

2019 NFL Play by Play Data Analysis

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5/28/2020

Introduction and Goals:

In this project, I will be exploring, visualizing, analyzing, and modeling 2019 NFL play by play data that is publicly available online. The goal of this project is to learn something and gain interesting insights that would not have been possible without data. I hope to come to a conclusion at the end that is useful and applicable for a wide variety of people.

Here, I clear my workspace, load some useful packages, and read in the data set.

```
rm(list = ls())
library(tidyverse)

## -- Attaching packages ----- ti
## v ggplot2 3.3.0      v purrr  0.3.4
## v tibble  3.0.1      v dplyr  0.8.5
## v tidyr   1.0.2      v stringr 1.4.0
## v readr   1.3.1      v forcats 0.5.0

## -- Conflicts ----- tidyvers
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()     masks stats::lag()

library(nflfastR)

## Loading required package: nflscrapR
## Loading required package: nnet
## Loading required package: magrittr
##
## Attaching package: 'magrittr'
## The following object is masked from 'package:purrr':
##
##     set_names
## The following object is masked from 'package:tidyr':
##
##     extract

library(ggimage)

pbp = readRDS(url('https://raw.githubusercontent.com/guga31bb/nflfastR-data/master/data/play_by_play_2019'))
```

Here, we will look at the first 5 rows of the data set to see what we're working with. Next, we'll at the strucutre, so that we can get a better understanding of the variables used. Lastly, we'll summarize the variables to get a quick peak.

```
head(pbp)
```

```
## # A tibble: 6 x 306
##   play_id game_id home_team away_team posteam posteam_type defteam side_of_field
##   <dbl>   <dbl> <chr>      <chr>      <chr>   <chr>      <chr>   <chr>
## 1     35  2.02e9 CHI        GB        GB       away      CHI     CHI
## 2     50  2.02e9 CHI        GB        GB       away      CHI     GB
## 3     71  2.02e9 CHI        GB        GB       away      CHI     GB
## 4     95  2.02e9 CHI        GB        GB       away      CHI     GB
## 5    125  2.02e9 CHI        GB        GB       away      CHI     GB
## 6    155  2.02e9 CHI        GB        CHI      home      GB     CHI
## # ... with 298 more variables: yardline_100 <dbl>, game_date <date>,
## #   quarter_seconds_remaining <dbl>, half_seconds_remaining <dbl>,
## #   game_seconds_remaining <dbl>, game_half <chr>, quarter_end <dbl>,
## #   drive <dbl>, sp <dbl>, qtr <dbl>, down <dbl>, goal_to_go <dbl>, time <chr>,
## #   yrdln <chr>, ydstogo <dbl>, ydsnet <dbl>, desc <chr>, play_type <chr>,
## #   yards_gained <dbl>, shotgun <dbl>, no_huddle <dbl>, qb_dropback <dbl>,
## #   qb_kneel <dbl>, qb_spike <dbl>, qb_scramble <dbl>, pass_length <chr>,
## #   pass_location <chr>, air_yards <dbl>, yards_after_catch <dbl>,
## #   run_location <chr>, run_gap <chr>, field_goal_result <chr>,
## #   kick_distance <dbl>, extra_point_result <chr>, two_point_conv_result <chr>,
## #   home_timeouts_remaining <dbl>, away_timeouts_remaining <dbl>,
## #   timeout <dbl>, timeout_team <chr>, td_team <chr>,
## #   posteam_timeouts_remaining <dbl>, defteam_timeouts_remaining <dbl>,
## #   total_home_score <dbl>, total_away_score <dbl>, posteam_score <dbl>,
## #   defteam_score <dbl>, score_differential <dbl>, posteam_score_post <dbl>,
## #   defteam_score_post <dbl>, score_differential_post <dbl>,
## #   no_score_prob <dbl>, opp_fg_prob <dbl>, opp_safety_prob <dbl>,
## #   opp_td_prob <dbl>, fg_prob <dbl>, safety_prob <dbl>, td_prob <dbl>,
## #   extra_point_prob <dbl>, two_point_conversion_prob <dbl>, ep <dbl>,
## #   epa <dbl>, total_home_epa <dbl>, total_away_epa <dbl>,
## #   total_home_rush_epa <dbl>, total_away_rush_epa <dbl>,
## #   total_home_pass_epa <dbl>, total_away_pass_epa <dbl>, air_epa <dbl>,
## #   yac_epa <dbl>, comp_air_epa <dbl>, comp_yac_epa <dbl>,
## #   total_home_comp_air_epa <dbl>, total_away_comp_air_epa <dbl>,
## #   total_home_comp_yac_epa <dbl>, total_away_comp_yac_epa <dbl>,
## #   total_home_raw_air_epa <dbl>, total_away_raw_air_epa <dbl>,
## #   total_home_raw_yac_epa <dbl>, total_away_raw_yac_epa <dbl>, wp <dbl>,
## #   def_wp <dbl>, home_wp <dbl>, away_wp <dbl>, wpa <dbl>, home_wp_post <dbl>,
## #   away_wp_post <dbl>, total_home_rush_wpa <dbl>, total_away_rush_wpa <dbl>,
## #   total_home_pass_wpa <dbl>, total_away_pass_wpa <dbl>, air_wpa <dbl>,
## #   yac_wpa <dbl>, comp_air_wpa <dbl>, comp_yac_wpa <dbl>,
## #   total_home_comp_air_wpa <dbl>, total_away_comp_air_wpa <dbl>,
## #   total_home_comp_yac_wpa <dbl>, total_away_comp_yac_wpa <dbl>,
## #   total_home_raw_air_wpa <dbl>, total_away_raw_air_wpa <dbl>, ...
```

```
str(pbp)
```

```
## tibble [47,480 x 306] (S3: tbl_df/tbl/data.frame)
## $ play_id      : num [1:47480] 35 50 71 95 125 155 195 216 238 260 ...
## $ game_id      : num [1:47480] 2.02e+09 2.02e+09 2.02e+09 2.02e+09 2.02e+09 ...
## $ home_team    : chr [1:47480] "CHI" "CHI" "CHI" "CHI" ...
## $ away_team    : chr [1:47480] "GB" "GB" "GB" "GB" ...
## $ posteam      : chr [1:47480] "GB" "GB" "GB" "GB" ...
```

```

## $ posteam_type           : chr [1:47480] "away" "away" "away" "away" ...
## $ defteam                : chr [1:47480] "CHI" "CHI" "CHI" "CHI" ...
## $ side_of_field          : chr [1:47480] "CHI" "GB" "GB" "GB" ...
## $ yardline_100           : num [1:47480] 35 75 75 75 85 57 52 47 47 40 ...
## $ game_date              : Date[1:47480], format: "2019-09-05" "2019-09-05" ...
## $ quarter_seconds_remaining : num [1:47480] 900 900 873 825 795 781 753 718 714 672 ...
## $ half_seconds_remaining  : num [1:47480] 1800 1800 1773 1725 1695 ...
## $ game_seconds_remaining  : num [1:47480] 3600 3600 3573 3525 3495 ...
## $ game_half              : chr [1:47480] "Half1" "Half1" "Half1" "Half1" ...
## $ quarter_end            : num [1:47480] 0 0 0 0 0 0 0 0 0 0 ...
## $ drive                  : num [1:47480] 1 1 1 1 1 2 2 2 2 2 ...
## $ sp                     : num [1:47480] 0 0 0 0 0 0 0 0 0 0 ...
## $ qtr                   : num [1:47480] 1 1 1 1 1 1 1 1 1 1 ...
## $ down                   : num [1:47480] NA 1 2 3 4 1 1 2 3 1 ...
## $ goal_to_go             : num [1:47480] 0 0 0 0 0 0 0 0 0 0 ...
## $ time                   : chr [1:47480] "15:00" "15:00" "14:33" "13:45" ...
## $ yrdln                 : chr [1:47480] "CHI 35" "GB 25" "GB 25" "GB 25" ...
## $ ydstogo               : num [1:47480] 0 10 10 10 20 10 10 5 5 10 ...
## $ ydsnet                : num [1:47480] -10 -10 -10 -10 -10 12 12 12 12 12 ...
## $ desc                  : chr [1:47480] "15-E.Pineiro kicks 65 yards from CHI 35 to er
## $ play_type              : chr [1:47480] "kickoff" "run" "pass" "pass" ...
## $ yards_gained           : num [1:47480] 0 0 0 -10 0 0 5 0 7 0 ...
## $ shotgun               : num [1:47480] 0 0 0 1 0 1 1 1 1 1 ...
## $ no_huddle              : num [1:47480] 0 0 0 0 0 0 0 0 0 0 ...
## $ qb_dropback           : num [1:47480] 0 0 1 1 0 0 0 1 1 1 ...
## $ qb_kneel              : num [1:47480] 0 0 0 0 0 0 0 0 0 0 ...
## $ qb_spike              : num [1:47480] 0 0 0 0 0 0 0 0 0 0 ...
## $ qb_scramble           : num [1:47480] 0 0 0 0 0 0 0 0 1 0 ...
## $ pass_length           : chr [1:47480] NA NA "short" NA ...
## $ pass_location         : chr [1:47480] NA NA "left" NA ...
## $ air_yards             : num [1:47480] NA NA -1 NA NA NA NA 2 NA 15 ...
## $ yards_after_catch     : num [1:47480] NA NA 1 NA NA NA NA NA NA NA ...
## $ run_location          : chr [1:47480] NA "left" NA NA ...
## $ run_gap               : chr [1:47480] NA "tackle" NA NA ...
## $ field_goal_result     : chr [1:47480] NA NA NA NA ...
## $ kick_distance         : num [1:47480] NA NA NA NA 53 NA NA NA NA NA ...
## $ extra_point_result    : chr [1:47480] NA NA NA NA ...
## $ two_point_conv_result  : chr [1:47480] NA NA NA NA ...
## $ home_timeouts_remaining : num [1:47480] 3 3 3 3 3 3 3 3 3 3 ...
## $ away_timeouts_remaining : num [1:47480] 3 3 3 3 3 3 3 3 3 3 ...
## $ timeout               : num [1:47480] 0 0 0 0 0 0 0 0 0 0 ...
## $ timeout_team          : chr [1:47480] NA NA NA NA ...
## $ td_team               : chr [1:47480] NA NA NA NA ...
## $ posteam_timeouts_remaining : num [1:47480] 3 3 3 3 3 3 3 3 3 3 ...
## $ defteam_timeouts_remaining : num [1:47480] 3 3 3 3 3 3 3 3 3 3 ...
## $ total_home_score      : num [1:47480] 0 0 0 0 0 0 0 0 0 0 ...
## $ total_away_score      : num [1:47480] 0 0 0 0 0 0 0 0 0 0 ...
## $ posteam_score         : num [1:47480] NA 0 0 0 0 0 0 0 0 0 ...
## $ defteam_score         : num [1:47480] NA 0 0 0 0 0 0 0 0 0 ...
## $ score_differential     : num [1:47480] NA 0 0 0 0 0 0 0 0 0 ...
## $ posteam_score_post    : num [1:47480] 0 0 0 0 0 0 0 0 0 0 ...
## $ defteam_score_post    : num [1:47480] 0 0 0 0 0 0 0 0 0 0 ...
## $ score_differential_post : num [1:47480] 0 0 0 0 0 0 0 0 0 0 ...
## $ no_score_prob         : num [1:47480] 0.00137 0.00137 0.00157 0.00186 0.00211 ...

```

```
## $ opp_fg_prob : num [1:47480] 0.163 0.163 0.188 0.226 0.327 ...
## $ opp_safety_prob : num [1:47480] 0.00444 0.00444 0.0057 0.00664 0.01096 ...
## $ opp_td_prob : num [1:47480] 0.254 0.254 0.295 0.35 0.467 ...
## $ fg_prob : num [1:47480] 0.2331 0.2331 0.2131 0.1712 0.0545 ...
## $ safety_prob : num [1:47480] 0.00366 0.00366 0.00398 0.00453 0.00429 ...
## $ td_prob : num [1:47480] 0.341 0.341 0.292 0.24 0.134 ...
## $ extra_point_prob : num [1:47480] 0 0 0 0 0 0 0 0 0 ...
## $ two_point_conversion_prob : num [1:47480] 0 0 0 0 0 0 0 0 0 ...
## $ ep : num [1:47480] 0.815 0.815 0.0506 -0.9371 -3.1584 ...
## $ epa : num [1:47480] 0 -0.764 -0.988 -2.221 0.715 ...
## $ total_home_epa : num [1:47480] 0 0.764 1.752 3.973 3.259 ...
## $ total_away_epa : num [1:47480] 0 -0.764 -1.752 -3.973 -3.259 ...
## $ total_home_rush_epa : num [1:47480] 0 0.764 0.764 0.764 0.764 ...
## $ total_away_rush_epa : num [1:47480] 0 -0.764 -0.764 -0.764 -0.764 ...
## $ total_home_pass_epa : num [1:47480] 0 0 0.988 3.209 3.209 ...
## $ total_away_pass_epa : num [1:47480] 0 0 -0.988 -3.209 -3.209 ...
## $ air_epa : num [1:47480] NA NA -1.1 NA NA ...
## $ yac_epa : num [1:47480] NA NA 0.107 NA NA ...
## $ comp_air_epa : num [1:47480] 0 0 -1.1 0 0 ...
## $ comp_yac_epa : num [1:47480] 0 0 0.107 0 0 ...
## $ total_home_comp_air_epa : num [1:47480] 0 0 1.1 1.1 1.1 ...
## $ total_away_comp_air_epa : num [1:47480] 0 0 -1.1 -1.1 -1.1 ...
## $ total_home_comp_yac_epa : num [1:47480] 0 0 -0.107 -0.107 -0.107 ...
## $ total_away_comp_yac_epa : num [1:47480] 0 0 0.107 0.107 0.107 ...
## $ total_home_raw_air_epa : num [1:47480] 0 0 1.1 1.1 1.1 ...
## $ total_away_raw_air_epa : num [1:47480] 0 0 -1.1 -1.1 -1.1 ...
## $ total_home_raw_yac_epa : num [1:47480] 0 0 -0.107 -0.107 -0.107 ...
## $ total_away_raw_yac_epa : num [1:47480] 0 0 0.107 0.107 0.107 ...
## $ wp : num [1:47480] NA 0.5 0.479 0.453 0.386 ...
## $ def_wp : num [1:47480] NA 0.5 0.521 0.547 0.614 ...
## $ home_wp : num [1:47480] NA 0.5 0.521 0.547 0.614 ...
## $ away_wp : num [1:47480] NA 0.5 0.479 0.453 0.386 ...
## $ wpa : num [1:47480] NA -0.0207 -0.0261 -0.0669 0.0576 ...
## $ home_wp_post : num [1:47480] NA 0.521 0.547 0.614 0.556 ...
## $ away_wp_post : num [1:47480] NA 0.479 0.453 0.386 0.444 ...
## $ total_home_rush_wpa : num [1:47480] 0 0.0207 0.0207 0.0207 0.0207 ...
## $ total_away_rush_wpa : num [1:47480] 0 -0.0207 -0.0207 -0.0207 -0.0207 ...
## $ total_home_pass_wpa : num [1:47480] 0 0 0.0261 0.093 0.093 ...
## $ total_away_pass_wpa : num [1:47480] 0 0 -0.0261 -0.093 -0.093 ...
## $ air_wpa : num [1:47480] NA NA -0.0316 NA NA ...
## [list output truncated]
```

```
summary(pbp)
```

```
##      play_id      game_id      home_team      away_team
## Min.   : 35      Min.   :2.019e+09      Length:47480      Length:47480
## 1st Qu.:1092     1st Qu.:2.019e+09      Class :character   Class :character
## Median :2158     Median :2.019e+09      Mode  :character   Mode  :character
## Mean   :2177     Mean   :2.019e+09
## 3rd Qu.:3234     3rd Qu.:2.019e+09
## Max.   :5921     Max.   :2.020e+09
##
##      posteam      posteam_type      defteam      side_of_field
## Length:47480      Length:47480      Length:47480      Length:47480
## Class :character   Class :character   Class :character   Class :character
```

```

## Mode :character Mode :character Mode :character Mode :character
##
##
##
## yardline_100 game_date quarter_seconds_remaining
## Min. : 1.0 Min. :2019-09-05 Min. : 0.0
## 1st Qu.:31.0 1st Qu.:2019-10-06 1st Qu.:140.0
## Median :50.0 Median :2019-11-03 Median :386.0
## Mean :48.9 Mean :2019-11-05 Mean :406.7
## 3rd Qu.:70.0 3rd Qu.:2019-12-08 3rd Qu.:651.0
## Max. :99.0 Max. :2020-02-02 Max. :900.0
## NA's :1748 NA's :34
## half_seconds_remaining game_seconds_remaining game_half
## Min. : 0.0 Min. : 0 Length:47480
## 1st Qu.: 268.0 1st Qu.: 789 Class :character
## Median : 784.5 Median :1800 Mode :character
## Mean : 799.5 Mean :1697
## 3rd Qu.:1278.0 3rd Qu.:2575
## Max. :1800.0 Max. :3600
## NA's :34 NA's :34
## quarter_end drive sp qtr
## Min. :0.00000 Min. : 1.00 Min. :0.00000 Min. :1.00
## 1st Qu.:0.00000 1st Qu.: 6.00 1st Qu.:0.00000 1st Qu.:2.00
## Median :0.00000 Median :12.00 Median :0.00000 Median :3.00
## Mean :0.02264 Mean :11.81 Mean :0.07355 Mean :2.57
## 3rd Qu.:0.00000 3rd Qu.:17.00 3rd Qu.:0.00000 3rd Qu.:4.00
## Max. :1.00000 Max. :33.00 Max. :1.00000 Max. :5.00
##
## down goal_to_go time yrdln
## Min. :1.000 Min. :0.00000 Length:47480 Length:47480
## 1st Qu.:1.000 1st Qu.:0.00000 Class :character Class :character
## Median :2.000 Median :0.00000 Mode :character Mode :character
## Mean :1.986 Mean :0.05042
## 3rd Qu.:3.000 3rd Qu.:0.00000
## Max. :4.000 Max. :1.00000
## NA's :7648
## ydstogo ydsnet desc play_type
## Min. : 0.000 Min. : -22.00 Length:47480 Length:47480
## 1st Qu.: 3.000 1st Qu.: 14.00 Class :character Class :character
## Median : 9.000 Median : 42.00 Mode :character Mode :character
## Mean : 7.279 Mean : 41.12
## 3rd Qu.:10.000 3rd Qu.: 69.00
## Max. :40.000 Max. : 99.00
##
## yards_gained shotgun no_huddle qb_dropback
## Min. : -28.000 Min. : 0.00 Min. : 0.00000 Min. : 0.0000
## 1st Qu.: 0.000 1st Qu.: 0.00 1st Qu.: 0.00000 1st Qu.: 0.0000
## Median : 0.000 Median : 0.00 Median : 0.00000 Median : 0.0000
## Mean : 4.061 Mean : 0.49 Mean : 0.05965 Mean : 0.4515
## 3rd Qu.: 6.000 3rd Qu.: 1.00 3rd Qu.: 0.00000 3rd Qu.: 1.0000
## Max. : 93.000 Max. : 1.00 Max. : 1.00000 Max. : 1.0000
## NA's :1710 NA's :1710
## qb_kneel qb_spike qb_scramble pass_length

```

```

## Min. :0.000000 Min. :0.000000 Min. :0.00000 Length:47480
## 1st Qu.:0.000000 1st Qu.:0.000000 1st Qu.:0.00000 Class :character
## Median :0.000000 Median :0.000000 Median :0.00000 Mode :character
## Mean :0.008993 Mean :0.001706 Mean :0.01891
## 3rd Qu.:0.000000 3rd Qu.:0.000000 3rd Qu.:0.00000
## Max. :1.000000 Max. :1.000000 Max. :1.00000
##
## pass_location air_yards yards_after_catch run_location
## Length:47480 Min. :-19.000 Min. :-12.00 Length:47480
## Class :character 1st Qu.: 2.000 1st Qu.: 1.00 Class :character
## Mode :character Median : 5.000 Median : 3.00 Mode :character
## Mean : 8.224 Mean : 5.21
## 3rd Qu.: 13.000 3rd Qu.: 7.00
## Max. : 63.000 Max. : 85.00
## NA's :28925 NA's :35702
## run_gap field_goal_result kick_distance extra_point_result
## Length:47480 Length:47480 Min. : 2.00 Length:47480
## Class :character Class :character 1st Qu.:33.00 Class :character
## Mode :character Mode :character Median :40.00 Mode :character
## Mean :41.88
## 3rd Qu.:50.00
## Max. :75.00
## NA's :42393
## two_point_conv_result home_timeouts_remaining away_timeouts_remaining
## Length:47480 Min. :0.000 Min. :0.000
## Class :character 1st Qu.:2.000 1st Qu.:2.000
## Mode :character Median :3.000 Median :3.000
## Mean :2.523 Mean :2.482
## 3rd Qu.:3.000 3rd Qu.:3.000
## Max. :3.000 Max. :3.000
##
## timeout timeout_team td_team
## Min. :0.0000 Length:47480 Length:47480
## 1st Qu.:0.0000 Class :character Class :character
## Median :0.0000 Mode :character Mode :character
## Mean :0.0439
## 3rd Qu.:0.0000
## Max. :1.0000
## NA's :1710
## posteam_timeouts_remaining defteam_timeouts_remaining total_home_score
## Min. :0.000 Min. :0.00 Min. : 0.00
## 1st Qu.:2.000 1st Qu.:2.00 1st Qu.: 3.00
## Median :3.000 Median :3.00 Median :10.00
## Mean :2.515 Mean :2.53 Mean :11.74
## 3rd Qu.:3.000 3rd Qu.:3.00 3rd Qu.:17.00
## Max. :3.000 Max. :3.00 Max. :53.00
## NA's :1770 NA's :1770
## total_away_score posteam_score defteam_score score_differential
## Min. : 0.00 Min. : 0.00 Min. : 0.00 Min. : -49.000
## 1st Qu.: 3.00 1st Qu.: 3.00 1st Qu.: 3.00 1st Qu.: -7.000
## Median :10.00 Median :10.00 Median :10.00 Median : 0.000
## Mean :11.66 Mean :10.89 Mean :12.17 Mean : -1.282
## 3rd Qu.:17.00 3rd Qu.:17.00 3rd Qu.:19.00 3rd Qu.: 6.000
## Max. :59.00 Max. :59.00 Max. :59.00 Max. : 49.000

```

```

##          NA's :2036    NA's :2036    NA's :2036
## posteam_score_post defteam_score_post score_differential_post
## Min. : 0.00    Min. : 0.00    Min. : -49.00
## 1st Qu.: 3.00    1st Qu.: 3.00    1st Qu.: -7.00
## Median :10.00    Median :10.00    Median : 0.00
## Mean :11.08    Mean :12.11    Mean : -1.03
## 3rd Qu.:17.00    3rd Qu.:19.00    3rd Qu.: 6.00
## Max. :59.00    Max. :59.00    Max. : 49.00
## NA's :1770    NA's :1770    NA's :1770
## no_score_prob    opp_fg_prob    opp_safety_prob    opp_td_prob
## Min. :0.00000    Min. :0.00000    Min. :0.00000    Min. :0.00000
## 1st Qu.:0.00254    1st Qu.:0.03193    1st Qu.:0.00009    1st Qu.:0.03616
## Median :0.02300    Median :0.07804    Median :0.00085    Median :0.11604
## Mean :0.12503    Mean :0.08955    Mean :0.00219    Mean :0.13222
## 3rd Qu.:0.17128    3rd Qu.:0.14324    3rd Qu.:0.00340    3rd Qu.:0.21601
## Max. :1.00000    Max. :0.34620    Max. :0.02890    Max. :0.48494
## NA's :73    NA's :73    NA's :73    NA's :73
## fg_prob    safety_prob    td_prob    extra_point_prob
## Min. :0.0000    Min. :0.00000    Min. :0.0000    Min. :0.00000
## 1st Qu.:0.1549    1st Qu.:0.00172    1st Qu.:0.1873    1st Qu.:0.00000
## Median :0.2340    Median :0.00294    Median :0.3200    Median :0.00000
## Mean :0.2460    Mean :0.00258    Mean :0.2972    Mean :0.02446
## 3rd Qu.:0.3303    3rd Qu.:0.00358    3rd Qu.:0.4109    3rd Qu.:0.00000
## Max. :0.9946    Max. :0.01490    Max. :0.9130    Max. :0.97076
## NA's :73    NA's :73    NA's :73
## two_point_conversion_prob    ep    epa
## Min. :0.000000    Min. : -3.5116    Min. : -13.4947
## 1st Qu.:0.000000    1st Qu.: 0.7426    1st Qu.: -0.5964
## Median :0.000000    Median : 1.6013    Median : -0.0021
## Mean :0.001187    Mean : 1.7973    Mean : 0.0212
## 3rd Qu.:0.000000    3rd Qu.: 3.0492    3rd Qu.: 0.5715
## Max. :0.473500    Max. : 6.5009    Max. : 9.2448
## NA's :1784    NA's :2080
## total_home_epa    total_away_epa    total_home_rush_epa
## Min. : -60.88799    Min. : -48.36267    Min. : -19.03895
## 1st Qu.: -7.20304    1st Qu.: -7.72413    1st Qu.: -2.99627
## Median : 0.16001    Median : -0.16001    Median : 0.11562
## Mean : 0.05175    Mean : -0.05175    Mean : 0.05887
## 3rd Qu.: 7.72413    3rd Qu.: 7.20304    3rd Qu.: 3.02979
## Max. : 48.36267    Max. : 60.88799    Max. : 24.87936
##
## total_away_rush_epa    total_home_pass_epa    total_away_pass_epa    air_epa
## Min. : -24.87936    Min. : -53.21247    Min. : -42.21344    Min. : -9.681
## 1st Qu.: -3.02979    1st Qu.: -6.52287    1st Qu.: -6.90083    1st Qu.: -0.590
## Median : -0.11562    Median : 0.00656    Median : -0.00656    Median : -0.030
## Mean : -0.05887    Mean : -0.17135    Mean : 0.17135    Mean : 0.504
## 3rd Qu.: 2.99627    3rd Qu.: 6.90083    3rd Qu.: 6.52287    3rd Qu.: 1.562
## Max. : 19.03895    Max. : 42.21344    Max. : 53.21247    Max. : 6.437
## NA's :29093
## yac_epa    comp_air_epa    comp_yac_epa    total_home_comp_air_epa
## Min. : -11.795    Min. : -9.6808    Min. : -10.5436    Min. : -56.47
## 1st Qu.: -0.571    1st Qu.: 0.0000    1st Qu.: 0.0000    1st Qu.: 23.86
## Median : 0.000    Median : 0.0000    Median : 0.0000    Median : 69.50
## Mean : -0.314    Mean : 0.0549    Mean : 0.1742    Mean : 72.85

```

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## 3rd Qu.: 0.588 3rd Qu.: 0.0000 3rd Qu.: 0.0000 3rd Qu.:117.74
## Max. : 9.985 Max. : 5.8121 Max. : 9.9847 Max. :209.14
## NA's :29134 NA's :1722 NA's :1738
## total_away_comp_air_epa total_home_comp_yac_epa total_away_comp_yac_epa
## Min. :-209.14 Min. :-123.209 Min. :-69.059
## 1st Qu.: -117.74 1st Qu.: -28.689 1st Qu.: -14.935
## Median : -69.50 Median : -4.347 Median : 4.347
## Mean : -72.85 Mean : -7.903 Mean : 7.903
## 3rd Qu.: -23.86 3rd Qu.: 14.935 3rd Qu.: 28.689
## Max. : 56.47 Max. : 69.059 Max. :123.209
##
## total_home_raw_air_epa total_away_raw_air_epa total_home_raw_yac_epa
## Min. :-125.56 Min. :-178.26 Min. :-300.076
## 1st Qu.: 2.47 1st Qu.: -85.73 1st Qu.: -177.290
## Median : 36.48 Median : -36.48 Median : -127.364
## Mean : 39.86 Mean : -39.86 Mean : -133.868
## 3rd Qu.: 85.73 3rd Qu.: -2.47 3rd Qu.: -85.317
## Max. : 178.26 Max. : 125.56 Max. : 4.376
##
## total_away_raw_yac_epa wp def_wp home_wp
## Min. : -4.376 Min. :0.0000 Min. :0.0000 Min. :0.0000
## 1st Qu.: 85.317 1st Qu.:0.2631 1st Qu.:0.2506 1st Qu.:0.2663
## Median :127.364 Median :0.5105 Median :0.4895 Median :0.5052
## Mean :133.868 Mean :0.5048 Mean :0.4952 Mean :0.5060
## 3rd Qu.:177.290 3rd Qu.:0.7494 3rd Qu.:0.7369 3rd Qu.:0.7562
## Max. :300.076 Max. :1.0000 Max. :1.0000 Max. :1.0000
## NA's :2094 NA's :2094 NA's :1890
## away_wp wpa home_wp_post away_wp_post
## Min. :0.0000 Min. :-0.9729 Min. :0.0000 Min. :0.0000
## 1st Qu.:0.2438 1st Qu.: -0.0140 1st Qu.:0.2630 1st Qu.:0.2408
## Median :0.4948 Median : 0.0000 Median :0.5065 Median :0.4934
## Mean :0.4940 Mean : 0.0017 Mean :0.5060 Mean :0.4939
## 3rd Qu.:0.7337 3rd Qu.: 0.0129 3rd Qu.:0.7592 3rd Qu.:0.7370
## Max. :1.0000 Max. : 0.8383 Max. :1.0000 Max. :1.0000
## NA's :1890 NA's :453 NA's :1995 NA's :1995
## total_home_rush_wpa total_away_rush_wpa total_home_pass_wpa
## Min. :-4.1933 Min. :-0.2672 Min. :-4.3234
## 1st Qu.: -3.2412 1st Qu.: 1.7736 1st Qu.: -0.8363
## Median : -2.7207 Median : 2.7207 Median : 1.5696
## Mean : -2.3567 Mean : 2.3567 Mean : 2.4285
## 3rd Qu.: -1.7736 3rd Qu.: 3.2412 3rd Qu.: 6.2961
## Max. : 0.2672 Max. : 4.1933 Max. : 8.5171
##
## total_away_pass_wpa air_wpa yac_wpa comp_air_wpa
## Min. :-8.5171 Min. :-0.997 Min. :-0.957 Min. :-0.7739
## 1st Qu.: -6.2961 1st Qu.: -0.015 1st Qu.: -0.012 1st Qu.: 0.0000
## Median : -1.5696 Median : 0.000 Median : 0.000 Median : 0.0000
## Mean : -2.4285 Mean : 0.014 Mean : -0.008 Mean : 0.0015
## 3rd Qu.: 0.8363 3rd Qu.: 0.037 3rd Qu.: 0.013 3rd Qu.: 0.0000
## Max. : 4.3234 Max. : 0.899 Max. : 1.000 Max. : 0.8383
## NA's :29095 NA's :29107 NA's :1724
## comp_yac_wpa total_home_comp_air_wpa total_away_comp_air_wpa
## Min. :-0.8023 Min. :-2.19585 Min. :-3.20127
## 1st Qu.: 0.0000 1st Qu.: -0.70771 1st Qu.: -0.65970

```



```

## Median : 0.0000   Median :-0.04303   Median : 0.04303
## Mean    : 0.0047   Mean    : 0.11496   Mean    :-0.11496
## 3rd Qu.: 0.0000   3rd Qu.: 0.65970   3rd Qu.: 0.70771
## Max.    : 0.7236   Max.    : 3.20127   Max.    : 2.19585
## NA's    :1734
## total_home_comp_yac_wpa total_away_comp_yac_wpa total_home_raw_air_wpa
## Min.    :-1.6909   Min.    :-6.8903   Min.    :-12.026
## 1st Qu.: -0.1524   1st Qu.: -3.1015   1st Qu.: -6.466
## Median : 1.5228   Median :-1.5228   Median : -4.880
## Mean    : 1.7978   Mean    :-1.7978   Mean    : -4.378
## 3rd Qu.: 3.1015   3rd Qu.: 0.1524   3rd Qu.: -2.442
## Max.    : 6.8903   Max.    : 1.6909   Max.    : 3.268
##
## total_away_raw_air_wpa total_home_raw_yac_wpa total_away_raw_yac_wpa
## Min.    :-3.268   Min.    :-5.9471   Min.    :-16.7394
## 1st Qu.: 2.442   1st Qu.: -0.0694   1st Qu.: -11.8168
## Median : 4.880   Median : 7.3357   Median : -7.3357
## Mean    : 4.378   Mean    : 5.9723   Mean    : -5.9723
## 3rd Qu.: 6.466   3rd Qu.: 11.8168   3rd Qu.: 0.0694
## Max.    : 12.026   Max.    : 16.7394   Max.    : 5.9471
##
## punt_blocked first_down_rush first_down_pass first_down_penalty
## Min.    :0e+00   Min.    :0.0000   Min.    :0.0000   Min.    :0.0000
## 1st Qu.: 0e+00   1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.: 0.0000
## Median : 0e+00   Median : 0.0000   Median : 0.0000   Median : 0.0000
## Mean    : 3e-04   Mean    : 0.0718   Mean    : 0.1411   Mean    : 0.0237
## 3rd Qu.: 0e+00   3rd Qu.: 0.0000   3rd Qu.: 0.0000   3rd Qu.: 0.0000
## Max.    : 1e+00   Max.    : 1.0000   Max.    : 1.0000   Max.    : 1.0000
## NA's    :1710   NA's    :1710   NA's    :1710   NA's    :1710
## third_down_converted third_down_failed fourth_down_converted
## Min.    :0.0000   Min.    :0.0000   Min.    :0.0000
## 1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.: 0.0000
## Median : 0.0000   Median : 0.0000   Median : 0.0000
## Mean    : 0.0584   Mean    : 0.0904   Mean    : 0.0064
## 3rd Qu.: 0.0000   3rd Qu.: 0.0000   3rd Qu.: 0.0000
## Max.    : 1.0000   Max.    : 1.0000   Max.    : 1.0000
## NA's    :1710   NA's    :1710   NA's    :1710
## fourth_down_failed incomplete_pass touchback interception
## Min.    :0.0000   Min.    :0.0000   Min.    :0.00000   Min.    :0.0000
## 1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.: 0.00000   1st Qu.: 0.0000
## Median : 0.0000   Median : 0.0000   Median : 0.00000   Median : 0.0000
## Mean    : 0.0072   Mean    : 0.1388   Mean    : 0.03818   Mean    : 0.0092
## 3rd Qu.: 0.0000   3rd Qu.: 0.0000   3rd Qu.: 0.00000   3rd Qu.: 0.0000
## Max.    : 1.0000   Max.    : 1.0000   Max.    : 1.00000   Max.    : 1.0000
## NA's    :1710   NA's    :1710   NA's    :1710   NA's    :1710
## punt_inside_twenty punt_in_endzone punt_out_of_bounds punt_downed
## Min.    :0.0000   Min.    :0   Min.    :0.0000   Min.    :0.0000
## 1st Qu.: 0.0000   1st Qu.: 0   1st Qu.: 0.0000   1st Qu.: 0.0000
## Median : 0.0000   Median : 0   Median : 0.0000   Median : 0.0000
## Mean    : 0.0192   Mean    : 0   Mean    : 0.0053   Mean    : 0.0072
## 3rd Qu.: 0.0000   3rd Qu.: 0   3rd Qu.: 0.0000   3rd Qu.: 0.0000
## Max.    : 1.0000   Max.    : 1   Max.    : 1.0000   Max.    : 1.0000
## NA's    :1710   NA's    :1710   NA's    :1710   NA's    :1710
## punt_fair_catch kickoff_inside_twenty kickoff_in_endzone

```

```

## Min. :0.0000 Min. :0.0000 Min. :0.0000
## 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.0000
## Median :0.0000 Median :0.0000 Median :0.0000
## Mean :0.0139 Mean :0.0048 Mean :0.0084
## 3rd Qu.:0.0000 3rd Qu.:0.0000 3rd Qu.:0.0000
## Max. :1.0000 Max. :1.0000 Max. :1.0000
## NA's :1710 NA's :1710 NA's :1710
## kickoff_out_of_bounds kickoff_downed kickoff_fair_catch fumble_forced
## Min. :0e+00 Min. :0e+00 Min. :0e+00 Min. :0.0000
## 1st Qu.:0e+00 1st Qu.:0e+00 1st Qu.:0e+00 1st Qu.:0.0000
## Median :0e+00 Median :0e+00 Median :0e+00 Median :0.0000
## Mean :6e-04 Mean :1e-04 Mean :1e-04 Mean :0.0101
## 3rd Qu.:0e+00 3rd Qu.:0e+00 3rd Qu.:0e+00 3rd Qu.:0.0000
## Max. :1e+00 Max. :1e+00 Max. :1e+00 Max. :1.0000
## NA's :1710 NA's :1710 NA's :1710 NA's :1710
## fumble_not_forced fumble_out_of_bounds solo_tackle safety
## Min. :0.0000 Min. :0.0000 Min. :0.0000 Min. :0e+00
## 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0e+00
## Median :0.0000 Median :0.0000 Median :0.0000 Median :0e+00
## Mean :0.0047 Mean :0.0012 Mean :0.4605 Mean :4e-04
## 3rd Qu.:0.0000 3rd Qu.:0.0000 3rd Qu.:1.0000 3rd Qu.:0e+00
## Max. :1.0000 Max. :1.0000 Max. :1.0000 Max. :1e+00
## NA's :1710 NA's :1710 NA's :1710 NA's :1710
## penalty tackled_for_loss fumble_lost own_kickoff_recovery
## Min. :0.00000 Min. :0.0000 Min. :0.0000 Min. :0e+00
## 1st Qu.:0.00000 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0e+00
## Median :0.00000 Median :0.0000 Median :0.0000 Median :0e+00
## Mean :0.07515 Mean :0.0267 Mean :0.0068 Mean :2e-04
## 3rd Qu.:0.00000 3rd Qu.:0.0000 3rd Qu.:0.0000 3rd Qu.:0e+00
## Max. :1.00000 Max. :1.0000 Max. :1.0000 Max. :1e+00
## NA's :1710 NA's :1710 NA's :1710 NA's :1710
## own_kickoff_recovery_td qb_hit rush_attempt pass_attempt
## Min. :0 Min. :0.0000 Min. :0.0000 Min. :0.0000
## 1st Qu.:0 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.0000
## Median :0 Median :0.0000 Median :0.0000 Median :0.0000
## Mean :0 Mean :0.0638 Mean :0.3065 Mean :0.4366
## 3rd Qu.:0 3rd Qu.:0.0000 3rd Qu.:1.0000 3rd Qu.:1.0000
## Max. :0 Max. :1.0000 Max. :1.0000 Max. :1.0000
## NA's :1710 NA's :1710 NA's :1710 NA's :1710
## sack touchdown pass_touchdown rush_touchdown
## Min. :0.0000 Min. :0.0000 Min. :0.0000 Min. :0.0000
## 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.0000
## Median :0.0000 Median :0.0000 Median :0.0000 Median :0.0000
## Mean :0.0293 Mean :0.0305 Mean :0.0181 Mean :0.0104
## 3rd Qu.:0.0000 3rd Qu.:0.0000 3rd Qu.:0.0000 3rd Qu.:0.0000
## Max. :1.0000 Max. :1.0000 Max. :1.0000 Max. :1.0000
## NA's :1710 NA's :1710 NA's :1710 NA's :1710
## return_touchdown extra_point_attempt two_point_attempt field_goal_attempt
## Min. :0.0000 Min. :0.0000 Min. :0.0000 Min. :0.0000
## 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.0000
## Median :0.0000 Median :0.0000 Median :0.0000 Median :0.0000
## Mean :0.0011 Mean :0.0276 Mean :0.0026 Mean :0.0222
## 3rd Qu.:0.0000 3rd Qu.:0.0000 3rd Qu.:0.0000 3rd Qu.:0.0000
## Max. :1.0000 Max. :1.0000 Max. :1.0000 Max. :1.0000

```

```

## NA's :1710 NA's :1710 NA's :1710 NA's :1710
## kickoff_attempt punt_attempt fumble complete_pass
## Min. :0.0000 Min. :0.000 Min. :0.0000 Min. :0.0000
## 1st Qu.:0.0000 1st Qu.:0.000 1st Qu.:0.0000 1st Qu.:0.0000
## Median :0.0000 Median :0.000 Median :0.0000 Median :0.0000
## Mean :0.0594 Mean :0.049 Mean :0.0147 Mean :0.2573
## 3rd Qu.:0.0000 3rd Qu.:0.000 3rd Qu.:0.0000 3rd Qu.:1.0000
## Max. :1.0000 Max. :1.000 Max. :1.0000 Max. :1.0000
## NA's :1710 NA's :1710 NA's :1710 NA's :1710
## assist_tackle lateral_reception lateral_rush lateral_return
## Min. :0.0000 Min. :0e+00 Min. :0 Min. :0e+00
## 1st Qu.:0.0000 1st Qu.:0e+00 1st Qu.:0 1st Qu.:0e+00
## Median :0.0000 Median :0e+00 Median :0 Median :0e+00
## Mean :0.1351 Mean :2e-04 Mean :0 Mean :1e-04
## 3rd Qu.:0.0000 3rd Qu.:0e+00 3rd Qu.:0 3rd Qu.:0e+00
## Max. :1.0000 Max. :1e+00 Max. :1 Max. :1e+00
## NA's :1710 NA's :1710 NA's :1710 NA's :1710
## lateral_recovery passer_player_id passer_player_name receiver_player_id
## Min. :0.0000 Length:47480 Length:47480 Length:47480
## 1st Qu.:0.0000 Class :character Class :character Class :character
## Median :0.0000 Mode :character Mode :character Mode :character
## Mean :0.0019
## 3rd Qu.:0.0000
## Max. :1.0000
## NA's :1710
## receiver_player_name rusher_player_id rusher_player_name
## Length:47480 Length:47480 Length:47480
## Class :character Class :character Class :character
## Mode :character Mode :character Mode :character
##
##
##
## lateral_receiver_player_id lateral_receiver_player_name
## Length:47480 Length:47480
## Class :character Class :character
## Mode :character Mode :character
##
##
##
## lateral_rusher_player_id lateral_rusher_player_name lateral_sack_player_id
## Length:47480 Length:47480 Length:47480
## Class :character Class :character Class :character
## Mode :character Mode :character Mode :character
##
##
##
## lateral_sack_player_name interception_player_id interception_player_name
## Length:47480 Length:47480 Length:47480
## Class :character Class :character Class :character
## Mode :character Mode :character Mode :character
##

```

```

##
##
##
## lateral_interception_player_id lateral_interception_player_name
## Length:47480          Length:47480
## Class :character      Class :character
## Mode :character       Mode :character
##
##
##
##
## punt_returner_player_id punt_returner_player_name
## Length:47480          Length:47480
## Class :character      Class :character
## Mode :character       Mode :character
##
##
##
##
## lateral_punt_returner_player_id lateral_punt_returner_player_name
## Length:47480          Length:47480
## Class :character      Class :character
## Mode :character       Mode :character
##
##
##
##
## kickoff_returner_player_name kickoff_returner_player_id
## Length:47480          Length:47480
## Class :character      Class :character
## Mode :character       Mode :character
##
##
##
##
## lateral_kickoff_returner_player_id lateral_kickoff_returner_player_name
## Length:47480          Length:47480
## Class :character      Class :character
## Mode :character       Mode :character
##
##
##
##
## punter_player_id      punter_player_name kicker_player_name kicker_player_id
## Length:47480          Length:47480      Length:47480      Length:47480
## Class :character      Class :character  Class :character  Class :character
## Mode :character       Mode :character   Mode :character   Mode :character
##
##
##
##
## own_kickoff_recovery_player_id own_kickoff_recovery_player_name
## Length:47480          Length:47480
## Class :character      Class :character

```

```

## Mode :character          Mode :character
##
##
##
## blocked_player_id blocked_player_name tackle_for_loss_1_player_id
## Length:47480      Length:47480      Length:47480
## Class :character   Class :character   Class :character
## Mode :character    Mode :character    Mode :character
##
##
##
## tackle_for_loss_1_player_name tackle_for_loss_2_player_id
## Length:47480      Length:47480
## Class :character   Class :character
## Mode :character    Mode :character
##
##
##
## tackle_for_loss_2_player_name qb_hit_1_player_id qb_hit_1_player_name
## Length:47480      Length:47480      Length:47480
## Class :character   Class :character   Class :character
## Mode :character    Mode :character    Mode :character
##
##
##
## qb_hit_2_player_id qb_hit_2_player_name forced_fumble_player_1_team
## Length:47480      Length:47480      Length:47480
## Class :character   Class :character   Class :character
## Mode :character    Mode :character    Mode :character
##
##
##
## forced_fumble_player_1_player_id forced_fumble_player_1_player_name
## Length:47480      Length:47480
## Class :character   Class :character
## Mode :character    Mode :character
##
##
##
## forced_fumble_player_2_team forced_fumble_player_2_player_id
## Length:47480      Length:47480
## Class :character   Class :character
## Mode :character    Mode :character
##
##
##
## forced_fumble_player_2_player_name solo_tackle_1_team solo_tackle_2_team

```

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## Length:47480          Length:47480          Length:47480
## Class :character      Class :character      Class :character
## Mode :character      Mode :character      Mode :character
##
##
##
##
## solo_tackle_1_player_id solo_tackle_2_player_id solo_tackle_1_player_name
## Length:47480          Length:47480          Length:47480
## Class :character      Class :character      Class :character
## Mode :character      Mode :character      Mode :character
##
##
##
##
## solo_tackle_2_player_name assist_tackle_1_player_id
## Length:47480          Length:47480
## Class :character      Class :character
## Mode :character      Mode :character
##
##
##
##
## assist_tackle_1_player_name assist_tackle_1_team assist_tackle_2_player_id
## Length:47480          Length:47480          Length:47480
## Class :character      Class :character      Class :character
## Mode :character      Mode :character      Mode :character
##
##
##
##
## assist_tackle_2_player_name assist_tackle_2_team assist_tackle_3_player_id
## Length:47480          Length:47480          Length:47480
## Class :character      Class :character      Class :character
## Mode :character      Mode :character      Mode :character
##
##
##
##
## assist_tackle_3_player_name assist_tackle_3_team assist_tackle_4_player_id
## Length:47480          Length:47480          Length:47480
## Class :character      Class :character      Class :character
## Mode :character      Mode :character      Mode :character
##
##
##
##
## assist_tackle_4_player_name assist_tackle_4_team pass_defense_1_player_id
## Length:47480          Length:47480          Length:47480
## Class :character      Class :character      Class :character
## Mode :character      Mode :character      Mode :character
##
##
##

```

```

##
## pass_defense_1_player_name pass_defense_2_player_id pass_defense_2_player_name
## Length:47480          Length:47480          Length:47480
## Class :character      Class :character      Class :character
## Mode :character       Mode :character       Mode :character
##
##
##
##
## fumbled_1_team          fumbled_1_player_id fumbled_1_player_name
## Length:47480          Length:47480          Length:47480
## Class :character      Class :character      Class :character
## Mode :character       Mode :character       Mode :character
##
##
##
##
## fumbled_2_player_id fumbled_2_player_name fumbled_2_team
## Length:47480          Length:47480          Length:47480
## Class :character      Class :character      Class :character
## Mode :character       Mode :character       Mode :character
##
##
##
##
## fumble_recovery_1_team fumble_recovery_1_yards fumble_recovery_1_player_id
## Length:47480          Min.   :-15.00          Length:47480
## Class :character      1st Qu.: 0.00          Class :character
## Mode :character       Median : 0.00          Mode :character
##                      Mean  : 2.81
##                      3rd Qu.: 0.00
##                      Max.   :100.00
##                      NA's   :46865
## fumble_recovery_1_player_name fumble_recovery_2_team fumble_recovery_2_yards
## Length:47480          Length:47480          Min.   : 0.00
## Class :character      Class :character      1st Qu.: 0.00
## Mode :character       Mode :character      Median : 0.00
##                      Mean  : 1.44
##                      3rd Qu.: 0.00
##                      Max.   :12.00
##                      NA's   :47471
## fumble_recovery_2_player_id fumble_recovery_2_player_name return_team
## Length:47480          Length:47480          Length:47480
## Class :character      Class :character      Class :character
## Mode :character       Mode :character      Mode :character
##
##
##
##
## return_yards          penalty_team          penalty_player_id penalty_player_name
## Min.   :-19.0000      Length:47480      Length:47480      Length:47480
## 1st Qu.: 0.0000      Class :character  Class :character  Class :character
## Median : 0.0000      Mode :character  Mode :character  Mode :character
## Mean    : 0.7531

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```

## 3rd Qu.: 0.0000
## Max. :104.0000
## NA's :1710
## penalty_yards replay_or_challenge replay_or_challenge_result
## Min. : 0.00 Min. :0.000000 Length:47480
## 1st Qu.: 5.00 1st Qu.:0.000000 Class :character
## Median : 5.00 Median :0.000000 Mode :character
## Mean : 8.48 Mean :0.009204
## 3rd Qu.:10.00 3rd Qu.:0.000000
## Max. :53.00 Max. :1.000000
## NA's :43912
## penalty_type defensive_two_point_attempt defensive_two_point_conv
## Length:47480 Min. :0e+00 Min. :0
## Class :character 1st Qu.:0e+00 1st Qu.:0
## Mode :character Median :0e+00 Median :0
## Mean :1e-04 Mean :0
## 3rd Qu.:0e+00 3rd Qu.:0
## Max. :1e+00 Max. :1
## NA's :1710 NA's :1710
## defensive_extra_point_attempt defensive_extra_point_conv season
## Min. :0 Min. :0 Min. :2019
## 1st Qu.:0 1st Qu.:0 1st Qu.:2019
## Median :0 Median :0 Median :2019
## Mean :0 Mean :0 Mean :2019
## 3rd Qu.:0 3rd Qu.:0 3rd Qu.:2019
## Max. :0 Max. :0 Max. :2019
## NA's :1710 NA's :1710
## cp cpoe season_type week
## Min. :0.182 Min. : -88.933 Length:47480 Min. : 1.000
## 1st Qu.:0.576 1st Qu.: -49.001 Class :character 1st Qu.: 5.000
## Median :0.685 Median : 20.031 Mode :character Median : 9.000
## Mean :0.661 Mean : -0.022 Mean : 9.432
## 3rd Qu.:0.778 3rd Qu.: 32.369 3rd Qu.:14.000
## Max. :0.889 Max. : 75.650 Max. :22.000
## NA's :29708 NA's :29708
## game_key game_time_eastern game_time_local iso_time
## Min. :57900 Length:47480 Length:47480 Min. :1.568e+12
## 1st Qu.:57966 Class :character Class :character 1st Qu.:1.570e+12
## Median :58033 Mode :character Mode :character Median :1.573e+12
## Mean :58033 Mean :1.573e+12
## 3rd Qu.:58099 3rd Qu.:1.576e+12
## Max. :58167 Max. :1.581e+12
##
## game_type site_id site_city site_fullname
## Length:47480 Min. :1048 Length:47480 Length:47480
## Class :character 1st Qu.:2076 Class :character Class :character
## Mode :character Median :2850 Mode :character Mode :character
## Mean :3083
## 3rd Qu.:3757
## Max. :5786
##
## site_state roof_type drive_start_time drive_end_time
## Length:47480 Length:47480 Length:47480 Length:47480
## Class :character Class :character Class :character Class :character

```



```

## Mode :character Mode :character Mode :character Mode :character
##
##
##
##
## drive_start_yardline drive_end_yardline drive_how_started drive_how_ended
## Length:47480 Length:47480 Length:47480 Length:47480
## Class :character Class :character Class :character Class :character
## Mode :character Mode :character Mode :character Mode :character
##
##
##
##
## drive_play_count drive_yards_penalized drive_time_of_possession
## Min. : 0.000 Min. : -30.0000 Length:47480
## 1st Qu.: 4.000 1st Qu.: 0.0000 Class :character
## Median : 7.000 Median : 0.0000 Mode :character
## Mean : 7.411 Mean : 0.1912
## 3rd Qu.:10.000 3rd Qu.: 0.0000
## Max. :21.000 Max. : 53.0000
##
## drive_inside20 drive_first_downs drive_possession_team_abbrev
## Min. :0.0000 Min. :0.000 Length:47480
## 1st Qu.:0.0000 1st Qu.:1.000 Class :character
## Median :0.0000 Median :2.000 Mode :character
## Mean :0.4004 Mean :2.543
## 3rd Qu.:1.0000 3rd Qu.:4.000
## Max. :1.0000 Max. :8.000
##
## scoring_team_abbrev scoring_type alert_play_type play_type_nfl
## Length:47480 Length:47480 Length:47480 Length:47480
## Class :character Class :character Class :character Class :character
## Mode :character Mode :character Mode :character Mode :character
##
##
##
##
## time_of_day yards end_yardline_side end_yardline_number
## Length:47480 Min. : -85.000 Length:47480 Min. : -126.00
## Class :character 1st Qu.: 0.000 Class :character 1st Qu.: 20.00
## Mode :character Median : 4.000 Mode :character Median : 30.00
## Mean : 9.587 Mean : 28.88
## 3rd Qu.:12.000 3rd Qu.: 40.00
## Max. :185.000 Max. : 50.00
## NA's :3504 NA's :6996
##
## series series_success success passer
## Min. : 1.00 Min. :0.000 Min. :0.0000 Length:47480
## 1st Qu.:14.00 1st Qu.:0.000 1st Qu.:0.0000 Class :character
## Median :29.00 Median :1.000 Median :0.0000 Mode :character
## Mean :29.18 Mean :0.579 Mean :0.4189
## 3rd Qu.:43.00 3rd Qu.:1.000 3rd Qu.:1.0000
## Max. :76.00 Max. :1.000 Max. :1.0000
## NA's :7721 NA's :8158 NA's :2080
##
## rusher receiver pass rush

```

```
## Length:47480      Length:47480      Min.   :0.0000      Min.   :0.0000
## Class :character  Class :character  1st Qu.:0.0000      1st Qu.:0.0000
## Mode  :character  Mode  :character  Median :0.0000      Median :0.0000
##                                     Mean  :0.4646      Mean  :0.2768
##                                     3rd Qu.:1.0000      3rd Qu.:1.0000
##                                     Max.   :1.0000      Max.   :1.0000
##
##      name          first_down      play      passer_id
## Length:47480      Min.   :0.000      Min.   :0.0000      Length:47480
## Class :character  1st Qu.:0.000      1st Qu.:1.0000      Class :character
## Mode  :character  Median :0.000      Median :1.0000      Mode  :character
##                                     Mean  :0.234      Mean  :0.7585
##                                     3rd Qu.:0.000      3rd Qu.:1.0000
##                                     Max.   :1.000      Max.   :1.0000
##                                     NA's   :1710
##      rusher_id      receiver_id      qb_epa
## Length:47480      Length:47480      Min.   :-13.4947
## Class :character  Class :character  1st Qu.: -0.5945
## Mode  :character  Mode  :character  Median :  0.0000
##                                     Mean  :  0.0286
##                                     3rd Qu.:  0.5753
##                                     Max.   :  9.2448
##                                     NA's   :2080
```

Data Manipulation:

Here I will manipulate the data by creating some new columns that I plan on using later in the analysis. First, I convert the play type variable to a factor, so that it is easier to use. I create a column called good_play. In this data set, a win probability function is included, which I will use. I classify a good play as 1 when a team's win probability increases or stays the same because of a particular play and 0 when the win probability decreases after the play. I create a column that is 1 if the play type is a passing play and 0 if it is anything else. I create a column called yardage that has 3 possible values: long, medium, and short. If there are 8 yards to go until the 1st down marker, then yardage is long. If there's 4-7 yards to go, then medium yardage. If less than 4 yards to go, then short yardage.

```
pbp$play_type = as.factor(pbp$play_type)

pbp$good_play = ifelse(pbp$wpa >= 0, 1, 0)

pbp$pass = ifelse(pbp$play_type == "pass", 1, 0)

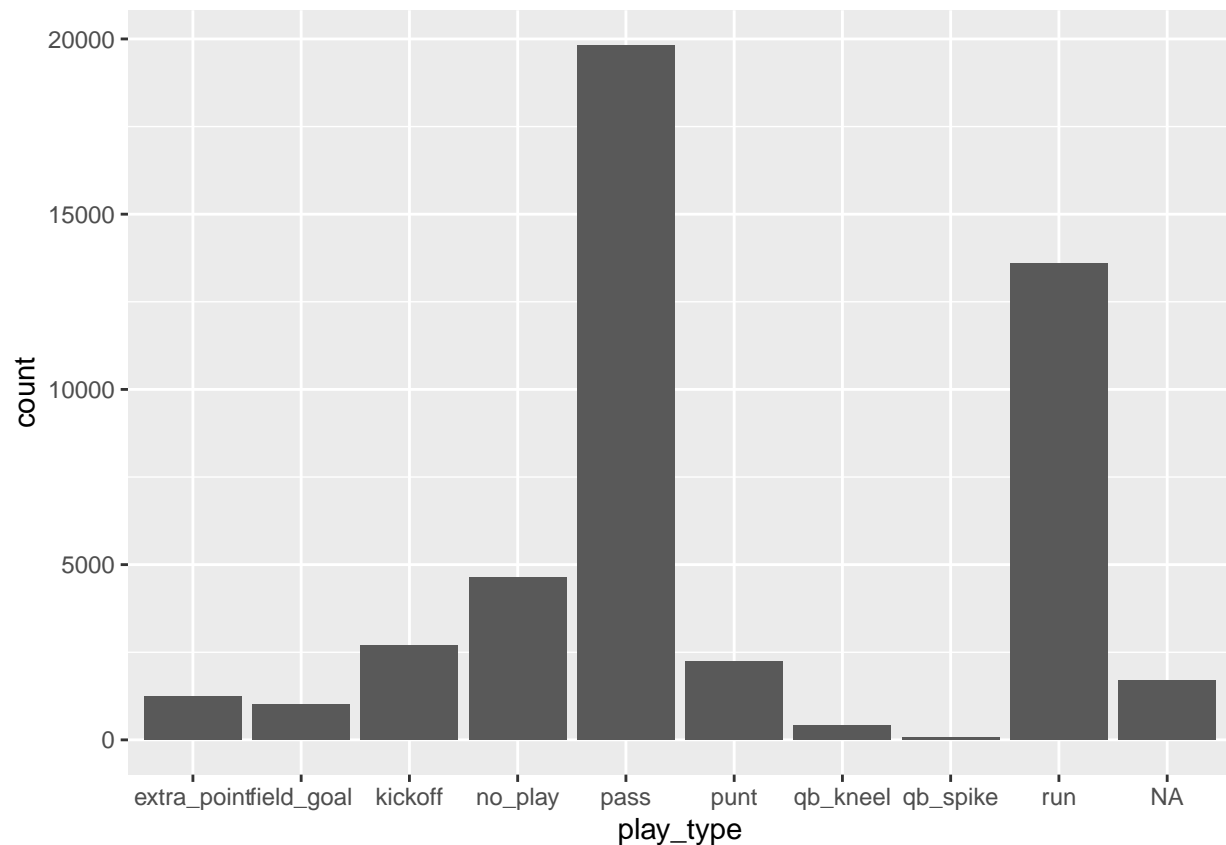
pbp$yardage = case_when(pbp$ydstogo >= 8 ~ "long",
                        pbp$ydstogo >= 4 ~ "medium",
                        TRUE ~ "short")
```

Data Visualization and Exploration:

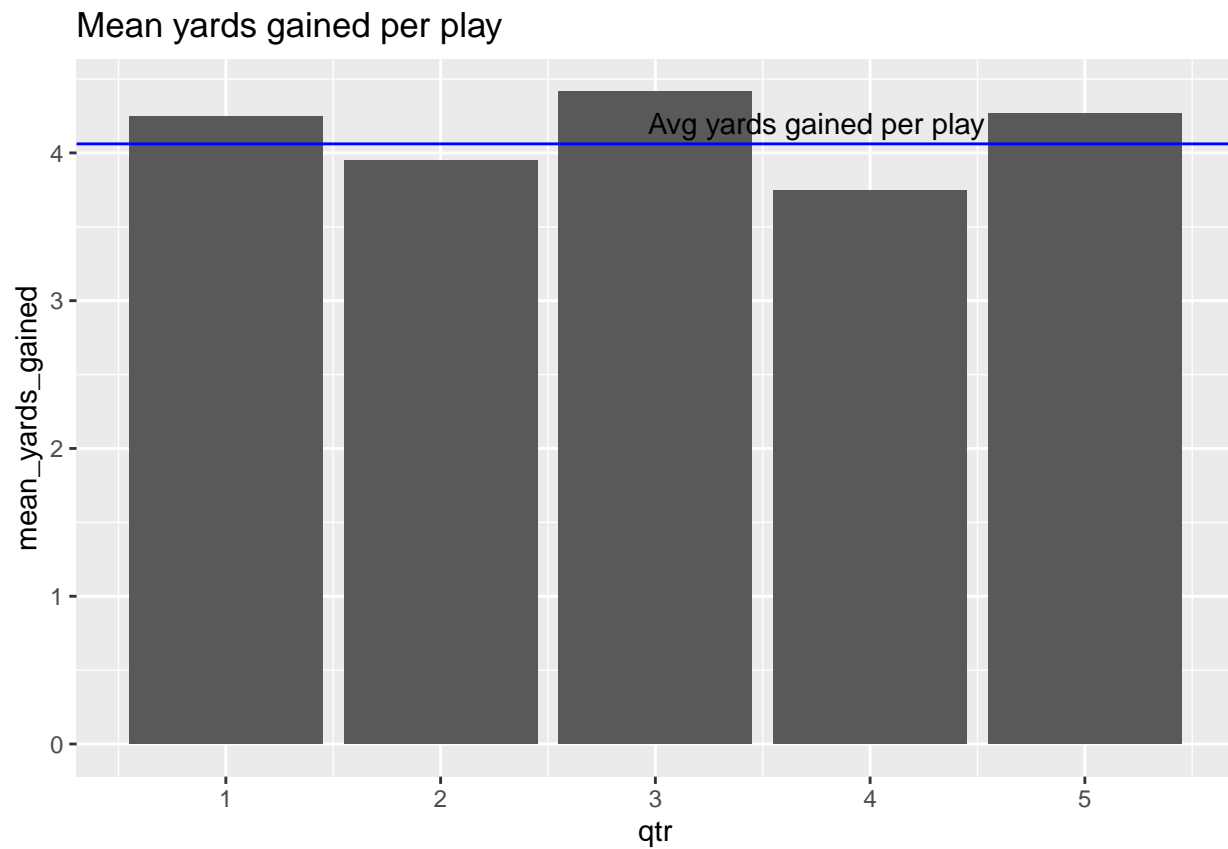
In this, I will create some different types of visualizations to see if I can find anything meaningful or interesting. These graphs can provide to be useful when communicating with those who lack the jargon that goes along with analytics and statistics.

Noteworthy: Quarter 5 means Overtime

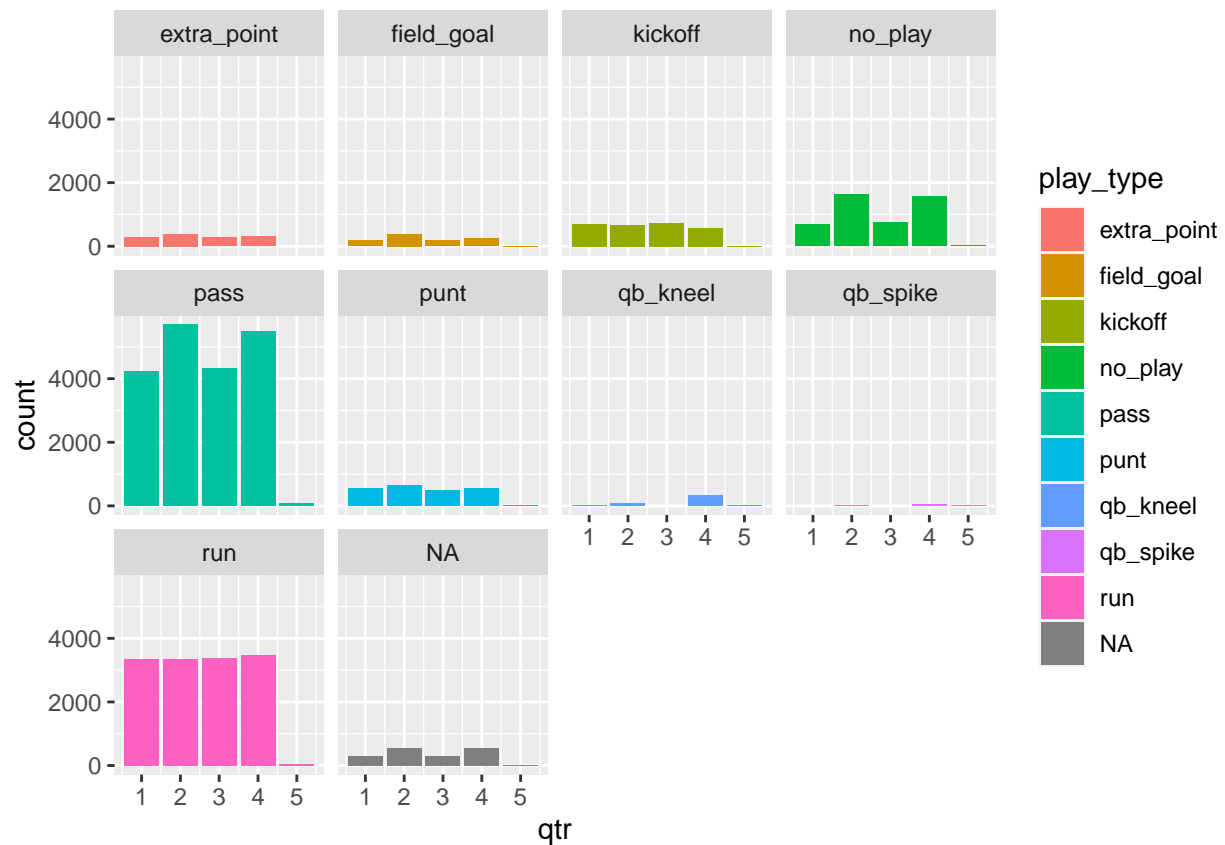
```
## Bar Chart that counts number of plays of different play types
pbp %>%
  ggplot(aes(x= play_type)) + geom_bar()
```



```
## Graph of average yards gained per play in each quarter
pbp %>% group_by(qtr) %>% summarise(mean_yards_gained = mean(yards_gained, na.rm = TRUE)) %>%
  ggplot(aes(x= qtr, y = mean_yards_gained)) + geom_bar(stat = "identity") +
  labs(title = "Mean yards gained per play") +
  geom_hline(yintercept = mean(pbp$yards_gained, na.rm = TRUE), color = "blue") +
  annotate("text", label = "Avg yards gained per play", x = 3.75, y = 4.2)
```



```
## Distribution of play types by quarter  
pbp %>%  
  ggplot(aes(x= qtr, fill = play_type)) + geom_bar() + facet_wrap(~play_type)
```



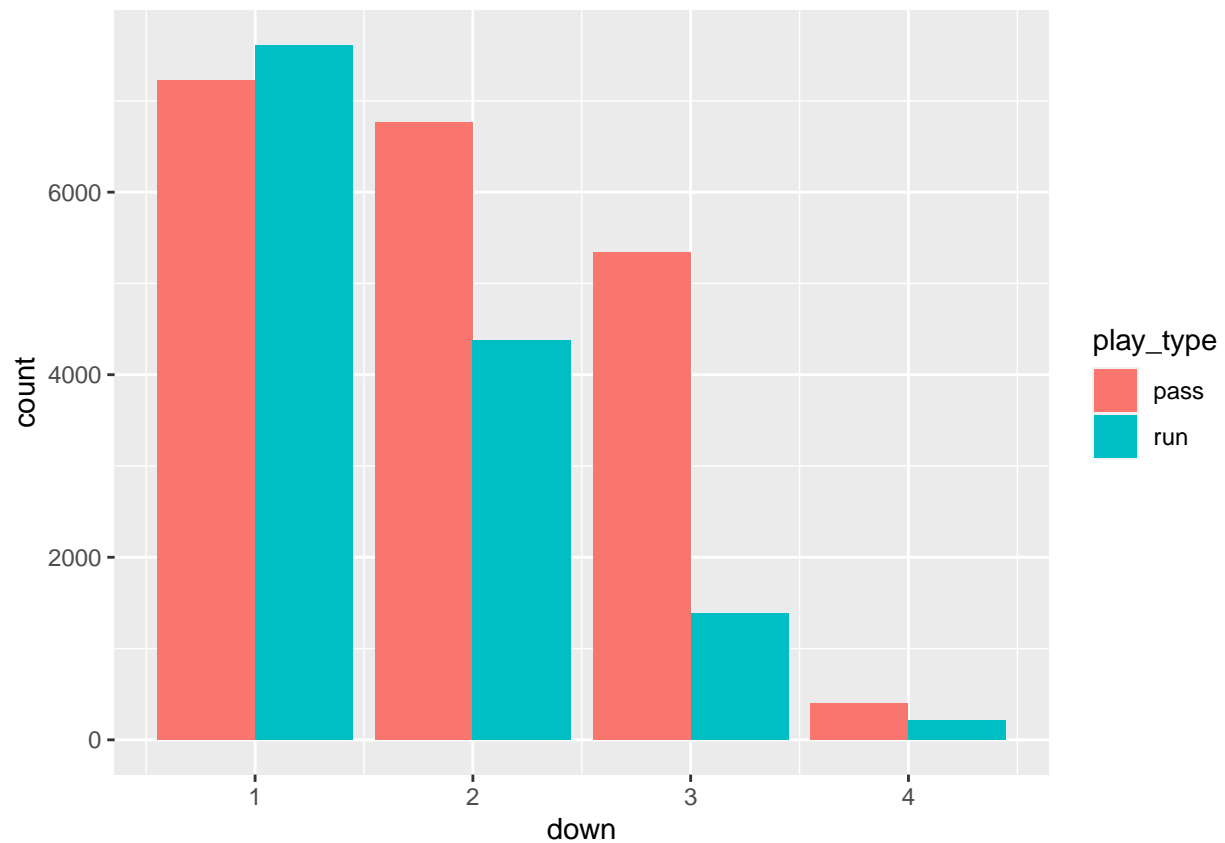
```
## Graph of pass vs run plays broken down by down
```

```
pbp %>%
```

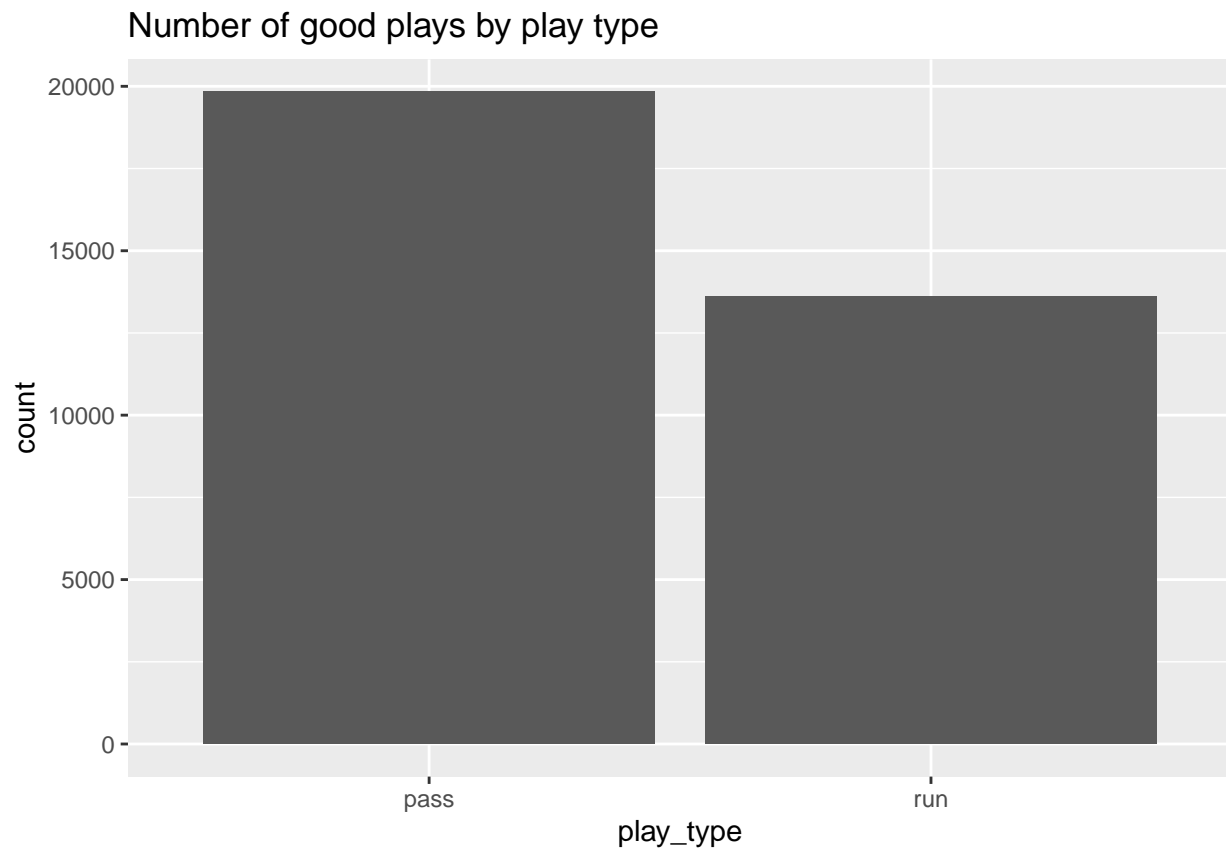
```
  filter(play_type == "pass" | play_type == "run") %>%
```

```
  ggplot(aes(x= down, fill = play_type)) + geom_bar(position="dodge")
```

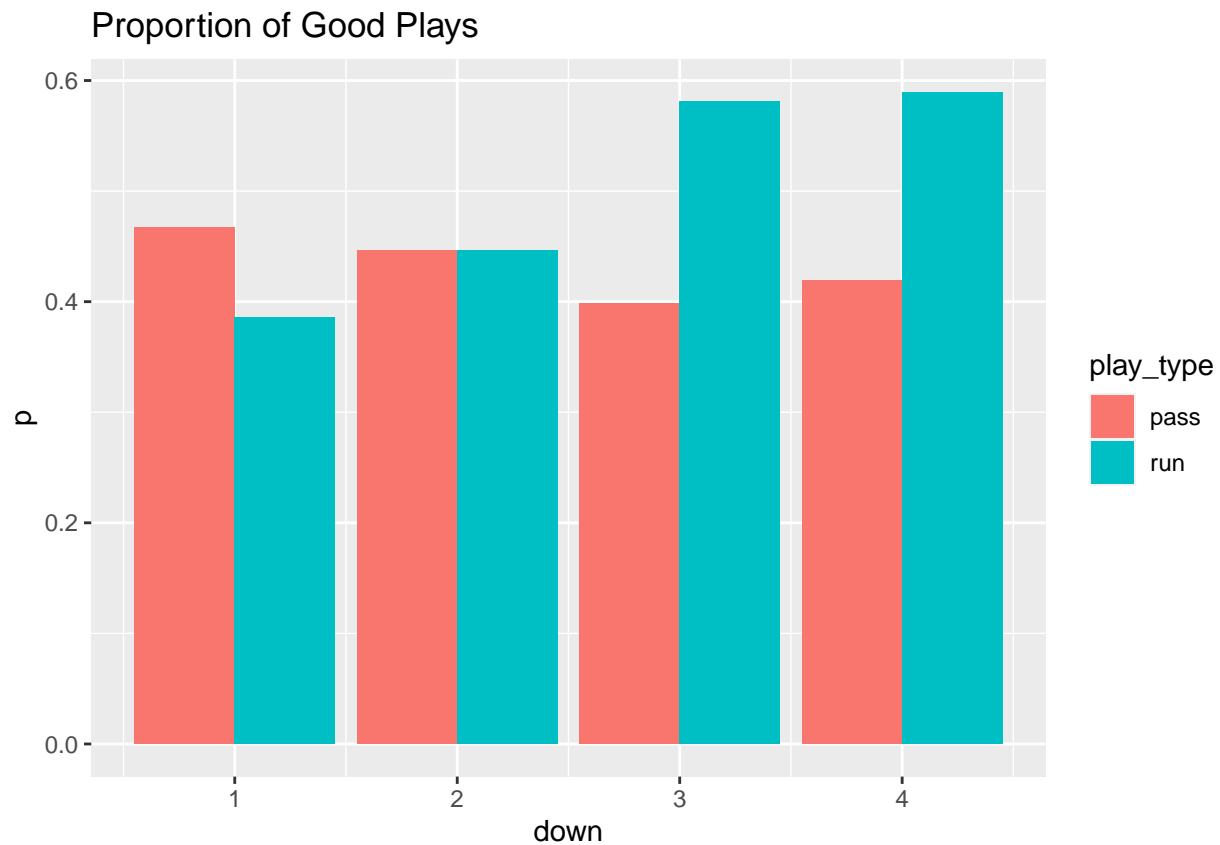
```
## Warning: Removed 116 rows containing non-finite values (stat_count).
```



```
## Graph showing number of good plays broken down by pass vs run plays
pbp %>%
  filter(play_type == "pass" | play_type == "run") %>%
  ggplot(aes(x= play_type, fill = good_play)) + geom_bar(position="dodge") +
  labs(title = "Number of good plays by play type")
```



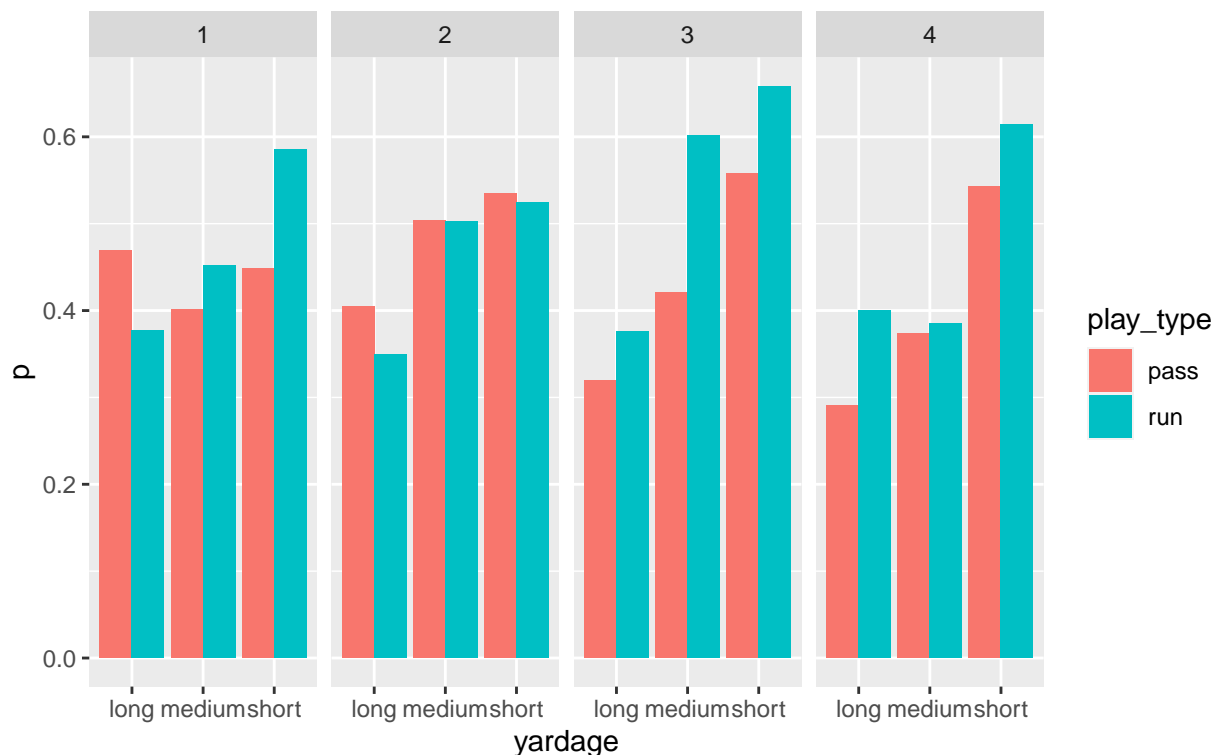
```
## Graph of proportion of good plays grouped by down & play type
pbp %>%
  filter(play_type == "pass" | play_type == "run", is.na(good_play) == FALSE, down != 5) %>%
  group_by(down, play_type) %>%
  summarise(p = sum(good_play) / length(good_play)) %>%
  ggplot(aes(x = down, y = p, fill = play_type)) +
  geom_bar(stat = "identity", position = "dodge") +
  labs(title = "Proportion of Good Plays")
```



```
## Graph of proportion of good plays grouped by down, play type, and yardage
pbp %>%
  filter(play_type == "pass" | play_type == "run", is.na(good_play) == FALSE, down != 5) %>%
  group_by(yardage, play_type, down) %>%
  summarise(p = sum(good_play) / length(good_play)) %>%
  ggplot(aes(x= yardage, y = p, fill = play_type)) +
  geom_bar(stat = "identity", position = "dodge") +
  facet_grid(~down) +
  labs(title = "Percentage of good plays based on down, play type, and yardage",
       subtitle = "8+ yards = long, 4-7 yards = medium, < 4 = short")
```


Percentage of good plays based on down, play type, and yardage

8+ yards = long, 4–7 yards = medium, < 4 = short



Insights from Data Visualizations:

Hypothesis Testing:

After exploring the data a bit, I became curious about whether there is a difference in the proportion of passing plays between the 1st and 2nd half of the game. To do this, I will complete a paired t-test that measures the difference of each team's 1st and 2nd half proportion.

Null Hypothesis: $H_0: D = 0$; Half has no effect on the proportion of passing plays
 Alternative Hypothesis: $H_a: D \neq 0$; Half does have an effect on the proportion of passing plays

```
team_quarter_pct_passing_first_half = pbp %>%
  filter(qtr == 1 | qtr == 2) %>%
  group_by(posteam) %>%
  filter(play_type != "no_play", is.na(play_type) != TRUE) %>%
  summarise(pct_passing = sum(pass) / length(pass))

team_quarter_pct_passing_second_half = pbp %>%
  filter(qtr == 3 | qtr == 4) %>%
  group_by(posteam) %>%
  filter(play_type != "no_play", is.na(play_type) != TRUE) %>%
  summarise(pct_passing = sum(pass) / length(pass))

t.test(team_quarter_pct_passing_first_half$pct_passing, team_quarter_pct_passing_second_half$pct_passing,
  paired = TRUE, alternative = "two.sided")

##
## Paired t-test
##
```

```
## data: team_quarter_pct_passing_first_half$pct_passing and team_quarter_pct_passing_second_half$pct_
## t = 0.038568, df = 31, p-value = 0.9695
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.01793267 0.01862397
## sample estimates:
## mean of the differences
## 0.0003456508
```

Based on the results of the paired t test, there is no evidence to suggest that the proportion of passing plays changes based on which half it is. The p-value of 0.9695 is extremely high. The mean difference was 0.0003456508, which is very close to 0. The 95% Confidence interval was (-0.01793267, 0.01862397). Based on these, I believe that it's safe to say that the true mean difference is extremely close to 0.

Classification Model: I plan to attempt to predict if a play is a run or pass play based on different variables in the data set. I believe this could be a very useful tool for a defensive coordinator to utilize. If successful, a coordinator would be better equipped to call defensive audibles if analytics teams were able to quickly make predictions based on certain game scenarios.

```
## Building train and test data sets

classifier_data_set = pbp %>% filter(play_type == "pass" | play_type == "run", is.na(down) != TRUE)

n = length(classifier_data_set$play_id)

train_rows = sample(n, n/2)

train = classifier_data_set[train_rows,]
test = classifier_data_set[-train_rows,]

## Training the classifier

## pass is 1 if pass play, 0 if not
log_m1 = glm(pass ~ wp + ydstogo + down + game_seconds_remaining, data = train, family = "binomial")
summary(log_m1)

##
## Call:
## glm(formula = pass ~ wp + ydstogo + down + game_seconds_remaining,
##      family = "binomial", data = train)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -3.2307  -1.1101   0.6048   0.9839   2.0350
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)   -1.419e+00  8.844e-02  -16.04 < 2e-16 ***
## wp            -1.462e+00  6.028e-02  -24.25 < 2e-16 ***
## ydstogo        1.356e-01  5.575e-03   24.32 < 2e-16 ***
## down           8.611e-01  2.546e-02   33.82 < 2e-16 ***
## game_seconds_remaining -5.054e-05  1.625e-05   -3.11  0.00187 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
```

```
##
## Null deviance: 22466 on 16658 degrees of freedom
## Residual deviance: 20206 on 16654 degrees of freedom
## AIC: 20216
##
## Number of Fisher Scoring iterations: 4
log_probs1 = predict(log_m1, newdata = test, type = "response")
log_p1 = ifelse(log_probs1 > 0.5, 1, 0)
c_matrix1 = table(log_p1 == test$pass)
c_matrix1

##
## FALSE TRUE
## 5685 10975

log_m2 = glm(pass ~ wp + ydstogo + down, data = train, family = "binomial")
summary(log_m2)

##
## Call:
## glm(formula = pass ~ wp + ydstogo + down, family = "binomial",
## data = train)
##
## Deviance Residuals:
## Min 1Q Median 3Q Max
## -3.2447 -1.1198 0.6138 0.9867 2.0288
##
## Coefficients:
## Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.505607 0.083889 -17.95 <2e-16 ***
## wp -1.470784 0.060086 -24.48 <2e-16 ***
## ydstogo 0.135504 0.005574 24.31 <2e-16 ***
## down 0.862468 0.025451 33.89 <2e-16 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 22466 on 16658 degrees of freedom
## Residual deviance: 20216 on 16655 degrees of freedom
## AIC: 20224
##
## Number of Fisher Scoring iterations: 4
log_probs2 = predict(log_m2, newdata = test, type = "response")
log_p2 = ifelse(log_probs2 > 0.5, 1, 0)
c_matrix2 = table(log_p2 == test$pass)
c_matrix2

##
## FALSE TRUE
## 5692 10968

log_m3 = glm(pass ~ down + ydstogo + td_prob + fg_prob + posteam,
data = train, family = "binomial")
summary(log_m3)
```

```
##
## Call:
## glm(formula = pass ~ down + ydstogo + td_prob + fg_prob + posteam,
##      family = "binomial", data = train)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -2.9044  -1.1561   0.6403   1.0107   2.3407
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.230206   0.150074  -8.197 2.46e-16 ***
## down         0.688097   0.029062  23.677 < 2e-16 ***
## ydstogo      0.103643   0.006113  16.956 < 2e-16 ***
## td_prob     -2.242800   0.184440 -12.160 < 2e-16 ***
## fg_prob      0.911201   0.221258   4.118 3.82e-05 ***
## posteamATL   0.475547   0.135588   3.507 0.000453 ***
## posteamBAL  -0.416484   0.131967  -3.156 0.001600 **
## posteamBUF  -0.173583   0.132261  -1.312 0.189377
## posteamCAR   0.272415   0.133580   2.039 0.041416 *
## posteamCHI   0.049752   0.135427   0.367 0.713340
## posteamCIN   0.271486   0.137779   1.970 0.048788 *
## posteamCLE   0.152058   0.138014   1.102 0.270568
## posteamDAL   0.047356   0.132716   0.357 0.721227
## posteamDEN   0.018971   0.137363   0.138 0.890157
## posteamDET   0.131226   0.132859   0.988 0.323296
## posteamGB    0.214314   0.132582   1.616 0.105993
## posteamHOU   0.170963   0.131752   1.298 0.194420
## posteamIND  -0.186250   0.135026  -1.379 0.167783
## posteamJAX   0.154734   0.136454   1.134 0.256808
## posteamKC    0.274921   0.130855   2.101 0.035644 *
## posteamLA    0.256455   0.135532   1.892 0.058462 .
## posteamLAC   0.371202   0.139594   2.659 0.007834 **
## posteamLV   -0.065837   0.133529  -0.493 0.621977
## posteamMIA   0.380680   0.138995   2.739 0.006166 **
## posteamMIN  -0.155427   0.131195  -1.185 0.236135
## posteamNE    0.195805   0.132448   1.478 0.139313
## posteamNO    0.442122   0.135758   3.257 0.001127 **
## posteamNYG   0.491665   0.137860   3.566 0.000362 ***
## posteamNYJ   0.137300   0.138639   0.990 0.322008
## posteamPHI   0.219572   0.131032   1.676 0.093795 .
## posteamPIT   0.068704   0.140607   0.489 0.625111
## posteamSEA   0.035743   0.130575   0.274 0.784290
## posteamSF   -0.247549   0.127363  -1.944 0.051939 .
## posteamTB    0.256709   0.133602   1.921 0.054676 .
## posteamTEN  -0.247582   0.130752  -1.894 0.058288 .
## posteamWAS   0.155597   0.144188   1.079 0.280532
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
```

```

##      Null deviance: 22466  on 16658  degrees of freedom
## Residual deviance: 20482  on 16623  degrees of freedom
## AIC: 20554
##
## Number of Fisher Scoring iterations: 4
log_probs3 = predict(log_m3, newdata = test, type = "response")
log_p3 = ifelse(log_probs3 > 0.5, 1, 0)
c_matrix3 = table(log_p3 == test$pass)
c_matrix3

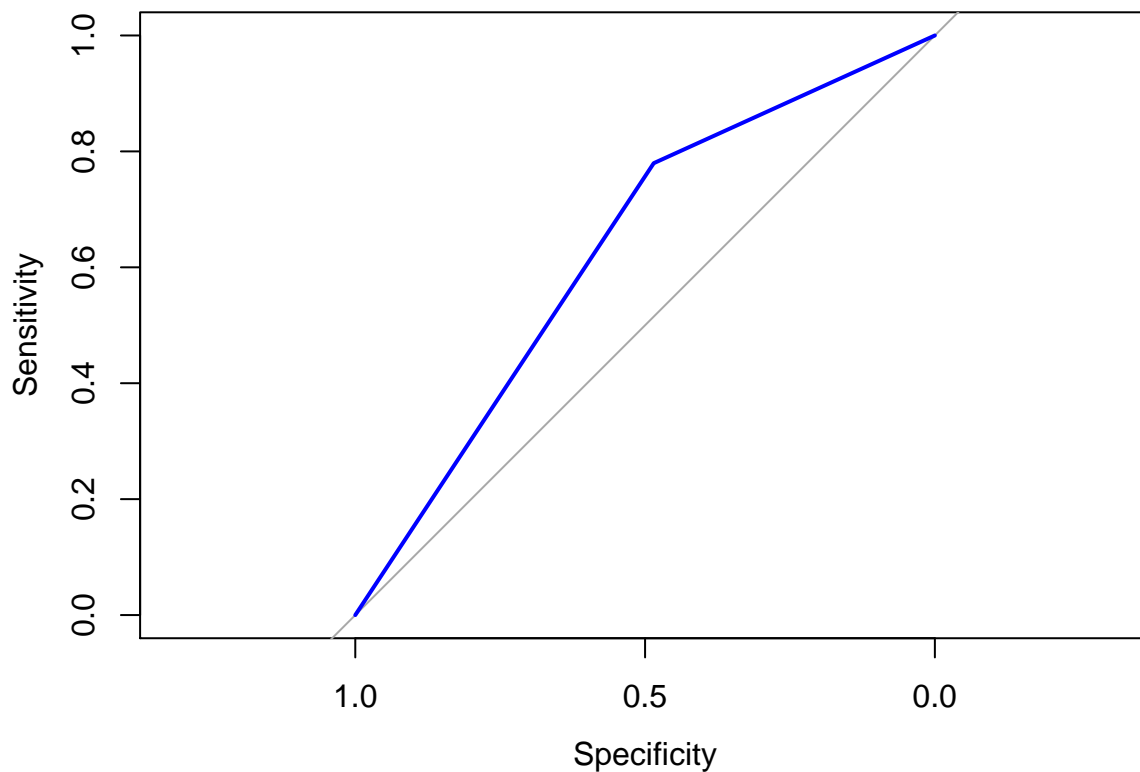
##
## FALSE  TRUE
## 5952 10708
best_logistic_model_prop = 11095 / (11095 + 5565)
best_logistic_model_prop

## [1] 0.6659664
library("pROC")

## Type 'citation("pROC")' for a citation.
##
## Attaching package: 'pROC'
## The following objects are masked from 'package:stats':
##
##      cov, smooth, var
ROC = roc(test$pass, log_p2)

## Setting levels: control = 0, case = 1
## Setting direction: controls < cases
plot(ROC, col = "blue")

```



```
auc(ROC)
```

```
## Area under the curve: 0.6324
```

Talk about other variables and using more specific data sets on players and teams

Beneficial to defensive coordinators

```
first_down = pbp %>% filter(down == 1) %>%
  filter(play_type == "pass" | play_type == "run") %>%
  mutate(pass = ifelse(play_type == "pass", 1, 0))
second_down = pbp %>% filter(down == 2) %>%
  filter(play_type == "pass" | play_type == "run") %>%
  mutate(pass = ifelse(play_type == "pass", 1, 0))
third_down = pbp %>% filter(down == 3) %>%
  filter(play_type == "pass" | play_type == "run") %>%
  mutate(pass = ifelse(play_type == "pass", 1, 0))
fourth_down = pbp %>% filter(down == 4) %>%
  filter(play_type == "pass" | play_type == "run" | play_type == "field_goal" | play_type == "punt") %>%
  mutate(pass = ifelse(play_type == "pass", 1, 0))

first_down$play_type = as.factor(first_down$play_type)
second_down$play_type = as.factor(second_down$play_type)
third_down$play_type = as.factor(third_down$play_type)
fourth_down$play_type = as.factor(fourth_down$play_type)
```

```

first_down_pct_passing = first_down %>%
  group_by(posteam) %>%
  summarize(pct_passing = sum(pass) / length(pass)) %>%
  mutate("down" = 1)

second_down_pct_passing = second_down %>%
  group_by(posteam) %>%
  summarize(pct_passing = sum(pass) / length(pass)) %>%
  mutate("down" = 2)

third_down_pct_passing = third_down %>%
  group_by(posteam) %>%
  summarize(pct_passing = sum(pass) / length(pass)) %>%
  mutate("down" = 3)

fourth_down_pct_passing = fourth_down %>%
  group_by(posteam) %>%
  summarize(pct_passing = sum(pass) / length(pass)) %>%
  mutate("down" = 4)

fourth_down_pct_running = fourth_down %>%
  mutate("run" = ifelse(play_type == "run", 1, 0)) %>%
  group_by(posteam) %>%
  summarize(pct_running = sum(run) / length(run)) %>%
  mutate("down" = 4)

fourth_down_aggressiveness = merge(fourth_down_pct_passing, fourth_down_pct_running, by = "posteam")
head(fourth_down_aggressiveness)

##   posteam pct_passing down.x pct_running down.y
## 1    ARI  0.11475410      4  0.04918033      4
## 2    ATL  0.14678899      4  0.04587156      4
## 3    BAL  0.17171717      4  0.11111111      4
## 4    BUF  0.06766917      4  0.07518797      4
## 5    CAR  0.12698413      4  0.06349206      4
## 6    CHI  0.12598425      4  0.03937008      4

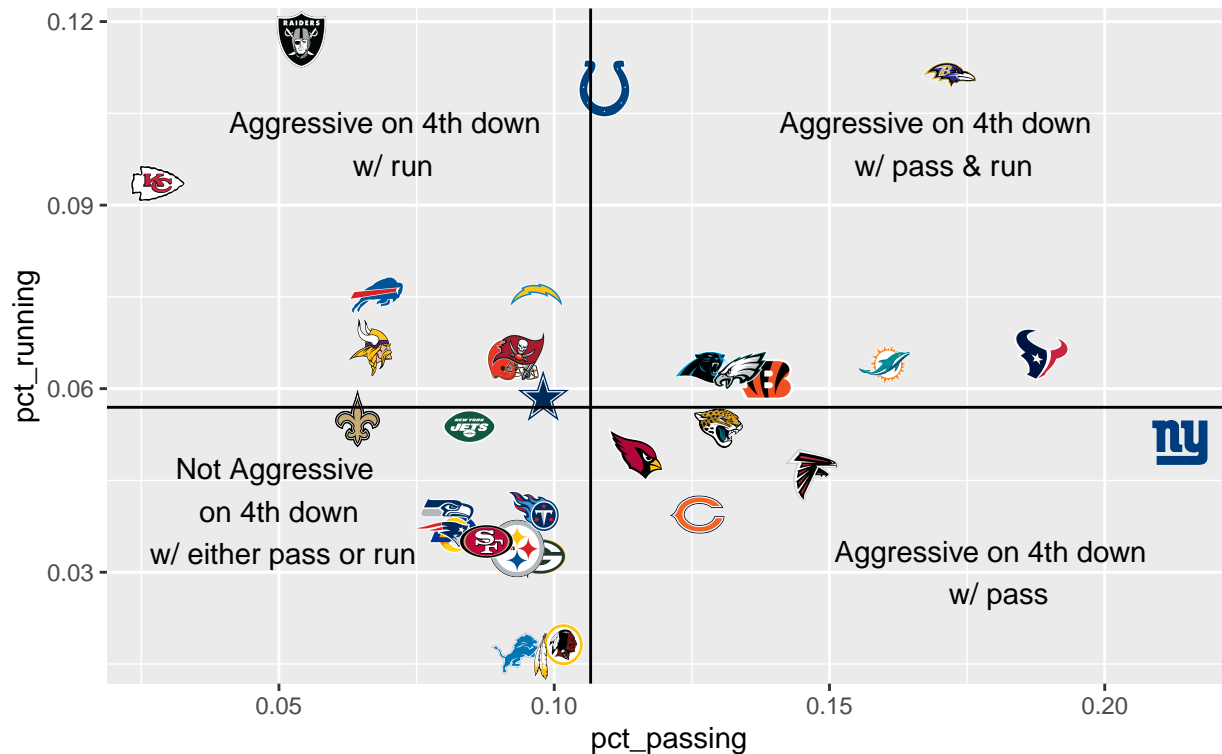
## Getting rid of team logos of old teams
logos = teams_colors_logos %>% select(team_abbr, team_logo_espn) %>%
  filter(team_abbr != "LAR", team_abbr != "SD", team_abbr != "STL", team_abbr != "OAK")

## Visualizing fourth down aggressiveness of teams
ggplot(fourth_down_aggressiveness, aes(x= pct_passing, y = pct_running)) +
  geom_image(aes(image = logos$team_logo_espn), size = 0.05, asp = 16 / 9) +
  geom_hline(yintercept = mean(fourth_down_aggressiveness$pct_running)) +
  geom_vline(xintercept = mean(fourth_down_aggressiveness$pct_passing)) +
  annotate("text", x=.17, y=.1, label = "Aggressive on 4th down \n w/ pass & run") +
  annotate("text", x=.07, y=.1, label = "Aggressive on 4th down \n w/ run") +
  annotate("text", x=.05, y=.04, label = "Not Aggressive \n on 4th down \n w/ either pass or run") +
  annotate("text", x=.18, y=.03, label = "Aggressive on 4th down \n w/ pass") +
  labs(title = "Fourth Down Aggressiveness",
       subtitle = "Percent of 4th down plays that were passing or running plays")

```

Fourth Down Aggressiveness

Percent of 4th down plays that were passing or running plays



```
x1= merge(first_down_pct_passing, second_down_pct_passing, by = "posteam")
x2= merge(x1, third_down_pct_passing, by = "posteam")
x3= merge(x2, fourth_down_pct_passing, by = "posteam")
```

```
## Warning in merge.data.frame(x2, fourth_down_pct_passing, by = "posteam"): column
## names 'pct_passing.x', 'down.x', 'pct_passing.y', 'down.y' are duplicated in the
## result
```

```
colnames(x3) = c("Team", "first_down_passing", "Down1", "second_down_passing", "Down2 ",
                 "third_down_passing", "Down3", "fourth_down_passing", "Down4")
```

```
x3 = x3 %>% select(Team, first_down_passing, second_down_passing, third_down_passing, fourth_down_passing)
head(x3)
```

```
##   Team first_down_passing second_down_passing third_down_passing
## 1  ARI      0.5183486      0.5921450      0.8256410
## 2  ATL      0.5855131      0.7014085      0.8398058
## 3  BAL      0.3894325      0.4792746      0.6237624
## 4  BUF      0.4916667      0.5231214      0.7260870
## 5  CAR      0.5427975      0.6592179      0.8454106
## 6  CHI      0.5186916      0.6023055      0.8139535
##   fourth_down_passing
## 1      0.11475410
## 2      0.14678899
## 3      0.17171717
## 4      0.06766917
## 5      0.12698413
```



```
## 6          0.12598425
```

```
g1= ggplot(data = x3) + geom_histogram(aes(x = first_down_passing), binwidth = .01) +  
  geom_vline(xintercept = mean(first_down_pct_passing$pct_passing), col = "blue", size = 1) +  
  scale_x_continuous(limits = c(0,1))  
  
g2= ggplot(data = x3) + geom_histogram(aes(x = second_down_passing), binwidth = .01) +  
  geom_vline(xintercept = mean(second_down_pct_passing$pct_passing), col = "blue", size = 1) +  
  scale_x_continuous(limits = c(0,1))  
  
g3= ggplot(data = x3) + geom_histogram(aes(x = third_down_passing), binwidth = .01) +  
  geom_vline(xintercept = mean(third_down_pct_passing$pct_passing), col = "blue", size = 1)+  
  scale_x_continuous(limits = c(0,1))  
  
g4= ggplot(data = x3) + geom_histogram(aes(x = fourth_down_passing), binwidth = .01) +  
  geom_vline(xintercept = mean(fourth_down_pct_passing$pct_passing), col = "blue", size = 1)+  
  scale_x_continuous(limits = c(0,1))  
  
library(gridExtra)
```

```
##  
## Attaching package: 'gridExtra'  
## The following object is masked from 'package:dplyr':  
##  
##      combine
```

```
grid.arrange(g1,g2,g3,g4, nrow=2)
```

```
## Warning: Removed 2 rows containing missing values (geom_bar).  
## Warning: Removed 2 rows containing missing values (geom_bar).  
## Warning: Removed 2 rows containing missing values (geom_bar).  
## Warning: Removed 2 rows containing missing values (geom_bar).
```

