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Health Information Systems

Inpatient Rehabilitation Facilities: Intensive Rehabilitation Services

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Index

Introduction and Sources

The aim of this paper is presenting and illustrating Inpatient Rehabilitation Facilities (also called IRF) in the United States.
Every graph and image contained in this document was necessary for representing data and information so they could be properly analyzed and has been produced through R programming.
The code through which the images and data were produced is represented too and it is properly documented.

The dataset used in order to extract knowledge and explore trends are:

- Inpatient Rehabilitation Facility - General Information
- Inpatient Rehabilitation Facility - Conditions
- Inpatient Rehabilitation Facility - Provider Data
- Inpatient Rehabilitation Facility - National Data

Used for "Ownership", "Location", "Condition Treated" and "Quality" chapters.

Provided by CMS at

https://data.cms.gov/provider-data/search?theme=Inpatient%20rehabilitation%20facilities

and

- Inpatient Rehabilitation Facility Provider by CMG Table, CY 2018

Used for "Days of Service and Stay Count" and "Cost and Prices" chapters.

Provided by CMS at:

https://data.cms.gov/Medicare-Hospice/Inpatient-Rehabilitation-Facility-Provider-by-CMG-/b5fu-3pm4

Types of Inpatient Rehabilitation Facilities

IRFs are care center for people who need rehabilitation and have specific medical needs that require frequent and continuous nursing care.
To qualify as an IRF, a facility must meet Medicare's conditions of participation for acute care hospitals and must be primarily focused on treating conditions that typically require intensive rehabilitation, among other requirements.
To qualify for a covered IRF stay, a doctor must first diagnose you with a condition that requires frequent and face to-face supervision by a rehabilitation physician.
It must also be determined that you would be able to tolerate and benefit from the intense therapy offered.

IRF can be divided in two main categories:

1. IRF which are part of a hospital, for example a specific unit of an hospital
2. IRF as independent medical rehabilitation facilities

Another taxonomy can be formalized depending on the level of care that the patient and his/her relatives require:

1. **Basic IRF**

   Provide rehabilitation for a patient after a surgery, injury with a certain severity, illness.
   Those kind of facilities provide multiple services performed by rehabilitation physicians for example occupational therapy and rehabilitation nursing.
   Patients who are admitted must be able to tolerate three hours of intense rehabilitation services per day.

2. **Skilled Nursing Facility**

   those are advanced structures and facilities which provide efficient nursing and rehab for the patient, usually after hospital discharge.

3. **Nursing Home**

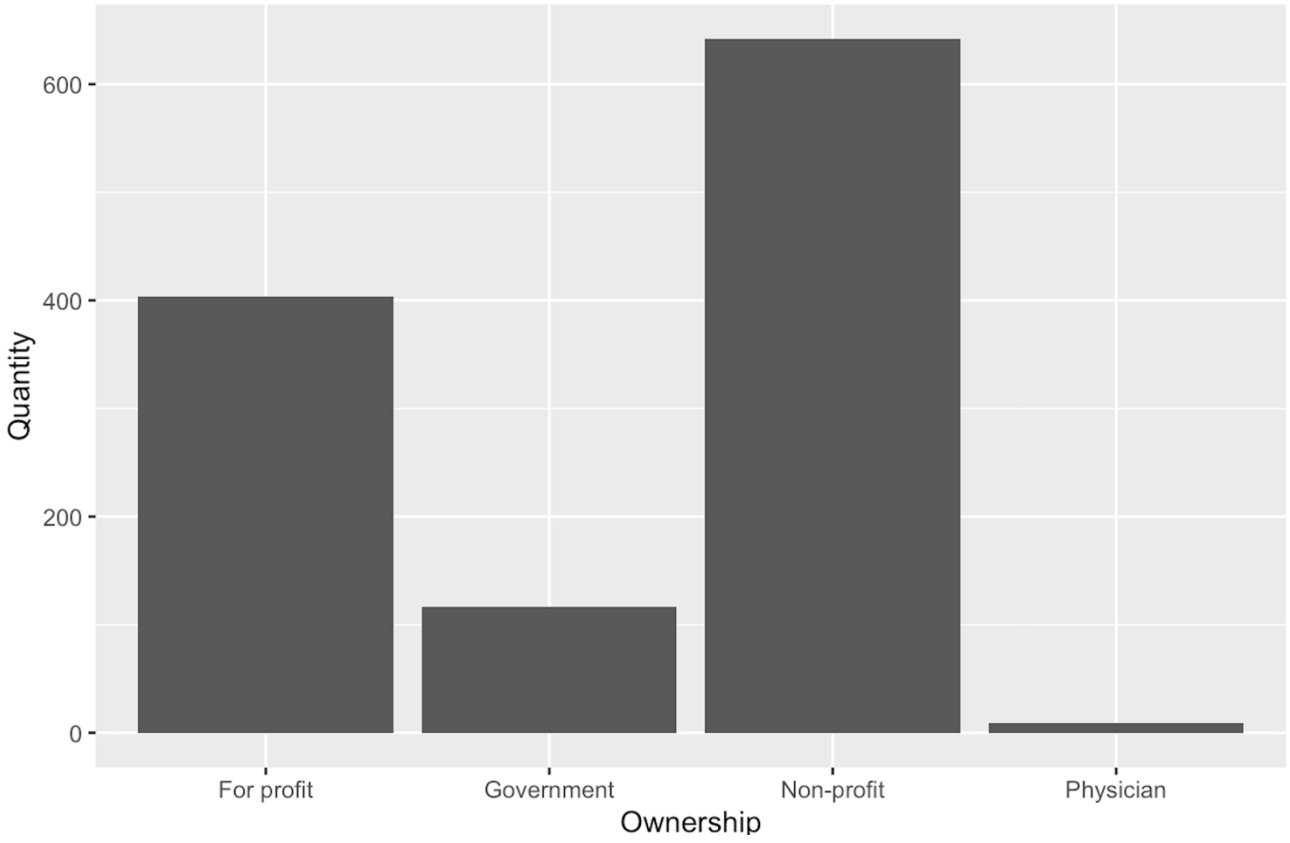
   Facilities that are actually homes and residences that provide permanent assistance to people. This solution is usually chosen when elder people aren't independent or they are incapable of living by their own.

4. **Long-Term Acute Care Hospitals**

   Serve patients with several and complex needs requiring extended care for more than 25 days.

Ownership

Different kinds of ownerships exist when we talk about Inpatient Rehabilitation Facilities.




```
ggplot(data=data, aes(x=Ownership, y=Quantity)) +
    geom_bar(stat="identity")
```

Figure 1: Actual facilities' ownership in the United States .

The graph (figure 1) shows the kinds of ownership for all the IRF Centers for Medicare & Medicaid Services (CMS) in the United States in 2020.
There are four types of ownership:

- For profit: profit institutions
- Non profit: non profit institutions

- Government: held by government
- Physician: owned by a physician

Now let's visualize those numbers using data exploration techniques:

```
> myTable <- table(file$Ownership.Type)
> myTable

For profit Government Non-profit  Physician
       404        117        642          9

> prop.table(myTable)*100

For profit Government Non-profit  Physician
34.4709898  9.9829352 54.7781570  0.7679181
```

Figure 2: Quantity and percentage for each ownership type.

As we can see from the picture, the majority of the institutions we are considering are non-profit, this means they invest all their earning for organizational and quality purposes.
The other large slice is occupied by the "for profit" type, followed by "Government" and "Physician".
Why the majority of them belong to the "non-profit" ownership type?
This particular status has many benefits, some of them for the institution or company itself, but others can also be applied to the community and those who attend the center.
Being a non-profit allows a rehabilitation center to exist free of federal and state income taxes, and in many cases it can also include exemption from property tax. Additionally, non-profits are able to apply for grants and other funds that are only available to 501(c)(3) type organizations [6].
501(c)(3) refers to a section of the IRS code that describes the requirements needed for organizations to qualify as tax-exempt [7].
The benefits actually are exceptionally helpful to patients as well. Most obvious is the price; many for-profit companies charge expensive rates to attend programs at the company's facilities.

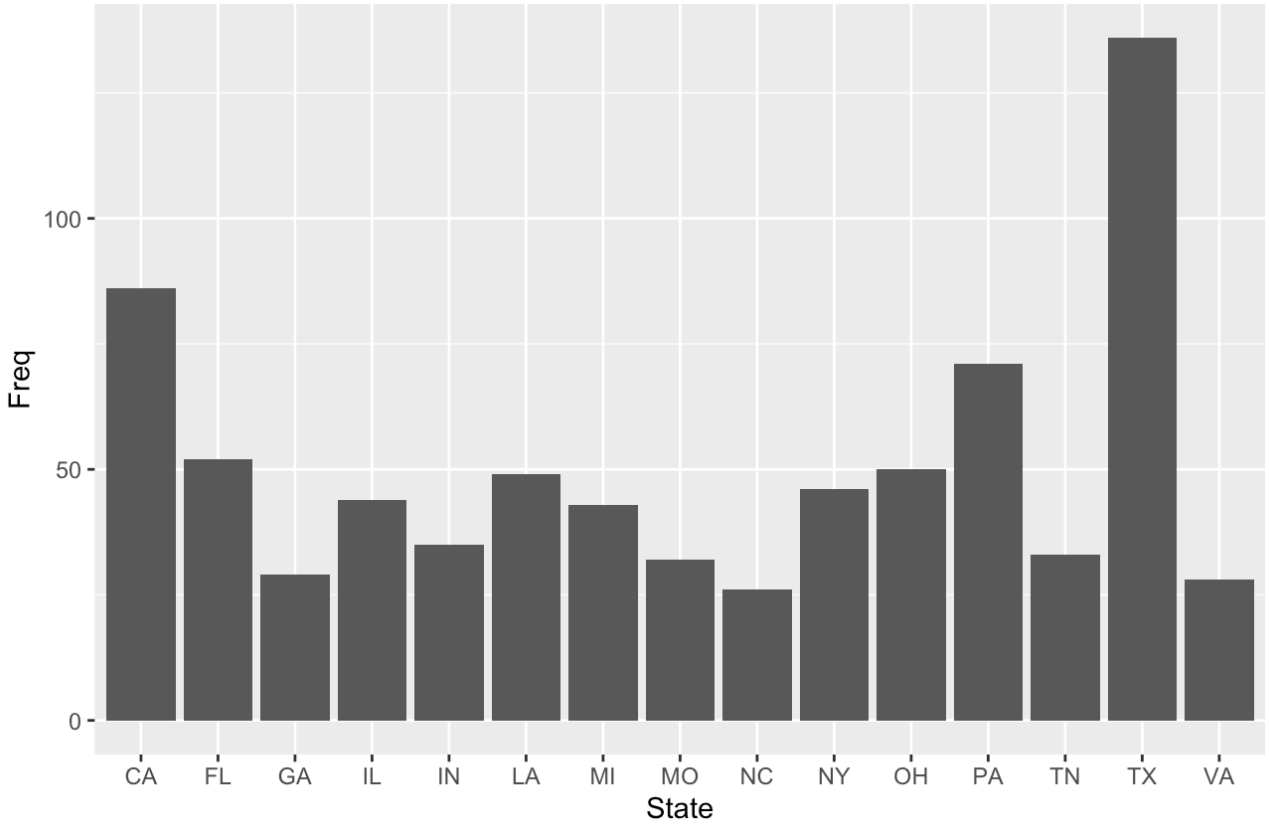
This often places the care offered by the company beyond the reach of the average person.

Because they have fewer taxes and are able to receive special grants, in general many non-profit facilities are less expensive than companies or “for profit” facilities. However, they don’t have to sacrifice the quality of care they offer, and many times the staff is more passionate.

These companies, and the people who work at them, are invested in the patient and driven to make a difference in people’s lives.

Location

More than 1200 Inpatient Rehabilitation Facilities exist in the US.
After declining for several years, the total number of **IRFs** increased between 2013 and 2014 and remained relatively stable in 2015 at 1182 facilities nationwide [28].




```
> State<-file$State
> State<-table(State)
> stateframe<-data.frame(State)
> some_states<-stateframe[(stateframe[,2]>25),]
> ggplot(data=some_states, aes(x=State, y=Freq)) + geom_bar(stat="identity")
```

Figure 3: States in the US with the largest quantity of IRFs.

The graph in Figure 2 shows the states with higher number of Inpatient Rehabilitation Facilities in the US in 2020.
The ones that stand out (California, Pennsylvania, Texas) are the most industrialized states in the US and that is not a surprising fact.

Healthcare is a business after all, especially in the United States: the areas with higher density of healthcare facilities and hospital are metropolis.

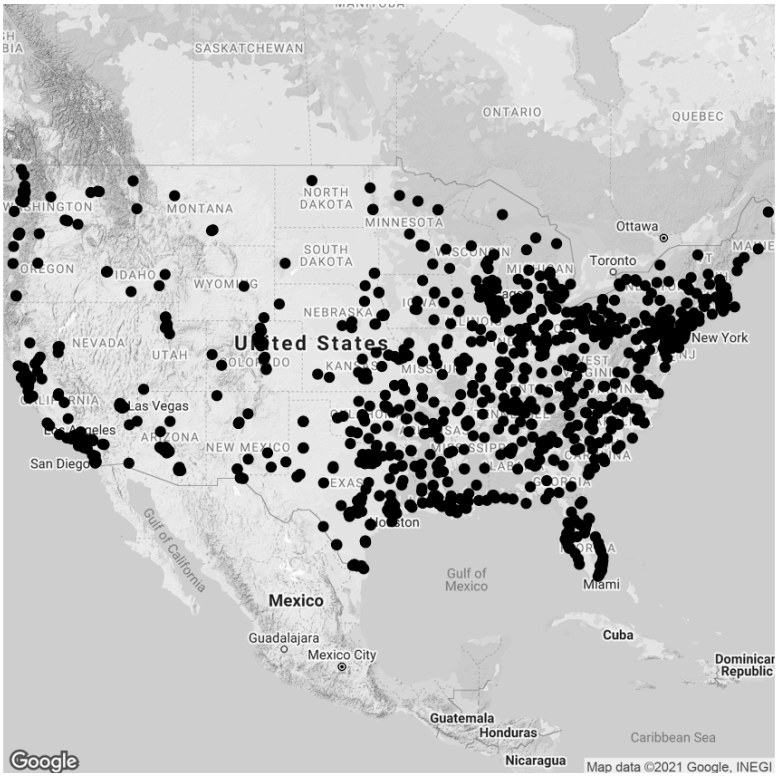
Now let's represent through some maps the locations of all the IRFs in the US in order to see the bigger picture:

```
> file<-read.csv("General_Information_Dec2020.csv")
> address<-paste(file$Address.Line.1, file$City, file$State)
> file$Address.Line.1<-address
> coordinates<-geocode(file$Address.Line.1)
```

Figure 4: conversion from Address to coordinates for every facility.

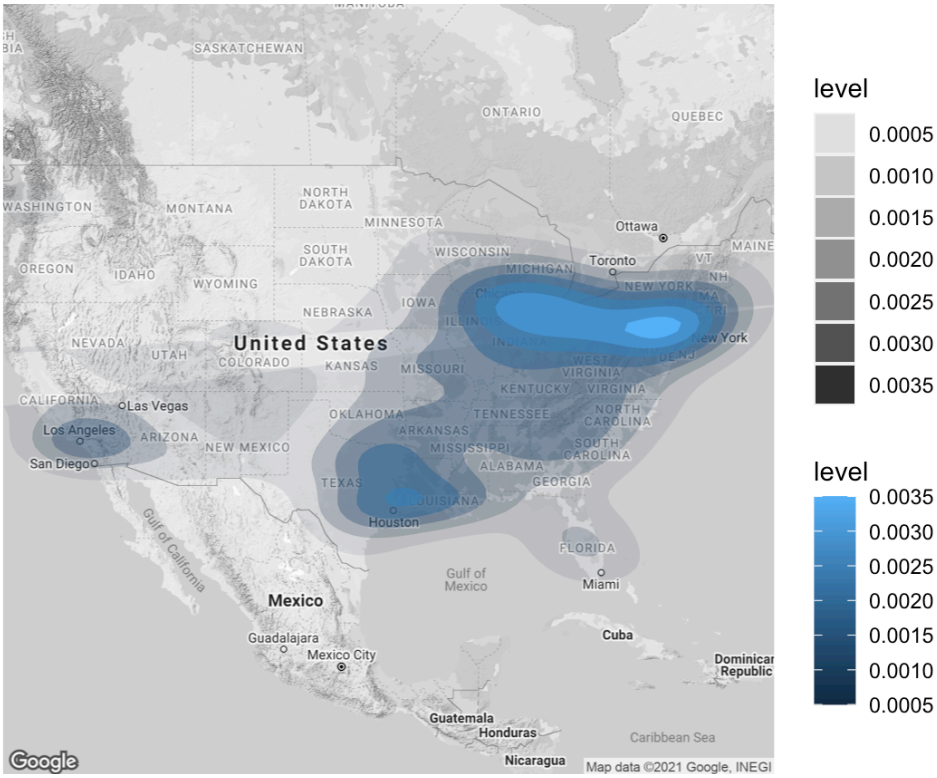
```
> usmap<-qmap("USA", zoom=4, color="bw")
```

Figure 5: creation of the US map.




```
> usmap+geom_point(aes(x=lon, y=lat), data=coordinates)
```

Figure 6: All the facilities in the US.




```
> usmap+stat_density2d(aes(x=lon, y=lat, fill=..level.., alpha=..level..),geom="polygon", data
=coordinates)
```

Figure 7: Density of all the facilities in the US.

The areas with higher density are the ones that include more facilities.

Inpatient Rehabilitation Facilities are mainly located in the east side of the US, especially near the east coast and in California on the other coast.

This density measure is very similar to the population density in the US, they follow the same trend.

Conditions Treated

As we already discussed, a particularly serious condition is one of the main requirements in order to be admitted in those facilities.
In this chapter we'll focus on the different types of condition that are treated in IRF along with their frequencies.
An entire specialized team, including physicians, therapists and nurses, assist each patient with individualized treatment and recovery plans for a range of conditions, including:

- Stroke rehabilitation
- Joint condition (orthopedics)
- Femur fracture
- Amputation
- Nervous system disorder
- Head trauma (brain injury, disease or condition)
- Spinal cord injury or disease
- Other medically complex conditions (not as frequent as the others)

Now let's analyse the frequency of cases with those disturbs:

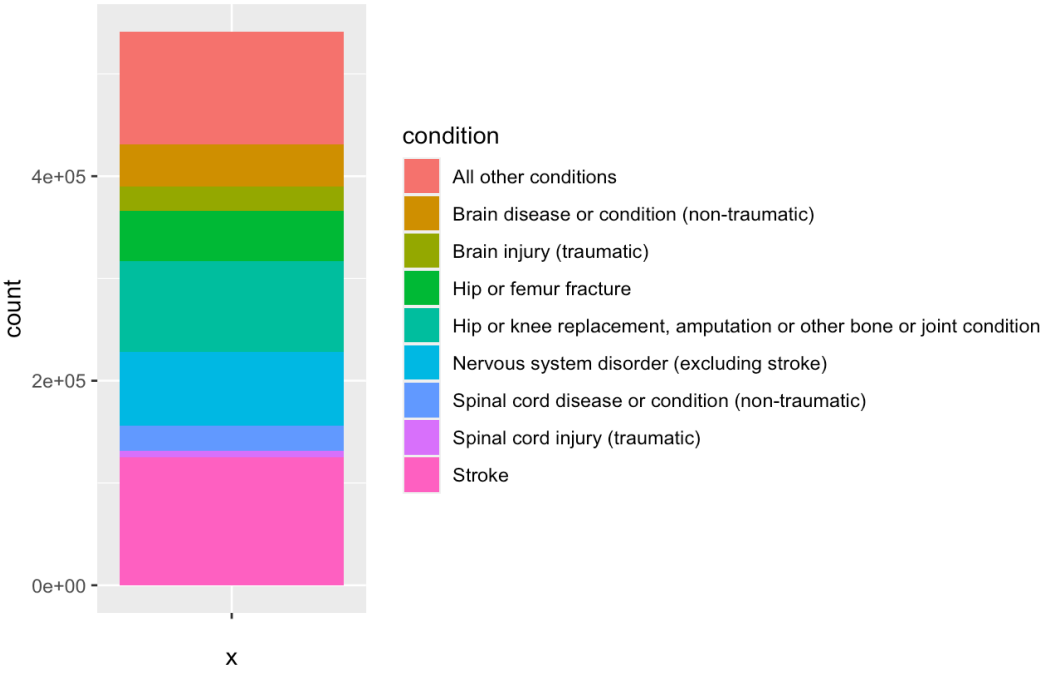
	condition	x
1	All other conditions	110479
2	Brain disease or condition (non-traumatic)	40881
3	Brain injury (traumatic)	23948
4	Hip or femur fracture	49284
5	Hip or knee replacement, amputation or other bone o...	88469
6	Nervous system disorder (excluding stroke)	72486
7	Spinal cord disease or condition (non-traumatic)	24213
8	Spinal cord injury (traumatic)	6839
9	Stroke	124869

```
> file<-read.csv('Conditions_Dec2020.csv')
> file[which(file[,12]=='less than 11', arr.ind=TRUE), 12] <- '6'
> file<-file[(file[,12]!='Not Available'),]
> count<-as.numeric(file[,12])
> condition<-file[,11]
> frame<-data.frame(condition,count)
> newframe<-aggregate(frame$count, by=list(condition=frame$condition), FUN=sum)
```

Figure 8: Table that shows the number of cases for each condition.

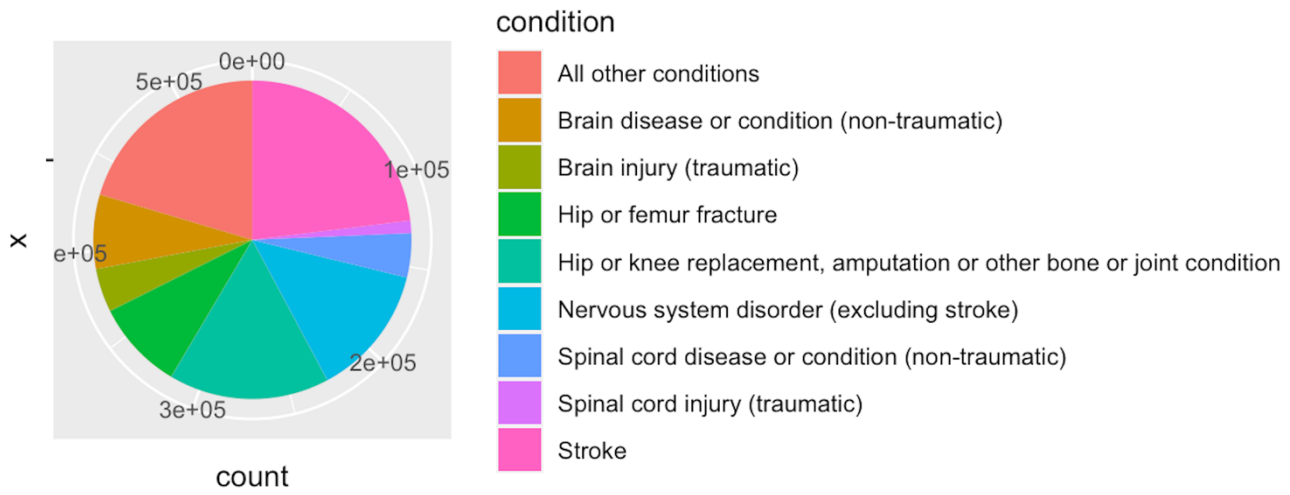
This table has been obtained by aggregating the count of patients in every Medicare IRFs in the United States in 2020 by condition.

If we represent those information for analyzing purpose we obtain:




```
> newframe<-aggregate(frame$count, by=list(condition=frame$condition), FUN=sum)
> newframe<-rename(newframe, count = x)
> bp <- ggplot(newframe, aes(x="", y=count, fill=condition)) + geom_bar(width = 1, stat = "identity")
```

Figure 9: Chart that represents the number of cases for each condition.




```
> pie <- bp + coord_polar("y", start=0)
> pie
```

Figure 10: Pie chart that represents the number of cases for each condition.

As we can see from the graphs in Figure 9 and Figure 10 the most frequent conditions are "Stroke" and "All other conditions".

While "All other conditions" is not particularly interesting because it's an aggregation of more less frequent conditions, data about stroke are meaningful.

Stroke can be a dangerous event and is a leading cause of serious long-term disability. Stroke reduces mobility in more than half of stroke survivors.

In an article published by CDC about stroke and apoplexy [9] some telling and concerning statistics are reported:

- In 2018, **1 in every 6 deaths** from cardiovascular disease was due to stroke.
- Someone in the United States has a stroke every **40 seconds**. Every **4 minutes**, someone dies of stroke.
- Every year, more than **795,000 people** in the United States have a stroke. About 610,000 of these are first or new strokes.[2]
- About 185,000 strokes—**nearly 1 of 4**—are in people who have had a previous stroke.[2]
- Stroke-related costs in the United States came to nearly **$46 billion** between 2014 and 2015.This total includes the cost of health care services, medicines to treat stroke, and missed days of work.

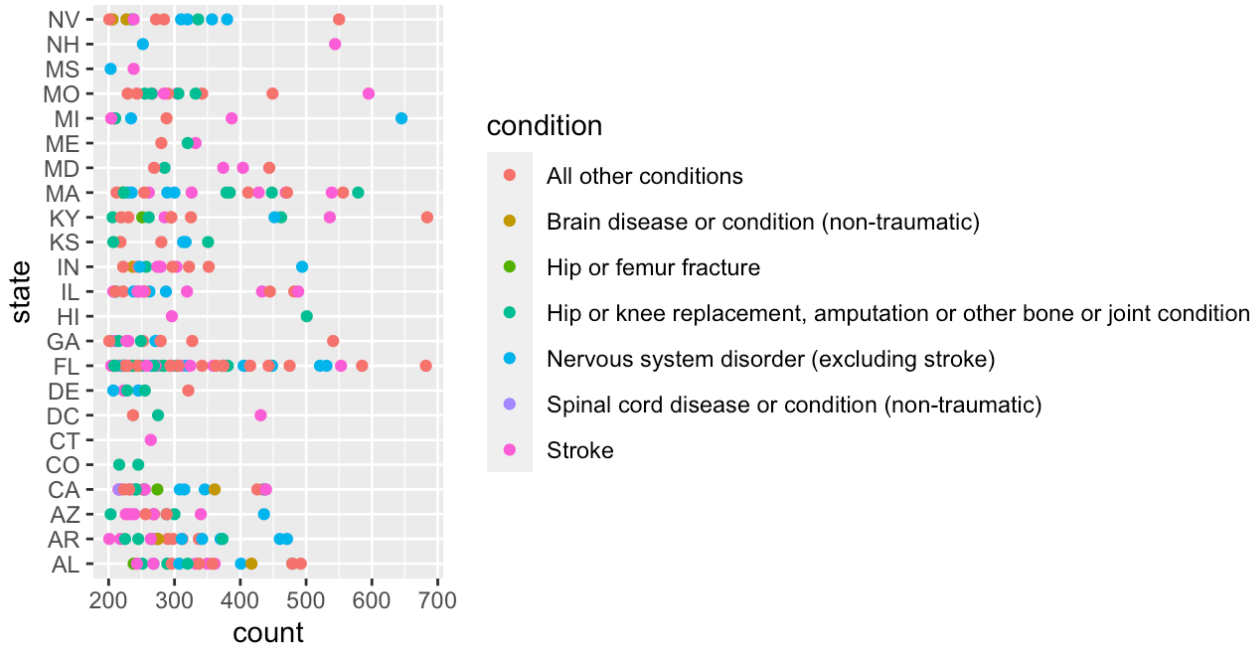
High blood pressure, high cholesterol, smoking, obesity, and diabetes are leading causes of stroke. 1 in 3 US adults has at least one of these conditions or habits.

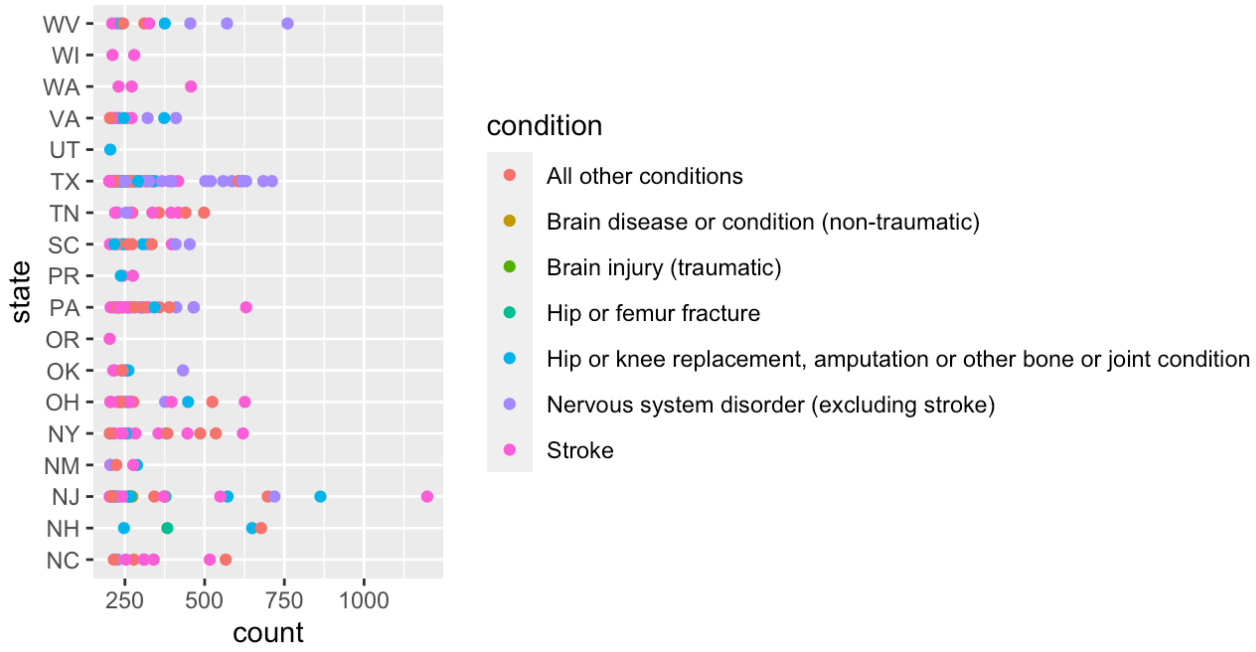
A similar situation concerns the condition called “hip or knee replacement, amputation or other bone or joint condition”. As the “bone and joint burden” website reports [10] nearly one in two Americans over the age of 18, and many children, is restricted by a musculoskeletal disorder arthritis, back pain, fracture, and other ailments which affect function and mobility. Bone and joint conditions are a serious and frequent problem as well. Of course the severity of those disturbs depends on the severity of the causes that started them.

Osteoarthritis for example is the most common joint disorder. It occurs when the cartilage between two joints wears down so the bones rub together, resulting in swelling and stiffness. Obesity is once again one of the main causes and when it is particularly serious can lead to dangerous outcomes in terms of bone and joint disorders.

As we just saw the main cause of the most frequent conditions treated in IRFs is the American population’s bad life habits.

Let us now conclude the condition analysis by showing charts that represent the most frequent conditions for the different institutions spread across the US.






```
file<-read.csv("Conditions_Dec2020.csv")
file<-file[(file[,12]!='less than 11'),]
file<-file[(file[,12]!='Not Available'),]
count<-as.numeric(file[,12])
state<-file[,6]
condition<-file[,11]
frame<-data.frame(state,count,condition)
frame<-frame[(frame[,2]>200),]
frame1<-frame[1:272,]
frame2<-frame[273:544,]

ggplot(frame1, aes(count, state)) + geom_point(aes(color = condition))
ggplot(frame2, aes(count, state)) + geom_point(aes(color = condition))
```

Figure 11: Most frequent conditions treated by institutions in the United States.

Every point in the graph is a particularly frequent condition (more than 200 cases) treated by a certain institution in a certain state.
The ones that jump out are:

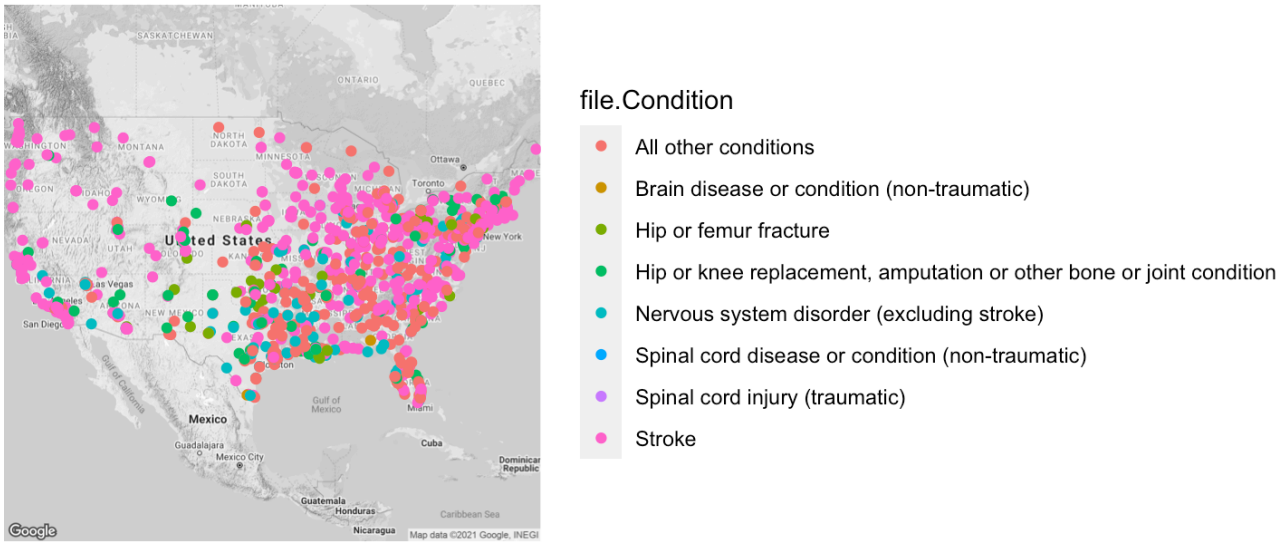
- Florida (FL): Nervous system disorder and all other conditions
- Massachusetts (MA): Stroke and hip or knee replacement, amputation or other bone and joint condition
- Illinois (IL): Stroke
- Arkansas (AR): Nervous system disorder
- New Jersey (NJ): Stroke
- North Carolina (NC): Stroke
- New York (NY): Stroke and all other conditions
- Texas (TX): Nervous system disorder and Stroke
- West Virginia (WV): Nervous system disorder

Now let's try to represent on the United States map all the facilities along with the more frequent condition for each facility.

```
> file<-file %>% group_by(Address.Line.1) %>% slice(which.max(Count))
> coordinates<-geocode(file$Address.Line.1)
```

Figure 12: Creation of the coordinates, extraction of the more frequent condition for each facility.

This is the result we obtain:




```
> mydata<-data.frame(coordinates$lon,coordinates$lat,file$Condition)
> usmap+geom_point(aes(x=coordinates.lon, y=coordinates.lat, color=file.Condition), data=mydat
a)
```

Figure 13: All the facilities in the US along with their more frequent conditions.

The map in figure 6 confirms our previous considerations: the condition that stands out is definitely “Stroke”.

Services Provided

In the last chapter we saw what conditions afflict patients in IRFs and what are the most frequent ones.
In the first chapters we mentioned the services provided by Inpatient Rehabilitation Facilities in order to properly treat those conditions, let's now explore them in more depth.
Medicare-covered services offered by IRF include:

- **Medical care and rehabilitation nursing:** As we already said those facilities hosts seriously ill patients that need continuous nursing care and much more attention compared to medical and nursing care the regular hospitals offer. Rehabilitation nursing is also more demanding than normal nursing activity The rehabilitation nurse is a nurse who specializes in helping people with disabilities and chronic illness attain optimal function, health, and adapt to an altered lifestyle. Rehabilitation nurses assist patients in their move toward independence by setting realistic goals and treatment plans. They work as part of a multidisciplinary team and often coordinate patient care and team activities.

- **Physical, occupational, and speech therapy:** Occupational therapy is the use of assessment and intervention to develop, recover, or maintain the meaningful activities, or occupations, of individuals, groups, or communities. In those context, patients may have been through severe trauma, brain damage. They might not be able to move or speak anymore. These therapies use a step-wise approach with the aim of regaining the capacities lost.

- **Social worker assistance:** A social work assistant works to help people cope with challenging problems. They advise people who are dealing with issues like unemployment, divorce, adoption or a diagnosis of a serious illness. Some social work assistants focus on families who need assistance in dealing with problems like addiction, while others deal primarily with people suffering from disabilities or the elderly. In IRFs they provide additional psychological support.

- **Psychological services:** As the article about inpatient mental health rehabilitation services by Care Quality Commission [15] says: “as well as evidence based psychological therapies (such as cognitive behavior therapy for psychosis and family interventions), clinical psychologists may also facilitate reflective practice sessions with the team to develop psychological formulations which support therapeutic rapport and optimism. They may also provide training and supervision to other staff to provide low intensity psychological interventions, such as behavioral activation, anxiety management and relaxation techniques, relapse prevention, and motivational interviewing for co-morbid substance misuse“.

- **Orthotic and prosthetic services:** Prosthetics and orthotics are clinical disciplines that deal with artificial limbs (prostheses) for people with amputations and supportive devices (orthoses) for people with musculoskeletal weakness or neurological disorders. In the previous chapter we saw that among the disturbs there was amputation. Those services help people with these kind of conditions become familiar with the tools and devices used.

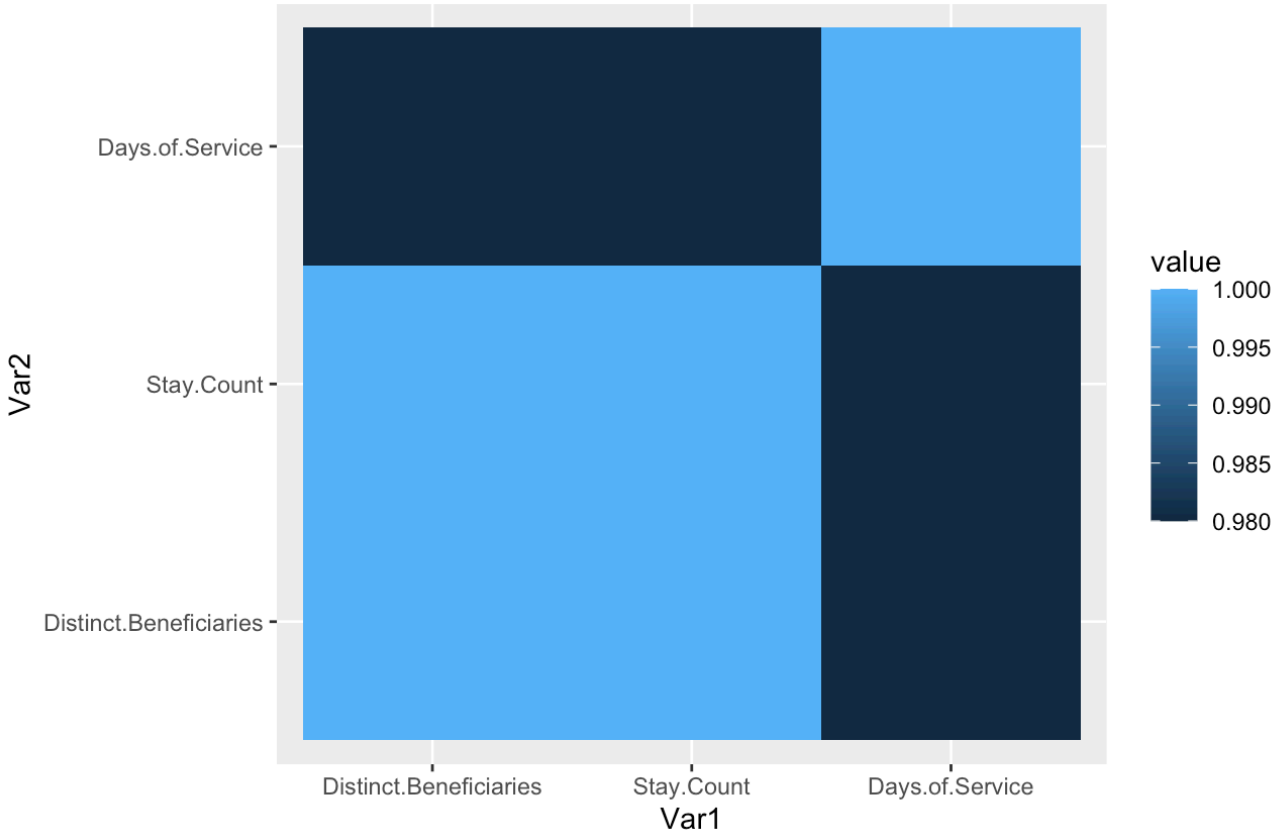
Days of Service and Stay Count

In this chapter we will focus on the number of stays and the days of service for the patients treated in IRF.

The dataset considered for this analysis presents summarized information about the year 2018 on patients and services provided to Medicare beneficiaries by every kind of IRF.

Beneficiaries of IRF services can be admitted multiple times and spent a certain amount of days depending on their health status, independence, type and severity of their conditions.

Let's now explore our data by taking a look at the correlation between the days of service, stay count and number of patient with a certain condition:



```
> file<-read.csv("provider.csv")
> mydata <- file[, c(9, 10, 11)]
> library('reshape2')
> cormat <- round(cor(mydata),2)
> melted_cormat <- melt(cormat)
> View(melted_cormat)
> ggplot(data = melted_cormat, aes(x=Var1, y=Var2, fill=value)) +
+     geom_tile()
```

Figure 14: Correlation between Days of Service, Stay count and number of patients per condition.

As we can see from the graph, the results should not surprise us.
Days of service has very high correlation (0.98) with both the number of beneficiaries and the stay count because they are highly proportional while the stay count has max correlation with the number of beneficiaries not only because it is proportional but almost identical as we will examine in depth later.

Now we manipulate our data in order to make some more analysis.

	Grouping	Description	Beneficiaries	SB_Ratio	DB_Ratio
1	1003	Amputation, lower extremity, M<36.25	7044	1.107183	15.433135
2	1002	Amputation, lower extremity, M>36.25 and M<47.65	2053	1.040429	10.959571
3	1001	Amputation, lower extremity, M>47.65	197	1.010152	8.441624
4	1102	Amputation, non-lower extremity, M<36.35	148	1.027027	12.770270
5	1101	Amputation, non-lower extremity, M>36.35	30	1.000000	10.466667
6	2101	Burns, M>0	121	1.041322	13.743802
7	1404	Cardiac, M<31.15	11151	1.041700	12.638508
8	1403	Cardiac, M>31.15 and M<38.55	5981	1.014880	10.202809
9	1402	Cardiac, M>38.55 and M<48.85	4984	1.013443	8.940409
10	1401	Cardiac, M>48.85	795	1.005031	6.506918

```
> file<-read.csv("provider.csv")
> file<-file[88:2788,]
> mydata<-file[, c(7, 8, 9, 10, 11)]
> View(mydata)
> mydata<-aggregate(cbind(Distinct.Beneficiaries, Stay.Count, Days.of.Service) ~ Grouping + Groupin
g.Description, data=mydata, FUN=sum, na.rm=TRUE)
> mydata$Days.of.Service<-mydata$Days.of.Service/mydata$Distinct.Beneficiaries
> mydata$Stay.Count<-mydata$Stay.Count/mydata$Distinct.Beneficiaries
> colnames(mydata) <- c('Grouping', 'Description', 'Beneficiaries', 'SB_Ratio', 'DB_Ratio')
```

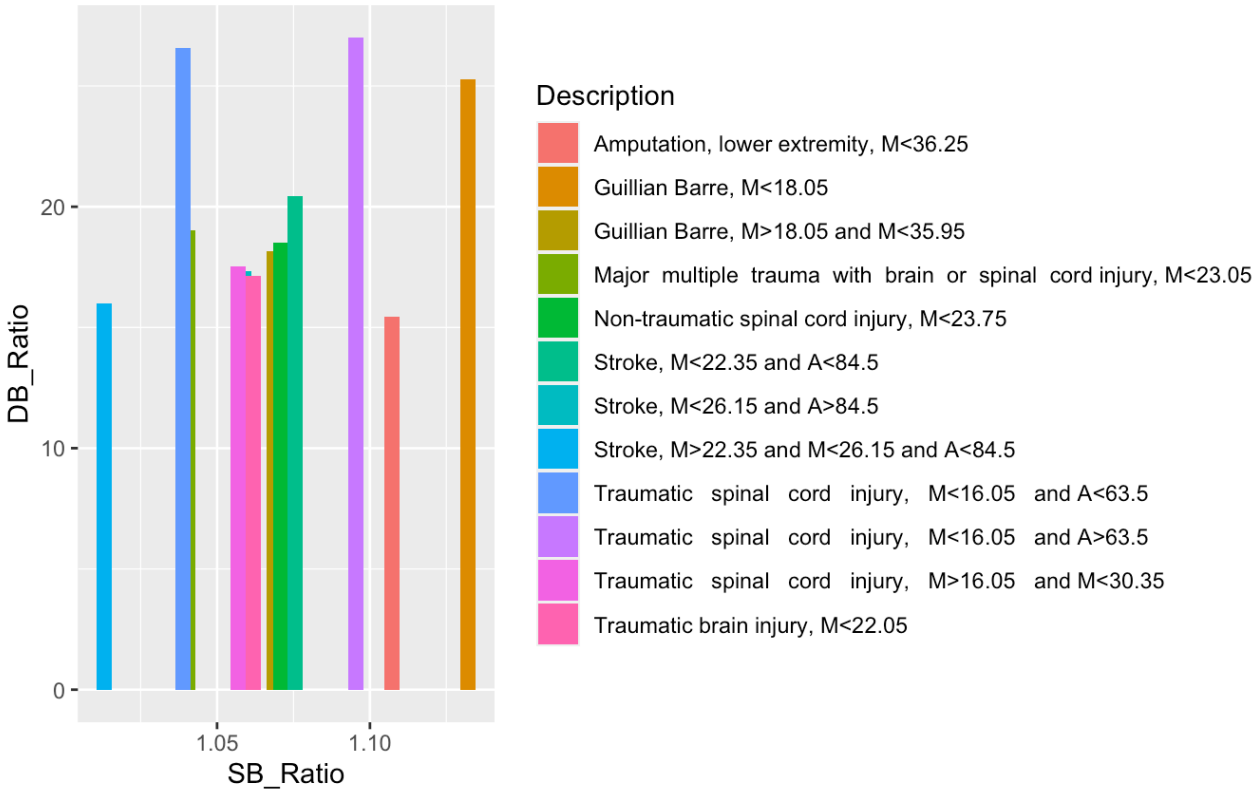
Figure 15: Data format after manipulation.

The table represents the format after the data about all the states has been grouped by category (“Distinct Beneficiaries”, “Stay Count” and “Days of Services” has been aggregated with the sum function) and “Days of Service” and “Stay Count” has been replaced with their respective ratio with “Beneficiaries” in order to examine those variables for every condition’s type and severity.

Now let’s see some interesting values:

```
> max(mydata$DB_Ratio)
[1] 27.01013
> max(mydata$SB_Ratio)
[1] 1.132075
> mydata$Description[which.max(mydata$DB_Ratio)]
[1] "Traumatic spinal cord injury, M<16.05 and A>63.5"
> mydata$Description[which.max(mydata$SB_Ratio)]
[1] "Guillian Barre, M<18.05"
> mean(mydata$DB_Ratio)
[1] 11.77622
> mean(mydata$SB_Ratio)
[1] 1.023052
```

Figure 16: Max and mean values of the ratios.



```
> mydata_max<-mydata[(mydata[,5]>=15),]
> ggplot(data=mydata_max, aes(x=SB_Ratio, y=DB_Ratio, fill=Description)) + geom_bar(stat="identit
y", width=0.005)
```

Figure 17: Conditions with the highest DB ratio along with their S-B ratio.

As we can see from the graph, the condition which implies "Traumatic spinal cord injury" are among the ones that request a large amount of days.
The actual maximum value for the "days-beneficiaries ratio" variable is 27.010 and the condition's description of the record in which this value occurs is "Traumatic spinal cord injury, M<16.05 and A>63.5".
It is a particular severe case of spinal cord injury where the movement skills, coordination of movement of the patient is low (M) and the age is high (A).
A complete spinal cord injury causes permanent damage to the area of the spinal cord that is affected. Paraplegia or tetraplegia are results of complete spinal cord injuries.
We know that a traumatic spinal cord injury has devastating consequences for the physical well-being of patients, and besides that, a condition like this one requires a large amount of time and attention in order to be properly treated, this explains the amount of days required.
This condition comprises in many cases the loss of independence of the patient along with severe social and vocational consequences.
Unfortunately in some situations when the damages are serious, the patient will not be able to recover, in other cases they manage step by step to regain their movement capacity and independence through the help of physical and occupational therapy practitioners [19].

The maximum value assumed by "SB_ratio" is 1.13 and it is assumed by the "Guillian Barre M<18.05", a syndrome with no cure which treatment requires multiple days in order to be performed.
The number of stays per patient is never high because few conditions require more than one stay in order to be treated.

Now let's take a look to the minimum values:

```
> min(mydata$SB_Ratio)
[1] 1
> min(mydata$DB_Ratio)
[1] 5.978378
> mydata$Description[which.min(mydata$DB_Ratio)]
[1] "Replacement of lower extremity joint, M>49.55"
```

Figure 18: Min values of the ratios.

As we can see from Figure 11 the minimum value assumed by the Stay-Beneficiaries Ratio is 1 because each condition has obviously at least one stay in order to be treated.

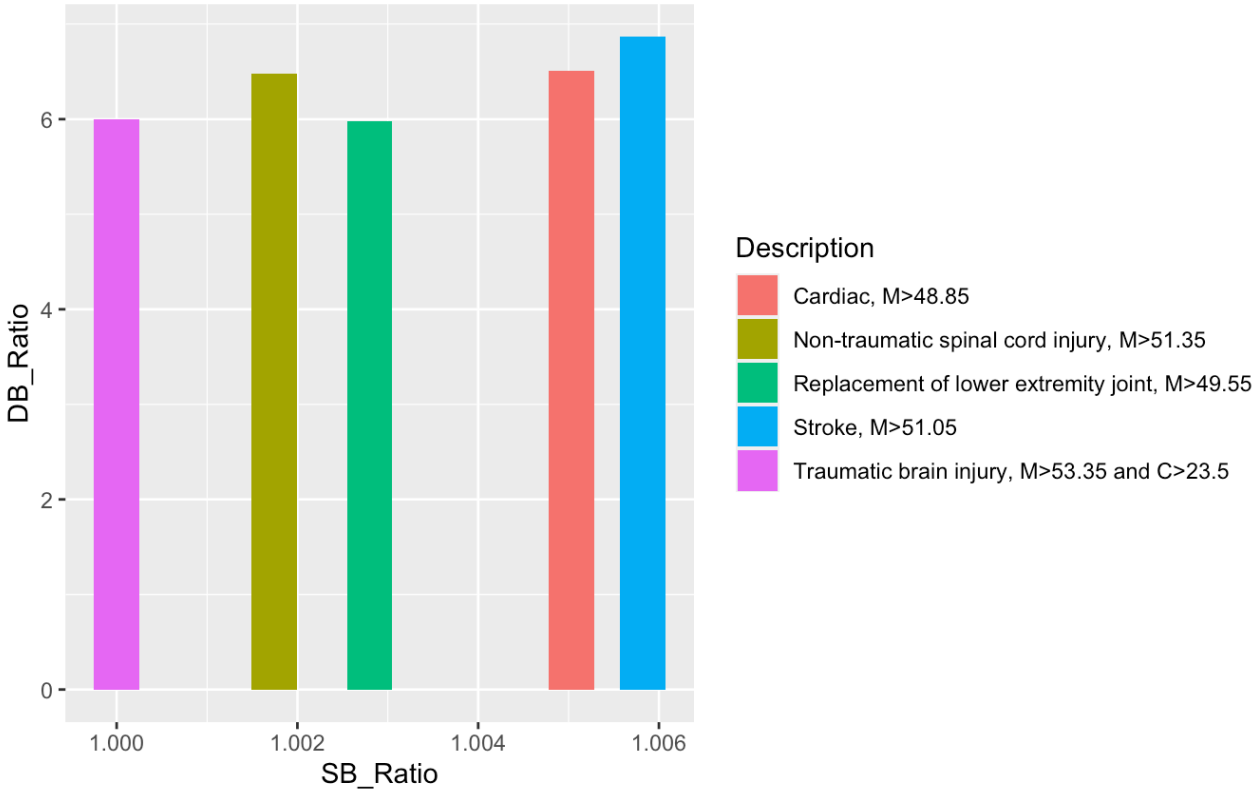
The minimum value of the Days-Beneficiaries Ratio (also represented in figure 12, a graph that shows the conditions with the lowest Days-Beneficiaries ratio) is assumed by the "Replacement of lower extremity joint, M>49.55" condition which is a replacement surgery that involves hip or knee joint in patient with high movement skill.

Joint replacement surgery is a procedure that many people undergo to relieve chronic joint pain and improve joint mobility when other non-surgical treatments have proved unsuccessful.

It is not a risky procedure: the success rate is 95% [20].

The recovery time depends on the quality of the surgery and postoperative care taken by the patient after the surgery.

Most people can get back to their routine activities within a few weeks after the surgery, even less when patients already had high movement skills.




```
> mydata<-mydata[(mydata[,5]<=7),]
> ggplot(data=mydata, aes(x=SB_Ratio, y=DB_Ratio, fill=Description)) + geom_bar(stat="identity", wi
dth=0.0001)
```

Figure 19: Conditions with the lowest DB ratio along with their S-B ratio.

Cost and Prices

Medicare insurance covers most of the cost of care when you stay at an inpatient rehabilitation facility.
Medicare Part A reimburses stays at an inpatient rehabilitation facility in the same way as it reimburses regular hospital stays so the insurance covers medically necessary care you get in an inpatient rehabilitation facility or unit.

As the Medicare official website asserts [22], you pay this for each benefit period:

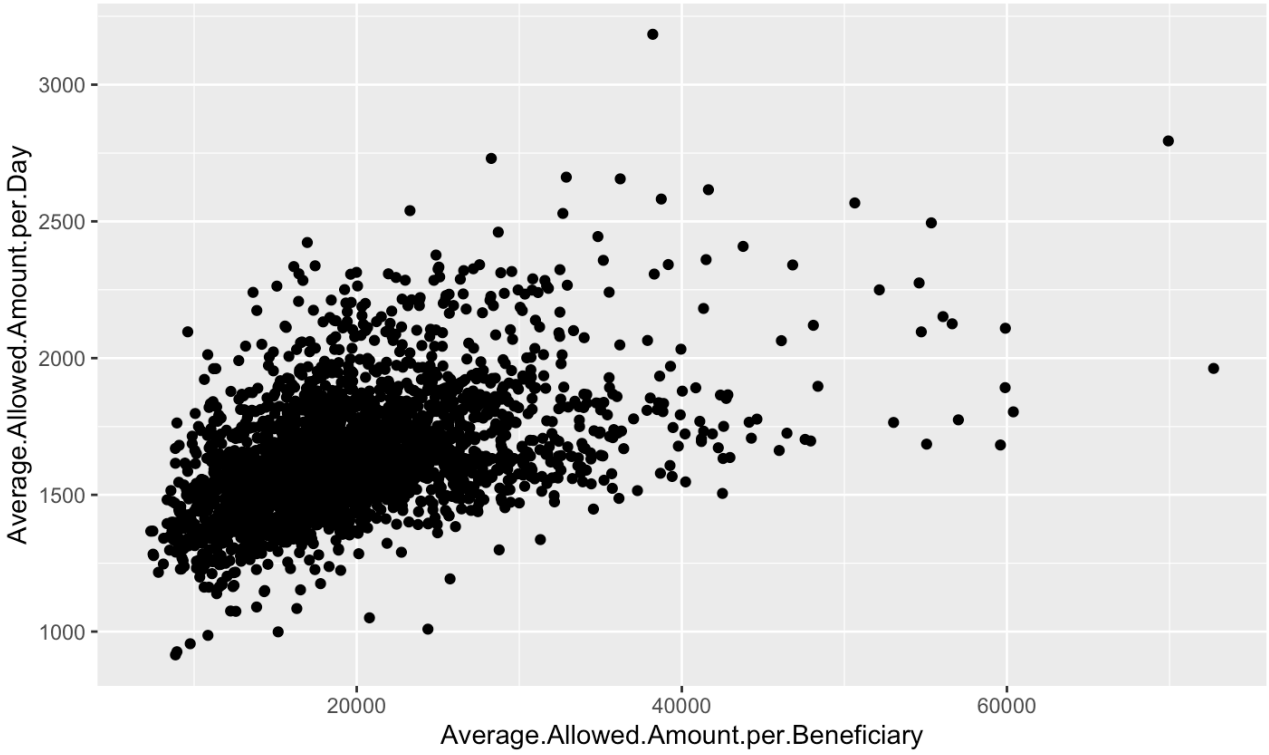
- Days 1-60: $1,364 deductible.
- Days 61-90: $341 coinsurance each day.
- Days 91 and beyond: $682 coinsurance per each "lifetime reserve day" after day 90 for each benefit period (up to 60 days over your lifetime).
- Each day after the lifetime reserve days: All costs.

Let's now examine data about the all nation grouped by the conditions treated:

```
> max(file$Average.Allowed.Amount.per.Beneficiary)
[1] 48411.52
> max(file$Average.Allowed.Amount.per.Day)
[1] 1866.19
> file$Grouping.Description[which.max(file$Average.Allowed.Amount.per.Beneficiary)]
[1] "Traumatic spinal cord injury, M<16.05 and A>63.5"
> file$Grouping.Description[which.max(file$Average.Allowed.Amount.per.Day)]
[1] "Amputation, non-lower extremity, M<36.35"
```

Figure 20: Maximum values for the Average Allowed Amounts

The average allowed amount is the Average of the Medicare Allowed Amount per beneficiary. The Medicare Allowed Amount is the sum of the amount Medicare pays, the deductible and coinsurance amounts that the beneficiary is responsible for paying, and any amounts that a third party is responsible for paying.




```
> ggplot(file, aes(x=Average.Allowed.Amount.per.Beneficiary, y=Average.Allowed.Amount.per.Da
y)) + geom_point()
> cor(file$Average.Allowed.Amount.per.Beneficiary, file$Average.Allowed.Amount.per.Day)
[1] 0.4701721
```

Figure 21: Maximum values for the Average Allowed Amounts

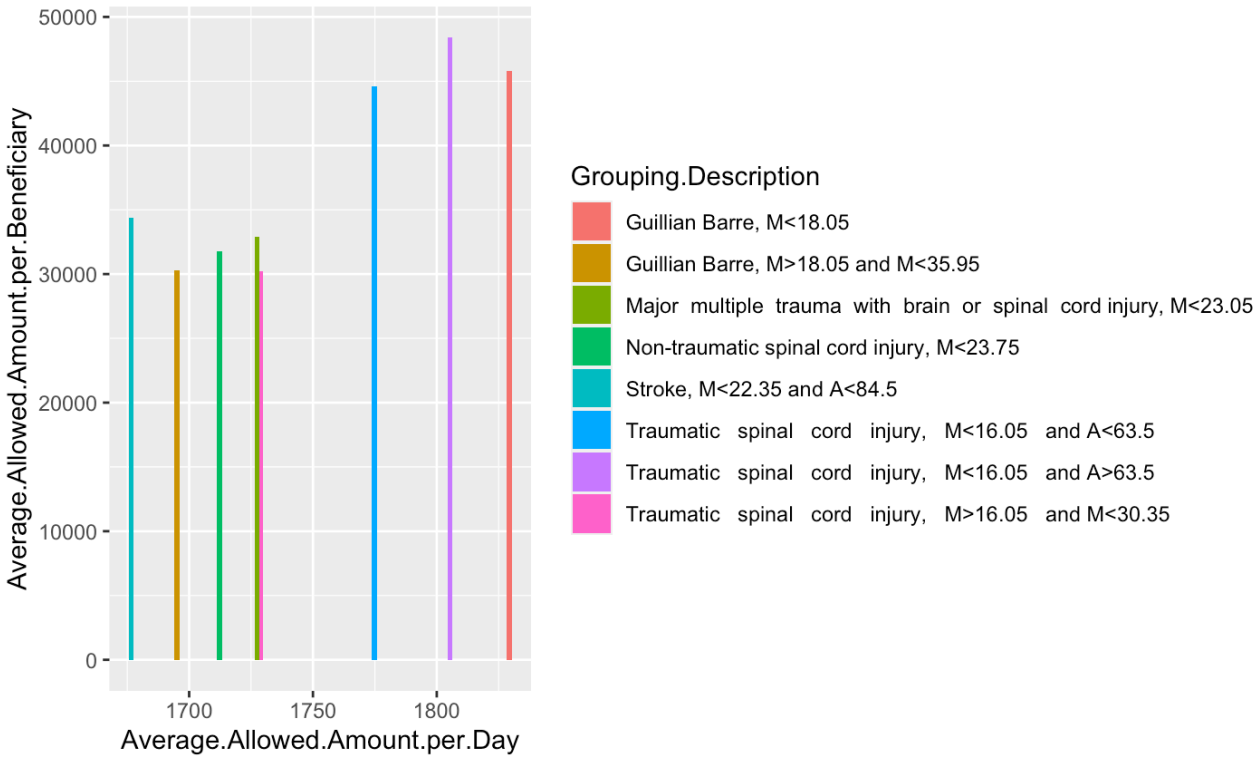
Those two cost variables are equally important and not so similar as seems.
If we properly look at the graph in figure 14, we see that the variables are in fact correlated (about 47%) but this correlations is not that high so it is important to consider both variables.

As we can see from the data in figure 13 the condition related to the maximum value assumed by “Average Allowed Amount per Beneficiary” is, again, “Traumatic spinal cord injury, M<16.05 and A>63.5” while the condition related to the maximum value assumed by “Average Allowed Amount per Day” is “Amputation, non-lower extremity, M<36.35”.

Rehabilitation after major lower extremity amputation could be long and costly.
The treatment period can be long, many operations need to be performed and many qualified personnel members are required: the patient have to be operated, trained

in order to use a prosthetic device or tool and introduced back to his or her life. According to Brigham and Women's hospital's department of rehabilitation, amputation care can be divided up into nine specific periods of evaluation and intervention [23], each with its' particular set of treatment goals and objectives. They are:

1. **Preoperative**: Involves medical and physical assessment, patient education, realistic short and long term goals
2. **Amputation Surgery/Dressing**: Involves surgical residual limb length determination, closure of wound, nerve management and limb reconstruction.
3. **Acute Post-Surgical**: This phase begins immediately post-operatively and continues until the patient is discharged from the acute care hospital. Goals at this stage are pain control, optimization of range of motion and strength of both lower and upper extremity musculature
4. **Pre-prosthetic**: Involves residual limb shaping, increasing range of motion and muscle strength, cardiovascular training, progressive functional mobility training without a prosthesis and patient education and preparation for prosthetic use
5. **Prosthetic Prescription/Fabrication**: Involves team consensus on prosthetic prescription to satisfy the needs, desires and abilities of the patient
6. **Prosthetic Training**: Prosthetic management and training to increase wearing time and functional use.
7. **Community Integration**: Involves resumption of family and community roles, addressing emotional needs and developing healthy coping strategies, and resumption of previous and adapted recreational activities.
8. **Vocational Rehabilitation**: Involves assessment and training for work activities, and assessment of further education needs or job modification
9. **Follow-Up**: Includes lifelong prosthetic, functional, and medical assessment and psychological support.




```
> file<-file[(file[,3]>=30000),]
> ggplot(data=file, aes(x=Average.Allowed.Amount.per.Day, y=Average.Allowed.Amount.per.Benefic
iary, fill=Grouping.Description)) + geom_bar(stat="identity",width=2)
```

Figure 22: Maximum values for the Average Allowed Amounts for each condition.

The graph in figure 14 plots only the conditions with the highest Average Allowed Amount per Beneficiary values for each condition along with their Average Allowed Amount per Day.

The ones that stand out are “Traumatic spinal cord injury, M<16.05 and A>63.5”, “Traumatic spinal cord injury, M<16.05 and A<63.5” and “Guillian Barre M<18.05”. We already saw these condition during the previous chapter which is “Days of service and stay count”.

Spinal cord injury involves multiple operations and occupational therapy sessions so rehabilitation is particularly costly too.

The results of spinal cord injury (SCI) bring not only damage to independence and physical function, but also cause many complications. Neurogenic bladder and bowel, urinary tract infections, pressure ulcers, orthostatic hypotension, fractures, deep vein thrombosis, spasticity, heterotrophic ossification, contractures, autonomic dysreflexia, pulmonary and cardiovascular problems, and depressive

disorders are frequent complications after SCI [24]. These complications have to be properly treated and this leads to an increasing cost.
Guilliam Barre syndrome follows the same pattern: people need physical help and therapy before and during recovery. The care may include:

- Movement of your arms and legs to help keep your muscles flexible and strong

- Physical therapy during recovery to help you cope with fatigue and regain strength and proper movement

- Training with adaptive devices, such as a wheelchair or braces, to give you mobility and self-care skills

In addition There's no cure for Guillain-Barre syndrome. It can be treated and most people will eventually make a full recovery, although it can occasionally be life-threatening and some people are left with long-term problems, this can lead to a continuous need of care and a raise of cost.

Now let's examine the cost related to deductible and coinsurance, which are obtained by subtracting the amount Medicare assurance pays from the average allowed amount:

```
> file$Average.Payment.Amount.per.Beneficiary<-file$Average.Allowed.Amount.per.Beneficiary-fil
e$Average.Payment.Amount.per.Beneficiary
> file$Average.Payment.Amount.per.Day<-file$Average.Allowed.Amount.per.Day-file$Average.Paymen
t.Amount.per.Day
> colnames(file)[4]<-"Average.deductible.coinsurance.per.Beneficiary"
> colnames(file)[7]<-"Average.deductible.coinsurance.per.Day"
> mean(file$Average.deductible.coinsurance.per.Beneficiary)
[1] 413.547
> mean(file$Average.deductible.coinsurance.per.Day)
[1] 34.97414
> max(file$Average.deductible.coinsurance.per.Beneficiary)
[1] 1826.55
> max(file$Average.deductible.coinsurance.per.Day)
[1] 98.57
> file$Grouping.Description[which.max(file$Average.deductible.coinsurance.per.Beneficiary)]
[1] "Traumatic   spinal   cord   injury,   M<16.05   and A<63.5"
```

Figure 23: Mean and Maximum values for deductible and coinsurance values

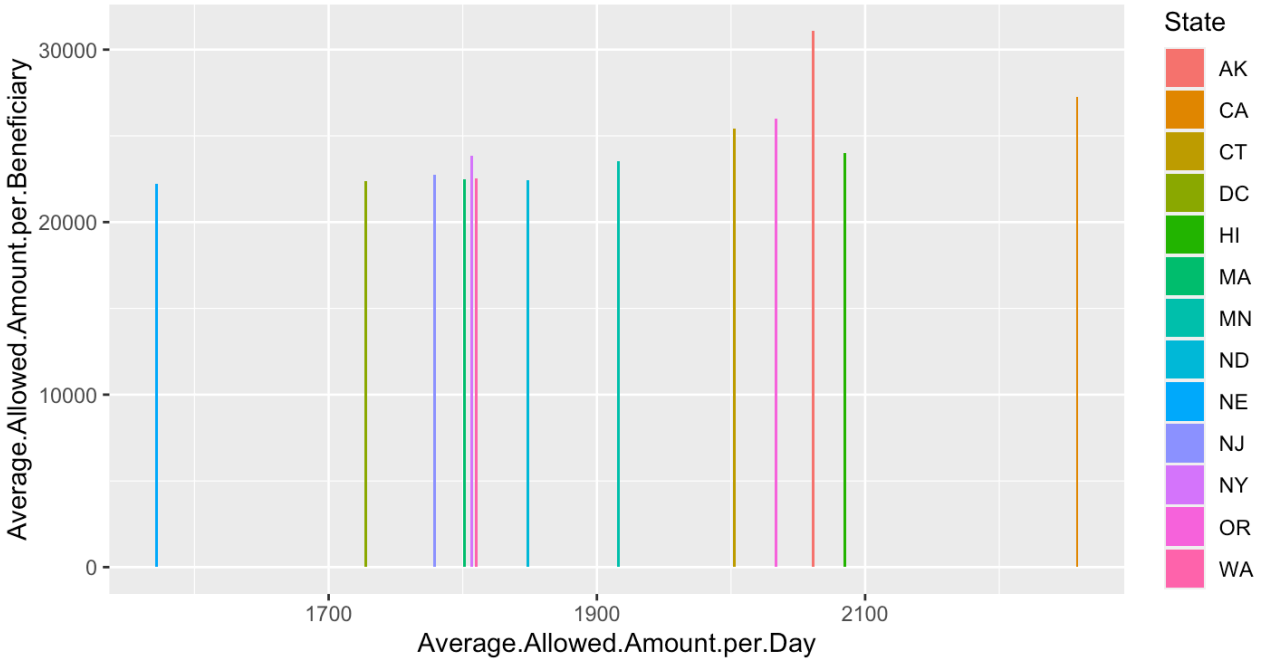
413.547$ is the mean of the average cost per beneficiary concerning deductible and coinsurance so the amount that the patient has to pay, while 34.97$ is the mean of the average cost per day.

The description of the max value of the average deductible and coinsurance cost per beneficiary is again “Traumatic spinal cord injury, M<16.05 and A<63.5”, this should not surprise us because this cost value is highly correlated with the average allowed amount per beneficiary so they reach their respective max value in the same condition.

If we aggregate the data by state the result we obtain is the following:

```
> file<-file[88:2788,]
> file<-file[, c(2, 13, 14, 15, 21, 22, 23)]
> file<-aggregate(cbind(Average.Allowed.Amount.per.Beneficiary, Average.Payment.Amount.per.Ben
eficiary, Average.Standard.Payment.Amount.per.Beneficiary, Average.Allowed.Amount.per.Day, Ave
rage.Payment.Amount.per.Day, Average.Standard.Payment.Amount.per.Day) ~ State, data=file, FUN=
mean, na.rm=TRUE)
```

Figure 24: Data aggregation by state




```
> file<-file[(file[,2]>=22000),]
> ggplot(data=file, aes(x=Average.Allowed.Amount.per.Day, y=Average.Allowed.Amount.per.Benefic
iary, fill=State)) + geom_bar(stat="identity",width=2)
```

Figure 25: Highest values for the Average Allowed Amounts for State.

The graph in figure 17 shows the state with the highest values of Average allowed amount.
The maximum value for “Allowed Amount per Day” is assumed by California (CA) while the maximum value for “Allowed Amount per Beneficiary” is assumed by Alaska (AK).

```
> max(file$Average.Allowed.Amount.per.Beneficiary)
[1] 31076.54
> file$State[which.max(file$Average.Allowed.Amount.per.Beneficiary)]
[1] "AK"
```

Figure 26: Maximum value for the Average Allowed Amount per Beneficiary for State.

As the Los Angeles Times asserts [26]: doctors in areas such as Los Angeles, with more hospitals and other resources, are more likely to have patients admitted, order tests and schedule visits, largely because they can.
In fact, the researchers say, medical treatment often has more to do with resources, available hospital beds, specialists and equipment, than how sick patients really are. Where resources are abundant, studies show, physicians order more treatment.
By comparison, at Providence Little Company of Mary Medical Center San Pedro, where the median household income of the surrounding community is twice that of White Memorial, patients spend an average of 15 days in the hospital in the last six months of life. Not surprisingly, Medicare’s cost for Little Company patients in the last two years of life is less than half that of White Memorial patients.

California is one of the wealthiest and most populated states in the US so the first result is perfectly logical, the second, instead, is quite strange and interesting.
Alaska’s per-capita expenditures on health care have been growing significantly faster than the national average over the last 30-some years [27].
As explained in a new report [28], is that various state regulations, along with other unique Alaskan factors such as population density, have influenced the high spending on health care. According to Dr. Benedic Ippolito, the author of the report, these factors include:

1. Labor costs: the cost of attracting qualified health care workers to Alaska is high.
2. Lack of competition: there are state regulations which disincentivize competition between businesses.
3. High Medicaid costs: Medicaid (which offer benefits not covered by Medicare for people with limited income and resources) payments to doctors here are much higher than Medicare (which mainly provides health coverage for the elderly) reimbursements. In Alaska, Medicaid expenditures are up to 56% higher than the national average.

Alaska desperately needs health care cost reform. Paying for high and rising health care costs is unsustainable for Alaskans.

Quality

The quality of inpatient rehabilitation facilities (IRFs) is of great interest to policymakers as these facilities are tasked with providing high-intensity rehabilitation care to Medicare beneficiaries who have recently encountered health challenges resulting in compromised function. Quality is in fact the main factor that is taken in account when a facility is chosen, it is also an essential feature for every healthcare facility.

In the datasets used for this analysis a few provider variables are used as quality indicator for a specific facility:

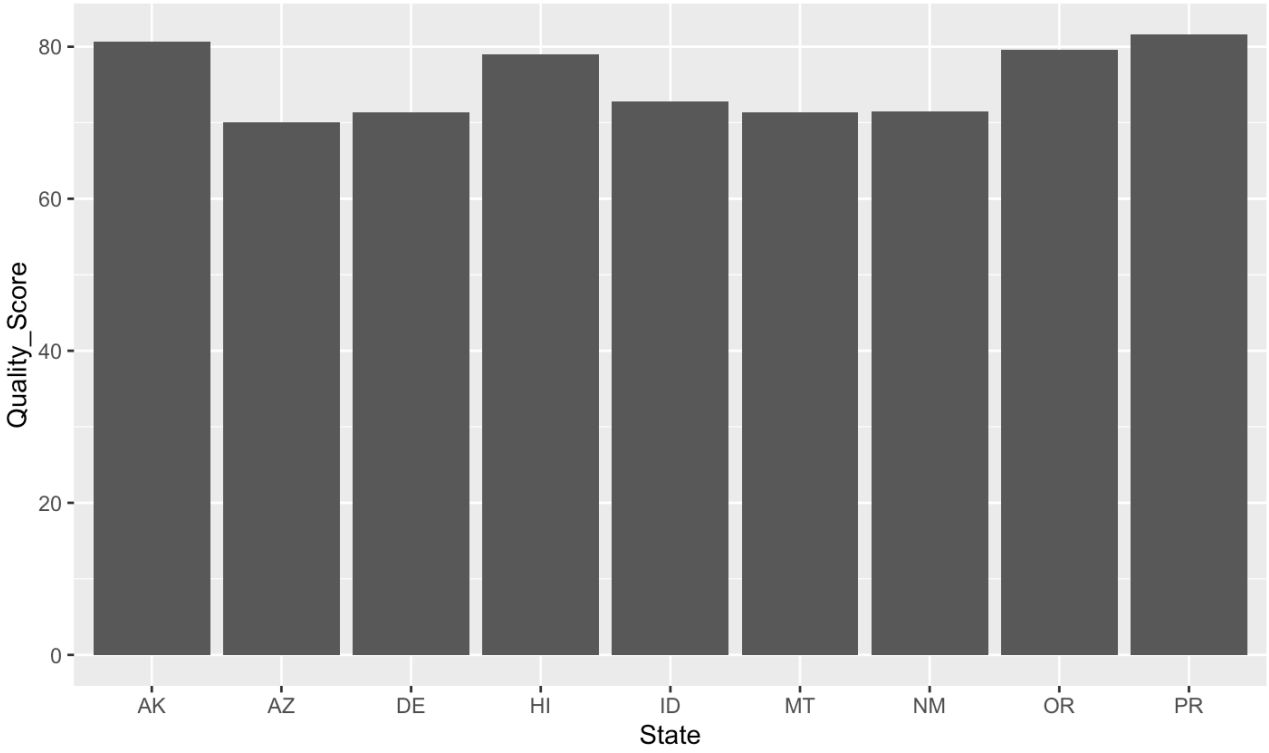
- I_019_02_DTC_NUMBER: Observed Number of Discharges to Community
- I_019_02_DTC_VOLUME: Number of Eligible Stays for DTC Measure
- I_019_02_DTC_OBS_RATE: Ratio between Number and Volume, it is the indicator we'll use in order to evaluate a facility's quality

Now let's use the variables we just discussed in order to estimate the quality of the facilities in the US:

```
> file<-read.csv('Provider_Dec2020.csv')
> file<-subset(file, Measure.Code=='I_019_02_DTC_OBS_RATE')
> file<-file[(file[,12]!='Not Available'),]
> file$Score<-as.numeric(file$Score)
> mydata<-aggregate(file$Score, by=list(State=file$State), FUN=mean)
> names(mydata)<-c('State', 'Quality_Score')
```

Figure 27: Mean quality for every State in the US.

First thing we calculate the mean I_019_02_DTC_OBS_RATE quality value for every state, then we plot the states with the higher values:




```
> mydata<-mydata[(mydata[,2]>70),]
> ggplot(data=mydata, aes(x=State, y=Quality_Score)) + geom_bar(stat="identity")
```

Figure 28: States in the US with maximum average quality.

As we can see from the graph, the maximum quality values are assumed by Alaska (AK), Oregon (OR), Puerto Rico (PR) and Hawaii (HI).

```
> max(mydata$Quality_Score)
[1] 81.63667
> mydata$State[which.max(mydata$Quality_Score)]
[1] "PR"
```

Figure 29: Maximum Quality Value.

Puerto Rico is considered one of the best country in the US when we talk about rehabilitation thanks to the Healthsouth facilities.

HealthSouth serves patients through its network of inpatient rehabilitation hospitals, outpatient rehabilitation satellite clinics and home health agencies. HealthSouth's hospitals provide a higher level of rehabilitative care to patients who are recovering from conditions such as stroke and other neurological disorders, orthopedic, cardiac and pulmonary conditions, brain and spinal cord injuries, and

amputations [29]. The metrics used in order to evaluate the quality of those facilities are based also on clinical outcomes and patient experience.

In order to properly discuss about Oregon's IRF, first let's represent on a map every facilities in the US along with their quality measure.

```
> file<-read.csv('Provider_Dec2020.csv')
> address<-paste(file$Address.Line.1, file$City, file$State)
> file$Address.Line.1<-address
> file<-file[,c(3,11,12)]
> file<-subset(file, Measure.Code=="I_019_02_DTC_OBS_RATE")
> file<-file[(file[,3]!='Not Available'),]
> file$Score<-as.numeric(file$Score)
```

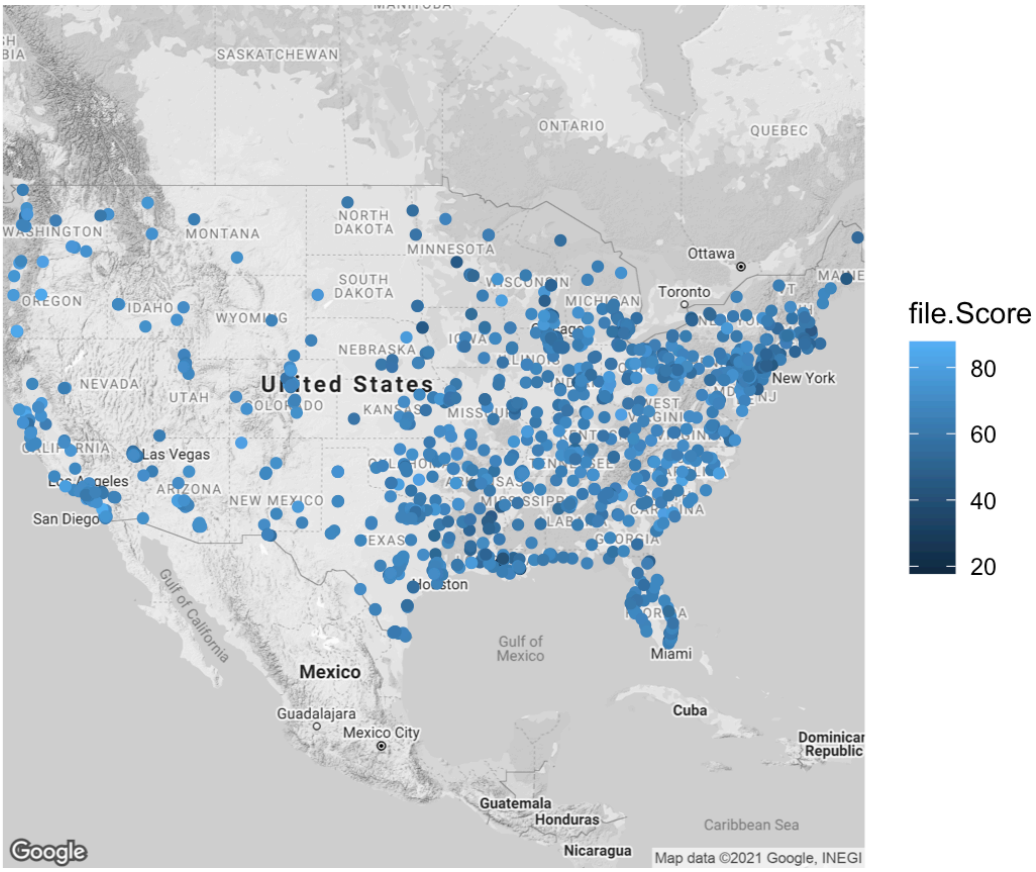
Figure 30: Data manipulation in order to obtain quality measure for every facility.

	Address.Line.1	Measure.Code	Score
52	3800 RIDGEWAY DRIVE BIRMINGHAM AL	I_019_02_DTC_OBS_RATE	65.09
117	4465 NARROW LANE RD MONTGOMERY AL	I_019_02_DTC_OBS_RATE	63.06
182	107 GOVERNORS DRIVE HUNTSVILLE AL	I_019_02_DTC_OBS_RATE	67.83
247	1736 EAST MAIN STREET DOTHAN AL	I_019_02_DTC_OBS_RATE	64.53
312	900 OAK MOUNTAIN COMMONS LANE PELHAM AL	I_019_02_DTC_OBS_RATE	62.70
377	801 GOODYEAR AVE GADSDEN AL	I_019_02_DTC_OBS_RATE	62.66
442	3715 US HIGHWAY 431 NORTH PHENIX CITY AL	I_019_02_DTC_OBS_RATE	67.42
507	50 MEDICAL PARK EAST DRIVE BIRMINGHAM AL	I_019_02_DTC_OBS_RATE	67.72
572	2000 PEPPERELL PARKWAY. OPELIKA AL	I_019_02_DTC_OBS_RATE	61.56
637	SRC 223E BIRMINGHAM AL	I_019_02_DTC_OBS_RATE	65.68

Figure 31: Data format after manipulation.

```
> coordinates<-geocode(file$Address.Line.1)
> mydata<-data.frame(coordinates$lon,coordinates$lat,file$Score)
> usmap<-qmap("USA",zoom=4,color="bw")
```

Figure 32: Creation of the map and facilities' coordinates.




```
> usmap+geom_point(aes(x=coordinates.lon, y=coordinates.lat, color=file.Score), data=mydata)
```

Figure 33: All the facilities in the US along with their quality measure: I_019_02_DTC_OBS_RATE.

```
> mean(mydata$file.Score)
[1] 64.71341
```

Figure 34: Average national quality value

Oregon is the state in the main continent with the highest IRF quality.
As we can see from Figure 24, Oregon hasn't so many facilities like Texas, Florida or California but every one of them has a particularly high score in term of quality measures.
A famous facility is definitely the Oregon Rehabilitation Center which inpatient unit is nationally recognized and boasts an exceptional rate of patient success [30].

If we pay attention to the map represented in Figure 24 the countries with a low quality measure seem to be Mississipi, Lousiana, North Dakota, South Dakota and Minnesota among others.
Quality in both East Coast and West Coast and in the southern state is high.
California has a high density of good facilities for example.

Figure 25 tells us that the national average is about 64,7 meaning that 64.7% of the patients manage to recover from a stay in an inpatient rehabilitation facility.
As we already discussed in the previous chapters, a lot of conditions are treated and many of them can be really serious and difficult even for advanced medicine.
Considering this fact, 64,7% isn't a low result at all.

Conclusion: a few considerations

This analysis was helpful and stimulating.
First of all it was really interesting to study Inpatient Rehabilitation Facilities in the United States.
Sanity in Italy is different compared to the US, so that point of view was interesting too.
Discovering trends and facts through data was fascinating, especially when they surprised me.
I would have never guessed that Alaska was the country with the highest average cost per beneficiary or that Puerto Rico and Hawaii were the ones with the highest quality level.
Besides those, some facts concerned me.
When I talked about the conditions treated in IRF and I realized that about 25% of them was stroke I wasn't surprised.
Those strokes are mainly caused by smoking and terrible nutrition, so half of them could be avoided.
Sometimes those facts are reported through news or television programs, but I never realized how serious the situation was.
Not only because of the money the government and the assurances periodically spend on treating condition caused by these factors, it is not all about money.
People die when those kind of disturbs are serious.
Their lifestyle need to be changed because it is dangerous.
This could be reached through education, news, sensitizing campaigns that use analysis and data in order to make American citinzens aware of the problem they have.
The process could be difficult but have to be completed no matter the cost because life itself is at risk.

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