# NOAA Storm Database Exploratory Analysis for identification of Most Destructive Events in terms of health and economic consequences

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## Synopsis

This document contains exploratory data analysis of NOAA Storm Database.In this analysis I have tried to find most destructive events in terms of population health and economic consequences. For population health effects, I took number of fatalaties and injuries caused by each event into account. For economic consequences, I took property damage and crop damage expenses into account.To compare destruction caused by harmful events, a bar plot was created for all of such events.

## Data Processing

Loading the Storm Data from compressed comma separated file compressed in bz2 format.

```
storm_data <- read.csv("./repdata_data_StormData.csv.bz2", header=T, sep=",")
head(storm_data)
```

```
##   STATE__           BGN_DATE BGN_TIME TIME_ZONE COUNTY COUNTYNAME STATE  EVTYPE
## 1       1  4/18/1950 0:00:00     0130       CST     97     MOBILE    AL TORNADO
## 2       1  4/18/1950 0:00:00     0145       CST      3    BALDWIN    AL TORNADO
## 3       1  2/20/1951 0:00:00     1600       CST     57    FAYETTE    AL TORNADO
## 4       1   6/8/1951 0:00:00     0900       CST     89    MADISON    AL TORNADO
## 5       1 11/15/1951 0:00:00     1500       CST     43    CULLMAN    AL TORNADO
## 6       1 11/15/1951 0:00:00     2000       CST     77 LAUDERDALE    AL TORNADO
##   BGN_RANGE BGN_AZI BGN_LOCATI END_DATE END_TIME COUNTY_END COUNTYENDN
## 1         0                                               0         NA
## 2         0                                               0         NA
## 3         0                                               0         NA
## 4         0                                               0         NA
## 5         0                                               0         NA
## 6         0                                               0         NA
##   END_RANGE END_AZI END_LOCATI LENGTH WIDTH F MAG FATALITIES INJURIES PROPDMG
## 1         0                      14.0   100 3   0          0       15    25.0
## 2         0                       2.0   150 2   0          0        0     2.5
## 3         0                       0.1   123 2   0          0        2    25.0
## 4         0                       0.0   100 2   0          0        2     2.5
## 5         0                       0.0   150 2   0          0        2     2.5
## 6         0                       1.5   177 2   0          0        6     2.5
```

```
##   PROPDMGEXP CROPDMG CROPDMGEXP WFO STATEOFFIC ZONENAMES LATITUDE LONGITUDE
## 1          K       0                                         3040      8812
## 2          K       0                                         3042      8755
## 3          K       0                                         3340      8742
## 4          K       0                                         3458      8626
## 5          K       0                                         3412      8642
## 6          K       0                                         3450      8748
##   LATITUDE_E LONGITUDE_ REMARKS REFNUM
## 1       3051       8806              1
## 2          0          0              2
## 3          0          0              3
## 4          0          0              4
## 5          0          0              5
## 6          0          0              6
```

### Finding Most Harmful Events with respect to Population Health

Aggregating (sum) fatalities values w.r.t Event Type.

```r
fatalities_per_event <- tapply(storm_data$FATALITIES, storm_data$EVTYPE, sum)
```

Aggregating (sum) injuries values w.r.t Event Type.

```r
injuries_per_event <- tapply(storm_data$INJURIES, storm_data$EVTYPE, sum)
```

Taking sum of fatalities and injuries caused by each event. From now on this sum will be referred by health effects.

```r
health_effects_per_event <- fatalities_per_event + injuries_per_event
```

Excluding events with no health effects to find harmful events.

```r
health_effects_per_harmful_event <- health_effects_per_event[health_effects_per_event > 0]
```

Converting health effects per harmful event object to DataFrame type.

```r
health_effects_per_harmful_event_df <- data.frame(Event=names(health_effects_per_harmful_event), Health_

head(health_effects_per_harmful_event_df)
```

```
##          Event Health_Effects
## 1     AVALANCE              1
## 2    AVALANCHE            394
## 3    BLACK ICE             25
## 4     BLIZZARD            906
## 5 blowing snow              2
## 6 BLOWING SNOW             14
```

Caclulating average number of health effects caused by harmful events.

```
harmful_events_avg_effects <- mean(health_effects_per_harmful_event_df$Health_Effects)
harmful_events_avg_effects
```

```
## [1] 707.6045
```

#### Results

Finding most harmful events by extracting events from the dataframe having number of effects greater than average.

```
hlth_efcts_per_most_hrmfl_event_df <- health_effects_per_harmful_event_df[health_effects_per_harmful_eve
hlth_efcts_per_most_hrmfl_event_df
```

```
##                   Event Health_Effects
## 4              BLIZZARD            906
## 32       EXCESSIVE HEAT           8428
## 42          FLASH FLOOD           2755
## 47                FLOOD           7259
## 52                  FOG            796
## 67                 HAIL           1376
## 69                 HEAT           3037
## 77           HEAVY SNOW           1148
## 93            HIGH WIND           1385
## 109   HURRICANE/TYPHOON           1339
## 117           ICE STORM           2064
## 123           LIGHTNING           6046
## 173   THUNDERSTORM WIND           1621
## 176 THUNDERSTORM WINDS            972
## 184             TORNADO          96979
## 191           TSTM WIND           7461
## 210            WILDFIRE            986
## 214        WINTER STORM           1527
```

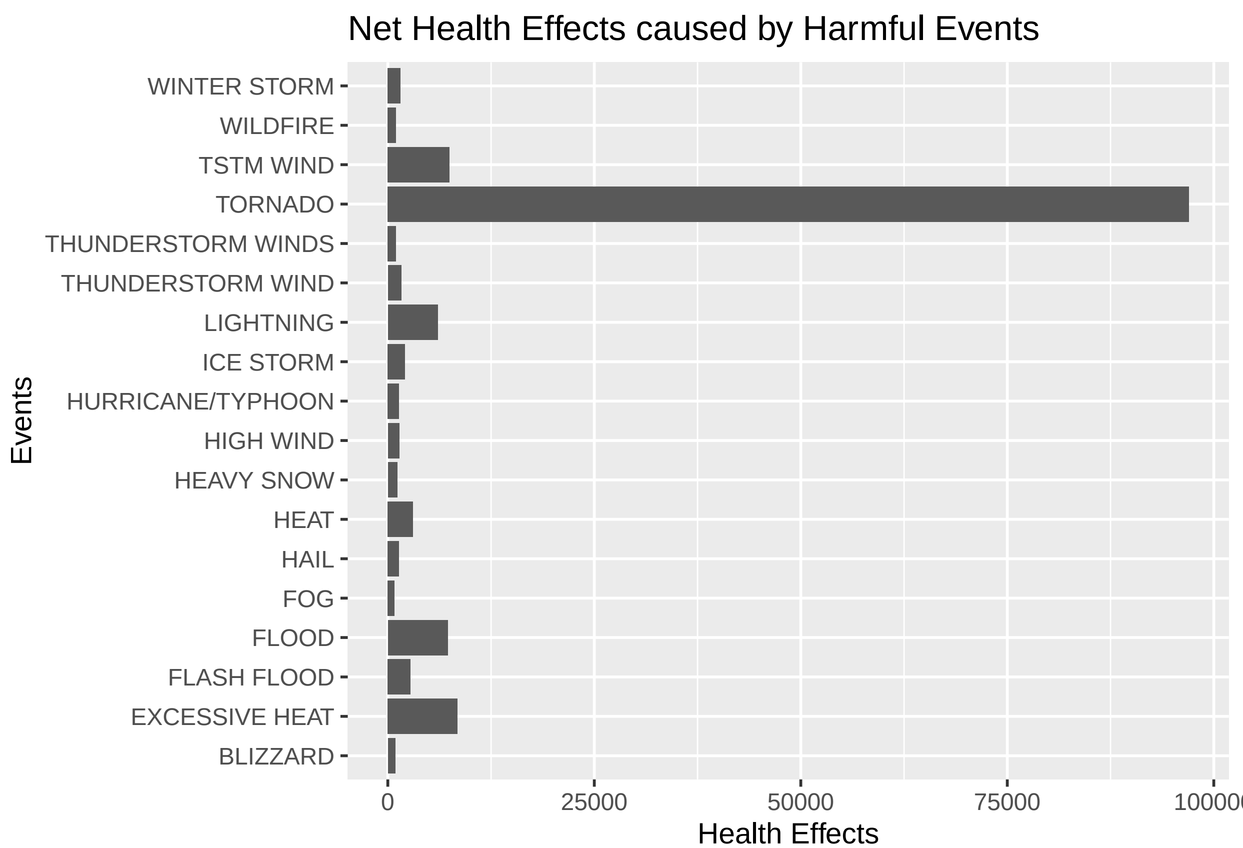
Plotting Health Effects against most harmful events.

```
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 3.6.3
```

```
plot <-ggplot(data=hlth_efcts_per_most_hrmfl_event_df, aes(x=Event, y=Health_Effects), ) +
  geom_bar(stat="identity") + labs(title = "Net Health Effects caused by Harmful Events") + xlab("Event

plot
```




It looks like from above bar plot that Tornado is the most harmful event w.r.t population health.

### Finding Events with greatest economic consequences

Checking unique entries in property damage estimates exponents.

```
unique(storm_data$PROPDMGEXP)
```

```
##  [1] K M   B m + 0 5 6 ? 4 2 3 h 7 H - 1 8
## Levels:  - ? + 0 1 2 3 4 5 6 7 8 B h H K m M
```

Translating exponents of property damage estimates into numbers. This translation is recorded in new attribute.

Note: Numeric entries in exponents are translated into power of 10 and '-','+','?' values in exponents are ignored

```
numeric_prop_dmg_exp <- (storm_data$PROPDMGEXP)

numeric_prop_dmg_exp <- sub("K", 1000, numeric_prop_dmg_exp)
numeric_prop_dmg_exp <- sub("h", 100, numeric_prop_dmg_exp)
numeric_prop_dmg_exp <- sub("H", 100, numeric_prop_dmg_exp)
numeric_prop_dmg_exp <- sub("B", 1000000000, numeric_prop_dmg_exp)
numeric_prop_dmg_exp <- sub("b", 1000000000, numeric_prop_dmg_exp)
numeric_prop_dmg_exp <- sub("M", 1000000, numeric_prop_dmg_exp)
```

```r
numeric_prop_dmg_exp <- sub("m", 1000000, numeric_prop_dmg_exp)
numeric_prop_dmg_exp <- sub("0", 1, numeric_prop_dmg_exp)
numeric_prop_dmg_exp <- sub("1", 10, numeric_prop_dmg_exp)
numeric_prop_dmg_exp <- sub("2", 100, numeric_prop_dmg_exp)
numeric_prop_dmg_exp <- sub("3", 1000, numeric_prop_dmg_exp)
numeric_prop_dmg_exp <- sub("4", 10000, numeric_prop_dmg_exp)
numeric_prop_dmg_exp <- sub("5", 100000, numeric_prop_dmg_exp)
numeric_prop_dmg_exp <- sub("6", 1000000, numeric_prop_dmg_exp)
numeric_prop_dmg_exp <- sub("7", 10000000, numeric_prop_dmg_exp)
numeric_prop_dmg_exp <- sub("8", 100000000, numeric_prop_dmg_exp)
# replacing empty values with 0
numeric_prop_dmg_exp <- sub("", 0, numeric_prop_dmg_exp)
```

Checking unique entries in crop damage estimates exponents.

```r
unique(storm_data$CROPDMGEXP)
```

```
## [1]   M K m B ? 0 k 2
## Levels:  ? 0 2 B k K m M
```

Translating exponents of crop damage estimates into numbers. This translation is recorded in new attribute.

Note: Numeric entries in exponents are translated into power of 10 and '-','+','?' values in exponents are ignored

```r
numeric_crop_dmg_exp <- (storm_data$CROPDMGEXP)

numeric_crop_dmg_exp <- sub("K", 1000, numeric_crop_dmg_exp)
numeric_crop_dmg_exp <- sub("k", 1000, numeric_crop_dmg_exp)
numeric_crop_dmg_exp <- sub("B", 1000000000, numeric_crop_dmg_exp)
numeric_crop_dmg_exp <- sub("M", 1000000, numeric_crop_dmg_exp)
numeric_crop_dmg_exp <- sub("m", 1000000, numeric_crop_dmg_exp)
numeric_crop_dmg_exp <- sub("0", 1, numeric_crop_dmg_exp)
numeric_crop_dmg_exp <- sub("2", 100, numeric_crop_dmg_exp)
# replacing empty values with 0
numeric_crop_dmg_exp <- sub("", 0, numeric_crop_dmg_exp)
```

Creating new dataframe from original data. New dataframe will consist of subset of attributes from original data and newly created attributes in previous steps.

```r
strm_dta_fr_ecnmc_consqncs <- data.frame(storm_data$EVTYPE, storm_data$PROPDMG, storm_data$PROPDMGEXP, n

names(strm_dta_fr_ecnmc_consqncs) <- c("Event", "Prop_Dmg", "Prop_Dmg_Exp", "Numeric_Prop_Dmg_Exp", "Cro

head(strm_dta_fr_ecnmc_consqncs)
```

```
##     Event Prop_Dmg Prop_Dmg_Exp Numeric_Prop_Dmg_Exp Crop_Dmg Crop_Dmg_Exp
## 1 TORNADO     25.0            K               010100        0
## 2 TORNADO      2.5            K               010100        0
## 3 TORNADO     25.0            K               010100        0
## 4 TORNADO      2.5            K               010100        0
## 5 TORNADO      2.5            K               010100        0
```

```
## 6 TORNADO      2.5            K               010100        0
##   Numeric_Crop_Dmg_Exp
## 1                    0
## 2                    0
## 3                    0
## 4                    0
## 5                    0
## 6                    0
```

Removing entries having '-','+','?' values in exponents.

```
strm_dta_fr_ecnmc_consqncs <- strm_dta_fr_ecnmc_consqncs[strm_dta_fr_ecnmc_consqncs$Prop_Dmg_Exp != "-"
```

Performing Data Type conversion of attributes.

```
strm_dta_fr_ecnmc_consqncs$Event <- as.character(strm_dta_fr_ecnmc_consqncs$Event)
strm_dta_fr_ecnmc_consqncs$Numeric_Crop_Dmg_Exp <- as.numeric(strm_dta_fr_ecnmc_consqncs$Numeric_Crop_Dm
```

```
## Warning: NAs introduced by coercion
```

```
strm_dta_fr_ecnmc_consqncs$Numeric_Prop_Dmg_Exp <- as.numeric(strm_dta_fr_ecnmc_consqncs$Numeric_Prop_Dm
```

```
## Warning: NAs introduced by coercion
```

```
head(strm_dta_fr_ecnmc_consqncs)
```

```
##     Event Prop_Dmg Prop_Dmg_Exp Numeric_Prop_Dmg_Exp Crop_Dmg Crop_Dmg_Exp
## 1 TORNADO     25.0            K                10100        0
## 2 TORNADO      2.5            K                10100        0
## 3 TORNADO     25.0            K                10100        0
## 4 TORNADO      2.5            K                10100        0
## 5 TORNADO      2.5            K                10100        0
## 6 TORNADO      2.5            K                10100        0
##   Numeric_Crop_Dmg_Exp
## 1                    0
## 2                    0
## 3                    0
## 4                    0
## 5                    0
## 6                    0
```

Multiplying Damage values with corresponding numeric exponent values and storing the result in new attributes.

```
prop_dmg_expense <- strm_dta_fr_ecnmc_consqncs$Prop_Dmg * strm_dta_fr_ecnmc_consqncs$Numeric_Prop_Dmg_Ex
crop_dmg_expense <- strm_dta_fr_ecnmc_consqncs$Crop_Dmg * strm_dta_fr_ecnmc_consqncs$Numeric_Crop_Dmg_Ex

strm_dta_fr_ecnmc_consqncs$prop_dmg_expense <- prop_dmg_expense
strm_dta_fr_ecnmc_consqncs$crop_dmg_expense <- crop_dmg_expense

head(strm_dta_fr_ecnmc_consqncs)
```

```
##     Event Prop_Dmg Prop_Dmg_Exp Numeric_Prop_Dmg_Exp Crop_Dmg Crop_Dmg_Exp
## 1 TORNADO     25.0            K                10100        0
## 2 TORNADO      2.5            K                10100        0
## 3 TORNADO     25.0            K                10100        0
## 4 TORNADO      2.5            K                10100        0
## 5 TORNADO      2.5            K                10100        0
## 6 TORNADO      2.5            K                10100        0
##   Numeric_Crop_Dmg_Exp prop_dmg_expense crop_dmg_expense
## 1                    0           252500                0
## 2                    0            25250                0
## 3                    0           252500                0
## 4                    0            25250                0
## 5                    0            25250                0
## 6                    0            25250                0
```

Adding property damage and cost damage expenses and storing result in new attribute.

```
strm_dta_fr_ecnmc_consqncs$net_dmg_expense <- strm_dta_fr_ecnmc_consqncs$prop_dmg_expense + strm_dta_fr_

head(strm_dta_fr_ecnmc_consqncs)
```

```
##     Event Prop_Dmg Prop_Dmg_Exp Numeric_Prop_Dmg_Exp Crop_Dmg Crop_Dmg_Exp
## 1 TORNADO     25.0            K                10100        0
## 2 TORNADO      2.5            K                10100        0
## 3 TORNADO     25.0            K                10100        0
## 4 TORNADO      2.5            K                10100        0
## 5 TORNADO      2.5            K                10100        0
## 6 TORNADO      2.5            K                10100        0
##   Numeric_Crop_Dmg_Exp prop_dmg_expense crop_dmg_expense net_dmg_expense
## 1                    0           252500                0          252500
## 2                    0            25250                0           25250
## 3                    0           252500                0          252500
## 4                    0            25250                0           25250
## 5                    0            25250                0           25250
## 6                    0            25250                0           25250
```

Aggregating (sum) net damage expenses w.r.t Event.

```
net_dmg_expense_per_event <- tapply(strm_dta_fr_ecnmc_consqncs$net_dmg_expense, strm_dta_fr_ecnmc_consq

## removing NA values
net_dmg_expense_per_event <- net_dmg_expense_per_event[!is.na(net_dmg_expense_per_event)]
## converting to dataframe

net_dmg_expense_per_event_df <- data.frame(Event=names(net_dmg_expense_per_event), Economic_Cost=net_dmg

head(net_dmg_expense_per_event_df)
```

```
##                    Event Economic_Cost
## 1    HIGH SURF ADVISORY       2020000
## 2         COASTAL FLOOD             0
## 3           FLASH FLOOD        505000
```

```
## 4            LIGHTNING            0
## 5       TSTM WIND (G45)         80800
## 6           WATERSPOUT            0
```

Caclulating average economic cost across all events.

```
avg_economic_cost <- mean(net_dmg_expense_per_event_df$Economic_Cost)
avg_economic_cost
```

```
## [1] 5.065047e+17
```

### Results

Finding most harmful events w.r.t economic consequences by extracting events from the dataframe having economic cost greater than average.

```
ecnmc_cost_per_hrmfl_event_df <- net_dmg_expense_per_event_df[net_dmg_expense_per_event_df$Economic_Cos
ecnmc_cost_per_hrmfl_event_df
```

```
##                          Event Economic_Cost
## 62     COLD AND WET CONDITIONS   6.60000e+17
## 117          EXCESSIVE WETNESS   1.42000e+18
## 151           FLOOD/RAIN/WINDS   1.12800e+18
## 156                     FREEZE   4.45550e+18
## 171                      FROST   6.50000e+17
## 244  HEAVY RAIN/SEVERE WEATHER   2.50000e+20
## 336  HURRICANE OPAL/HIGH WINDS   1.01000e+19
## 731 TORNADOES, TSTM WIND, HAIL   1.60025e+20
```

Formatting Economic Cost in Billions

```
ecnmc_cost_per_hrmfl_event_df$Economic_Cost_Billion <- round(ecnmc_cost_per_hrmfl_event_df$Economic_Cos
ecnmc_cost_per_hrmfl_event_df
```

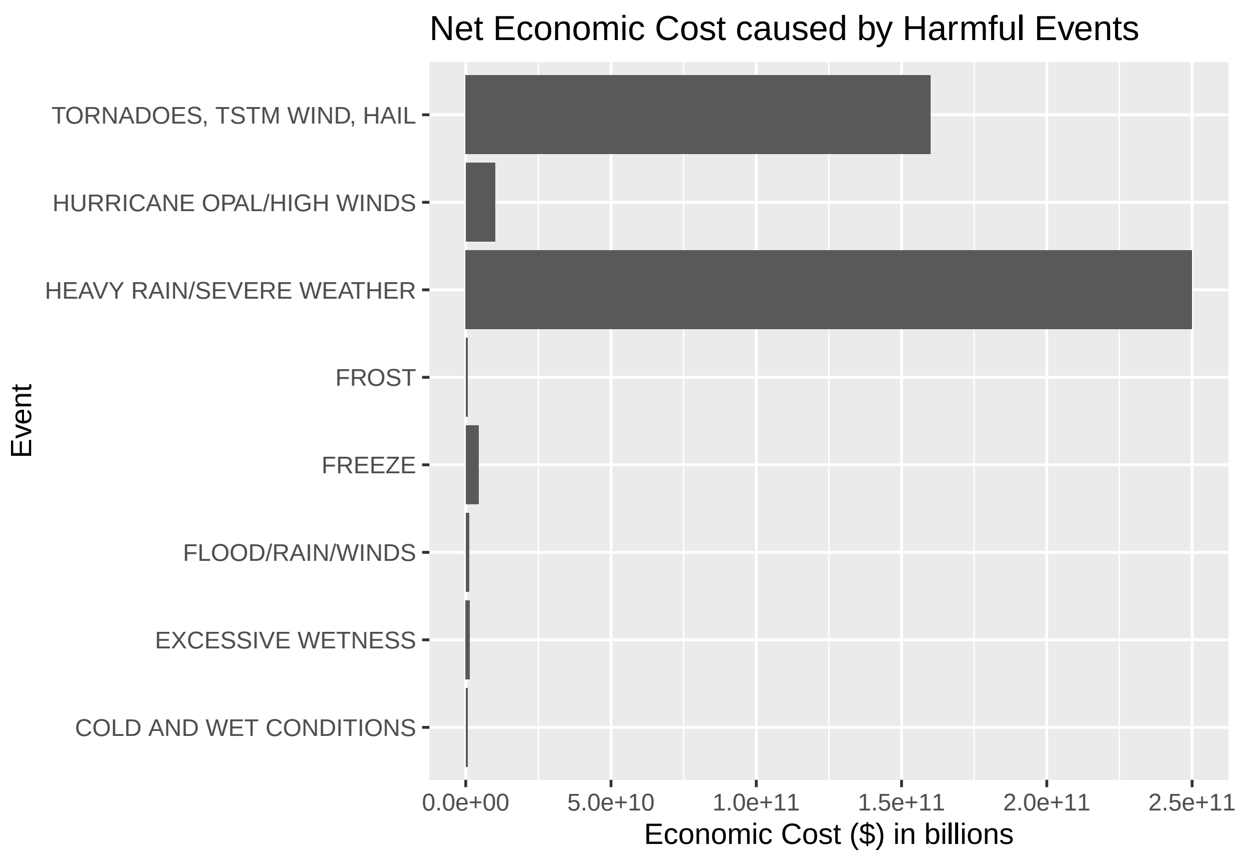
```
##                          Event Economic_Cost Economic_Cost_Billion
## 62     COLD AND WET CONDITIONS   6.60000e+17           6.60000e+08
## 117          EXCESSIVE WETNESS   1.42000e+18           1.42000e+09
## 151           FLOOD/RAIN/WINDS   1.12800e+18           1.12800e+09
## 156                     FREEZE   4.45550e+18           4.45550e+09
## 171                      FROST   6.50000e+17           6.50000e+08
## 244  HEAVY RAIN/SEVERE WEATHER   2.50000e+20           2.50000e+11
## 336  HURRICANE OPAL/HIGH WINDS   1.01000e+19           1.01000e+10
## 731 TORNADOES, TSTM WIND, HAIL   1.60025e+20           1.60025e+11
```

Plotting Economic Consequences against most harmful events.

```
library(ggplot2)

ecnmc_cnsqnc_plot <-ggplot(data=ecnmc_cost_per_hrmfl_event_df, aes(x=Event, y=Economic_Cost_Billion)) +
  geom_bar(stat="identity") + labs(title = "Net Economic Cost caused by Harmful Events") + xlab("Event")

ecnmc_cnsqnc_plot
```




From above above bar plot we can deduce that HEAVY RAIN / SEVER WEATHER has greatest economic consequences.