reported MMR vaccinations.
- Next step would be to look at reports of measles, mumps and rubella rates in the 32 reported states in the academic year 2019-2020, and study effectiveness, or lack thereof of these vaccinations.

## 5. Acknowledgements

This data comes from #tidytuesday and is originally from The Wallstreet Journal. This dataset was recently published in their article named “What’s the Measles Vaccination Rate at Your Child’s School?”.