Peer-graded Assignment: Course Project 2

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1. Questions & Answers

- Across the United States, which types of events (as indicated in the EVTYPE variable) are most harmful with respect to population health?
  - **Tornados have caused greated number of fatalities (5,633) and injuries (91,347)**
- Across the United States, which types of events have the greatest economic consequences?
  - **Floods have caused the most significant damage 144.7 Billion USD, followd by HURRICANE/TYPHOON with 69.3 Billion USD damage**

2. Data Processing

2.1 Environment

```
setwd("~/Soft/Rtest/datasciencecoursera/05_Reproducible_Research/")
library("data.table")
library("ggplot2")
```

2.2 Data download

```
# defile the url
#fileUrl <- "https://d396qusza40orc.cloudfront.net/repdata%2Fdata%2FStormData.csv.bz2"
# download the file into ./data/
#download.file(fileUrl, destfile = "./data/repdata_data_StormData.csv.bz2")
```

read the `csv.bz2` file, rename as `storm`

```
# load data frame
storm <- read.csv("./data/repdata_data_StormData.csv.bz2")
head(storm)
```

```
##   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
```

```
# shape of data frame
dim(storm) # 902297 x 37
```

```
## [1] 902297     37
```

```
str(storm)
```

```
## 'data.frame':    902297 obs. of  37 variables:
##  $ STATE__   : num  1 1 1 1 1 1 1 1 1 1 ...
##  $ BGN_DATE  : chr  "4/18/1950 0:00:00" "4/18/1950 0:00:00" "2/20/1951 0:00:00" 
"6/8/1951 0:00:00" ...
##  $ BGN_TIME  : chr  "0130" "0145" "1600" "0900" ...
##  $ TIME_ZONE : chr  "CST" "CST" "CST" "CST" ...
##  $ COUNTY    : num  97 3 57 89 43 77 9 123 125 57 ...
##  $ COUNTYNAME: chr  "MOBILE" "BALDWIN" "FAYETTE" "MADISON" ...
##  $ STATE     : chr  "AL" "AL" "AL" "AL" ...
##  $ EVTYPE    : chr  "TORNADO" "TORNADO" "TORNADO" "TORNADO" ...
##  $ BGN_RANGE : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ BGN_AZI   : chr  "" "" "" "" ...
##  $ BGN_LOCATI: chr  "" "" "" "" ...
##  $ END_DATE  : chr  "" "" "" "" ...
##  $ END_TIME  : chr  "" "" "" "" ...
##  $ COUNTY_END: num  0 0 0 0 0 0 0 0 0 0 ...
##  $ COUNTYENDN: logi  NA NA NA NA NA NA ...
##  $ END_RANGE : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ END_AZI   : chr  "" "" "" "" ...
##  $ END_LOCATI: chr  "" "" "" "" ...
##  $ LENGTH    : num  14 2 0.1 0 0 1.5 1.5 0 3.3 2.3 ...
##  $ WIDTH     : num  100 150 123 100 150 177 33 33 100 100 ...
##  $ F         : int  3 2 2 2 2 2 2 1 3 3 ...
##  $ MAG       : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ FATALITIES: num  0 0 0 0 0 0 0 0 1 0 ...
##  $ INJURIES  : num  15 0 2 2 2 6 1 0 14 0 ...
##  $ PROPDMG   : num  25 2.5 25 2.5 2.5 2.5 2.5 2.5 25 25 ...
##  $ PROPDMGEXP: chr  "K" "K" "K" "K" ...
##  $ CROPDMG   : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ CROPDMGEXP: chr  "" "" "" "" ...
##  $ WFO       : chr  "" "" "" "" ...
##  $ STATEOFFIC: chr  "" "" "" "" ...
##  $ ZONENAMES : chr  "" "" "" "" ...
##  $ LATITUDE  : num  3040 3042 3340 3458 3412 ...
##  $ LONGITUDE : num  8812 8755 8742 8626 8642 ...
##  $ LATITUDE_E: num  3051 0 0 0 0 ...
##  $ LONGITUDE_: num  8806 0 0 0 0 ...
##  $ REMARKS   : chr  "" "" "" "" ...
##  $ REFNUM    : num  1 2 3 4 5 6 7 8 9 10 ...
```

```
# event types
length(unique(storm$EVTYPE)) # 985 event types
```

```
## [1] 985
```

According to the Storm Data Documentation (https://d396qusza40orc.cloudfront.net/repdata%2Fpeer2_doc%2Fpd01016005curr.pdf), the health variables include `FATALITIES` and `INJURIES` . with datamage to property `PROPDMG` and to crops `CROPDMG` We narrow down the column numbers to accelerate following analytics

2.3 Data subset

```
colList <- c("EVTYPE"
             , "FATALITIES"
             , "INJURIES"
             , "PROPDMG"
             , "PROPDMGEXP"
             , "CROPDMG"
             , "CROPDMGEXP"
)
storm <- storm[, colList]
head(storm)
```

```
##    EVTYPE FATALITIES INJURIES PROPDMG PROPDMGEXP CROPDMG CROPDMGEXP
## 1 TORNADO          0       15    25.0          K       0
## 2 TORNADO          0        0     2.5          K       0
## 3 TORNADO          0        2    25.0          K       0
## 4 TORNADO          0        2     2.5          K       0
## 5 TORNADO          0        2     2.5          K       0
## 6 TORNADO          0        6     2.5          K       0
```

There is 1 observation with `ENVTYPE == "?"` which should be removed as well

```
# sum(storm$EVTYPE=="?") # 1
# storm[(storm$EVTYPE=="?"), ] # may be due to measurement error
#storm <-
storm <- storm[(storm$EVTYPE!="?"), ]
```

We see the following 4 columns have zero values (lucily there are no negative values), meaning it caused no harm to population health, and are also removed by rows

2.4 Missing values

```
summary(storm$INJURIES)
```

```
##      Min.   1st Qu.    Median      Mean   3rd Qu.      Max. 
##    0.0000    0.0000    0.0000    0.1557    0.0000 1700.0000
```

```
summary(storm$FATALITIES)
```

```
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max. 
##   0.0000   0.0000   0.0000   0.0168   0.0000 583.0000
```

```
summary(storm$PROPDMG)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##    0.00    0.00    0.00   12.06    0.50 5000.00
```

```
summary(storm$CROPDMG)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.000   0.000   0.000   1.527   0.000 990.000
```

```
storm <- storm[(storm$INJURIES > 0 | storm$FATALITIES > 0 | storm$PROPDMG > 0 | storm
$CROPDMG > 0),]
dim(storm) # (902297x37) --> (254632x7)
```

```
## [1] 254632      7
```

```
head(storm)
```

```
##    EVTYPE FATALITIES INJURIES PROPDMG PROPDMGEXP CROPDMG CROPDMGEXP
## 1 TORNADO          0       15    25.0          K       0
## 2 TORNADO          0        0     2.5          K       0
## 3 TORNADO          0        2    25.0          K       0
## 4 TORNADO          0        2     2.5          K       0
## 5 TORNADO          0        2     2.5          K       0
## 6 TORNADO          0        6     2.5          K       0
```

2.5 -EXP column conversions

Change PROPDMGEXP and CROPDMG columns into upper case

```
storm$PROPDMGEXP <- toupper(storm$PROPDMGEXP)
storm$CROPDMGEXP <- toupper(storm$CROPDMGEXP)
```

Check if they are all upper case now

```
unique(storm$PROPDMGEXP)
```

```
##  [1] "K" "M" ""  "B" "+" "0" "5" "6" "4" "H" "2" "7" "3" "-"
```

```
unique(storm$CROPDMGEXP)
```

```
## [1] ""  "M" "K" "B" "?" "0"
```

Map property damage alphanumeric exponents to numeric values

```
propDmgKey <-  c("\"\"" = 10^0,
                 "-" = 10^0,
                 "+" = 10^0,
                 "0" = 10^0,
                 "1" = 10^1,
                 "2" = 10^2,
                 "3" = 10^3,
                 "4" = 10^4,
                 "5" = 10^5,
                 "6" = 10^6,
                 "7" = 10^7,
                 "8" = 10^8,
                 "9" = 10^9,
                 "H" = 10^2,
                 "K" = 10^3,
                 "M" = 10^6,
                 "B" = 10^9)
storm$PROPDMGEXP <- propDmgKey[as.character(storm$PROPDMGEXP)]
storm[is.na(storm[,'PROPDMGEXP']),'PROPDMGEXP'] <- 10^0
```

Map crop damage alphanumeric exponents to numeric values

```
cropDmgKey <-  c("\"\"" = 10^0,
                "?" = 10^0,
                "0" = 10^0,
                "K" = 10^3,
                "M" = 10^6,
                "B" = 10^9)
storm$CROPDMGEXP <- cropDmgKey[as.character(storm$CROPDMGEXP)]
storm[is.na(storm[,'CROPDMGEXP']),'CROPDMGEXP'] <- 10^0
```

2.6 Calculate economic cost for property and crop

```
## add 2 new columns in storm
## propCost = PROPDMG * PROPDMGEXP
## cropCost = CROPDMG * CROPDMGEXP
storm$propCost = storm$PROPDMG * storm$PROPDMGEXP
storm$cropCost = storm$CROPDMG * storm$CROPDMGEXP
head(storm)
```

```
##    EVTYPE FATALITIES INJURIES PROPDMG PROPDMGEXP CROPDMG CROPDMGEXP propCost
## 1 TORNADO          0       15    25.0       1000       0          1    25000
## 2 TORNADO          0        0     2.5       1000       0          1     2500
## 3 TORNADO          0        2    25.0       1000       0          1    25000
## 4 TORNADO          0        2     2.5       1000       0          1     2500
## 5 TORNADO          0        2     2.5       1000       0          1     2500
## 6 TORNADO          0        6     2.5       1000       0          1     2500
##   cropCost
## 1        0
## 2        0
## 3        0
## 4        0
## 5        0
## 6        0
```

Calculate cost by EVTYPE

```
storm <- as.data.table(storm)
storm <- storm[, .(EVTYPE
          , FATALITIES
          , INJURIES
          , PROPDMG
          , PROPDMGEXP
          , propCost = PROPDMG * PROPDMGEXP
          , cropCost = CROPDMG * CROPDMGEXP
         )]
```

```
#storm <- as.data.table(storm)
totalCostDT <- storm[, .(propCost = sum(propCost)
                     , cropCost = sum(cropCost)
                     , totalCost = sum(propCost) + sum(cropCost)
                     ), by = .(EVTYPE)]
totalCostDT <- totalCostDT[order(-totalCost),]
totalCostDT <- totalCostDT[1:10, ]
head(totalCostDT)
```

```
##                EVTYPE     propCost   cropCost    totalCost
## 1:              FLOOD 144657709807 5661968450 150319678257
## 2: HURRICANE/TYPHOON  69305840000 2607872800  71913712800
## 3:            TORNADO  56947380676  414953270  57362333946
## 4:        STORM SURGE  43323536000       5000  43323541000
## 5:               HAIL  15735267513 3025954473  18761221986
## 6:        FLASH FLOOD  16822673978 1421317100  18243991078
```

2.7 Calculate total fatalities and injuries

```
totalFatalitiesDT <- storm[, .(FATALITIES = sum(FATALITIES)
                             , INJURIES = sum(INJURIES)
                             , totalS = sum(FATALITIES) + sum(INJURIES))
                          , by = .(EVTYPE)]
totalFatalitiesDT <- totalFatalitiesDT[order(-FATALITIES)]
totalFatalitiesDT <- totalFatalitiesDT[1:10,]
head(totalFatalitiesDT)
```

```
##            EVTYPE FATALITIES INJURIES totalS
## 1:        TORNADO       5633    91346  96979
## 2: EXCESSIVE HEAT       1903     6525   8428
## 3:    FLASH FLOOD        978     1777   2755
## 4:           HEAT        937     2100   3037
## 5:      LIGHTNING        816     5230   6046
## 6:      TSTM WIND        504     6957   7461
```

```
totalFatalitiesDT[EVTYPE == "TORNADO",]
```

```
##     EVTYPE FATALITIES INJURIES totalS
## 1: TORNADO       5633    91346  96979
```

3. Answers

3.1 Across the United States, which types of events (as indicated in the EVTYPE variable) are most harmful with respect to population health?

```
#?melt
harmful_events <- melt(
    totalFatalitiesDT
    , id.vars = 'EVTYPE'
    , variable.name = "harm"
)
head(harmful_events)
```

```
##            EVTYPE       harm value
## 1:        TORNADO FATALITIES  5633
## 2: EXCESSIVE HEAT FATALITIES  1903
## 3:    FLASH FLOOD FATALITIES   978
## 4:           HEAT FATALITIES   937
## 5:      LIGHTNING FATALITIES   816
## 6:      TSTM WIND FATALITIES   504
```

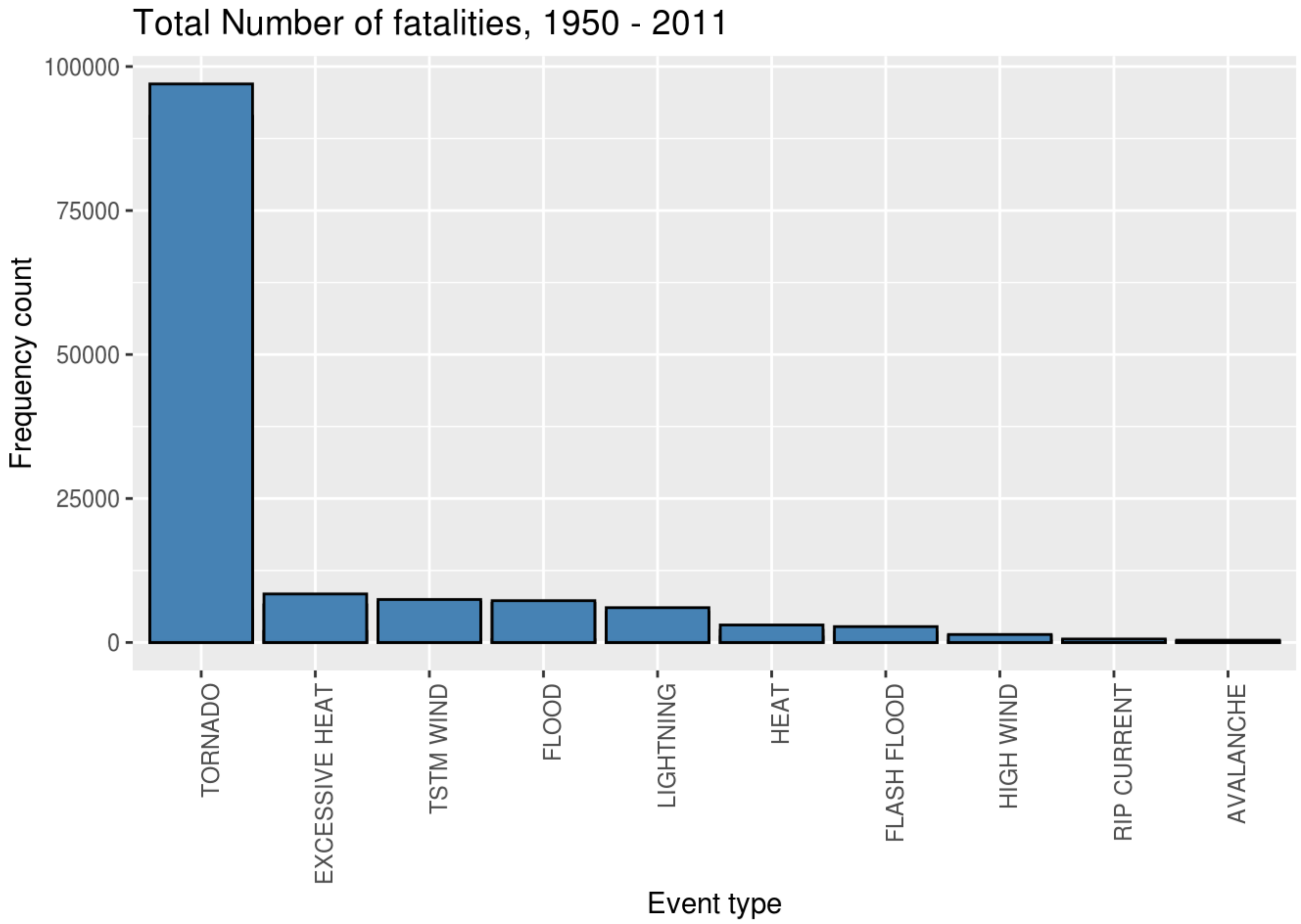
```
str(harmful_events)
```

```
## Classes 'data.table' and 'data.frame':   30 obs. of  3 variables:
##  $ EVTYPE: chr  "TORNADO" "EXCESSIVE HEAT" "FLASH FLOOD" "HEAT" ...
##  $ harm  : Factor w/ 3 levels "FATALITIES","INJURIES",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ value : num  5633 1903 978 937 816 ...
##  - attr(*, ".internal.selfref")=<externalptr>
```

```
str(harmful_events$harm)
```

```
##  Factor w/ 3 levels "FATALITIES","INJURIES",..: 1 1 1 1 1 1 1 1 1 1 ...
```

```
g <- ggplot(data = harmful_events
           , aes(x = reorder(EVTYPE, -value)
                , y = value)
           )
g <- g + geom_bar(
    color = "black"
    , stat = 'identity'
    , fill = "steelblue"
    , position = 'dodge'
)
g <- g + xlab("Event type") + ylab("Frequency count")
g <- g + ggtitle("Total Number of fatalities, 1950 - 2011")
g <- g + theme(axis.text.x = element_text(angle = 90, hjust = 1))
g
```

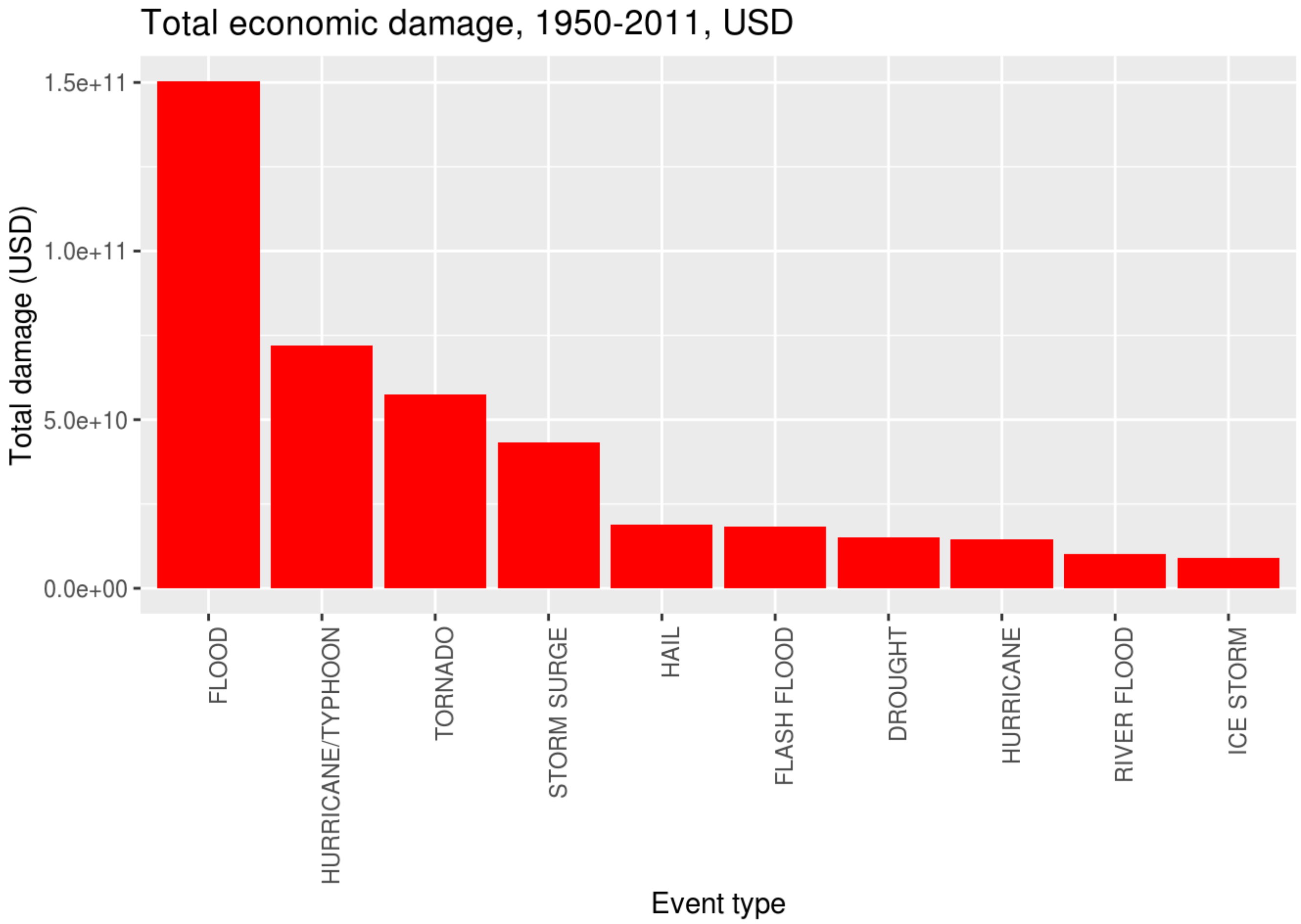


3.2 Across the United States, which types of events (as indicated in the EVTYPE variable) are most harmful with respect to population health?

```
econ_consequences <- melt(totalCostDT, id.vars = 'EVTYPE', variable.name = "Damage_Ty
pe")
head(econ_consequences)
```

```
##               EVTYPE Damage_Type        value
## 1:             FLOOD    propCost 144657709807
## 2: HURRICANE/TYPHOON    propCost  69305840000
## 3:           TORNADO    propCost  56947380676
## 4:       STORM SURGE    propCost  43323536000
## 5:              HAIL    propCost  15735267513
## 6:       FLASH FLOOD    propCost  16822673978
```

```
g <- NULL
g <- ggplot(data = econ_consequences, aes(x = reorder(EVTYPE, -value), y = value))
g <- g + geom_bar(stat = 'identity', fill = 'red', position = "dodge")
g <- g + xlab("Event type") + ylab("Total damage (USD)")
g <- g + ggtitle("Total economic damage, 1950-2011, USD")
g <- g + theme(axis.text.x = element_text(angle = 90, hjust = 1))
g
```


Total economic damage, 1950-2011, USD
Total damage (USD)
1.5e+11
1.0e+11
5.0e+10
0.0e+00
FLOOD
HURRICANE/TYPHOON
TORNADO
STORM SURGE
HAIL
FLASH FLOOD
DROUGHT
HURRICANE
RIVER FLOOD
ICE STORM
Event type