How Severe Weather Events Affect Health and the Economy

Reproducible Research Course Project #2

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Synopisis

This report investigates data from the NOAA Storm Database to identify the type of storms that cause the greatest impact to both population health and economic damage. The data examined is from 1950 to 2011, where the earlier years of the database there are generally fewer events recorded. However, no attempts were made to account for the fewer recorded events.

According to the data that we accesssed, and our analysis, the worst impacts are: Tornados - which inflicted nearly 100,000 injuries and fatalities, combined. Floods - which caused over $150 billion in damages

Background

The Storm Data may be found at the here

For more information about the data set you may review the National Weather Service Storm Data Documentation

Or the National Climatic Data Center Storm Events FAQ

Data Processing

```
library(tidyverse)
library(tufte)
library(stringdist)

options(scipen=999) # force non-scientific notation
```

Load the data

- Download the data, if it doesn't already exist within the local ./data subfolder.
- Read it in using the base read.csv() function. Note that the data is read in directly from the compressed bz2 format.

```
url <- "https://d396qusza40orc.cloudfront.net/repdata%2Fdata%2FStormData.csv.bz2"

ifelse(!dir.exists(file.path("data")), dir.create(file.path("data")), "Folder already exists")
```

```
## [1] "Folder already exists"
```

```
destfile <- "./data/StormData.csv.bz2"

if (!file.exists(destfile)) {
  download.file(url ,destfile,method="curl")
}

data <- read.csv(bzfile("./data/StormData.csv.bz2"),
                 header = TRUE, stringsAsFactors = FALSE)
```

Transform the data

From the related documentation, it appears that the only the following variables are useful for this study: * **EVTYPE**, the event type * **FATALITIES**, the number of fatalities * **INJURIES**, the number of injuries * **PROPDMG**, the amount of property damage * **PROPDMGEXP**, the exponent of the property damage * **CROPDMG**, the amount of crop damage * **CROPDMGEXP**, the exponent of the crop damage

```
str(data)
```

```
## '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 ...
```

```
data_master_cp <- data # keep a master copy for now.
#subset data for only relevent columns
data<- data[c("EVTYPE","FATALITIES","INJURIES","PROPDMG","PROPDMGEXP","CROPDMG","CROPDMGEXP")]
```

According to the information provided, *2.1.1 Storm Data Event Table*, there are 48 event types (EVTYPE), however the count of the unique values for EVTYPE reveal that there are actually 985 distinct event types. Inspection of the data reveals that the there is case sensitivity, spelling errors, and other information that was added to the EVTYPE. The package *stringdist::amatch()* was used in an attempt to find the approximate match. Note that the parameters of amatch used were selected simply following suggestions in Stack Overflow. Other parameters were attempted but not much effort spent in trying to optimize this process.

```
print("number of event types before processing:")
```

```
## [1] "number of event types before processing:"
```

```
length(unique(data$EVTYPE))
```

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

```
#convert EVTYPE to lower case to help improve matching and reduce redundancy
data<- data %>% mutate(EVTYPE = tolower(EVTYPE))

# EVTYPES copied from 2.1.1 Storm Data Event Table of the documentation (again, convert to lower case t
event_names <- tolower(c("Astronomical Low Tide", "Avalanche", "Blizzard", "Coastal Flood", "Cold/Wind

data$EVTYPE <- data$EVTYPE <- factor(amatch(data$EVTYPE, table = event_names, method='osa',maxDist=4),

print("number of event types after processing:")
```

```
## [1] "number of event types after processing:"
```

```
length(unique(data$EVTYPE))
```

```
## [1] 48
```

Process the Population Health data

It is assumed that the public health factors that are of interest would be the total number of inujuries, and the total fatalities. Summarize the data to find each total by the Event Type. This is done by using *dplyr*. The most harmful events are what is of interest, therefore only the top ten are kept. However, it would be easy to keep all 48, if it were required for future studies. *tidyr::gather()* is then used to create a tidy dataset.

```r
#Subset for factors affecting population health
populationHealth <- data %>%
      group_by(EVTYPE) %>%
      summarize(injuries = sum(INJURIES), fatalities = sum(FATALITIES))
```

```
## Warning: Factor `EVTYPE` contains implicit NA, consider using
## `forcats::fct_explicit_na`
```

```r
# Distill the Top 10 data, for both injuries and fatalities.

# add the factors together
populationHealth$sum <- populationHealth$injuries + populationHealth$fatalities
#order by sum
populationHealth <- populationHealth[order(-populationHealth$sum),]
#remove sum column (extraneous information)
populationHealth <- populationHealth[-4]
#select the top ten
populationHealth <- populationHealth[1:10,]

#gather the data to convert to long format
populationHealth <- gather(populationHealth, "fatalities", "injuries", key = "incident", value = "cases
populationHealth <- populationHealth[order(-populationHealth$cases),]
print(populationHealth)
```

```
## # A tibble: 20 x 3
##    EVTYPE            incident   cases
##    <fct>             <chr>      <dbl>
##  1 tornado           injuries   91364
##  2 high wind         injuries    8397
##  3 flood             injuries    7909
##  4 excessive heat    injuries    6527
##  5 tornado           fatalities  5633
##  6 lightning         injuries    5232
##  7 thunderstorm wind injuries    2439
##  8 <NA>              injuries    2334
##  9 heat              injuries    2104
## 10 ice storm         injuries    1975
## 11 excessive heat    fatalities  1903
## 12 flash flood       injuries    1785
## 13 flash flood       fatalities   999
## 14 <NA>              fatalities   944
## 15 heat              fatalities   937
## 16 lightning         fatalities   818
## 17 high wind         fatalities   792
## 18 flood             fatalities   612
## 19 thunderstorm wind fatalities   199
## 20 ice storm         fatalities    90
```

Process the Economic Damage data

As per the information sheet describing the data, the *xxDMG* and *xxDMGEXP* variables together indicate the economic cost. xxDMG is the value and xxDMGEXP is the exponent, or multiplier. However, the xxDMGEXP is not given in numeric values, but in acronyms.

> Estimates should be rounded to three significant digits, followed by an alphabetical character signifying the magnitude of the number, i.e., 1.55B for $1,550,000,000. Alphabetical characters used to signify magnitude include "K" for thousands, "M" for millions, and "B" for billions. — STORM DATA PREPARATION, Section2.7

Examine the possible values within the DMGEXP variables:

```
unique(data$PROPDMGEXP)
```

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

```
unique(data$CROPDMGEXP)
```

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

As can be seen above, there are many entries that include other characters besides those described within the documentation ("K", "M", or "B"). Most of the other characters are numeric. Therefore, my assumption is that the character is always representative of the scientific notation exponent.

xxxDMGEXP	meaning	numeric	value
0	base	0	10^0
1		1	10^1
H, h, 2	hecto	2	10^2
K, k, 3	kilo	3	10^3
4		4	10^4
5		5	10^5
M, m, 6	mega	6	10^6
7		7	10^7
8		8	10^8
B, b, 9	giga	9	10^9

There are other characters, but for now conider them to mean it is a multiplier of 1.

AS with Population Health, the data is summarize to find each total by the Event Type. Only the ten most harmful events are kept and then the data is converted to a tidy dataset.

```
#Convert multiplier to numeric
data$PROPDMGEXP <- as.numeric(recode(data$PROPDMGEXP,
                           '0'             ='1e+0',
                           '1'             ='1e+01',
                           'H'             ='1e+02',
                           'h'             ='1e+02',
                           '2'             ='1e+02',
                           'K'             ='1e+03',
                           'k'             ='1e+03',
                           '3'             ='1e+03',
                           '4'             ='1e+04',
                           '5'             ='1e+05',
                           'M'             ='1e+06',
                           'm'             ='1e+06',
                           '6'             ='1e+06',
```

```
                            '7'             ='1e+07',
                            '8'             ='1e+08',
                            'B'             ='1e+09',
                            'b'             ='1e+09',
                            '9'             ='1e+09',
                            .default        ='1'))

data$CROPDMGEXP <- as.numeric(recode(data$CROPDMGEXP,
                            '0'             ='1e+0',
                            '1'             ='1e+01',
                            'H'             ='1e+02',
                            'h'             ='1e+02',
                            '2'             ='1e+02',
                            'K'             ='1e+03',
                            'k'             ='1e+03',
                            '3'             ='1e+03',
                            '4'             ='1e+04',
                            '5'             ='1e+05',
                            'M'             ='1e+06',
                            'm'             ='1e+06',
                            '6'             ='1e+06',
                            '7'             ='1e+07',
                            '8'             ='1e+08',
                            'B'             ='1e+09',
                            'b'             ='1e+09',
                            '9'             ='1e+09',
                            .default        ='1'))


#Mulitply value by the exponent
data$PropDmgTotl <- data$PROPDMG * data$PROPDMGEXP
data$CropDmgTotl <- data$CROPDMG * data$CROPDMGEXP

#Subset for factors affecting economic data
econDamage <- data %>%
      group_by(EVTYPE) %>%
      summarize(property = sum(PropDmgTotl), crop = sum(CropDmgTotl))
```

```
## Warning: Factor `EVTYPE` contains implicit NA, consider using
## `forcats::fct_explicit_na`
```

```
# Distill the Top 10 data, for both property and crop damage

# add the factors together
econDamage$sum <- econDamage$property + econDamage$crop
#order by sum
econDamage <- econDamage[order(-econDamage$sum),]
#remove sum
econDamage <- econDamage[1:3]
#select the top ten
econDamage <- econDamage[1:10,]
```

```
#gather the data to convert to long format
econDamage <- gather(econDamage, "property", "crop", key = "incident", value = "value")
econDamage <- econDamage[order(-econDamage$value),]
print(econDamage)
```

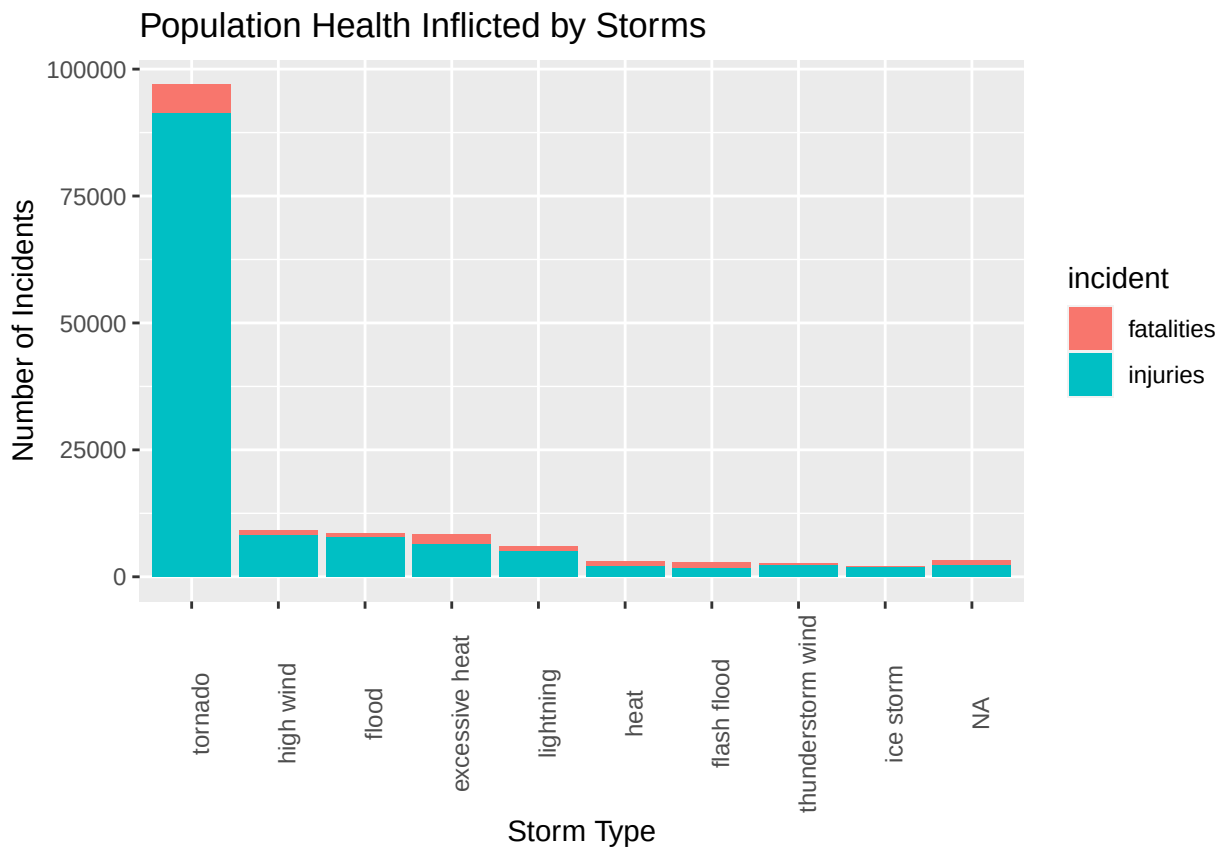
```
## # A tibble: 20 x 3
##    EVTYPE              incident         value
##    <fct>               <chr>            <dbl>
##  1 flood               property 144810802357
##  2 <NA>                property  74498066629.
##  3 hurricane (typhoon) property  69305840000
##  4 tornado             property  56952254426.
##  5 flash flood         property  17139746082.
##  6 hail                property  15741123563.
##  7 drought             crop      13972566000
##  8 <NA>                crop      10457375360
##  9 high wind           property  10363909188
## 10 tropical storm      property   7703890550
## 11 flood               crop       5737183950
## 12 ice storm           crop       5022113500
## 13 ice storm           property   4186382860
## 14 hail                crop       3026794473
## 15 hurricane (typhoon) crop       2607872800
## 16 flash flood         crop       1436433150
## 17 high wind           crop       1233299350
## 18 drought             property   1046106000
## 19 tropical storm      crop        678346000
## 20 tornado             crop        414963020
```

Results

Population Health

Question: Across the United States, which types of events are most harmful with respect to population health? Assume that there is no weighting for fatalities vs injuries. I.e., it is the *total* number of all incidents affecting health that are important. Therefore, as per the following chart, the event that causes the largest impact to population health are **tornados** with **91346 total incidents**.

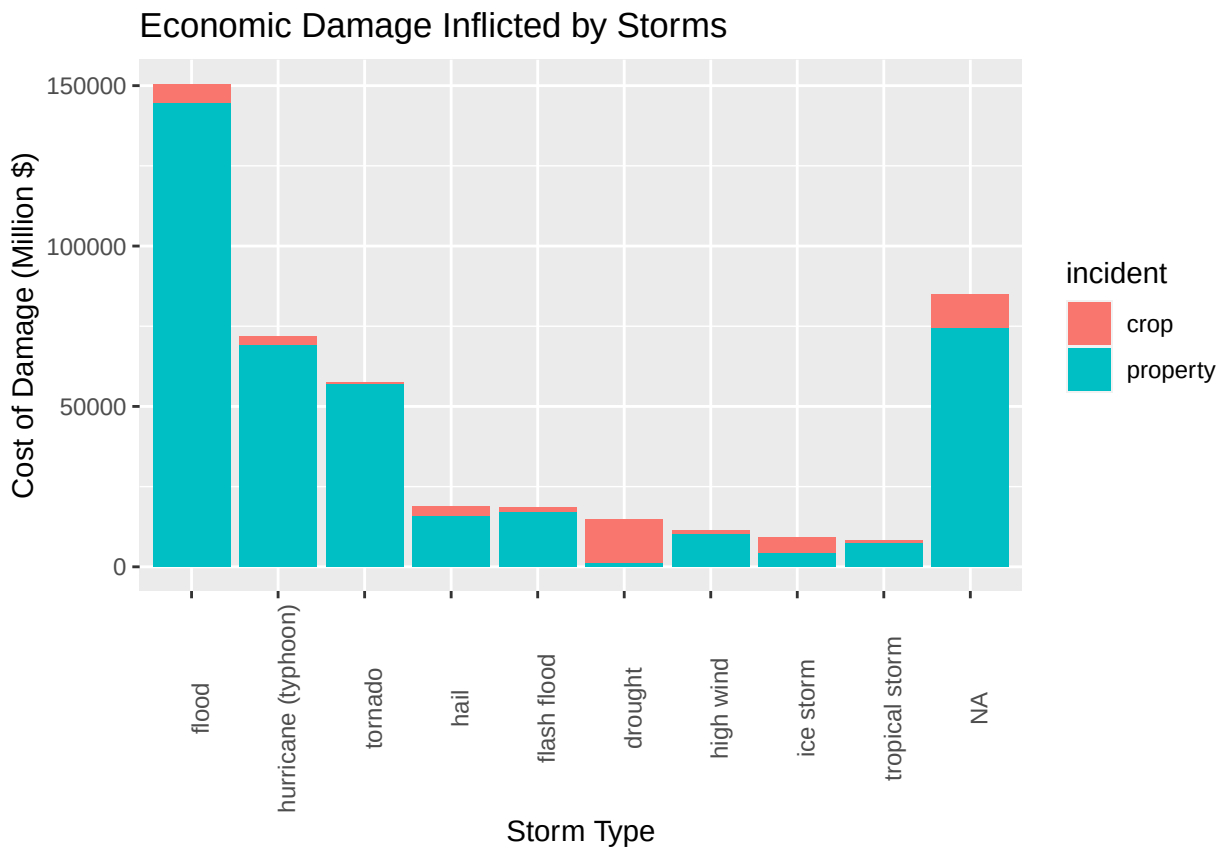
```
ggplot(data=populationHealth,
       aes(x=reorder(EVTYPE, -cases), y = cases, fill = incident)) +
  geom_bar(stat="identity") +
  theme(axis.text.x = element_text(angle=90)) +
  ggtitle("Population Health Inflicted by Storms") +
  xlab("Storm Type") +
  ylab("Number of Incidents")
```



Economic Damage

Question: Across the United States, which types of events have the greatest economic consequences? As indicated in the following chart, the event that causes the largest economic impact are **floods** with over **144 billion dollars in total damages**.

```
ggplot(data=econDamage,
       aes(x=reorder(EVTYPE, -value), y = value/1000000, fill = incident)) +
  geom_bar(stat="identity") +
  theme(axis.text.x = element_text(angle=90)) +
  ggtitle("Economic Damage Inflicted by Storms") +
  xlab("Storm Type") +
  ylab("Cost of Damage (Million $)")
```



Note About Results

This report relies heavily upon both the event type (EVTYPE) being accurate and the costs being entered correctly. Both fields are questionable and further refinement would need to be made to be able to draw reliable conclusions.

The EVTYPE entries are not in the format dictated by the specification. The specification states that event name should be the one that most accurately describes the meteorological event. However, from the data it appears that multiple events were included in single entires. Therefore further work needs to be completed in order to determine which is the appropriate event to use (or divide up those data points).

Most entries do not follow the specified format, often employing abbreviations. A mapping could be created to line up abbreviations with their appropriate event name. However, according to the specification there are multiple similar events; such as Cold/Wind Chill vs Extreme Cold/Wind Chill which further complicates how to determine which was the intended EVTYPE.

The specification identifies how to utilize the cost exponent field, which does not appear to have been followed. Assumptions were made on how to deal with this but those assumptions introduce error into the analysis.