Unsupervised Explore Analysis

Outline

- K-means clustering
- Hierarchical Clustering
- Principal component analysis (PCA)

k - means Clustering Analysis

To Do Check List: - Data Updated?? from the changes in the website on May 2021 - Did I look at the correct variables? - What variables can I add? What variables can I take out?

Things that I should check when completing EDA: - Correlation Matrix - Did you need to scale the data? - What variables are important that are not numeric?

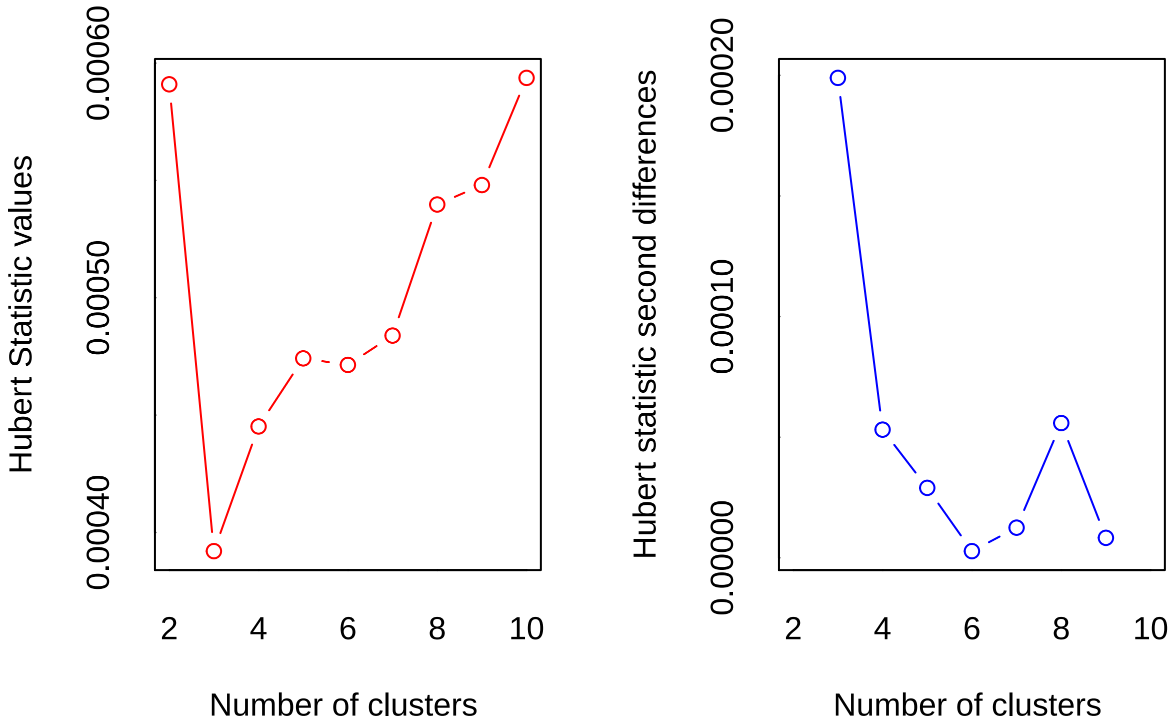
What issues am I having in the analysis for the K-means Analysis? -

Sourced methodology from https://cedric.cnam.fr/fichiers/art_2579.pdf

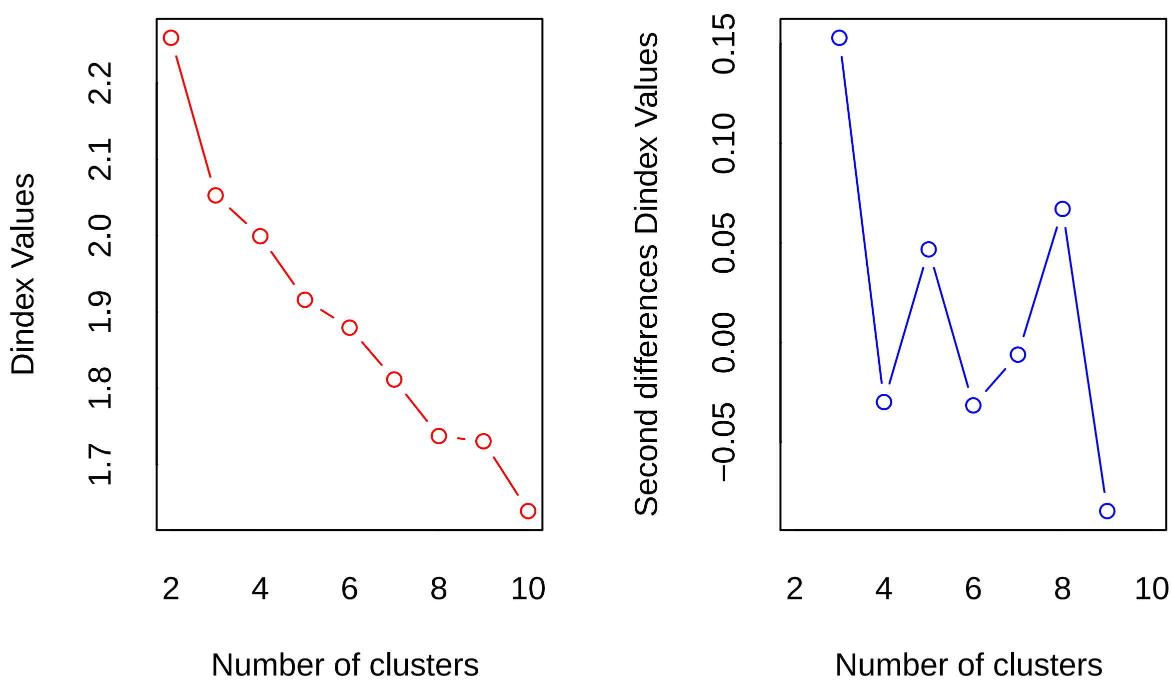
```
# ia.dist.data.nested <-
#   ia.dist.data.nested %>%
#   remove_rownames %>%
#   column_to_rownames(var="City")
#
# scaled.ia.dist.data <- scale(ia.dist.data.nested[,-7])

#Using the NBClust function to determine the number of clusters that are important to our data

#Using the Euclidean Distance and Complete Method
set.seed(26)
clusterNo = NbClust(scaled.ia.dist.data,distance="euclidean",
min.nc=2,max.nc=10,method="complete",index="all")
```




```
## *** : The Hubert index is a graphical method of determining the number of clusters.
##                 In the plot of Hubert index, we seek a significant knee that corresponds to a
##                 significant increase of the value of the measure i.e the significant peak in Hubert
##                 index second differences plot.
##
```

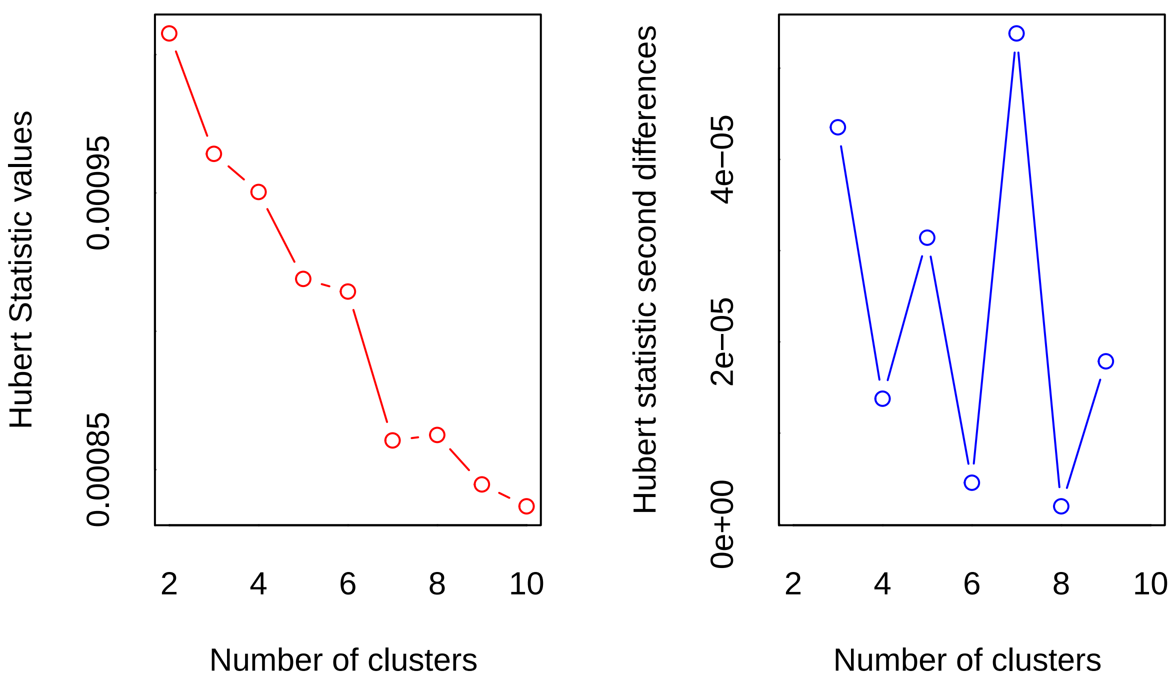



```
## *** : The D index is a graphical method of determining the number of clusters.
##                 In the plot of D index, we seek a significant knee (the significant peak in Dindex
##                 second differences plot) that corresponds to a significant increase of the value of
```

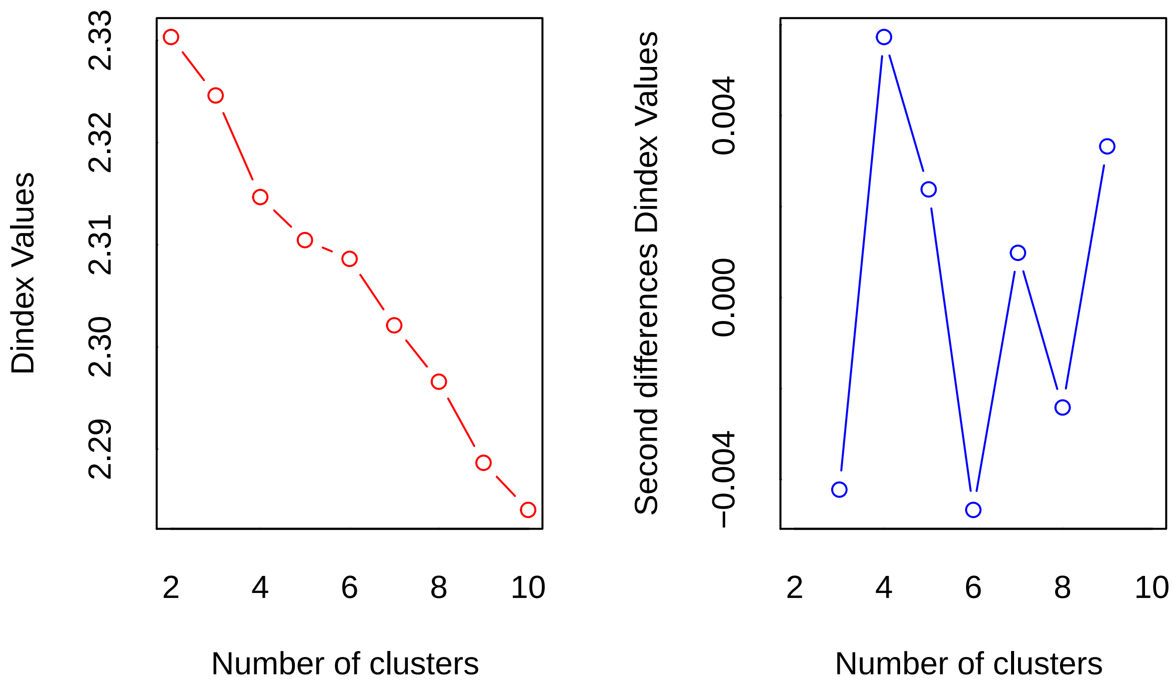
```
##                  the measure.
##
## *******************************************************************
## * Among all indices:
## * 6 proposed 2 as the best number of clusters
## * 11 proposed 3 as the best number of clusters
## * 2 proposed 4 as the best number of clusters
## * 1 proposed 7 as the best number of clusters
## * 1 proposed 8 as the best number of clusters
## * 2 proposed 9 as the best number of clusters
## * 1 proposed 10 as the best number of clusters
##
##                     ***** Conclusion *****
##
## * According to the majority rule, the best number of clusters is  3
##
##
## *******************************************************************
```

```
#Using the Euclidean Distance and Single Method (This may be the best method for our work, since we wan
set.seed(26)
clusterNo = NbClust(scaled.ia.dist.data,distance="euclidean",
min.nc=2,max.nc=10,method="single",index="all")
```

```
## Warning in pf(beale, pp, df2): NaNs produced
```

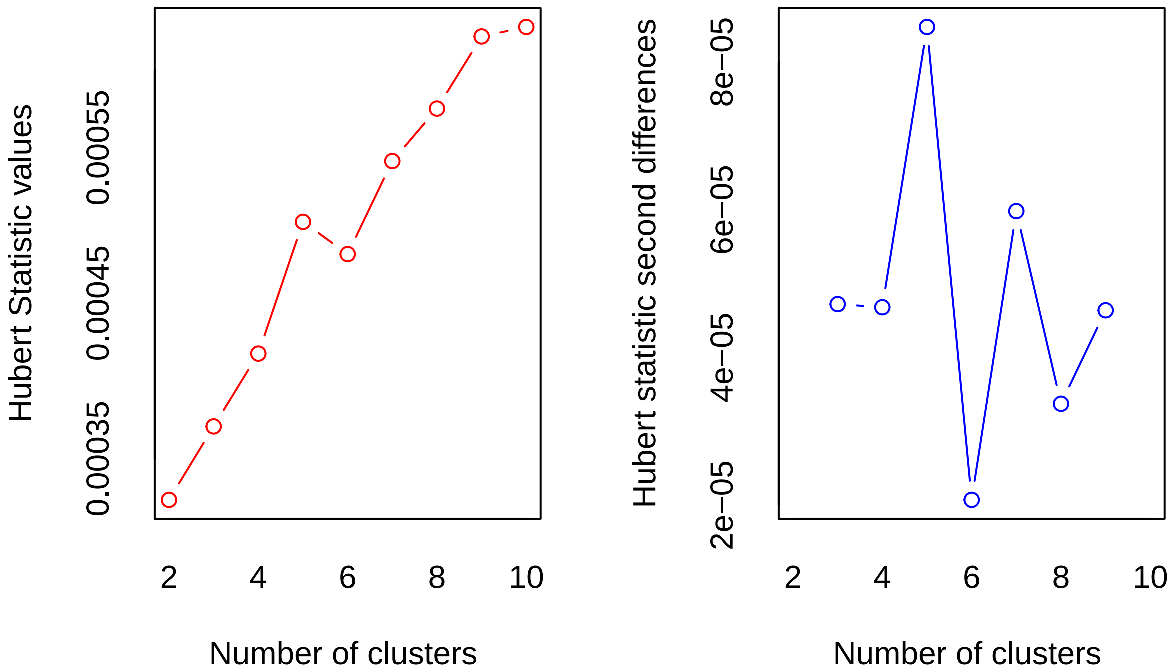



```
## *** : The Hubert index is a graphical method of determining the number of clusters.
##                  In the plot of Hubert index, we seek a significant knee that corresponds to a
##                  significant increase of the value of the measure i.e the significant peak in Hubert
##                  index second differences plot.
##
```

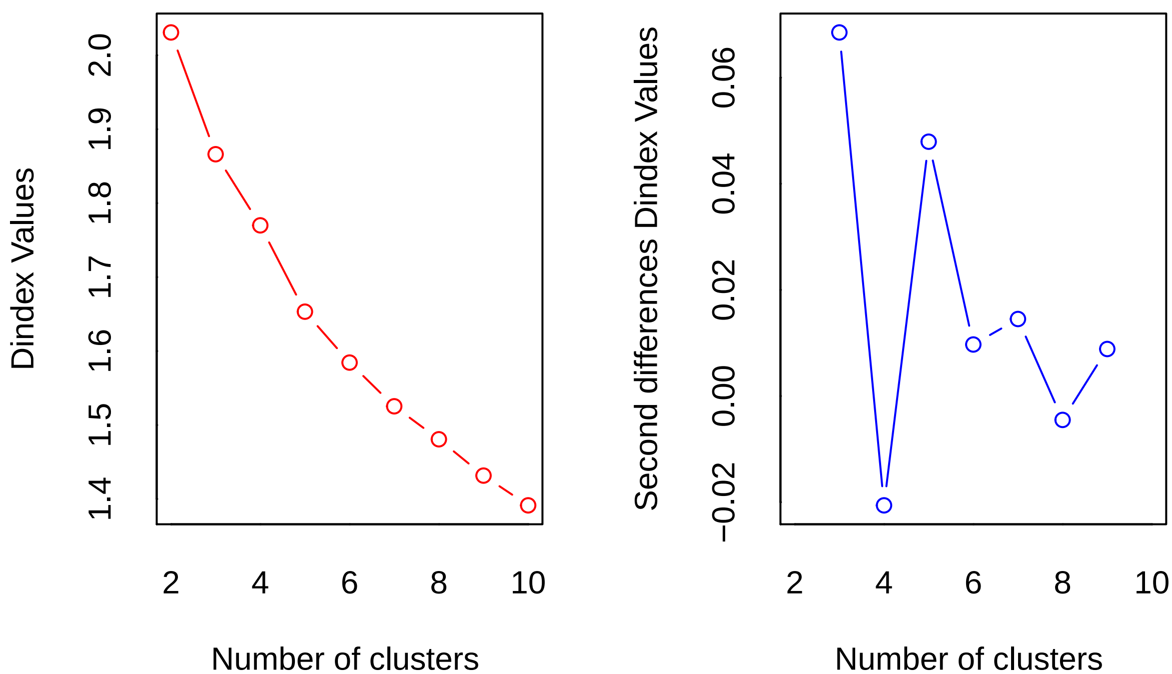



```
## *** : The D index is a graphical method of determining the number of clusters.
##                 In the plot of D index, we seek a significant knee (the significant peak in Dindex
##                 second differences plot) that corresponds to a significant increase of the value of
##                 the measure.
##
## *******************************************************************
## * Among all indices:
## * 9 proposed 2 as the best number of clusters
## * 1 proposed 3 as the best number of clusters
## * 7 proposed 4 as the best number of clusters
## * 1 proposed 5 as the best number of clusters
## * 1 proposed 9 as the best number of clusters
## * 5 proposed 10 as the best number of clusters
##
##                    ***** Conclusion *****
##
## * According to the majority rule, the best number of clusters is  2
##
##
## *******************************************************************
```

```
#Using the Euclidean Distance and Kmeans Method
set.seed(13)
clusterNo = NbClust(scaled.ia.dist.data,distance="euclidean",
min.nc=2,max.nc=10,method="kmeans",index="all")
```




```
## *** : The Hubert index is a graphical method of determining the number of clusters.
##                 In the plot of Hubert index, we seek a significant knee that corresponds to a
##                 significant increase of the value of the measure i.e the significant peak in Hubert
##                 index second differences plot.
##
```




```
## *** : The D index is a graphical method of determining the number of clusters.
##                 In the plot of D index, we seek a significant knee (the significant peak in Dindex
##                 second differences plot) that corresponds to a significant increase of the value of
##                 the measure.
##
```

```
## *******************************************************************
## * Among all indices:
## * 6 proposed 2 as the best number of clusters
## * 6 proposed 3 as the best number of clusters
## * 4 proposed 5 as the best number of clusters
## * 1 proposed 6 as the best number of clusters
## * 1 proposed 8 as the best number of clusters
## * 1 proposed 9 as the best number of clusters
## * 4 proposed 10 as the best number of clusters
##
##                    ***** Conclusion *****
##
## * According to the majority rule, the best number of clusters is  2
##
##
## *******************************************************************
```

```r
#Using the Euclidean Distance and Centroid Method
#set.seed(78)
#clusterNo = NbClust(scaled.ia.dist.data,distance="euclidean",
#min.nc=2,max.nc=10,method="centroid",index="all")
```

```r
#Let's look at the distance differences in the hospitals only
#scaled.hosp.dist.data <- scale(ia.dist.data.nested[,-7]) # Scaling the data by removing the city name

# View the firt 3 rows of the data
#head(scaled.ia.dist.data, n = 3)

# Compute k-means with k = 4
set.seed(123)
km.res <- kmeans(scaled.ia.dist.data, 2, nstart = 25)
print(km.res)
```

```
## K-means clustering with 2 clusters of sizes 484, 525
##
## Cluster means:
##   hosp.dist.mi fire.dist.mi dist.public.Elementary dist.public.Middle
## 1   -0.2809237   -0.1132019             -0.7223146         -0.7809283
## 2    0.2589849    0.1043614              0.6659052          0.7199415
##   dist.public.High postoff.dist.mi
## 1       -0.5786003      0.04602256
## 2        0.5334144     -0.04242841
##
## Clustering vector:
##               Ackley             Ackworth                Adair
##                    1                    1                    2
##                 Adel                Afton               Agency
##                    1                    1                    1
##            Ainsworth                Akron         Albert City
##                    2                    1                    2
##               Albia               Albion            Alburnett
##                    2                    1                    1
##               Alden            Alexander               Algona
##                    1                    1                    2
##             Alleman            Allerton              Allison
```

```
##             1            2            2
##          Alta   Alta Vista        Alton
##             1            2            1
##       Altoona       Alvord        Amana
##             1            1            1
##          Ames      Anamosa     Anderson
##             1            1            2
##       Andover       Andrew        Anita
##             2            2            2
##        Ankeny       Anthon    Aplington
##             1            2            1
##       Arcadia       Archer      Aredale
##             1            1            2
##         Arion       Arispe    Arlington
##             2            2            2
##     Armstrong Arnolds Park       Arthur
##             2            2            2
##        Asbury       Ashton    Aspinwall
##             1            1            1
##      Atalissa    Athelstan       Atkins
##             1            2            1
##      Atlantic       Auburn      Audubon
##             2            1            2
##       Aurelia       Aurora        Avoca
##             1            1            2
##      Ayrshire       Badger       Bagley
##             2            1            2
##       Baldwin     Balltown     Bancroft
##             2            1            2
##      Bankston  Barnes City       Barnum
##             1            2            1
##      Bartlett      Bassett      Batavia
##             2            2            2
##  Battle Creek       Baxter       Bayard
##             1            1            2
##        Beacon Beaconsfield       Beaman
##             2            2            1
##        Beaver   Beaverdale      Bedford
##             2            1            2
##  Belle Plaine     Bellevue      Belmond
##             1            2            1
##       Bennett      Bentley       Benton
##             2            1            2
##       Berkley      Bernard      Bertram
##             2            1            1
##    Bettendorf    Bevington   Birmingham
##             1            1            2
##    Blairsburg   Blairstown   Blakesburg
##             2            1            2
##     Blanchard      Blencoe     Blockton
##             2            2            2
##    Bloomfield   Blue Grass         Bode
##             1            1            2
##         Bolan    Bonaparte    Bondurant
```

```
##                    1                 2                 1
##                Boone            Bouton            Boxholm
##                    1                 1                 2
##               Boyden       Braddyville           Bradford
##                    1                 2                 1
##             Bradgate           Brandon            Brayton
##                    2                 1                 2
##                Breda       Bridgewater           Brighton
##                    1                 2                 2
##              Bristow             Britt            Bronson
##                    2                 2                 1
##             Brooklyn        Brunsville         Buck Grove
##                    2                 1                 2
##              Buckeye           Buffalo    Buffalo Center
##                    2                 1                 2
##            Burchinal        Burlington           Burr Oak
##                    1                 1                 2
##                 Burt            Bussey            Calamus
##                    2                 2                 1
##  California Junction         Callender             Calmar
##                    1                 1                 1
##              Calumet          Camanche          Cambridge
##                    1                 1                 1
##              Cantril            Carbon           Carlisle
##                    2                 2                 1
##            Carpenter           Carroll             Carson
##                    1                 1                 2
##          Carter Lake           Cascade              Casey
##                    1                 1                 2
##             Castalia           Castana        Cedar Falls
##                    1                 2                 1
##         Cedar Rapids   Center Junction       Center Point
##                    1                 1                 1
##          Centerville      Central City          Centralia
##                    2                 1                 1
##               Chapin          Chariton       Charles City
##                    1                 1                 2
##            Charlotte       Charter Oak         Chatsworth
##                    2                 2                 1
##              Chelsea          Cherokee            Chester
##                    2                 1                 2
##          Chillicothe           Churdan         Cincinnati
##                    2                 2                 2
##                Clare          Clarence           Clarinda
##                    1                 2                 1
##              Clarion       Clarksville            Clayton
##                    1                 1                 2
##           Clear Lake        Clearfield           Cleghorn
##                    1                 2                 1
##              Clemons          Clermont      Climbing Hill
##                    2                 1                 2
##              Clinton              Clio              Clive
##                    1                 2                 1
##              Clutier         Coalville             Coburg
```

```
##                  1                  1                  2
##             Coggon               Coin          Colesburg
##                  2                  1                  1
##             Colfax    College Springs            Collins
##                  1                  1                  1
##               Colo      Columbus City  Columbus Junction
##                  1                  2                  2
##            Colwell         Conesville             Conrad
##                  2                  2                  1
##             Conroy             Conway        Coon Rapids
##                  1                  2                  1
##            Coppock         Coralville             Corley
##                  2                  1                  2
##            Corning   Correctionville            Corwith
##                  2                  2                  2
##            Corydon             Cotter            Coulter
##                  2                  2                  1
##     Council Bluffs              Craig     Crawfordsville
##                  1                  1                  2
##           Crescent             Cresco            Creston
##                  1                  2                  1
##           Cromwell       Crystal Lake         Cumberland
##                  1                  2                  2
##            Cumming             Curlew            Cushing
##                  1                  2                  2
##           Cylinder        Dakota City      Dallas Center
##                  2                  1                  1
##               Dana            Danbury           Danville
##                  2                  2                  1
##          Davenport         Davis City             Dawson
##                  1                  2                  2
##             Dayton            De Soto      Decatur City
##                  2                  1                  2
##            Decorah             Dedham         Deep River
##                  1                  1                  2
##           Defiance           Delaware              Delhi
##                  2                  1                  1
##             Delmar             Deloit            Delphos
##                  2                  2                  2
##              Delta            Denison            Denmark
##                  2                  2                  1
##             Denver              Derby         Des Moines
##                  1                  2                  1
##             DeWitt             Dexter           Diagonal
##                  1                  2                  2
##   Diamondhead Lake            Dickens               Dike
##                  2                  2                  1
##              Dixon           Dolliver            Donahue
##                  1                  2                  1
##         Donnellson               Doon              Douds
##                  2                  1                  2
##          Dougherty           Dow City               Dows
##                  1                  2                  1
##        Drakesville            Dubuque             Dumont
```

```
##                    1                    1                    2
##               Duncan             Duncombe               Dundee
##                    2                    1                    1
##            Dunkerton               Dunlap              Durango
##                    1                    2                    1
##               Durant           Dyersville               Dysart
##                    1                    1                    1
##          Eagle Grove              Earlham              Earling
##                    2                    2                    2
##            Earlville                Early           East Amana
##                    1                    2                    1
##            East Peru            Eddyville             Edgewood
##                    2                    2                    1
##              Elberon                Eldon               Eldora
##                    1                    2                    1
##             Eldridge                Elgin             Elk Horn
##                    1                    1                    2
##      Elk Run Heights              Elkader              Elkhart
##                    1                    2                    1
##              Elkport              Elliott              Ellston
##                    1                    2                    2
##            Ellsworth                 Elma                  Ely
##                    2                    2                    1
##              Emerson           Emmetsburg              Epworth
##                    2                    2                    1
##                Essex          Estherville            Evansdale
##                    1                    2                    1
##               Everly                Exira               Exline
##                    2                    2                    2
##             Fairbank              Fairfax            Fairfield
##                    1                    1                    1
##               Farley          Farmersburg           Farmington
##                    1                    2                    2
##         Farnhamville             Farragut              Fayette
##                    2                    2                    2
##               Fenton             Ferguson              Fertile
##                    2                    1                    1
##               Floris                Floyd                Fonda
##                    1                    2                    2
##           Fontanelle          Forest City        Fort Atkinson
##                    2                    2                    1
##           Fort Dodge         Fort Madison             Fostoria
##                    1                    1                    2
##             Franklin               Fraser       Fredericksburg
##                    2                    2                    2
##            Frederika             Fredonia              Fremont
##                    2                    2                    2
##            Fruitland              Frytown                 Galt
##                    1                    1                    1
##                Galva               Garber          Garden City
##                    1                    1                    2
##         Garden Grove           Garnavillo               Garner
##                    2                    2                    2
##             Garrison               Garwin               Geneva
```

```
##                  1                1                1
##             George           Gibson          Gilbert
##                  1                2                1
##       Gilbertville    Gillett Grove           Gilman
##                  1                2                1
##       Gilmore City        Gladbrook         Glenwood
##                  2                1                1
##            Glidden        Goldfield          Goodell
##                  1                2                1
##         Goose Lake           Gowrie      Graettinger
##                  2                2                2
##               Graf          Grafton   Grand Junction
##                  1                1                2
##        Grand Mound      Grand River        Grandview
##                  1                2                2
##            Granger            Grant        Granville
##                  1                2                1
##            Gravity             Gray          Greeley
##                  2                1                1
##     Green Mountain           Greene       Greenfield
##                  1                2                2
##         Greenville           Grimes         Grinnell
##                  2                1                1
##           Griswold    Grundy Center           Gruver
##                  2                1                2
##           Guernsey   Guthrie Center       Guttenberg
##                  2                2                1
##             Halbur          Hamburg         Hamilton
##                  1                2                2
##            Hampton          Hancock       Hanlontown
##                  1                2                1
##            Hansell         Harcourt            Hardy
##                  1                2                2
##             Harlan           Harper    Harpers Ferry
##                  2                2                2
##             Harris         Hartford          Hartley
##                  2                1                1
##           Hartwick           Harvey         Hastings
##                  2                2                2
##           Havelock        Haverhill         Hawarden
##                  2                1                1
##            Hawkeye      Hayesville        Hayfield
##                  2                2                2
##           Hazleton          Hedrick        Henderson
##                  1                2                2
##            Hepburn         Hiawatha       High Amana
##                  1                1                1
##              Hills        Hillsboro           Hinton
##                  1                2                1
##       Holiday Lake          Holland         Holstein
##                  2                1                2
##         Holy Cross        Homestead        Hopkinton
##                  1                1                1
##            Hornick          Hospers         Houghton
```

```
##                 2               1               2
##           Hubbard          Hudson            Hull
##                 2               1               1
##          Humboldt        Humeston        Hutchins
##                 1               2               2
##            Huxley       Ida Grove         Imogene
##                 1               1               2
##      Independence       Indianola          Inwood
##                 1               1               1
##             Ionia       Iowa City      Iowa Falls
##                 2               1               1
##            Ireton       Irvington           Irwin
##                 1               2               2
##  Jackson Junction    Jacksonville         Jamaica
##                 2               2               2
##        Janesville       Jefferson           Jesup
##                 1               2               1
##   Jewell Junction        Johnston           Joice
##                 2               1               1
##            Jolley          Kalona          Kamrar
##                 2               1               2
##           Kanawha       Kellerton          Kelley
##                 2               2               1
##           Kellogg         Kensett            Kent
##                 1               1               1
##            Keokuk  Keomah Village       Keosauqua
##                 2               2               2
##             Keota         Keswick        Keystone
##                 2               2               1
##        Kimballton        Kingsley         Kinross
##                 2               1               2
##           Kirkman       Kirkville           Kiron
##                 2               2               2
##            Klemme         Knierim       Knoxville
##                 2               2               2
##          La Motte   La Porte City          Lacona
##                 1               1               1
##            Ladora       Lake City      Lake Mills
##                 2               1               2
##     Lake Panorama       Lake Park       Lake View
##                 2               2               1
##          Lakeside          Lakota     Lambs Grove
##                 1               2               1
##            Lamoni          Lamont       Lanesboro
##                 2               2               1
##           Lansing       Larchwood        Larrabee
##                 2               1               1
##           Latimer          Laurel         Laurens
##                 1               1               2
##            Lawler          Lawton       Le Claire
##                 2               1               1
##          Le Grand         Le Mars          Le Roy
##                 1               1               2
##            Leando         Ledyard          Lehigh
```

```
##                2                 2                     1
##         Leighton            Leland                 Lenox
##                2                 2                     2
##             Leon            Lester                 Letts
##                2                 1                     2
##            Lewis      Libertyville            Lidderdale
##                2                 1                     1
##     Lime Springs           Lincoln                Linden
##                2                 1                     2
##        Lineville        Linn Grove                Lisbon
##                2                 2                     1
##          Liscomb       Little Cedar           Little Rock
##                1                 2                     2
##     Little Sioux         Livermore             Lockridge
##                2                 2                     2
##            Logan        Lohrville             Lone Rock
##                2                 2                     2
##        Lone Tree        Long Grove               Lorimor
##                1                 1                     2
##      Lost Nation          Loveland               Lovilia
##                2                 1                     2
##         Low Moor            Lowden              Lu Verne
##                1                 2                     2
##            Luana             Lucas                Luther
##                2                 1                     1
##        Luxemburg           Luzerne             Lynnville
##                1                 1                     1
##           Lytton         Macedonia             Macksburg
##                2                 2                     2
##           Madrid          Magnolia Maharishi Vedic City
##                1                 2                     1
##           Malcom           Mallard                 Maloy
##                1                 2                     2
##          Malvern        Manchester               Manilla
##                2                 1                     2
##            Manly           Manning                Manson
##                1                 1                     2
##         Mapleton         Maquoketa              Marathon
##                2                 2                     2
##      Marble Rock            Marcus               Marengo
##                2                 1                     1
##           Marion             Marne            Marquette
##                1                 2                     2
##     Marshalltown          Martelle           Martensdale
##                1                 1                     1
##      Martinsburg        Marysville            Mason City
##                2                 2                     1
##       Masonville           Massena               Matlock
##                2                 2                     1
##          Maurice           Maxwell               Maynard
##                1                 1                     1
##        Maysville       McCallsburg            McCausland
##                1                 2                     1
##       McClelland          McGregor              McIntire
```

```
##                  1                  2                  2
##     Mechanicsville         Mediapolis          Melbourne
##                  2                  2                  2
##     Melcher-Dallas            Melrose             Melvin
##                  1                  2                  1
##              Menlo            Meriden            Merrill
##                  2                  1                  1
##           Meservey              Meyer       Middle Amana
##                  1                  2                  1
##         Middletown              Miles            Milford
##                  1                  2                  2
##             Miller        Millersburg          Millerton
##                  2                  2                  2
##               Milo             Milton            Minburn
##                  1                  2                  1
##             Minden            Mineola              Mingo
##                  1                  1                  1
##    Missouri Valley           Mitchell      Mitchellville
##                  1                  1                  1
##             Modale               Mona           Mondamin
##                  2                  2                  2
##           Monmouth             Monona             Monroe
##                  2                  2                  1
##          Montezuma         Monticello            Montour
##                  2                  1                  1
##           Montrose           Moorhead           Moorland
##                  2                  2                  1
##            Moravia             Morley        Morning Sun
##                  2                  2                  2
##           Morrison            Moulton       Mount Auburn
##                  1                  2                  1
##          Mount Ayr      Mount Pleasant     Mount Sterling
##                  2                  2                  2
##        Mount Union       Mount Vernon            Moville
##                  2                  1                  1
##             Murray          Muscatine             Mystic
##                  2                  1                  2
##             Nashua             Nemaha              Neola
##                  2                  2                  1
##             Nevada          New Albin        New Hampton
##                  1                  2                  2
##       New Hartford          New Haven        New Liberty
##                  1                  2                  1
##         New London         New Market     New Providence
##                  2                  1                  2
##         New Sharon         New Vienna       New Virginia
##                  2                  1                  1
##             Newell            Newhall             Newton
##                  1                  1                  1
##            Nichols            Nodaway       Nora Springs
##                  2                  2                  1
##  North Buena Vista      North English      North Liberty
##                  1                  2                  1
##   North Washington          Northboro          Northwood
```

```
##                 2                 2                 1
##           Norwalk            Norway              Numa
##                 1                 1                 2
##           Oakland     Oakland Acres          Oakville
##                 2                 1                 2
##         Ocheyedan           Odebolt           Oelwein
##                 2                 2                 1
##             Ogden           Okoboji              Olds
##                 2                 2                 2
##              Olin             Ollie             Onawa
##                 2                 2                 2
##            Onslow       Orange City           Orchard
##                 1                 1                 2
##            Orient           Orleans             Osage
##                 1                 2                 1
##           Osceola         Oskaloosa           Ossian
##                 2                 2                 1
##         Osterdock              Otho               Oto
##                 1                 1                 2
##           Otranto           Ottosen           Ottumwa
##                 1                 2                 1
##             Owasa            Oxford   Oxford Junction
##                 1                 1                 2
##             Oyens  Pacific Junction          Packwood
##                 1                 1                 2
##            Palmer              Palo            Panama
##                 1                 1                 2
##            Panora     Panorama Park         Park View
##                 2                 1                 1
##       Parkersburg           Parnell             Paton
##                 1                 2                 2
##         Patterson          Paullina             Pella
##                 1                 1                 2
##            Peosta          Percival             Perry
##                 1                 2                 1
##            Persia          Peterson           Pierson
##                 1                 2                 2
##       Pilot Mound           Pioneer            Pisgah
##                 2                 2                 2
##        Plainfield             Plano     Pleasant Hill
##                 1                 2                 1
##    Pleasant Plain        Pleasanton     Pleasantville
##                 2                 2                 1
##            Plover          Plymouth        Pocahontas
##                 2                 1                 1
##         Polk City           Pomeroy           Popejoy
##                 1                 2                 1
##          Portland        Portsmouth        Postville
##                 1                 2                 1
##      Prairie City       Prairieburg          Prescott
##                 1                 1                 2
##           Preston          Primghar         Princeton
##                 2                 1                 1
##      Promise City          Protivin           Pulaski
```

```
##                2              2              2
##       Quasqueton         Quimby      Radcliffe
##                1              1              2
##             Rake        Ralston       Randalia
##                2              1              2
##          Randall       Randolph       Rathbun
##                2              2              2
##          Raymond        Readlyn        Reasnor
##                1              1              1
##          Red Oak        Redding      Redfield
##                2              2              2
##         Reinbeck      Rembrandt         Remsen
##                1              2              1
##          Renwick         Rhodes     Riceville
##                2              2              2
##         Richland Rickardsville       Ricketts
##                2              1              2
##         Ridgeway         Rinard       Ringsted
##                2              2              2
##           Rippey    River Sioux     Riverdale
##                2              2              1
##        Riverside       Riverton         Robins
##                1              2              1
##        Rochester     Rock Falls    Rock Rapids
##                2              1              1
##      Rock Valley       Rockford       Rockwell
##                1              1              1
##    Rockwell City         Rodman         Rodney
##                2              2              2
##           Roland          Rolfe           Rome
##                2              2              2
##        Rose Hill      Roseville         Rossie
##                2              2              2
##            Rowan         Rowley          Royal
##                1              1              2
##             Rudd       Runnells        Russell
##                1              1              2
##          Ruthven        Rutland           Ryan
##                2              2              2
##           Sabula       Sac City     Sageville
##                2              2              1
##            Salem          Salix        Sanborn
##                2              1              1
##       Sandyville    Saylorville     Scarville
##                1              1              2
##         Schaller      Schleswig       Scranton
##                2              2              1
##        Searsboro Sergeant Bluff         Sexton
##                1              1              2
##          Seymour      Shambaugh  Shannon City
##                2              1              2
##       Sharpsburg      Sheffield         Shelby
##                2              1              2
##         Sheldahl        Sheldon     Shell Rock
```

```
##                1                 1                 1 
##       Shellsburg        Shenandoah          Sherrill 
##                1                 2                 1 
##       Shueyville            Sibley            Sidney 
##                1                 1                 2 
##        Sigourney       Silver City      Sioux Center 
##                2                 1                 1 
##       Sioux City      Sioux Rapids            Slater 
##                1                 2                 1 
##            Sloan         Smithland           Soldier 
##                1                 2                 2 
##            Solon            Somers       South Amana 
##                1                 2                 1 
##    South English           Spencer       Spillville 
##                2                 2                 1 
##      Spirit Lake      Spragueville       Spring Hill 
##                2                 2                 1 
##      Springbrook       Springville        St. Ansgar 
##                2                 1                 1 
##      St. Anthony      St. Benedict       St. Charles 
##                2                 2                 1 
##      St. Donatus        St. Joseph         St. Lucas 
##                1                 2                 1 
##        St. Marys          St. Olaf          St. Paul 
##                1                 2                 2 
##       Stacyville          Stanhope           Stanley 
##                2                 2                 1 
##          Stanton          Stanwood      State Center 
##                2                 2                 2 
##   Steamboat Rock         Stockport          Stockton 
##                1                 2                 1 
##       Stone City        Storm Lake        Story City 
##                1                 1                 1 
##            Stout         Stratford  Strawberry Point 
##                1                 2                 2 
##          Struble            Stuart             Sully 
##                1                 2                 1 
##           Sumner   Sun Valley Lake          Superior 
##                1                 2                 2 
##       Sutherland         Swaledale              Swan 
##                1                 1                 1 
##        Swea City           Swisher             Tabor 
##                2                 1                 2 
##             Tama         Templeton           Tennant 
##                1                 1                 2 
##           Terril            Thayer          Thompson 
##                2                 2                 2 
##             Thor         Thornburg          Thornton 
##                2                 2                 1 
##          Thurman            Tiffin           Tingley 
##                2                 1                 2 
##           Tipton           Titonka       Toeterville 
##                2                 2                 2 
##           Toledo           Toronto             Traer 
```

```
##                    1                    2                    1
##              Treynor              Tripoli            Truesdale
##                    1                    1                    1
##                Truro                Turin           Twin Lakes
##                    2                    2                    2
##                Udell            Underwood                Union
##                    2                    1                    1
##           Unionville   University Heights      University Park
##                    2                    1                    2
##               Urbana            Urbandale                  Ute
##                    1                    1                    2
##                 Vail              Valeria            Van Horne
##                    1                    1                    1
##            Van Meter             Van Wert               Varina
##                    1                    2                    2
##              Ventura               Victor             Villisca
##                    1                    2                    2
##              Vincent               Vining               Vinton
##                    1                    2                    1
##                Volga               Wadena             Wahpeton
##                    2                    2                    2
##              Walcott              Walford               Walker
##                    1                    1                    2
##            Wall Lake          Wallingford               Walnut
##                    1                    2                    2
##              Wapello             Washburn           Washington
##                    2                    1                    2
##               Washta             Waterloo           Waterville
##                    2                    1                    2
##              Watkins              Waucoma               Waukee
##                    1                    2                    1
##               Waukon              Waverly              Wayland
##                    2                    1                    2
##                 Webb              Webster         Webster City
##                    2                    2                    2
##               Weldon              Wellman            Wellsburg
##                    2                    1                    1
##               Welton               Wesley           West Amana
##                    2                    2                    1
##            West Bend          West Branch      West Burlington
##                    2                    1                    1
##         West Chester      West Des Moines         West Liberty
##                    2                    1                    1
##         West Okoboji           West Point           West Union
##                    2                    1                    1
##            Westfield             Westgate               Weston
##                    2                    1                    1
##           Westphalia             Westside             Westwood
##                    2                    1                    2
##           What Cheer            Wheatland              Whiting
##                    2                    2                    2
##           Whittemore              Whitten               Willey
##                    2                    1                    1
##             Williams         Williamsburg           Williamson
```

```
##                  2                    2                    1
##             Wilton      Windsor Heights             Winfield
##                  1                    1                    2
##          Winterset             Winthrop                Wiota
##                  1                    1                    2
##              Woden             Woodbine             Woodburn
##                  2                    2                    2
##           Woodward            Woolstock          Worthington
##                  1                    2                    1
##            Wyoming                 Yale               Yetter
##                  2                    2                    1
##           Yorktown              Zearing              Zwingle
##                  1                    2                    1
##          Millville
##                  1
##
## Within cluster sum of squares by cluster:
## [1] 1933.607 2663.077
##  (between_SS / total_SS =  24.0 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
```

```r
aggregate(ia.dist.data.nested[,-7], by=list(cluster=km.res$cluster), mean)
```

```
##   cluster hosp.dist.mi fire.dist.mi dist.public.Elementary dist.public.Middle
## 1       1     7.966303     2.063298               9.189214           10.75561
## 2       2    10.589195     2.705587              22.221631           27.41758
##   dist.public.High postoff.dist.mi
## 1         19.40729        2.051503
## 2         38.16582        1.811753
```

```r
#Add the original data to the clustering
dd <- cbind(ia.dist.data.nested[,-7], cluster = km.res$cluster)
head(dd)
```

```
##          hosp.dist.mi fire.dist.mi dist.public.Elementary dist.public.Middle
## Ackley      10.752386   0.20964318               9.364122           9.364122
## Ackworth    17.557559   4.50931622               5.485392           3.532412
## Adair       14.901110   0.08292593              33.958287          33.958287
## Adel        11.767396   0.17697943               9.757398          16.300612
## Afton       10.228697   0.10101117               8.988911           8.988911
## Agency       5.589762   0.10893199               5.027100          17.518109
##          dist.public.High postoff.dist.mi cluster
## Ackley           36.67893      0.01265446       1
## Ackworth         14.15004      4.82660575       1
## Adair            40.28068      0.06610386       2
## Adel             16.10238      0.45052746       1
## Afton            45.89492      0.06887685       1
## Agency           46.24354      0.06961048       1
```

```r
# Cluster number for each of the observations
head(km.res$cluster, 10)
```

```
##      Ackley     Ackworth        Adair         Adel        Afton       Agency
##           1            1            2            1            1            1
##   Ainsworth        Akron Albert City        Albia
##           2            1            2            2
```

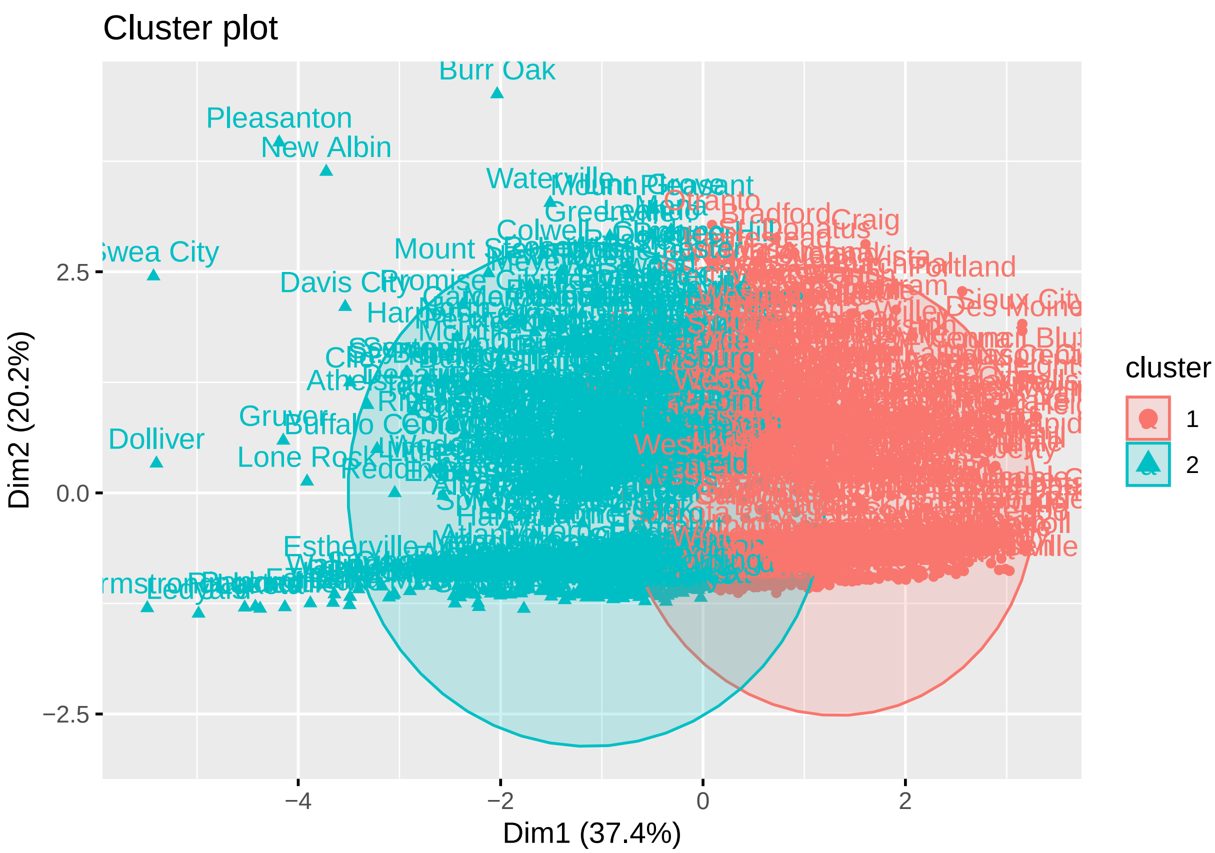
```r
# Cluster size
km.res$size
```

```
## [1] 484 525
```

```r
#Cluster means
km.res$centers
```

```
##   hosp.dist.mi fire.dist.mi dist.public.Elementary dist.public.Middle
## 1   -0.2809237   -0.1132019             -0.7223146         -0.7809283
## 2    0.2589849    0.1043614              0.6659052          0.7199415
##   dist.public.High postoff.dist.mi
## 1       -0.5786003      0.04602256
## 2        0.5334144     -0.04242841
```

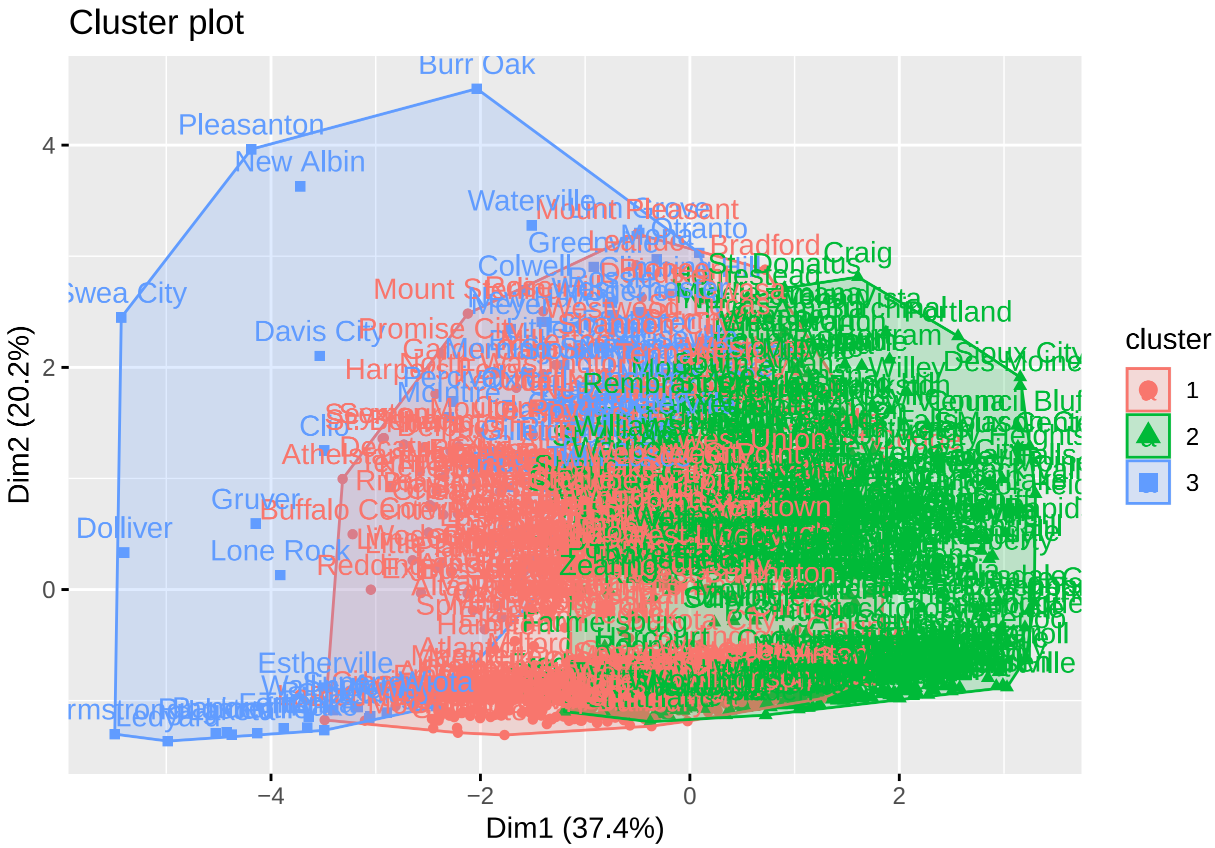
```r
#Visualizing the clusters
fviz_cluster(km.res, ia.dist.data.nested[,-7], ellipse.type = "norm")
```



Hierarchical clustering

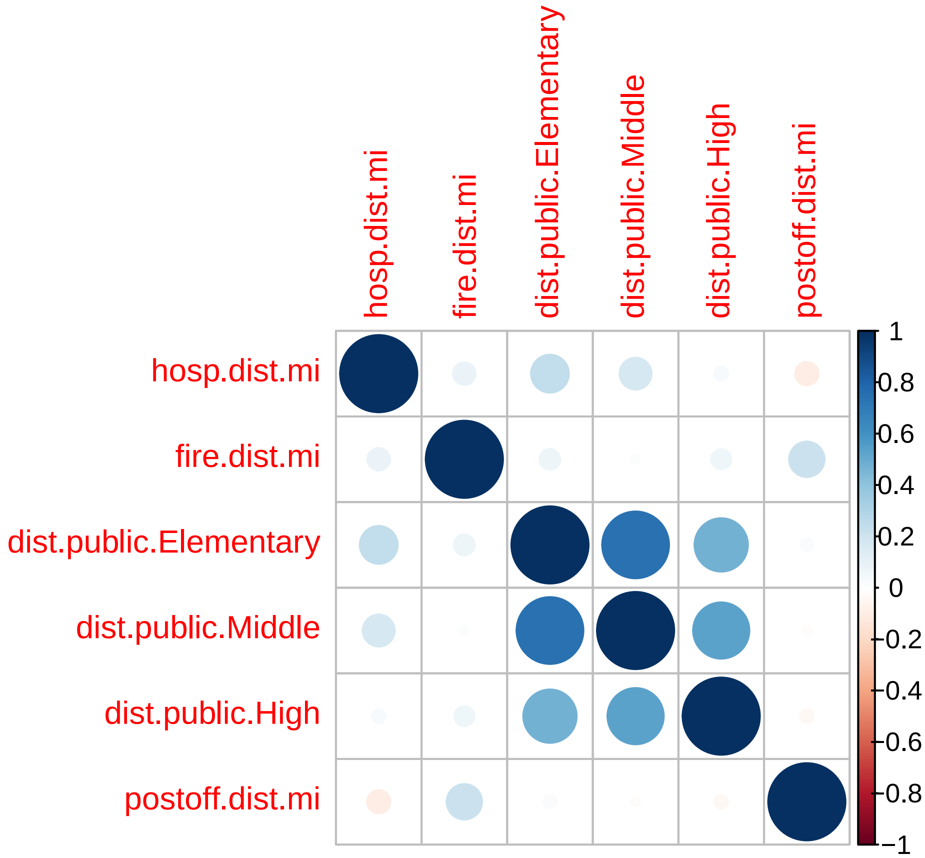
–To do: figure out to handle the NAs in the dataset. Should they be true NAs that are removed from the dataset or should there some sort of restructure in the data

```r
# Hierarchical clustering
# ++++++++++++++++++++++++
# Use hcut() which compute hclust and cut the tree
hc.cut <- hcut(scaled.ia.dist.data, k = 3, hc_method = "complete")
# Visualize dendrogram
#fviz_dend(hc.cut, show_labels = FALSE, rect = TRUE)
# Visualize cluster
fviz_cluster(hc.cut, ellipse.type = "convex")
```



Principal component analysis (PCA)

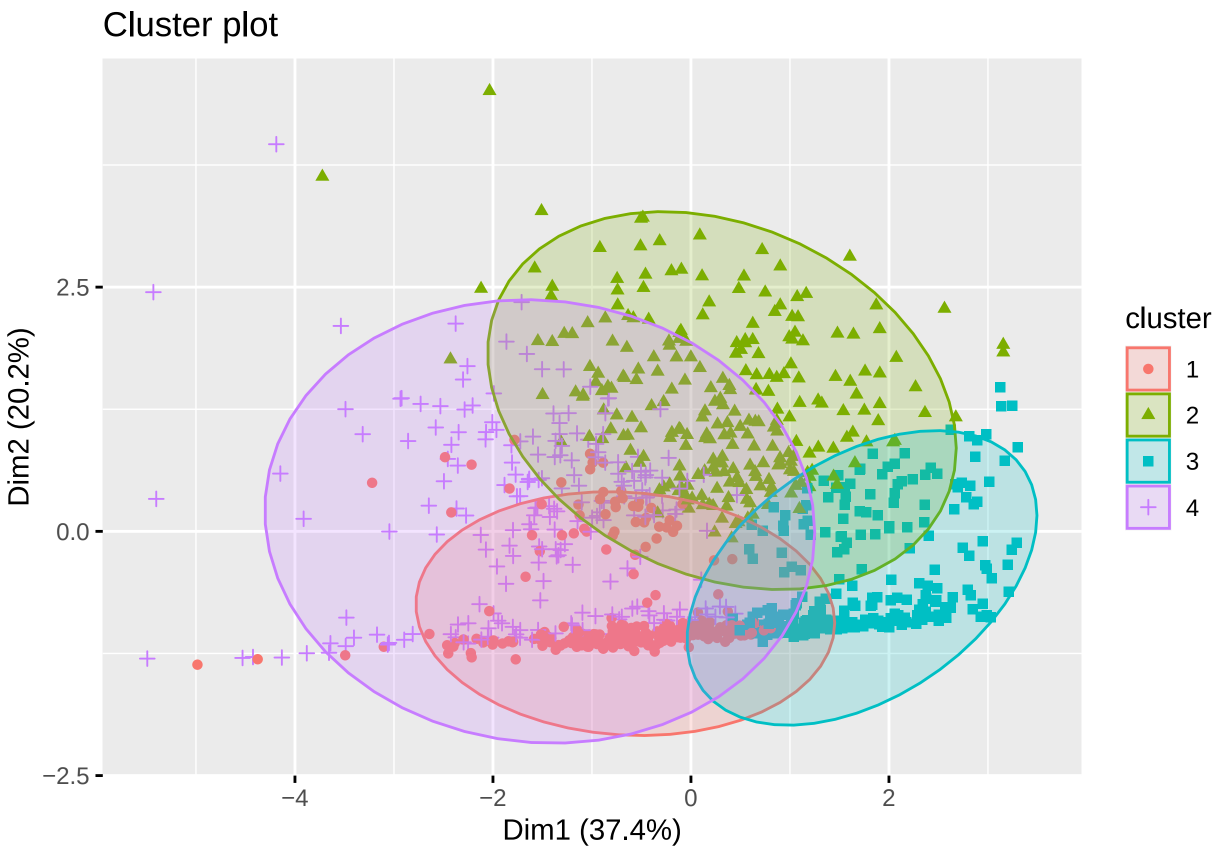
```r
M <- cor(scaled.ia.dist.data)
corrplot(M, method = "circle")
```




```
allpca <- prcomp(scaled.ia.dist.data)
summary(allpca)
```

```
## Importance of components:
##                           PC1    PC2    PC3    PC4     PC5     PC6
## Standard deviation     1.4987 1.1008 1.0094 0.8756 0.71719 0.49224
## Proportion of Variance 0.3743 0.2019 0.1698 0.1278 0.08573 0.04038
## Cumulative Proportion  0.3743 0.5763 0.7461 0.8739 0.95962 1.00000
```

```
# PAM clustering
# ++++++++++++++++++++
require(cluster)
pam.res <- pam(scaled.ia.dist.data, 4)
 # Visualize pam clustering
fviz_cluster(pam.res, geom = "point", ellipse.type = "norm")
```


Cluster plot
Dim2 (20.2%)
2.5
0.0
−2.5
−4
−2
0
2
Dim1 (37.4%)
cluster
1
2
3
4