

# Homework 2.5

2025-10-04

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I am first adding a model with per-capita variables to consider before starting homework 3. Homework 2's models are also included below.

Continuous target variable: Population, low access to store (% change), 2015 -19 [PCH\_LACCESS\_POP\_15\_19] [ACCESS]

Continuous predictor variables: nine variables with per capita alternatives

1. Grocery stores (% change), 2016-20 [PCH\_GROC\_16\_20] [STORES] Grocery stores/1,000 pop (% change), 2016-20 [PCH\_GROCPH\_16\_20] 2. Supercenters & club stores (% change), 2016-20 [PCH\_SUPER\_16\_20] Supercenters & club stores/1,000 pop (% change), 2016-20 [PCH\_SUPERCPH\_16\_20] 3. Convenience stores (% change), 2016-20 [PCH\_CONVS\_16\_20] Convenience stores/1,000 pop (% change), 2016-20 [PCH\_CONVSPH\_16\_20] 4. Specialized food stores (% change), 2016-20 [PCH\_SPECS\_16\_20] Specialized food stores/1,000 pop (% change), 2016-20 [PCH\_SPECSPTH\_16\_20] 5. SNAP-authorized stores (% change), 2017-23 [PCH\_SNAPS\_17\_23] SNAP-authorized stores/1,000 pop (% change), 2017-23 [PCH\_SNAPSPH\_17\_23] 6. WIC-authorized stores (% change), 2016-22 [PCH\_WICS\_16\_22] WIC-authorized stores/1,000 pop (% change), 2016-22 [PCH\_WICSPH\_16\_22] 7. Fast-food restaurants (% change), 2016-20 [PCH\_FFR\_16\_20] Fast-food restaurants/1,000 pop (% change), 2016-20 [PCH\_FFRPH\_16\_20] 8. Full-service restaurants (% change), 2016-20 [PCH\_FSR\_16\_20] Full-service restaurants/1,000 pop (% change), 2016-20 [PCH\_FSRPH\_16\_20] 9. Direct farm sales (% change), 2012 - 17 [PCH\_DIRSALES\_12\_17] [LOCAL] Direct farm sales per capita (% change), 2012 - 17 [PCH\_PC\_DIRSALES\_12\_17]

Binary variable to add later on: Persistent-poverty counties, 2017-21 [PERPOV17\_21] [SOCIOECONOMIC]

```
install.packages("ggfortify", repos="http://cran.us.r-project.org")
```

```
## Installing package into 'C:/Users/harip/AppData/Local/R/win-library/4.5'
## (as 'lib' is unspecified)
```

```
## package 'ggfortify' successfully unpacked and MD5 sums checked
##
```

```
## The downloaded binary packages are in
```

```
## C:\Users\harip\AppData\Local\Temp\Rtmpmkx5ik\downloaded_packages
```

```
install.packages("mvnrmtest", repos="http://cran.us.r-project.org")
```

```
## Installing package into 'C:/Users/harip/AppData/Local/R/win-library/4.5'
## (as 'lib' is unspecified)
```

```
## package 'mvnrmtest' successfully unpacked and MD5 sums checked
##
```

```
## The downloaded binary packages are in
```

```
## C:\Users\harip\AppData\Local\Temp\Rtmpmkx5ik\downloaded_packages
```

```
install.packages("datarium", repos="http://cran.us.r-project.org")
```

```
## Installing package into 'C:/Users/harip/AppData/Local/R/win-library/4.5'
## (as 'lib' is unspecified)
```

```

## package 'datarium' successfully unpacked and MD5 sums checked
##
## The downloaded binary packages are in
## C:\Users\harip\AppData\Local\Temp\Rtmpmkx5ik\downloaded_packages
install.packages("ggplot2", repos="http://cran.us.r-project.org")

## Installing package into 'C:/Users/harip/AppData/Local/R/win-library/4.5'
## (as 'lib' is unspecified)
## package 'ggplot2' successfully unpacked and MD5 sums checked
##
## The downloaded binary packages are in
## C:\Users\harip\AppData\Local\Temp\Rtmpmkx5ik\downloaded_packages
install.packages("car", repos="http://cran.us.r-project.org")

## Installing package into 'C:/Users/harip/AppData/Local/R/win-library/4.5'
## (as 'lib' is unspecified)
## package 'car' successfully unpacked and MD5 sums checked
##
## The downloaded binary packages are in
## C:\Users\harip\AppData\Local\Temp\Rtmpmkx5ik\downloaded_packages
library(MASS)
library(car)

## Loading required package: carData

library(datarium)
library(ggplot2)
library(broom)
library(ggfortify)
library(tidyverse)

## -- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
## v dplyr      1.1.4      v readr      2.1.5
## v forcats    1.0.0      v stringr   1.5.1
## v lubridate  1.9.4      v tibble    3.3.0
## v purrr      1.1.0      v tidyr     1.3.1

## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()     masks stats::lag()
## x dplyr::recode()  masks car::recode()
## x dplyr::select()  masks MASS::select()
## x purrr::some()    masks car::some()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors

library(mvnormtest)

library(readxl)
X2025_food_environment_atlas_data <- read_excel("2025-food-environment-atlas-data.xlsx",
  sheet = "ACCESS", skip = 1)
access <- read_excel("2025-food-environment-atlas-data.xlsx",
  sheet = "ACCESS", skip = 1)
access

```

```
## # A tibble: 3,144 x 68
##   FIPS State County LACCESS_POP15 LACCESS_POP19 PCH_LACCESS_POP_15_19
##   <chr> <chr> <chr>      <dbl>      <dbl>      <dbl>
## 1 01001 AL Autauga      18093.      18503.        2.27
## 2 01003 AL Baldwin      46400.      45789.       -1.32
## 3 01005 AL Barbour       6684.       5634.      -15.7
## 4 01007 AL Bibb         296.        365.       23.5
## 5 01009 AL Blount       5856.       3902.     -33.4
## 6 01011 AL Bullock       6100.       7480.       22.6
## 7 01013 AL Butler        2478.       2508.        1.23
## 8 01015 AL Calhoun      34221.      42575.       24.4
## 9 01017 AL Chambers       6794.       6745.      -0.720
## 10 01019 AL Cherokee       3519.       3506.     -0.358
## # i 3,134 more rows
## # i 62 more variables: PCT_LACCESS_POP15 <dbl>, PCT_LACCESS_POP19 <dbl>,
## # LACCESS_LOWI15 <dbl>, LACCESS_LOWI19 <dbl>, PCH_LACCESS_LOWI_15_19 <dbl>,
## # PCT_LACCESS_LOWI15 <dbl>, PCT_LACCESS_LOWI19 <dbl>, LACCESS_HHNV15 <dbl>,
## # LACCESS_HHNV19 <dbl>, PCH_LACCESS_HHNV_15_19 <dbl>,
## # PCT_LACCESS_HHNV15 <dbl>, PCT_LACCESS_HHNV19 <dbl>, LACCESS_SNAP15 <dbl>,
## # LACCESS_SNAP19 <dbl>, PCH_LACCESS_SNAP_15_19 <dbl>, ...
```

```
library(readxl)
X2025_food_environment_atlas_data <- read_excel("2025-food-environment-atlas-data.xlsx",
  sheet = "STORES", skip = 1)
stores <- read_excel("2025-food-environment-atlas-data.xlsx",
  sheet = "STORES", skip = 1)
stores
```

```
## # A tibble: 3,144 x 41
##   FIPS State County GROC16 GROC20 PCH_GROC_16_20 GROCPH16 GROCPH20
##   <chr> <chr> <chr>      <dbl> <dbl>      <dbl>      <dbl>      <dbl>
## 1 01001 AL Autauga         3      4        33.3    0.0542    0.0712
## 2 01003 AL Baldwin        29     29         0     0.140    0.126
## 3 01005 AL Barbour         4      5         25     0.155    0.203
## 4 01007 AL Bibb           5      4        -20     0.221    0.181
## 5 01009 AL Blount         5      4        -20     0.0870   0.0691
## 6 01011 AL Bullock         3 -9999     -9999    0.289  -9999
## 7 01013 AL Butler          3      3         0     0.150    0.154
## 8 01015 AL Calhoun        27     21     -22.2    0.235    0.185
## 9 01017 AL Chambers         7      5     -28.6    0.207    0.152
## 10 01019 AL Cherokee         5 -9999     -9999    0.194  -9999
## # i 3,134 more rows
## # i 33 more variables: PCH_GROCPH_16_20 <dbl>, SUPERC16 <dbl>, SUPERC20 <dbl>,
## # PCH_SUPERC_16_20 <dbl>, SUPERCPTH16 <dbl>, SUPERCPTH20 <dbl>,
## # PCH_SUPERCPTH_16_20 <dbl>, CONVS16 <dbl>, CONVS20 <dbl>,
## # PCH_CONVS_16_20 <dbl>, CONVSPTH16 <dbl>, CONVSPTH20 <dbl>,
## # PCH_CONVSPTH_16_20 <dbl>, SPECS16 <dbl>, SPECS20 <dbl>,
## # PCH_SPECS_16_20 <dbl>, SPECSPTH16 <dbl>, SPECSPTH20 <dbl>, ...
```

```
library(readxl)
X2025_food_environment_atlas_data <- read_excel("2025-food-environment-atlas-data.xlsx",
  sheet = "RESTAURANTS", skip = 1)
restaurants <- read_excel("2025-food-environment-atlas-data.xlsx",
  sheet = "RESTAURANTS", skip = 1)
restaurants
```

```
## # A tibble: 3,144 x 15
##   FIPS State County FFR16 FFR20 PCH_FFR_16_20 FFRPTH16 FFRPTH20
##   <chr> <chr> <chr>   <dbl> <dbl>         <dbl>      <dbl>      <dbl>
## 1 01001 AL Autauga      44    45          2.27      0.796      0.801
## 2 01003 AL Baldwin    156   172         10.3      0.751      0.750
## 3 01005 AL Barbour     23    24          4.35      0.891      0.976
## 4 01007 AL Bibb         7     7           0         0.310      0.316
## 5 01009 AL Blount     23    24          4.35      0.400      0.415
## 6 01011 AL Bullock      3     3           0         0.289      0.301
## 7 01013 AL Butler     18    21          16.7      0.898      1.08
## 8 01015 AL Calhoun    95   104          9.47      0.826      0.917
## 9 01017 AL Chambers    29    32          10.3      0.859      0.974
## 10 01019 AL Cherokee    15    18          20         0.582      0.685
## # i 3,134 more rows
## # i 7 more variables: PCH_FFRPTH_16_20 <dbl>, FSR16 <dbl>, FSR20 <dbl>,
## #   PCH_FSR_16_20 <dbl>, FSRPTH16 <dbl>, FSRPTH20 <dbl>, PCH_FSRPTH_16_20 <dbl>
```

```
library(readxl)
X2025_food_environment_atlas_data <- read_excel("2025-food-environment-atlas-data.xlsx",
  sheet = "LOCAL", skip = 1)
local <- read_excel("2025-food-environment-atlas-data.xlsx",
  sheet = "LOCAL", skip = 1)
local
```

```
## # A tibble: 3,161 x 98
##   FIPS State County DIRSALES_FARMS12 DIRSALES_FARMS17 PCH_DIRSALES_FARMS_1-1
##   <chr> <chr> <chr>         <dbl>         <dbl>         <dbl>
## 1 01001 AL Autauga          51          16         -68.6
## 2 01003 AL Baldwin        103          78         -24.3
## 3 01005 AL Barbour         13           9         -30.8
## 4 01007 AL Bibb            13          11         -15.4
## 5 01009 AL Blount         88          40         -54.5
## 6 01011 AL Bullock         12           2         -83.3
## 7 01013 AL Butler         31          20         -35.5
## 8 01015 AL Calhoun         50          52           4
## 9 01017 AL Chambers        22          13        -40.9
## 10 01019 AL Cherokee        14          14           0
## # i 3,151 more rows
## # i abbreviated name: 1: PCH_DIRSALES_FARMS_12_17
## # i 92 more variables: PCT_LOCLFARM12 <dbl>, PCT_LOCLFARM17 <dbl>,
## #   PCT_LOCLSALE12 <dbl>, PCT_LOCLSALE17 <dbl>, DIRSALES12 <dbl>,
## #   DIRSALES17 <dbl>, PCH_DIRSALES_12_17 <dbl>, PC_DIRSALES12 <dbl>,
## #   PC_DIRSALES17 <dbl>, PCH_PC_DIRSALES_12_17 <dbl>, FMRKT13 <dbl>,
## #   FMRKT18 <dbl>, PCH_FMRKT_13_18 <dbl>, FMRKTPTH13 <dbl>, ...
```

```
atlasog = merge(access, stores, by.x = "FIPS", by.y = "FIPS")
atlasog = merge(atlasog, restaurants, by.x = "FIPS", by.y = "FIPS")
atlasog = merge(atlasog, local, by.x = "FIPS", by.y = "FIPS")
```

```
## Warning in merge.data.frame(atlasog, local, by.x = "FIPS", by.y = "FIPS"):
## column names 'State.x', 'County.x', 'State.y', 'County.y' are duplicated in the
## result
```

Scatter plots and regression:

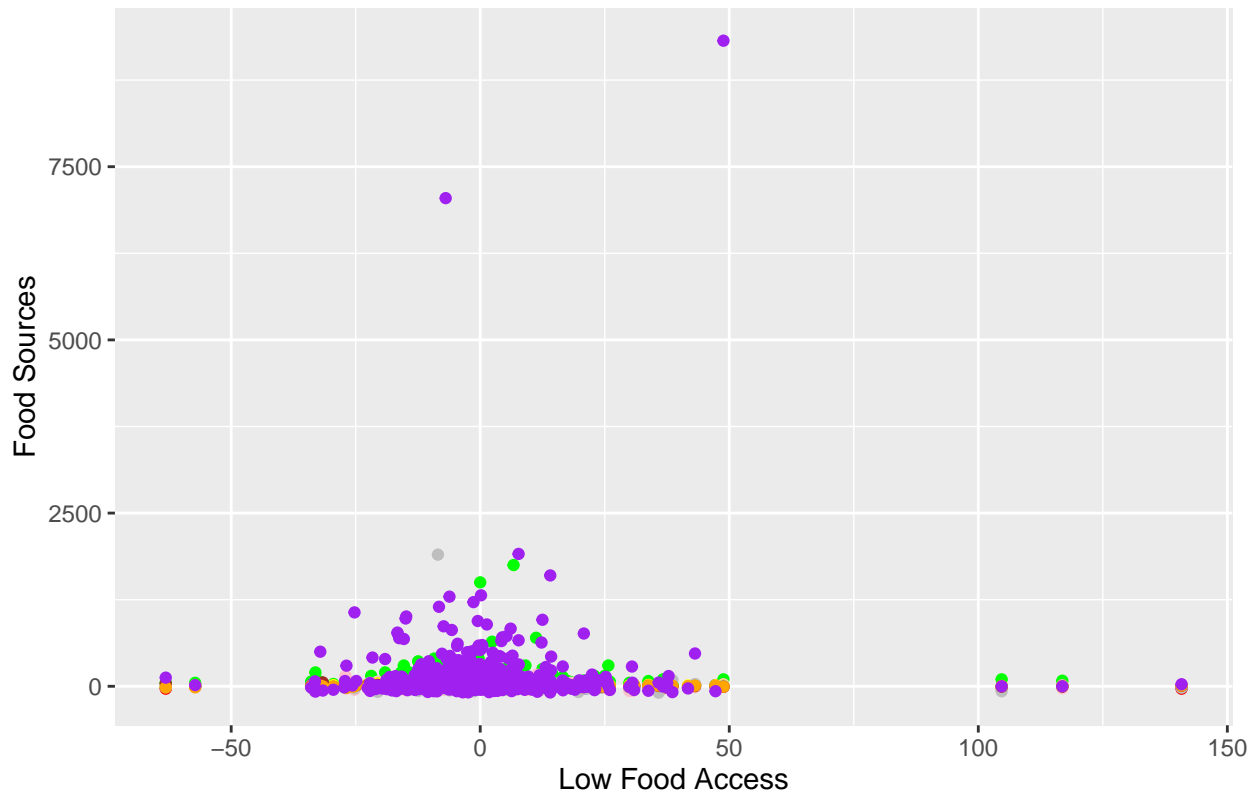
```

atlas = select(atlasog, PCH_LACCESS_POP_15_19, PCH_GROC_16_20, PCH_SUPER_16_20, PCH_CONVS_16_20, PCH_S
atlas = filter(atlas, PCH_LACCESS_POP_15_19 != -9999, PCH_GROC_16_20 != -9999, PCH_SUPER_16_20 != -999
atlas = filter(atlas, PCH_LACCESS_POP_15_19 != -8888, PCH_GROC_16_20 != -8888, PCH_SUPER_16_20 != -888

# adjust Jupyter plot size
options(repr.plot.width=4, repr.plot.height=4)
ggplot(atlas) +
  geom_point(aes(y = PCH_GROC_16_20, x = PCH_LACCESS_POP_15_19), color="red")+
  geom_point(aes(y = PCH_SUPER_16_20, x = PCH_LACCESS_POP_15_19), color="green")+
  geom_point(aes(y = PCH_CONVS_16_20, x = PCH_LACCESS_POP_15_19), color="blue")+
  geom_point(aes(y = PCH_SPECS_16_20, x = PCH_LACCESS_POP_15_19), color="pink")+
  geom_point(aes(y = PCH_SNAPS_17_23, x = PCH_LACCESS_POP_15_19), color="yellow")+
  geom_point(aes(y = PCH_WICS_16_22, x = PCH_LACCESS_POP_15_19), color="gray")+
  geom_point(aes(y = PCH_FFR_16_20, x = PCH_LACCESS_POP_15_19), color="brown")+
  geom_point(aes(y = PCH_FSR_16_20, x = PCH_LACCESS_POP_15_19), color="orange")+
  geom_point(aes(y = PCH_DIRSALES_12_17, x = PCH_LACCESS_POP_15_19), color="purple")+
  labs(title = "Low Food Access vs. Food Sources",
       x = "Low Food Access",
       y = "Food Sources")

```

Low Food Access vs. Food Sources



```

#There are two points that are clearly outliers at thousands of percents higher than the others, so I a
atlas2 = filter(atlas, PCH_LACCESS_POP_15_19 <5000, PCH_GROC_16_20 <5000, PCH_SUPER_16_20 <5000, PCH_C

#normalize predictors
colMeans(atlas2)

```

## PCH_LACCESS_POP_15_19	PCH_GROC_16_20	PCH_SUPER_16_20
## 0.2320956	-0.7079341	68.9385445
## PCH_CONVS_16_20	PCH_SPECS_16_20	PCH_SNAPS_17_23
## 2.6007777	-0.6579917	11.6952787
## PCH_WICS_16_22	PCH_FFR_16_20	PCH_FSR_16_20
## -5.6402305	6.6306411	1.8834212
## PCH_DIRSALES_12_17		
## 106.6679969		

```
mutate(atlas2, PCH_GROC_16_20 = PCH_GROC_16_20 + 0.7079341) |>
select(PCH_GROC_16_20)
```

##	PCH_GROC_16_20
## 1	0.70793410
## 2	0.70793410
## 3	6.31541074
## 4	0.70793410
## 5	-1.46597894
## 6	5.25338865
## 7	7.85079124
## 8	-8.11559531
## 9	-27.06984368
## 10	31.47716487
## 11	20.70793410
## 12	-18.04206590
## 13	-9.29206590
## 14	0.49380134
## 15	12.47263998
## 16	-6.43492304
## 17	3.16695049
## 18	-21.87271106
## 19	-6.18861762
## 20	-8.96948525
## 21	33.14036653
## 22	-14.67668128
## 23	-18.04206590
## 24	9.47986392
## 25	17.37460077
## 26	8.40024179
## 27	-1.17378633
## 28	-10.40317701
## 29	12.70793410
## 30	-0.84848613
## 31	-15.95873257
## 32	-27.86349447
## 33	2.84697153
## 34	39.99364839
## 35	-2.92842954
## 36	7.85079124
## 37	-18.40971296
## 38	8.74364839
## 39	3.32890184
## 40	2.27043410
## 41	1.85406591
## 42	7.61702501

## 43	0.38430950
## 44	0.36251096
## 45	15.70793410
## 46	-12.33554416
## 47	0.15848355
## 48	4.04126743
## 49	-3.31505441
## 50	-7.74277013
## 51	17.85079124
## 52	2.09682299
## 53	1.42221981
## 54	-4.63557735
## 55	5.46983886
## 56	-5.17441884
## 57	5.49835326
## 58	-6.11024772
## 59	0.70793410
## 60	-0.34469748
## 61	-0.93141016
## 62	16.70793410
## 63	2.34727836
## 64	-19.29206590
## 65	-2.57075442
## 66	6.26348966
## 67	-18.33968495
## 68	-28.70383061
## 69	-8.66706590
## 70	2.15024179
## 71	-8.59439148
## 72	-10.65570226
## 73	-6.05535092
## 74	5.83613923
## 75	-32.62539923
## 76	-6.43492304
## 77	6.89350111
## 78	-12.05802335
## 79	-5.20604439
## 80	-1.61764730
## 81	4.15620996
## 82	5.70793410
## 83	-0.37023302
## 84	5.46983886
## 85	6.26348966
## 86	10.23174362
## 87	7.26531115
## 88	3.58149732
## 89	2.88184714
## 90	23.43520683
## 91	3.20793410
## 92	11.81904521
## 93	9.04126743
## 94	19.22645262
## 95	-8.22063733
## 96	3.64911057

## 97	-0.22374292
## 98	0.70793410
## 99	13.20793410
## 100	7.52611592
## 101	6.16247955
## 102	6.38975228
## 103	10.23174362
## 104	2.21547179
## 105	8.75391111
## 106	7.52611592
## 107	14.99364839
## 108	-11.65161646
## 109	16.33293410
## 110	13.94322822
## 111	-22.36898898
## 112	14.16947256
## 113	6.59028704
## 114	5.05576019
## 115	4.62950273
## 116	5.33756373
## 117	10.23174362
## 118	-0.60785537
## 119	0.70793410
## 120	-28.70383061
## 121	-2.06984368
## 122	-9.49614753
## 123	11.23424989
## 124	10.36310651
## 125	6.42221981
## 126	-6.69947331
## 127	14.99364839
## 128	-16.36523663
## 129	0.70793410
## 130	-21.51428812
## 131	0.70793410
## 132	-1.61764730
## 133	-9.56233617
## 134	2.83559367
## 135	9.21857240
## 136	-8.38297499
## 137	20.70793410
## 138	-7.29206590
## 139	-4.29206590
## 140	0.70793410
## 141	-1.92364485
## 142	-12.05657102
## 143	-4.81353829
## 144	-1.99476860
## 145	-4.29206590
## 146	22.93015632
## 147	8.40024179
## 148	-12.92842954
## 149	-1.46597894
## 150	4.27936267

## 151 -27.86349447  
## 152 -9.70873257  
## 153 -27.59395269  
## 154 4.55408795  
## 155 -8.18095479  
## 156 13.61115991  
## 157 0.70793410  
## 158 -0.39096700  
## 159 -4.46447969  
## 160 -13.57778019  
## 161 -7.62539923  
## 162 -42.14920876  
## 163 -6.98437359  
## 164 8.81604221  
## 165 -29.29206590  
## 166 -12.80557941  
## 167 -7.62539923  
## 168 0.70793410  
## 169 -26.56479317  
## 170 -3.13821975  
## 171 -29.29206590  
## 172 0.70793410  
## 173 0.70793410  
## 174 0.70793410  
## 175 15.34208044  
## 176 -7.29206590  
## 177 -14.29206590  
## 178 13.20793410  
## 179 0.70793410  
## 180 40.70793410  
## 181 -9.63689349  
## 182 20.96109866  
## 183 -8.38297499  
## 184 -7.29206590  
## 185 17.37460077  
## 186 -10.40317701  
## 187 5.97109199  
## 188 0.70793410  
## 189 5.52721121  
## 190 -15.95873257  
## 191 6.11333951  
## 192 -13.57778019  
## 193 8.40024179  
## 194 20.70793410  
## 195 -22.82147766  
## 196 -0.83052744  
## 197 7.85079124  
## 198 -3.16303364  
## 199 -8.38297499  
## 200 -9.81838169  
## 201 14.34429774  
## 202 -16.93912472  
## 203 0.70793410  
## 204 7.15954700

## 205	-0.13240203
## 206	2.59472655
## 207	-7.62539923
## 208	-11.79206590
## 209	-2.94170094
## 210	10.23174362
## 211	7.85079124
## 212	-4.55522379
## 213	-4.29206590
## 214	0.70793410
## 215	2.04126743
## 216	-6.69947331
## 217	7.37460077
## 218	-6.26881009
## 219	9.21857240
## 220	8.87119941
## 221	13.20793410
## 222	-11.79206590
## 223	43.56507696
## 224	9.27936267
## 225	30.70793410
## 226	8.02500727
## 227	1.70295898
## 228	6.95793410
## 229	-11.05677178
## 230	-14.67668128
## 231	19.93870333
## 232	10.70793410
## 233	-17.65272164
## 234	-12.44996064
## 235	-25.00635161
## 236	5.05576019
## 237	-5.77855239
## 238	-6.02283513
## 239	6.59028704
## 240	2.18941558
## 241	-5.12539923
## 242	-6.26881009
## 243	-2.99576960
## 244	-6.16229491
## 245	36.00205175
## 246	-17.47388408
## 247	0.70793410
## 248	-39.29206590
## 249	0.70793410
## 250	-14.10688071
## 251	5.46983886
## 252	0.70793410
## 253	-9.29206590
## 254	0.70793410
## 255	0.70793410
## 256	27.98066137
## 257	1.77176389
## 258	-4.84762146

##	259	-13.69206590
##	260	-20.72063733
##	261	-22.01933863
##	262	0.27503367
##	263	13.61115991
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select(PCH_SUPER_16_20)
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## 6      -68.9385445
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## 8      -52.2718778
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select(PCH_CONVS_16_20)
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## 6     -12.060237159
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## 9      -7.863935595
## 10     12.493561923
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## 489	13.113508014
## 490	-14.365483582
## 491	29.174923235
## 492	17.440544614
## 493	-3.916567174
## 494	28.827793729
## 495	5.595943611
## 496	5.873798571
## 497	-28.407229313
## 498	-2.600777700
## 499	-0.899207019
## 500	7.603303933
## 501	-2.600777700
## 502	-5.321866135
## 503	10.660871046
## 504	-4.684111033
## 505	3.699852363
## 506	11.092168358
## 507	-0.782595882
## 508	25.247323566

## 509	-4.260528737
## 510	30.732555633
## 511	6.542079443
## 512	2.483968063
## 513	8.904451950
## 514	-1.108240387
## 515	1.089259200
## 516	0.625028752
## 517	-3.866600485
## 518	-4.452629552
## 519	-5.792267062
## 520	5.926354083
## 521	14.065888967
## 522	-2.600777700
## 523	20.148037466
## 524	-6.109549630
## 525	30.732555633
## 526	-4.240121962
## 527	-9.122516830
## 528	10.732555633
## 529	12.399222300
## 530	-13.000777700
## 531	8.570006403
## 532	-7.664068839
## 533	-5.990608208
## 534	2.522561958
## 535	-19.549930242
## 536	-12.012542406
## 537	-4.324915631
## 538	22.954777856
## 539	-6.172206271
## 540	-1.130189465
## 541	-2.600777700
## 542	-7.025556461
## 543	7.399222300
## 544	-4.873504973
## 545	-1.525508883
## 546	-20.378555478
## 547	-4.487570153
## 548	-10.934111033
## 549	14.966789868
## 550	3.136927218
## 551	18.827793729
## 552	-9.743634843
## 553	3.113508014
## 554	4.716295471
## 555	-16.554266072
## 556	13.528254558
## 557	16.003873463
## 558	6.973690385
## 559	-5.826584152
## 560	2.756365157
## 561	-0.725777700
## 562	-1.085626185

```
## 563      11.684936586
## 564      -6.304481404
## 565      -8.983756423
## 566     -11.075353971
## 567     164.065888967
## 568      -7.901131057
## 569      -3.952129051
## 570      -0.426864657
## 571      -8.483130641
## 572     -10.895708576
## 573       1.372732234
## 574     11.288111189
## 575    -14.365483582
## 576      -7.502738484
## 577       6.094874474
## 578      -7.306660053
## 579     11.684936586
## 580       1.747048387
## 581       1.944676845
## 582       0.887594393
## 583      -7.926221487
## 584      -0.517444367
## 585    -16.446931546
## 586      -5.232356647
## 587       4.946392111
## 588       3.053984205
## 589    -17.415592515
## 590       4.806629707
## 591      -5.010416254
## 592       3.748428649
## 593      -5.039802090
## 594      -4.728437274
## 595       5.091529992
## 596      -9.873504973
## 597       1.600902972
## 598    -16.886491986
## 599     -12.278197055
## 600    -15.504003506
```

```
mutate(atlas2, PCH_SPECS_16_20 = PCH_SPECS_16_20 + 0.6579917) |>
select(PCH_SPECS_16_20)
```

```
##      PCH_SPECS_16_20
## 1      8.0653991
## 2     -32.6753416
## 3     -16.8420083
## 4     -24.3420083
## 5      -8.0376605
## 6     -24.3420083
## 7     -15.3420083
## 8     -22.4189314
## 9      25.6579917
## 10     -10.4531194
## 11     125.6579917
## 12     -32.6753416
```

## 13	25.6579917
## 14	0.6579917
## 15	0.6579917
## 16	33.9913250
## 17	-13.8347619
## 18	0.6579917
## 19	39.1195302
## 20	0.6579917
## 21	-21.5642305
## 22	25.6579917
## 23	14.9437060
## 24	-34.6361259
## 25	-10.4531194
## 26	-7.0343160
## 27	-9.8683241
## 28	46.8118379
## 29	-15.1314820
## 30	-15.7803645
## 31	8.3502994
## 32	-13.6277226
## 33	13.1579917
## 34	40.6579917
## 35	-0.3585267
## 36	7.3246584
## 37	17.3246584
## 38	-1.6147356
## 39	9.0300847
## 40	-8.4329174
## 41	8.1579917
## 42	6.6103727
## 43	5.9211496
## 44	-7.2715237
## 45	-10.8804698
## 46	3.5151346
## 47	2.5447842
## 48	6.0633971
## 49	-12.2207962
## 50	-29.3420083
## 51	-30.1112391
## 52	-8.7170083
## 53	-5.1391097
## 54	-12.6753416
## 55	-49.3420083
## 56	3.5991682
## 57	2.2973360
## 58	-27.1197861
## 59	-3.1881621
## 60	-16.0086750
## 61	-7.3420083
## 62	5.6579917
## 63	-3.9931711
## 64	-49.3420083
## 65	-25.8125965
## 66	12.0865631

## 67	-27.1197861
## 68	-27.9134369
## 69	-24.3420083
## 70	-12.1079657
## 71	-9.7897695
## 72	-14.7266237
## 73	-26.7613631
## 74	0.6579917
## 75	-49.3420083
## 76	-13.6277226
## 77	-6.6590815
## 78	4.1062676
## 79	-26.7613631
## 80	-7.6753416
## 81	-4.8975639
## 82	-22.1991512
## 83	-6.5788504
## 84	-10.4531194
## 85	0.6579917
## 86	-19.3420083
## 87	22.8802139
## 88	-8.9164764
## 89	-28.5086750
## 90	33.9913250
## 91	-8.1139381
## 92	-7.0343160
## 93	-10.0562940
## 94	-3.8874628
## 95	-16.0086750
## 96	40.6579917
## 97	-9.4166352
## 98	20.6579917
## 99	8.9913250
## 100	-16.8858679
## 101	-6.4848654
## 102	-8.1257921
## 103	-2.7902842
## 104	4.9590670
## 105	-7.0343160
## 106	-13.6277226
## 107	50.6579917
## 108	3.0970161
## 109	-33.9573929
## 110	14.4510951
## 111	-43.7864527
## 112	15.8095069
## 113	-13.6277226
## 114	33.9913250
## 115	0.6579917
## 116	-12.2452341
## 117	20.6579917
## 118	-15.7056447
## 119	-19.3420083
## 120	50.6579917

## 121	-21.5642305
## 122	0.6579917
## 123	13.1579917
## 124	-1.2650852
## 125	-17.5238265
## 126	20.6579917
## 127	-14.7266237
## 128	-56.4848654
## 129	50.6579917
## 130	-26.0086750
## 131	33.9913250
## 132	-9.3420083
## 133	-4.6517428
## 134	-7.6753416
## 135	14.9437060
## 136	20.6579917
## 137	-13.6277226
## 138	0.6579917
## 139	72.0865631
## 140	60.6579917
## 141	-13.6277226
## 142	-6.1978003
## 143	-17.1991512
## 144	-7.0343160
## 145	-19.3420083
## 146	0.6579917
## 147	2.8319047
## 148	-16.0086750
## 149	5.9211496
## 150	-16.0086750
## 151	0.6579917
## 152	18.3050505
## 153	22.8802139
## 154	-11.8420083
## 155	6.5403446
## 156	23.7349148
## 157	17.3246584
## 158	26.5839176
## 159	0.6579917
## 160	0.6579917
## 161	-49.3420083
## 162	40.6579917
## 163	-32.6753416
## 164	-19.3420083
## 165	0.6579917
## 166	25.6579917
## 167	125.6579917
## 168	-32.6753416
## 169	17.3246584
## 170	14.4510951
## 171	14.9437060
## 172	-20.4958545
## 173	0.6579917
## 174	17.3246584

## 175	-16.0086750
## 176	-9.3420083
## 177	-32.6753416
## 178	-35.7056447
## 179	-13.6277226
## 180	-36.8420083
## 181	-10.4531194
## 182	-6.7494157
## 183	33.9913250
## 184	-10.4531194
## 185	50.6579917
## 186	-36.8420083
## 187	-36.8420083
## 188	-19.3420083
## 189	18.8398099
## 190	25.6579917
## 191	7.1096046
## 192	-5.5920083
## 193	-10.4531194
## 194	17.3246584
## 195	25.6579917
## 196	0.6579917
## 197	-49.3420083
## 198	0.6579917
## 199	0.6579917
## 200	20.6579917
## 201	0.6579917
## 202	17.3246584
## 203	75.6579917
## 204	33.9913250
## 205	-34.1246170
## 206	38.1579917
## 207	0.6579917
## 208	-27.9134369
## 209	-39.3420083
## 210	-36.8420083
## 211	17.3246584
## 212	45.1024361
## 213	-17.5238265
## 214	-8.4329174
## 215	-3.9931711
## 216	67.3246584
## 217	33.9913250
## 218	7.1096046
## 219	-7.4501164
## 220	-16.5295083
## 221	-21.5642305
## 222	33.9913250
## 223	0.6579917
## 224	0.6579917
## 225	-24.3420083
## 226	-4.6051662
## 227	3.7829917
## 228	-5.2243612

## 229	17.3246584
## 230	-17.5238265
## 231	-7.6753416
## 232	25.6579917
## 233	-13.3770960
## 234	-20.9106358
## 235	10.6579917
## 236	-8.8658178
## 237	3.5991682
## 238	0.6579917
## 239	-7.6753416
## 240	-12.3854866
## 241	-9.8683241
## 242	-3.1881621
## 243	1.9079917
## 244	7.4761735
## 245	-13.6277226
## 246	10.6579917
## 247	-49.3420083
## 248	0.6579917
## 249	-26.6147356
## 250	0.6579917
## 251	-41.4472715
## 252	40.6579917
## 253	50.6579917
## 254	0.6579917
## 255	-26.6147356
## 256	-16.7333126
## 257	4.7120458
## 258	-24.3420083
## 259	-0.4172771
## 260	33.9913250
## 261	-4.6051662
## 262	-17.8035468
## 263	-11.3420083
## 264	-20.1753416
## 265	0.6579917
## 266	-49.3420083
## 267	20.6579917
## 268	3.8837982
## 269	2.2123958
## 270	-36.1841136
## 271	0.6579917
## 272	-19.3420083
## 273	80.6579917
## 274	-4.8975639
## 275	-5.9457819
## 276	-24.3420083
## 277	-42.1991512
## 278	-17.9466595
## 279	-15.1314820
## 280	-49.3420083
## 281	0.6579917
## 282	-22.0692810

## 283	-18.3896273
## 284	-29.3420083
## 285	0.6579917
## 286	0.6579917
## 287	-39.3420083
## 288	-32.6753416
## 289	-49.3420083
## 290	-19.3420083
## 291	-34.6361259
## 292	-11.5371303
## 293	-19.3420083
## 294	-32.6753416
## 295	-8.4329174
## 296	-32.6753416
## 297	0.6579917
## 298	-11.8420083
## 299	33.9913250
## 300	25.6579917
## 301	-20.7705797
## 302	0.6579917
## 303	-32.6753416
## 304	-4.3420083
## 305	-26.6147356
## 306	-24.3420083
## 307	-10.4531194
## 308	-39.3420083
## 309	150.6579917
## 310	0.6579917
## 311	-11.3420083
## 312	-27.9134369
## 313	-11.1067142
## 314	13.1579917
## 315	0.6579917
## 316	4.2724495
## 317	2.7856513
## 318	4.8246584
## 319	-34.6361259
## 320	-25.0562940
## 321	39.1195302
## 322	16.0426071
## 323	-8.8156925
## 324	11.5013652
## 325	-16.3231404
## 326	-13.4596554
## 327	2.9835731
## 328	-32.6753416
## 329	6.7804407
## 330	20.6579917
## 331	57.8008488
## 332	-16.0086750
## 333	-54.8975639
## 334	18.3050505
## 335	4.1062676
## 336	-2.8975639

## 337	11.7691028
## 338	-10.4531194
## 339	0.6579917
## 340	-20.7705797
## 341	-0.4914336
## 342	50.6579917
## 343	0.6579917
## 344	-7.6622595
## 345	-32.6753416
## 346	-15.1314820
## 347	-11.1067142
## 348	-12.6753416
## 349	-15.4710406
## 350	-9.3420083
## 351	-13.6277226
## 352	-16.0086750
## 353	0.6579917
## 354	-13.6277226
## 355	-9.7586750
## 356	33.9913250
## 357	-40.2510992
## 358	0.6579917
## 359	-3.1076987
## 360	-49.3420083
## 361	-8.8658178
## 362	-32.6753416
## 363	-6.7744407
## 364	-11.8420083
## 365	-22.4189314
## 366	-30.5920083
## 367	-32.6753416
## 368	33.9913250
## 369	6.2135473
## 370	0.6579917
## 371	-24.3420083
## 372	-36.8420083
## 373	-32.6753416
## 374	-17.5238265
## 375	4.5041455
## 376	-26.6147356
## 377	0.6579917
## 378	-16.0086750
## 379	14.4510951
## 380	-27.9134369
## 381	60.6579917
## 382	22.8802139
## 383	-13.6277226
## 384	0.6579917
## 385	0.6579917
## 386	100.6579917
## 387	5.4198965
## 388	-36.8420083
## 389	0.6579917
## 390	17.3246584

## 391	-6.2985300
## 392	8.3502994
## 393	67.3246584
## 394	0.6579917
## 395	167.3246584
## 396	-11.8420083
## 397	-19.3420083
## 398	-6.4848654
## 399	50.6579917
## 400	-19.3420083
## 401	-16.0086750
## 402	16.0426071
## 403	60.6579917
## 404	67.3246584
## 405	3.8837982
## 406	0.6579917
## 407	0.6579917
## 408	0.6579917
## 409	-8.0376605
## 410	4.2294203
## 411	-61.8420083
## 412	27.9307190
## 413	40.6579917
## 414	0.6579917
## 415	-43.7864527
## 416	-14.2356253
## 417	3.7829917
## 418	67.3246584
## 419	33.9913250
## 420	-26.6147356
## 421	33.9913250
## 422	0.6579917
## 423	-3.8874628
## 424	-42.1991512
## 425	-24.3420083
## 426	-19.3420083
## 427	0.6579917
## 428	-14.9670083
## 429	50.6579917
## 430	17.3246584
## 431	-30.7705797
## 432	-10.8003416
## 433	50.6579917
## 434	7.8008488
## 435	0.6579917
## 436	-12.0002361
## 437	40.6579917
## 438	-9.7586750
## 439	13.1579917
## 440	-18.0086750
## 441	0.6579917
## 442	-32.6753416
## 443	-12.8555218
## 444	40.6579917

## 445	31.9079917
## 446	-30.9209557
## 447	-15.0562940
## 448	50.6579917
## 449	13.1579917
## 450	-21.5642305
## 451	0.6579917
## 452	15.6579917
## 453	11.7691028
## 454	-16.0086750
## 455	-26.3690353
## 456	-16.0086750
## 457	-9.3420083
## 458	0.6579917
## 459	-16.0086750
## 460	4.2724495
## 461	-13.6277226
## 462	-4.2870632
## 463	10.6579917
## 464	-7.6753416
## 465	-9.6868359
## 466	0.6579917
## 467	-16.0086750
## 468	-20.7705797
## 469	33.9913250
## 470	-1.3420083
## 471	-6.0086750
## 472	-11.3420083
## 473	24.4675155
## 474	0.6579917
## 475	50.6579917
## 476	0.6579917
## 477	10.6579917
## 478	-13.6277226
## 479	-27.9134369
## 480	-27.9134369
## 481	11.7691028
## 482	-39.3420083
## 483	0.6579917
## 484	-13.2954967
## 485	-4.6051662
## 486	0.6579917
## 487	0.6579917
## 488	25.6579917
## 489	-27.9134369
## 490	-39.3420083
## 491	33.9913250
## 492	-14.4363479
## 493	-16.0086750
## 494	75.6579917
## 495	19.4079917
## 496	-49.3420083
## 497	50.6579917
## 498	0.6579917

## 499	-19.0950947
## 500	25.6579917
## 501	-11.8420083
## 502	24.1874035
## 503	19.7056107
## 504	-59.3420083
## 505	-11.2231964
## 506	-17.1991512
## 507	-19.3420083
## 508	300.6579917
## 509	-5.5920083
## 510	5.2034462
## 511	7.3246584
## 512	-24.3420083
## 513	-5.2943893
## 514	50.6579917
## 515	15.7523313
## 516	-20.3946399
## 517	0.6579917
## 518	33.9913250
## 519	-37.8035468
## 520	-16.0086750
## 521	0.6579917
## 522	133.9913250
## 523	-3.3420083
## 524	0.6579917
## 525	-24.3420083
## 526	-32.6753416
## 527	67.3246584
## 528	-16.0086750
## 529	33.9913250
## 530	-37.8035468
## 531	-3.9397094
## 532	40.6579917
## 533	-24.3420083
## 534	-27.9134369
## 535	25.6579917
## 536	-32.6753416
## 537	13.1579917
## 538	20.6579917
## 539	20.6579917
## 540	16.4474654
## 541	12.1334015
## 542	42.5934756
## 543	42.3246584
## 544	-14.7266237
## 545	-16.9890671
## 546	0.6579917
## 547	60.6579917
## 548	4.6579917
## 549	25.6579917
## 550	5.6579917
## 551	-19.3420083
## 552	50.6579917

```
## 553      13.1579917
## 554     150.6579917
## 555       0.6579917
## 556     -16.0086750
## 557    -49.3420083
## 558    -35.7056447
## 559       0.6579917
## 560       0.6579917
## 561    -15.4710406
## 562    -20.7705797
## 563     73.3852644
## 564       0.6579917
## 565     -5.2243612
## 566       0.6579917
## 567   -39.3420083
## 568      1.6889195
## 569      5.4198965
## 570     -1.0369236
## 571       0.6579917
## 572     -4.6991512
## 573     -7.9134369
## 574     -9.6868359
## 575    -13.6277226
## 576    -13.6277226
## 577      5.9211496
## 578   -19.3420083
## 579     33.9913250
## 580     50.6579917
## 581     33.9913250
## 582    -32.6753416
## 583     -7.6753416
## 584    167.3246584
## 585    -66.0086750
## 586   -44.7965538
## 587     -7.0343160
## 588   -14.5962456
## 589      6.9079917
## 590   -14.7266237
## 591       0.6579917
## 592     18.8398099
## 593   -16.0086750
## 594       0.6579917
## 595       0.6579917
## 596     22.8802139
## 597   -13.6277226
## 598   -36.1841136
## 599   -24.3420083
## 600     75.6579917
```

```
mutate(atlas2, PCH_SNAPS_17_23 = PCH_SNAPS_17_23 - 11.6952787) |>
select(PCH_SNAPS_17_23)
```

```
##      PCH_SNAPS_17_23
## 1      1.811100428
## 2    -12.183083590
```

## 3	-16.685766276
## 4	-13.933416660
## 5	1.160959665
## 6	3.536508982
## 7	-14.018458899
## 8	-2.136168059
## 9	-15.085109289
## 10	8.545201723
## 11	-6.389156397
## 12	-3.673888739
## 13	-2.116048391
## 14	-9.499862488
## 15	-1.579192694
## 16	-7.766707237
## 17	-8.975411232
## 18	-5.042155321
## 19	-4.967798765
## 20	-12.372479613
## 21	5.537730638
## 22	-5.572829779
## 23	2.770130579
## 24	-3.318315085
## 25	-0.521303709
## 26	-10.453042682
## 27	-3.728572424
## 28	-5.718472059
## 29	12.090890352
## 30	-7.670510824
## 31	1.923398439
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## 598      1.831692163
## 599     -3.347749289
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select(PCH_WICS_16_22)
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## 10     -21.28284642
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## 13       8.58140697
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## 19     -14.35976950
## 20      -6.35976950
## 21       2.51523050
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## 558      -106.667997
## 559      -106.667997
## 560      -106.667997
## 561       188.570098
## 562       28.830843
## 563     -108.322843
## 564       92.846566
## 565      -77.714342
## 566     -140.041783
## 567     -147.165509
## 568      -31.791337
## 569     -93.587428
## 570     -12.537907
## 571       67.824983
## 572       40.801639
## 573     -138.329576
## 574     -99.234013
## 575      417.209072
## 576     -17.537562
## 577     -100.288103
## 578     -157.334664
## 579     -92.526583
## 580     -130.521208
## 581     -39.646720
## 582     -78.426239
## 583     -69.512502
## 584     -75.008608
## 585     -115.085847
## 586     -92.194313
## 587      -3.037634
## 588     -29.309506
## 589     -164.617477
## 590     -118.466836
## 591     -36.217246
## 592     -75.759964
## 593     -97.425573
## 594     -21.909054
## 595     -121.161993
## 596     -62.605700
## 597     -76.213451
## 598     -47.952401
## 599       29.010395
## 600       3.476931

```

```
cor(atlas2)
```

```

##          PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_SUPER_16_20
## PCH_LACCESS_POP_15_19          1.00000000    -0.12825303     0.01054011
## PCH_GROC_16_20              -0.12825303     1.00000000    -0.03476868
## PCH_SUPER_16_20              0.01054011    -0.03476868     1.00000000
## PCH_CONVS_16_20             -0.04837386    -0.10194873     0.08313836
## PCH_SPECS_16_20             -0.01327074    -0.03113158    -0.03446943
## PCH_SNAPS_17_23             -0.07170763     0.14143289    -0.01624929
## PCH_WICS_16_22              -0.04365784    -0.00269269    -0.03008571

```

```
## PCH_FFR_16_20 -0.17928865 0.14941098 -0.09015193
## PCH_FSR_16_20 0.04399629 0.08591949 -0.11639025
## PCH_DIRSALES_12_17 -0.04141853 0.05904253 0.06667660
## PCH_CONVS_16_20 PCH_SPECS_16_20 PCH_SNAPS_17_23
## PCH_LACCESS_POP_15_19 -0.048373860 -0.01327074 -0.071707633
## PCH_GROC_16_20 -0.101948734 -0.03113158 0.141432885
## PCH_SUPER_16_20 0.083138361 -0.03446943 -0.016249294
## PCH_CONVS_16_20 1.000000000 0.03017534 0.001181517
## PCH_SPECS_16_20 0.030175344 1.000000000 0.078258999
## PCH_SNAPS_17_23 0.001181517 0.07825900 1.000000000
## PCH_WICS_16_22 0.018046555 -0.03976880 -0.031334023
## PCH_FFR_16_20 -0.012903865 0.06940831 0.095304847
## PCH_FSR_16_20 0.095275731 0.06975211 0.090492833
## PCH_DIRSALES_12_17 0.026334746 -0.01929969 -0.036825560
## PCH_WICS_16_22 PCH_FFR_16_20 PCH_FSR_16_20
## PCH_LACCESS_POP_15_19 -0.043657843 -0.17928865 0.043996289
## PCH_GROC_16_20 -0.002692690 0.14941098 0.085919490
## PCH_SUPER_16_20 -0.030085712 -0.09015193 -0.116390245
## PCH_CONVS_16_20 0.018046555 -0.01290386 0.095275731
## PCH_SPECS_16_20 -0.039768796 0.06940831 0.069752112
## PCH_SNAPS_17_23 -0.031334023 0.09530485 0.090492833
## PCH_WICS_16_22 1.000000000 -0.01633849 0.005264114
## PCH_FFR_16_20 -0.016338491 1.000000000 0.063304297
## PCH_FSR_16_20 0.005264114 0.06330430 1.000000000
## PCH_DIRSALES_12_17 -0.029665757 0.06431184 -0.024182203
## PCH_DIRSALES_12_17
## PCH_LACCESS_POP_15_19 -0.04141853
## PCH_GROC_16_20 0.05904253
## PCH_SUPER_16_20 0.06667660
## PCH_CONVS_16_20 0.02633475
## PCH_SPECS_16_20 -0.01929969
## PCH_SNAPS_17_23 -0.03682556
## PCH_WICS_16_22 -0.02966576
## PCH_FFR_16_20 0.06431184
## PCH_FSR_16_20 -0.02418220
## PCH_DIRSALES_12_17 1.00000000
```

```
mshapiro.test(t(atlas2[,1:9]))
```

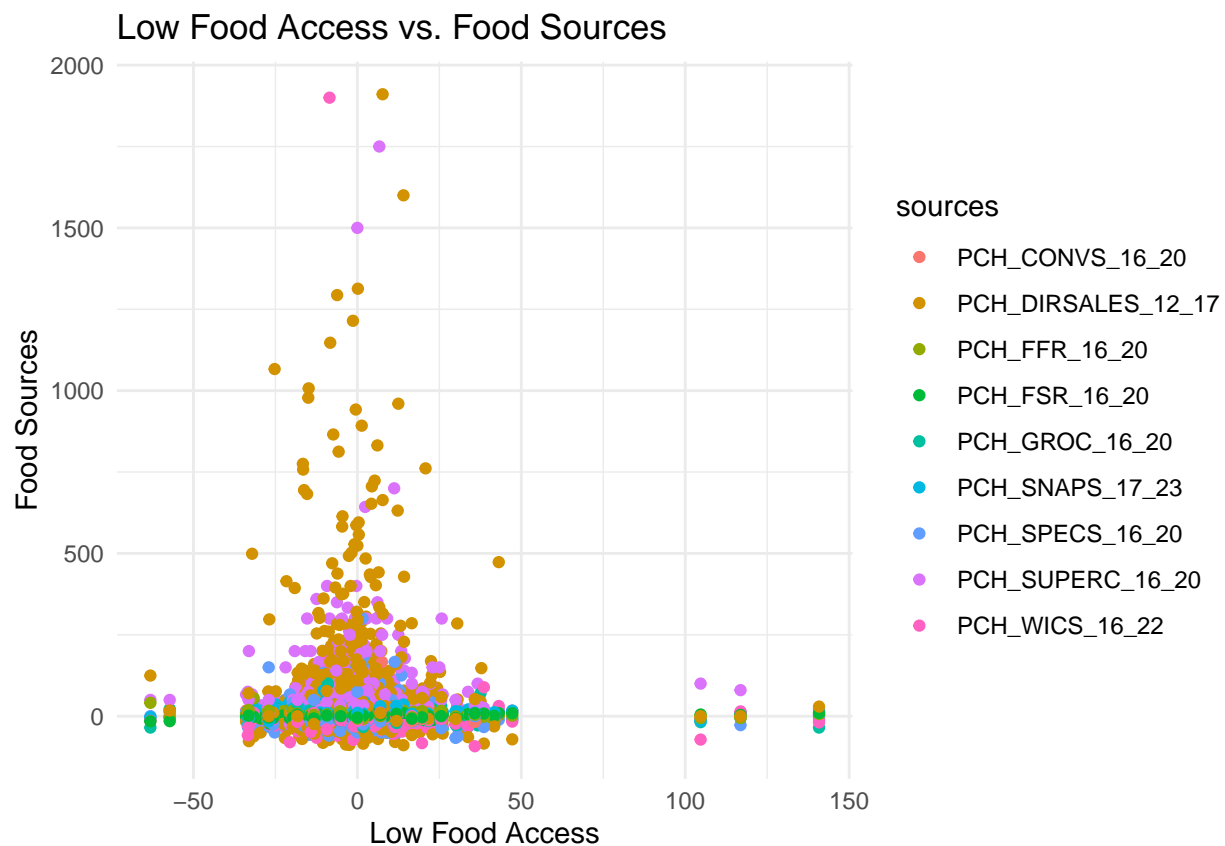
```
##
## Shapiro-Wilk normality test
##
## data: Z
## W = 0.12859, p-value < 2.2e-16
```

```
atlas2_long <- atlas2 |>
  pivot_longer(cols = c("PCH_GROC_16_20", "PCH_SUPER_16_20", "PCH_CONVS_16_20", "PCH_SPECS_16_20", "PCH_SNAPS_17_23", "PCH_WICS_16_22", "PCH_FFR_16_20", "PCH_FSR_16_20", "PCH_DIRSALES_12_17"),
               names_to = "sources",
               values_to = "food")
atlas2_long
```

```
## # A tibble: 5,400 x 3
## PCH_LACCESS_POP_15_19 sources food
## <dbl> <chr> <dbl>
## 1 -1.32 PCH_GROC_16_20 0
```

```
## 2          -1.32 PCH_SUPER_16_20    28.6
## 3          -1.32 PCH_CONVS_16_20     0
## 4          -1.32 PCH_SPECS_16_20     7.41
## 5          -1.32 PCH_SNAPS_17_23    13.5
## 6          -1.32 PCH_WICS_16_22    -6.90
## 7          -1.32 PCH_FFR_16_20     10.3
## 8          -1.32 PCH_FSR_16_20      4.24
## 9          -1.32 PCH_DIRS_12_17    79.0
## 10         -8.19 PCH_GROC_16_20      0
## # i 5,390 more rows
```

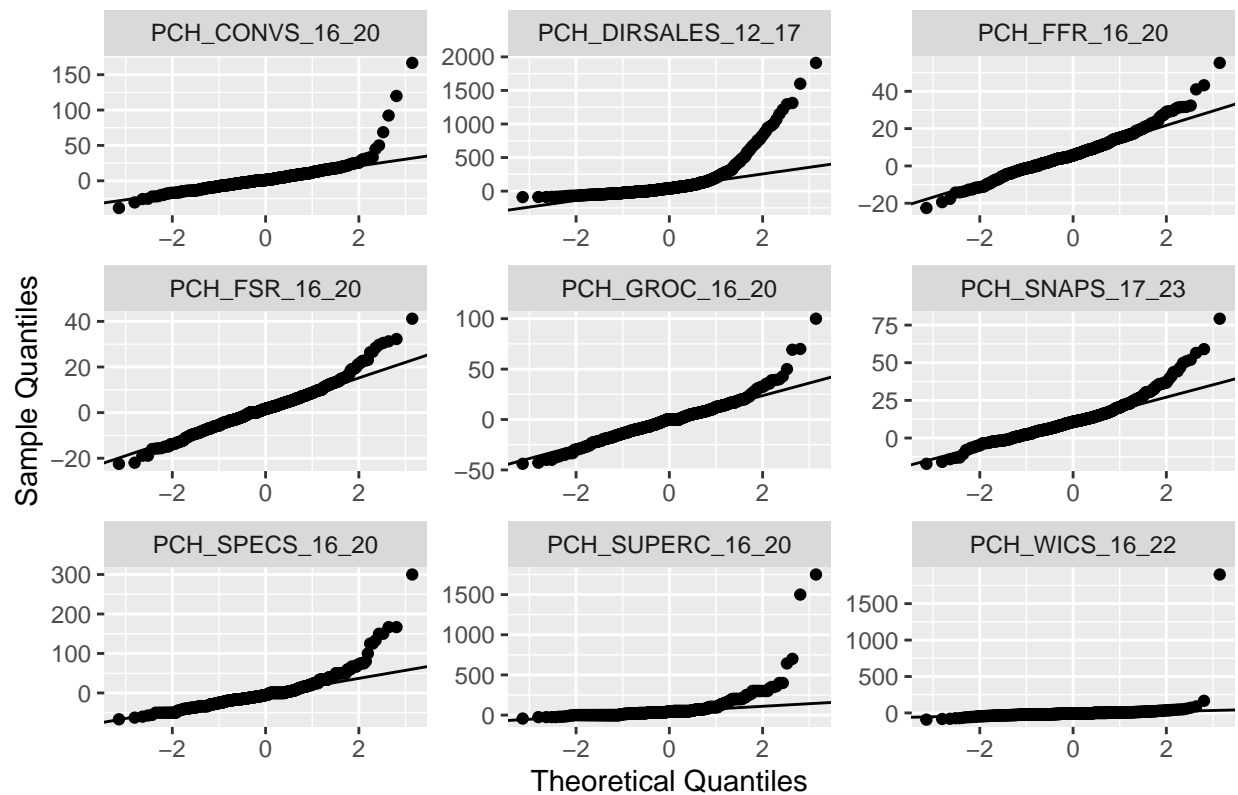
```
options(repr.plot.width = NULL, repr.plot.height = NULL)
ggplot(atlas2_long, aes(x = PCH_LACCESS_POP_15_19, y = food, color = sources)) +
  geom_point() +
  labs(title = "Low Food Access vs. Food Sources",
       x = "Low Food Access",
       y = "Food Sources") +
  theme_minimal()
```



```
options(repr.plot.width = 8, repr.plot.height = 3)

ggplot(atlas2_long, aes(sample = food)) +
  stat_qq() +
  stat_qq_line() +
  facet_wrap(~sources, scales = "free") +
  labs(title = "Q-Q Plots for Food Sources",
       x = "Theoretical Quantiles", y = "Sample Quantiles")
```

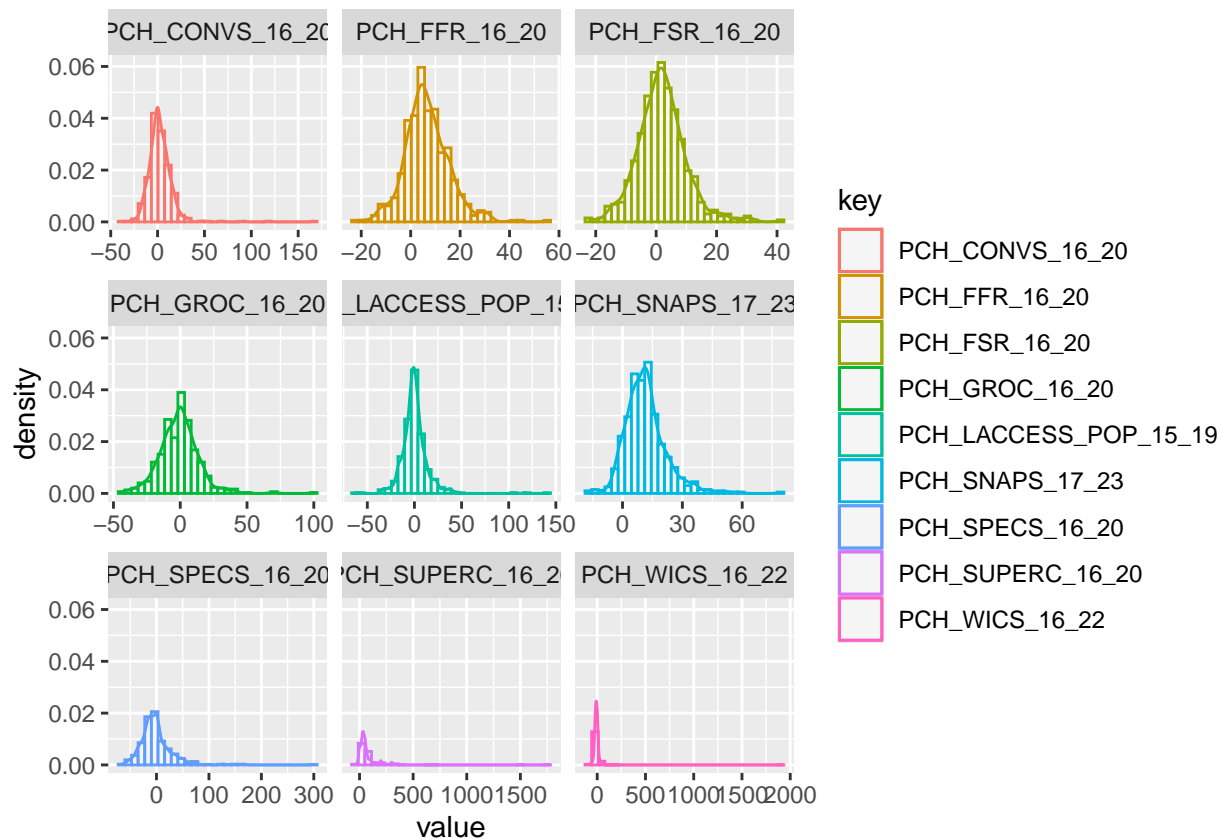
## Q-Q Plots for Food Sources



```
options(repr.plot.width = 8, repr.plot.height = 3)
```

```
d <- gather(atlas2[,c(1:9)])
ggplot(d, aes(x = value, color=key)) +
  facet_wrap(~key, scales = "free_x") +
  geom_histogram(aes(y=after_stat(density)), alpha=0.5,
    position="identity", fill="white")+
  geom_density(alpha=.2)
```

```
## `stat_bin()` using `bins = 30`. Pick better value `binwidth`.
```



```
model <- lm(PCH_LACCESS_POP_15_19 ~ ., data = atlas2)
model
```

```
##
## Call:
## lm(formula = PCH_LACCESS_POP_15_19 ~ ., data = atlas2)
##
## Coefficients:
##      (Intercept)      PCH_GROC_16_20      PCH_SUPER_16_20      PCH_CONVS_16_20
##      2.7315104      -0.1089864      0.0007048      -0.0718614
##      PCH_SPECS_16_20      PCH_SNAPS_17_23      PCH_WICS_16_22      PCH_FFR_16_20
##      -0.0032387      -0.0692429      -0.0089636      -0.2667556
##      PCH_FSR_16_20      PCH_DIRSAL_12_17
##      0.1400873      -0.0016520
```

```
predict(model, newdata=data.frame(PCH_GROC_16_20=1, PCH_SUPER_16_20=1, PCH_CONVS_16_20=1, PCH_SPECS_16_20=1, PCH_SNAPS_17_23=1, PCH_WICS_16_22=1, PCH_FFR_16_20=1, PCH_FSR_16_20=1, PCH_DIRSAL_12_17=1))
```

```
##      1
## 2.341602
```

```
summary(model)
```

```
##
## Call:
## lm(formula = PCH_LACCESS_POP_15_19 ~ ., data = atlas2)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
```

```
## -57.382 -6.965 -0.849 5.095 134.086
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    2.7315104  1.0976782   2.488  0.01311 *
## PCH_GROC_16_20 -0.1089864  0.0412257  -2.644  0.00842 **
## PCH_SUPER_16_20 0.0007048  0.0050674   0.139  0.88944
## PCH_CONVS_16_20 -0.0718614  0.0433000  -1.660  0.09752 .
## PCH_SPECS_16_20 -0.0032387  0.0187694  -0.173  0.86306
## PCH_SNAPS_17_23 -0.0692429  0.0572575  -1.209  0.22702
## PCH_WICS_16_22  -0.0089636  0.0074607  -1.201  0.23006
## PCH_FFR_16_20   -0.2667556  0.0673227  -3.962 8.33e-05 ***
## PCH_FSR_16_20    0.1400873  0.0760650   1.842  0.06602 .
## PCH_DIRSALES_12_17 -0.0016520  0.0026964  -0.613  0.54033
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14.65 on 590 degrees of freedom
## Multiple R-squared:  0.05645,    Adjusted R-squared:  0.04206
## F-statistic: 3.922 on 9 and 590 DF,  p-value: 7.339e-05
```

```
confint(model)
```

```
##              2.5 %      97.5 %
## (Intercept)    0.575678184  4.887342592
## PCH_GROC_16_20 -0.189953410 -0.028019341
## PCH_SUPER_16_20 -0.009247625  0.010657134
## PCH_CONVS_16_20 -0.156902236  0.013179402
## PCH_SPECS_16_20 -0.040101685  0.033624247
## PCH_SNAPS_17_23 -0.181696180  0.043210305
## PCH_WICS_16_22  -0.023616370  0.005689086
## PCH_FFR_16_20   -0.398976856 -0.134534329
## PCH_FSR_16_20   -0.009303806  0.289478395
## PCH_DIRSALES_12_17 -0.006947646  0.003643666
```

```
anova(model)
```

```
## Analysis of Variance Table
##
## Response: PCH_LACCESS_POP_15_19
##              Df Sum Sq Mean Sq F value    Pr(>F)
## PCH_GROC_16_20    1    2207   2207.5  10.2855  0.001413 **
## PCH_SUPER_16_20    1     5      5.0   0.0232  0.879120
## PCH_CONVS_16_20    1    524   523.5   2.4393  0.118862
## PCH_SPECS_16_20    1     31    31.0   0.1443  0.704169
## PCH_SNAPS_17_23    1    362   361.8   1.6859  0.194647
## PCH_WICS_16_22     1    269   268.8   1.2524  0.263550
## PCH_FFR_16_20     1   3358  3358.4  15.6481 8.557e-05 ***
## PCH_FSR_16_20     1    740   739.5   3.4457  0.063915 .
## PCH_DIRSALES_12_17 1     81    80.6   0.3754  0.540330
## Residuals        590 126628   214.6
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# rerunning the regression after omitting insignificant variables
```

```

atlas3 = select(atlas2, PCH_LACCESS_POP_15_19, PCH_GROC_16_20, PCH_CONVS_16_20, PCH_FFR_16_20, PCH_FSR_16_20)

atlas3_long <- atlas3 |>
  pivot_longer(cols = c("PCH_GROC_16_20", "PCH_CONVS_16_20", "PCH_FFR_16_20", "PCH_FSR_16_20"),
               names_to = "sources",
               values_to = "food")

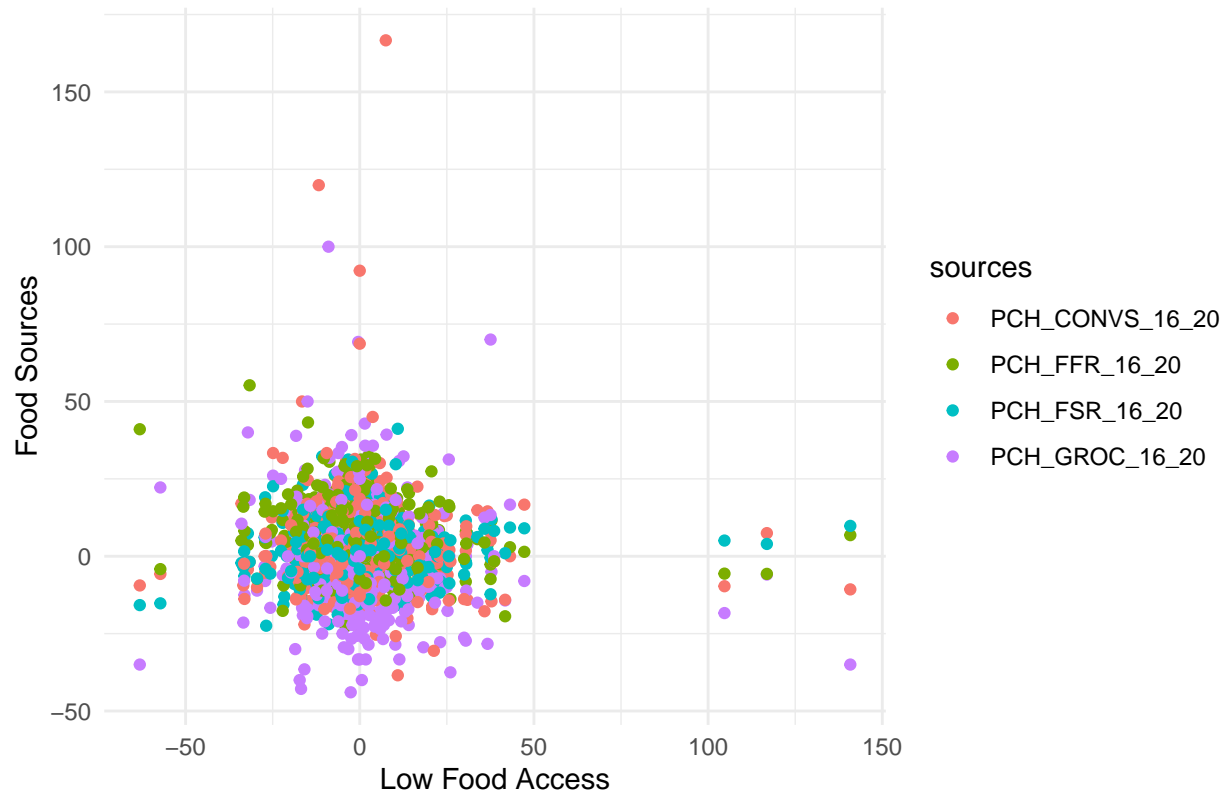
atlas3_long

## # A tibble: 2,400 x 3
##   PCH_LACCESS_POP_15_19 sources      food
##               <dbl> <chr>      <dbl>
## 1          -1.32 PCH_GROC_16_20    0
## 2          -1.32 PCH_CONVS_16_20    0
## 3          -1.32 PCH_FFR_16_20  10.3
## 4          -1.32 PCH_FSR_16_20   4.24
## 5          -8.19 PCH_GROC_16_20    0
## 6          -8.19 PCH_CONVS_16_20   2.82
## 7          -8.19 PCH_FFR_16_20   4.31
## 8          -8.19 PCH_FSR_16_20   2.74
## 9          -0.0797 PCH_GROC_16_20   5.61
## 10         -0.0797 PCH_CONVS_16_20   1.09
## # i 2,390 more rows

options(repr.plot.width = NULL, repr.plot.height = NULL)
ggplot(atlas3_long, aes(x = PCH_LACCESS_POP_15_19, y = food, color = sources)) +
  geom_point() +
  labs(title = "Low Food Access vs. Food Sources",
       x = "Low Food Access",
       y = "Food Sources") +
  theme_minimal()

```

## Low Food Access vs. Food Sources



```
colMeans(atlas3)
```

```
## PCH_LACCESS_POP_15_19      PCH_GROC_16_20      PCH_CONVS_16_20
##           0.2320956          -0.7079341          2.6007777
##           PCH_FFR_16_20      PCH_FSR_16_20
##           6.6306411          1.8834212
```

```
cor(atlas3)
```

```
##           PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_CONVS_16_20
## PCH_LACCESS_POP_15_19           1.00000000    -0.12825303    -0.04837386
## PCH_GROC_16_20                 -0.12825303     1.00000000    -0.10194873
## PCH_CONVS_16_20                -0.04837386    -0.10194873     1.00000000
## PCH_FFR_16_20                  -0.17928865     0.14941098    -0.01290386
## PCH_FSR_16_20                   0.04399629     0.08591949     0.09527573
##           PCH_FFR_16_20 PCH_FSR_16_20
## PCH_LACCESS_POP_15_19    -0.17928865     0.04399629
## PCH_GROC_16_20           0.14941098     0.08591949
## PCH_CONVS_16_20          -0.01290386     0.09527573
## PCH_FFR_16_20            1.00000000     0.06330430
## PCH_FSR_16_20            0.06330430     1.00000000
```

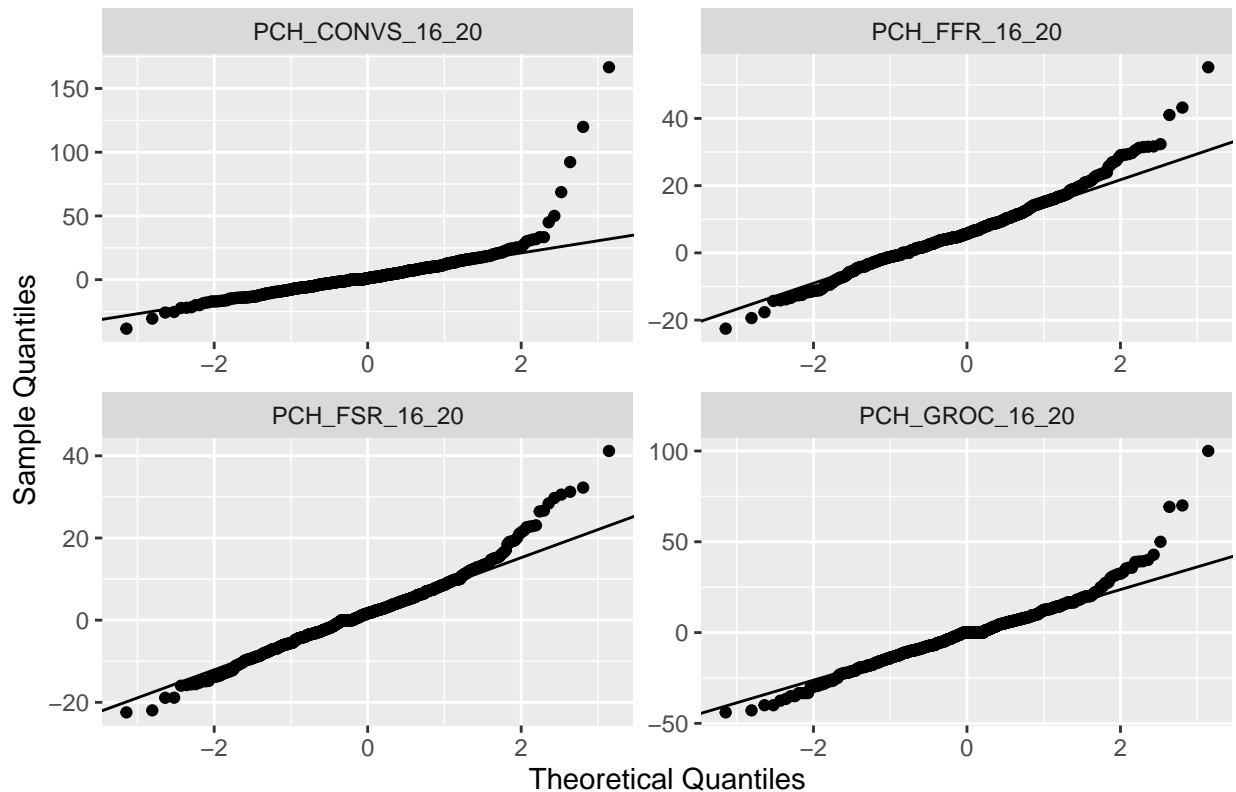
```
mshapiro.test(t(atlas3[,1:3]))
```

```
##
## Shapiro-Wilk normality test
##
## data:  Z
```

```
## W = 0.74753, p-value < 2.2e-16
options(repr.plot.width = 8, repr.plot.height = 3)

ggplot(atlas3_long, aes(sample = food)) +
  stat_qq() +
  stat_qq_line() +
  facet_wrap(~sources, scales = "free") +
  labs(title = "Q-Q Plots for Food Sources",
       x = "Theoretical Quantiles", y = "Sample Quantiles")
```

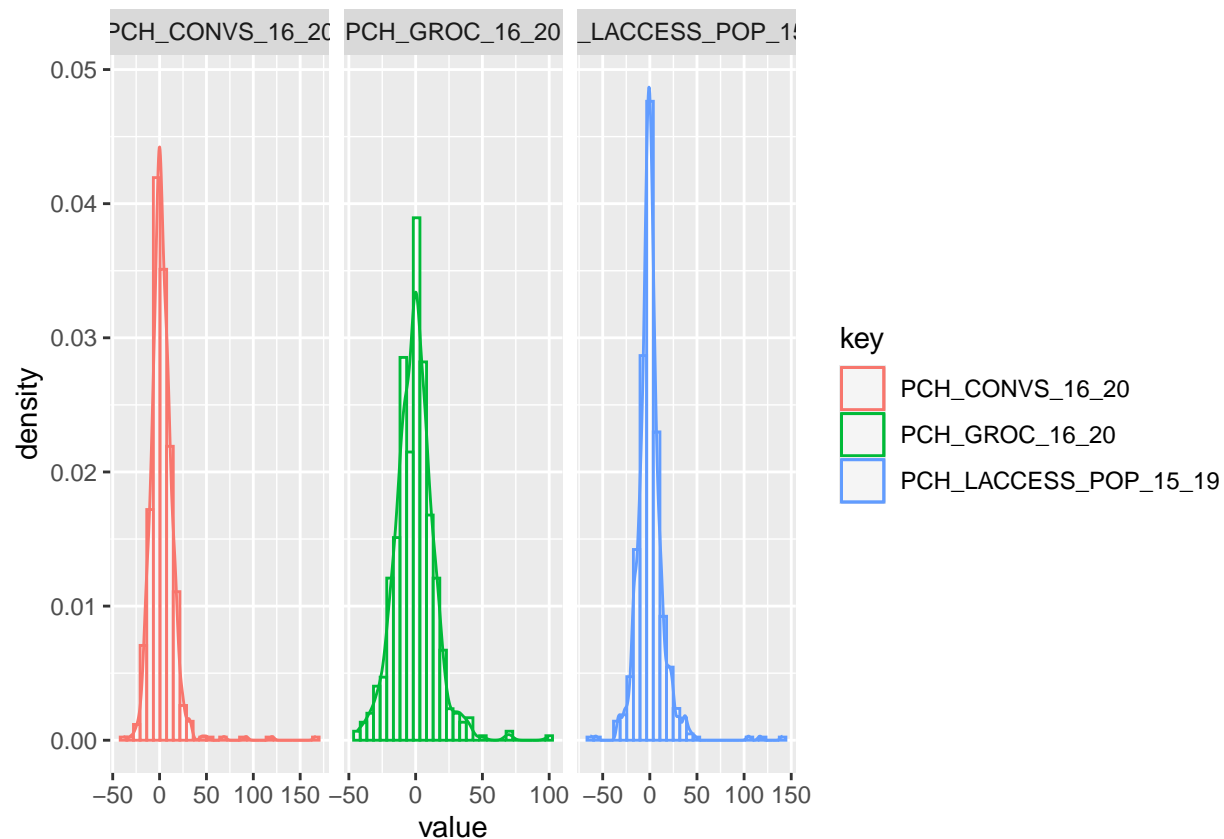
Q-Q Plots for Food Sources



```
options(repr.plot.width = 8, repr.plot.height = 3)

d <- gather(atlas3[,c(1:3)])
ggplot(d, aes(x = value, color=key)) +
  facet_wrap(~key, scales = "free_x") +
  geom_histogram(aes(y=after_stat(density)), alpha=0.5,
                position="identity", fill="white") +
  geom_density(alpha=.2)

## `stat_bin()` using `bins = 30`. Pick better value `binwidth`.
```



```
model2 <- lm(PCH_LACCESS_POP_15_19 ~ ., data = atlas3)
model2
```

```
##
## Call:
## lm(formula = PCH_LACCESS_POP_15_19 ~ ., data = atlas3)
##
## Coefficients:
## (Intercept)    PCH_GROC_16_20    PCH_CONV_S_16_20    PCH_FFR_16_20
##      1.91722        -0.11632         -0.07371         -0.27525
##    PCH_FSR_16_20
##      0.13238
```

```
predict(model2, newdata=data.frame(PCH_GROC_16_20=1,PCH_CONV_S_16_20=1,PCH_FFR_16_20=1,PCH_FSR_16_20=1))
```

```
##      1
## 1.584319
```

```
summary(model2)
```

```
##
## Call:
## lm(formula = PCH_LACCESS_POP_15_19 ~ ., data = atlas3)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -56.438  -6.769  -0.806   5.038 134.614
##
```

```
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1.91722    0.76076   2.520  0.01199 *
## PCH_GROC_16_20 -0.11632    0.04071  -2.857  0.00442 **
## PCH_CONVS_16_20 -0.07371    0.04300  -1.714  0.08702 .
## PCH_FFR_16_20  -0.27525    0.06653  -4.137  4.02e-05 ***
## PCH_FSR_16_20   0.13238    0.07505   1.764  0.07825 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14.63 on 595 degrees of freedom
## Multiple R-squared:  0.0514, Adjusted R-squared:  0.04503
## F-statistic: 8.061 on 4 and 595 DF,  p-value: 2.476e-06
```

```
confint(model2)
```

```
##               2.5 %      97.5 %
## (Intercept)    0.4231130  3.41132362
## PCH_GROC_16_20 -0.1962705 -0.03636466
## PCH_CONVS_16_20 -0.1581687  0.01074280
## PCH_FFR_16_20  -0.4059103 -0.14459048
## PCH_FSR_16_20  -0.0150061  0.27976852
```

```
anova(model2)
```

```
## Analysis of Variance Table
##
## Response: PCH_LACCESS_POP_15_19
##               Df Sum Sq Mean Sq F value    Pr(>F)
## PCH_GROC_16_20   1    2207   2207.5  10.3174  0.001389 **
## PCH_CONVS_16_20   1     512    512.1   2.3933  0.122385
## PCH_FFR_16_20    1    3513   3513.3  16.4204  5.747e-05 ***
## PCH_FSR_16_20    1     666    665.8   3.1117  0.078245 .
## Residuals       595  127305    214.0
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#per capita variables
```

```
atlaspc = select(atlasog, PCH_LACCESS_POP_15_19, PCH_GROCPH_16_20, PCH_SUPERCPH_16_20, PCH_CONVSPH_16_20)
atlaspc = filter(atlaspc, PCH_LACCESS_POP_15_19 != -9999, PCH_GROCPH_16_20 != -9999, PCH_SUPERCPH_16_20 != -9999)
atlaspc = filter(atlaspc, PCH_LACCESS_POP_15_19 != -8888, PCH_GROCPH_16_20 != -8888, PCH_SUPERCPH_16_20 != -8888)
```

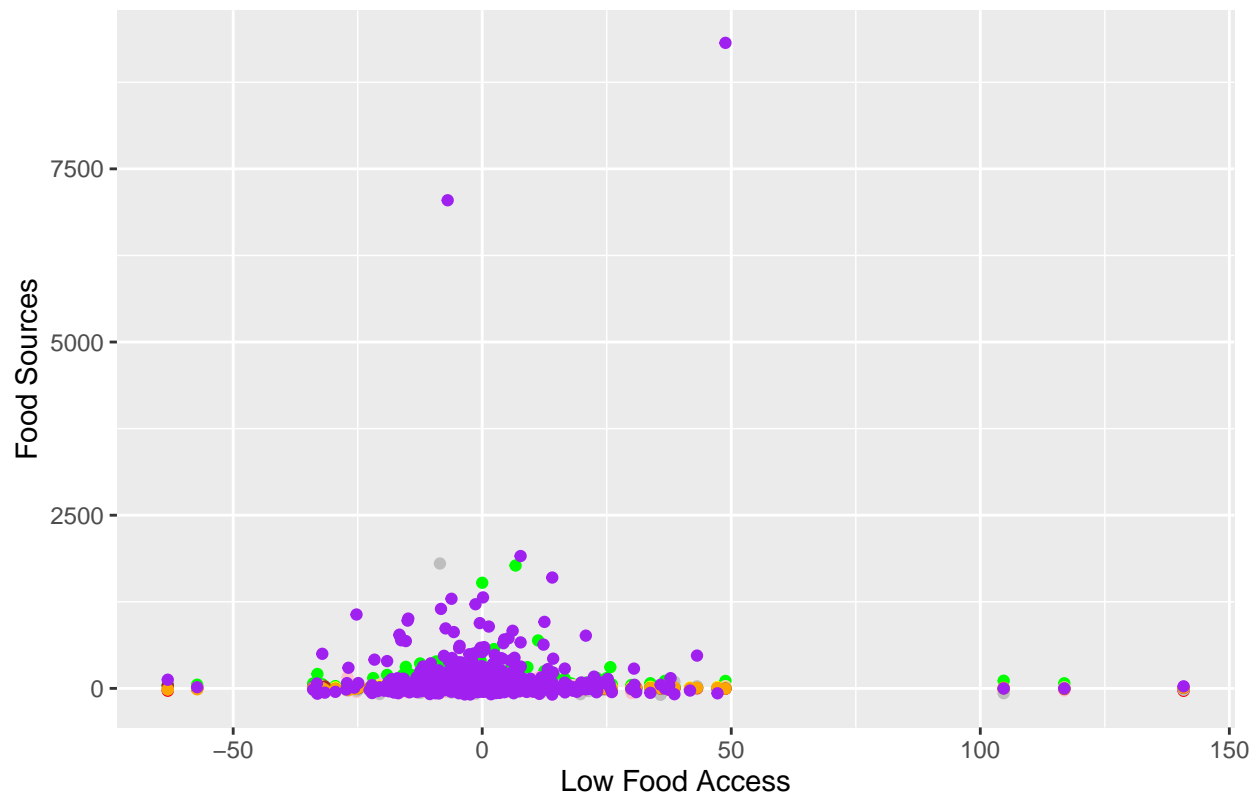
```
# adjust Jupyter plot size
```

```
options(repr.plot.width=4, repr.plot.height=4)
```

```
ggplot(atlaspc) +
  geom_point(aes(y = PCH_GROCPH_16_20, x = PCH_LACCESS_POP_15_19), color="red")+
  geom_point(aes(y = PCH_SUPERCPH_16_20, x = PCH_LACCESS_POP_15_19), color="green")+
  geom_point(aes(y = PCH_CONVSPH_16_20, x = PCH_LACCESS_POP_15_19), color="blue")+
  geom_point(aes(y = PCH_SPECSPTH_16_20, x = PCH_LACCESS_POP_15_19), color="pink")+
  geom_point(aes(y = PCH_SNAPSPH_17_23, x = PCH_LACCESS_POP_15_19), color="yellow")+
  geom_point(aes(y = PCH_WICSPH_16_22, x = PCH_LACCESS_POP_15_19), color="gray")+
  geom_point(aes(y = PCH_FFRPH_16_20, x = PCH_LACCESS_POP_15_19), color="brown")+
  geom_point(aes(y = PCH_FSRPH_16_20, x = PCH_LACCESS_POP_15_19), color="orange")+
  geom_point(aes(y = PCH_PC_DIRSALES_12_17, x = PCH_LACCESS_POP_15_19), color="purple")+
  labs(title = "Low Food Access vs. Food Sources",
       x = "Low Food Access",
```

```
y = "Food Sources")
```

## Low Food Access vs. Food Sources



*#There are two points that are clearly outliers at thousands of percents higher than the others, so I a*  
`atlaspc2 = filter(atlaspc, PCH_LACCESS_POP_15_19 < 5000, PCH_GROCPH_16_20 < 5000, PCH_SUPERCPH_16_20 < 5000)`

*#normalize predictors*  
`colMeans(atlaspc2)`

```
## PCH_LACCESS_POP_15_19      PCH_GROCPH_16_20      PCH_SUPERCPH_16_20
##           0.24494421          -3.19971535          64.48811454
##   PCH_CONVSPH_16_20      PCH_SPECSPTH_16_20      PCH_SNAPSPH_17_23
##           0.01554808          -3.02762626           9.07525966
##   PCH_WICSPTH_16_22      PCH_FFRPTH_16_20      PCH_FSRPTH_16_20
##          -9.98176367           3.86165602          -0.73829191
## PCH_PC_DIRSALES_12_17
##          107.15593946
```

```
mutate(atlaspc2, PCH_GROCPH_16_20 = PCH_GROCPH_16_20) |>
select(PCH_GROCPH_16_20)
```

```
##   PCH_GROCPH_16_20
## 1          -9.3768965
## 2          -2.0876384
## 3           6.4398125
## 4          -0.9071651
## 5          -7.9663482
## 6           2.5330160
```

## 7	7.7796674
## 8	-7.7037021
## 9	-28.2555126
## 10	24.9284656
## 11	17.7105537
## 12	-19.7476888
## 13	-11.1824702
## 14	-7.2106130
## 15	5.9466123
## 16	-10.0773599
## 17	-1.7981701
## 18	-32.8075213
## 19	-12.8642936
## 20	-14.0985083
## 21	19.0059297
## 22	-18.5220484
## 23	-19.9167767
## 24	9.1433776
## 25	16.6556968
## 26	1.2258812
## 27	-2.5639313
## 28	-5.4797150
## 29	10.5348978
## 30	-3.9844677
## 31	-15.7405819
## 32	-28.7243775
## 33	-0.1576572
## 34	36.1632495
## 35	-2.1649987
## 36	8.5543146
## 37	-22.5591385
## 38	8.6700315
## 39	2.5373632
## 40	-4.4624425
## 41	-3.3604451
## 42	3.6352613
## 43	-2.9852467
## 44	-1.1517980
## 45	9.7132174
## 46	-13.1559296
## 47	0.7121896
## 48	3.1813897
## 49	-2.9641749
## 50	-6.9071589
## 51	16.8582269
## 52	-0.4488572
## 53	3.3103831
## 54	-7.2527054
## 55	4.0923659
## 56	-7.8280476
## 57	5.4796502
## 58	-8.5819209
## 59	-4.2601913
## 60	-3.7386242

## 61	-3.2658071
## 62	5.6878227
## 63	-3.8924849
## 64	-22.0236505
## 65	-5.1790142
## 66	-0.6045026
## 67	-22.0239682
## 68	-31.4651157
## 69	-19.5919984
## 70	-11.6263610
## 71	5.0606103
## 72	-20.7097482
## 73	-9.2454596
## 74	-4.8792831
## 75	10.9616612
## 76	-0.3632131
## 77	-3.3174283
## 78	-4.2045003
## 79	-1.3582302
## 80	2.4275044
## 81	-0.7852842
## 82	-1.3500113
## 83	-1.1188930
## 84	12.7728778
## 85	-4.3333447
## 86	3.4285498
## 87	-0.8866161
## 88	8.2348066
## 89	-15.1594969
## 90	0.6148278
## 91	-1.5688683
## 92	-12.0125554
## 93	6.2052389
## 94	0.9904026
## 95	-7.4450040
## 96	1.7470727
## 97	-2.0145420
## 98	-0.1837310
## 99	-3.3138086
## 100	-3.1325993
## 101	2.8564738
## 102	-18.3021779
## 103	11.2589245
## 104	6.7018982
## 105	-22.8377009
## 106	13.3016154
## 107	-3.4356506
## 108	1.9619453
## 109	-0.8013946
## 110	2.6854030
## 111	2.0542176
## 112	-3.2208176
## 113	-3.9086231
## 114	-30.7533142

## 115	-14.4015644
## 116	-14.6701989
## 117	8.7735098
## 118	5.3118987
## 119	0.3848501
## 120	-14.4151875
## 121	10.6030328
## 122	-17.1103215
## 123	-10.3507733
## 124	-22.1837368
## 125	-2.1376963
## 126	-4.6106077
## 127	-7.5501452
## 128	0.7250149
## 129	-2.3470336
## 130	-13.2199311
## 131	10.2022351
## 132	-17.8887602
## 133	-14.6916441
## 134	-5.1622556
## 135	-2.0749083
## 136	-10.7988828
## 137	-4.0873322
## 138	-2.7888184
## 139	-2.8374525
## 140	16.5254841
## 141	9.3704443
## 142	-11.5449304
## 143	-1.7728725
## 144	4.7211120
## 145	-26.2167107
## 146	-9.3463126
## 147	-25.2895116
## 148	6.8456729
## 149	-6.9695415
## 150	15.3507544
## 151	2.4675581
## 152	-1.1557629
## 153	-3.5286624
## 154	-17.1252421
## 155	-10.5846473
## 156	-44.5848565
## 157	-5.8681872
## 158	6.7787830
## 159	-31.8933122
## 160	-20.5525158
## 161	-15.1015479
## 162	-0.4073471
## 163	-31.3418411
## 164	-4.0739460
## 165	-29.5736065
## 166	-2.0837679
## 167	-1.5402912
## 168	-1.9674883

## 169	14.0252645
## 170	-10.6457890
## 171	-15.4244240
## 172	14.5283126
## 173	-0.7900406
## 174	34.0144409
## 175	-12.5305865
## 176	15.4632935
## 177	-8.7782278
## 178	-8.4541173
## 179	15.2118565
## 180	-11.5282429
## 181	2.9831634
## 182	2.5336264
## 183	1.2599940
## 184	-15.0456167
## 185	4.0707705
## 186	-13.1100566
## 187	7.4701007
## 188	14.9064938
## 189	-24.5046078
## 190	-3.5229480
## 191	3.0971708
## 192	-3.8311390
## 193	-9.5008279
## 194	-15.6868004
## 195	7.4372148
## 196	-18.5069903
## 197	4.8614793
## 198	5.1269299
## 199	0.8037897
## 200	-0.1412874
## 201	-7.4908271
## 202	-14.8832557
## 203	-2.9596786
## 204	12.7634178
## 205	9.8687786
## 206	-9.1361154
## 207	-9.1719022
## 208	2.9237508
## 209	-0.9063819
## 210	-8.4744941
## 211	6.5006728
## 212	-9.7874722
## 213	5.6538374
## 214	8.5461480
## 215	11.2338993
## 216	-13.1853211
## 217	36.8087608
## 218	1.2454669
## 219	26.7819500
## 220	3.1908343
## 221	-0.2041611
## 222	6.2091104

## 223	-13.9196757
## 224	-14.9314621
## 225	18.1019338
## 226	8.1552048
## 227	-14.1248528
## 228	-12.8967547
## 229	-24.1572577
## 230	2.8101289
## 231	-7.7913418
## 232	-5.9492138
## 233	6.0214319
## 234	0.6114309
## 235	-7.4205082
## 236	-8.9665613
## 237	-4.7322822
## 238	-7.8546391
## 239	37.9818445
## 240	-17.4193778
## 241	0.5711993
## 242	-41.5904060
## 243	-0.8425001
## 244	-13.9183403
## 245	3.0649725
## 246	1.6235141
## 247	-10.3022618
## 248	2.5077647
## 249	0.9081088
## 250	25.1654528
## 251	-1.1591735
## 252	-7.3969558
## 253	-14.6420167
## 254	-20.5585268
## 255	-22.9676921
## 256	-0.5835028
## 257	8.7075979
## 258	-16.7525326
## 259	-12.3989266
## 260	8.9349347
## 261	-35.1644935
## 262	-3.0459307
## 263	-9.8291570
## 264	7.0645417
## 265	-16.6006155
## 266	9.9052296
## 267	-2.8746001
## 268	10.2975635
## 269	-1.7004164
## 270	-18.3571358
## 271	-11.0833426
## 272	18.2395366
## 273	7.0447097
## 274	61.0370335
## 275	12.7183658
## 276	13.4725909

## 277	2.2643078
## 278	-12.6124930
## 279	-0.4884965
## 280	74.9941152
## 281	8.6552989
## 282	-3.8958497
## 283	-14.8894579
## 284	-6.5559211
## 285	4.8131019
## 286	-3.6920071
## 287	15.9046088
## 288	-9.9466657
## 289	-8.1831206
## 290	-2.5684470
## 291	20.4558302
## 292	18.1809547
## 293	4.8737510
## 294	17.4198247
## 295	-13.7315611
## 296	-8.4087645
## 297	0.6161133
## 298	9.7673882
## 299	-5.5063069
## 300	-18.8447322
## 301	4.4271629
## 302	18.4851631
## 303	-7.8424657
## 304	6.3319636
## 305	-3.1515906
## 306	11.7577207
## 307	-16.3829899
## 308	13.9596084
## 309	7.2684875
## 310	-8.0119569
## 311	0.1110558
## 312	-3.3422756
## 313	37.6515652
## 314	6.6018646
## 315	9.6809068
## 316	-2.3592611
## 317	2.2040618
## 318	-10.0394227
## 319	-0.4673497
## 320	-6.3846755
## 321	-6.7545652
## 322	-7.9184957
## 323	-1.8299050
## 324	1.5036076
## 325	1.6379239
## 326	2.2794848
## 327	38.4142085
## 328	-23.0119325
## 329	-13.6860923
## 330	-13.2622904

## 331	-4.6157793
## 332	10.6300999
## 333	-34.3946283
## 334	-19.2547413
## 335	-11.0846056
## 336	-16.7031945
## 337	-13.6968280
## 338	-16.8722103
## 339	0.4386573
## 340	-21.3282728
## 341	7.4873943
## 342	-25.7857389
## 343	-12.2924665
## 344	-21.5854489
## 345	-9.1716086
## 346	-2.6655326
## 347	-7.1939361
## 348	-19.6193148
## 349	-10.7367284
## 350	-38.7007504
## 351	-4.8732060
## 352	1.5918735
## 353	-10.2478038
## 354	-2.8921650
## 355	-3.5393175
## 356	-21.2840991
## 357	-12.5699569
## 358	-16.0941939
## 359	10.7050249
## 360	8.7158931
## 361	-19.1017744
## 362	13.1049186
## 363	-7.6766388
## 364	6.2087232
## 365	7.6135487
## 366	-4.5912113
## 367	-7.0894165
## 368	-6.2792210
## 369	-4.9409753
## 370	8.6856341
## 371	-10.2587214
## 372	8.0507961
## 373	4.5778629
## 374	-15.7282836
## 375	-1.6318172
## 376	0.8526819
## 377	1.7054954
## 378	-10.3299449
## 379	37.9912628
## 380	-19.0253294
## 381	10.9561284
## 382	0.9072301
## 383	-13.7464332
## 384	14.8683643

## 385	9.0360548
## 386	-7.5446939
## 387	-17.0667935
## 388	-9.5209289
## 389	-21.2498472
## 390	-8.3048222
## 391	-8.5821521
## 392	9.7226291
## 393	-16.5138636
## 394	3.5979422
## 395	-1.5715042
## 396	1.8524772
## 397	-2.1618248
## 398	-11.5962445
## 399	-3.4089125
## 400	-7.2097835
## 401	-5.0111061
## 402	-13.3270310
## 403	5.9908414
## 404	10.0034756
## 405	-8.8283668
## 406	-1.5650772
## 407	5.2572954
## 408	-38.5289712
## 409	17.1050090
## 410	-45.3052836
## 411	-4.8492994
## 412	4.0124288
## 413	-13.4370647
## 414	-16.1603579
## 415	-27.7474701
## 416	10.1964895
## 417	-24.5331912
## 418	0.7983143
## 419	7.7900244
## 420	3.2888603
## 421	2.4599378
## 422	2.7220004
## 423	5.7371100
## 424	-11.1785125
## 425	-10.4504219
## 426	-5.3613585
## 427	5.6931984
## 428	-12.3569652
## 429	10.5481568
## 430	-12.5918635
## 431	-13.7519102
## 432	2.7921082
## 433	13.0582267
## 434	-5.7379949
## 435	-14.1502616
## 436	6.4009620
## 437	5.6497083
## 438	-9.9935369

## 439	-8.3082825
## 440	6.7610798
## 441	-0.5104500
## 442	17.3735339
## 443	-15.1356335
## 444	-10.6634213
## 445	24.5289373
## 446	-10.7318729
## 447	14.0690214
## 448	0.7160629
## 449	-22.8506545
## 450	21.7472638
## 451	1.5449235
## 452	-3.6302907
## 453	14.9989434
## 454	1.0440101
## 455	-1.3936238
## 456	2.8227031
## 457	0.3220471
## 458	-3.8008871
## 459	-10.6698502
## 460	-13.9732237
## 461	-18.7559209
## 462	-2.8160588
## 463	-0.4615727
## 464	3.6308625
## 465	-18.7235680
## 466	6.6171858
## 467	-3.2159935
## 468	13.9973928
## 469	-3.7528369
## 470	-16.9233204
## 471	-9.7691614
## 472	-15.0792725
## 473	3.3876778
## 474	-2.0740880
## 475	-41.1046677
## 476	-17.4463513
## 477	-4.2192719
## 478	-8.2942707
## 479	4.6761054
## 480	-13.4978885
## 481	-27.2817559
## 482	-33.9352060
## 483	-9.0678709
## 484	-22.6790643
## 485	-14.7930203
## 486	-8.5206923
## 487	-17.0535184
## 488	-21.9921684
## 489	-23.4539181
## 490	-25.3757920
## 491	19.3596094
## 492	-10.6684291

## 493	-8.2221828
## 494	4.8454987
## 495	-5.4498958
## 496	-0.7746730
## 497	-4.8701118
## 498	-8.2536466
## 499	-0.4795884
## 500	-3.2448882
## 501	-5.9349694
## 502	19.1583658
## 503	-19.6565287
## 504	11.7493908
## 505	-15.6530384
## 506	13.2054209
## 507	-1.0348041
## 508	27.1400145
## 509	11.3220094
## 510	-9.9433483
## 511	-9.3325887
## 512	-2.5811704
## 513	26.6061303
## 514	-4.6806321
## 515	9.7167597
## 516	-7.8346774
## 517	-19.3977985
## 518	2.1405025
## 519	-22.6164350
## 520	3.8240032
## 521	-5.3138295
## 522	70.3170439
## 523	-21.9253488
## 524	32.8614635
## 525	-1.9014047
## 526	6.0997417
## 527	-18.2415321
## 528	-3.5592559
## 529	0.5297242
## 530	-23.0210443
## 531	-15.4561984
## 532	-8.2541620
## 533	-5.8898113
## 534	-24.0034357
## 535	0.5018013
## 536	-11.1401188
## 537	-18.2640979
## 538	-9.1478342
## 539	14.5331770
## 540	4.6019527
## 541	-3.6180744
## 542	-11.9084599
## 543	-4.0402170
## 544	3.5664989
## 545	4.4002557
## 546	16.6303931

```

## 547      9.9573982
## 548     11.0816075
## 549     38.9514367
## 550      0.9040715
## 551    -34.7147115
## 552      7.2898509
## 553      6.4007014
## 554     -6.8382005
## 555     13.0568739
## 556    -25.6278679
## 557     -6.9288053
## 558      9.8922943
## 559     -1.5413530
## 560     -5.9360217
## 561    -22.4042075
## 562     -8.7289333
## 563     -9.7319550
## 564     -9.9606135
## 565    -26.1328068
## 566     -5.7390377
## 567     -7.0424178
## 568    -12.1556645
## 569     22.5934826
## 570    -13.1464650
## 571      1.8170543
## 572     -4.4774890
## 573    -25.6691201
## 574     12.7121404
## 575     -5.9275435
## 576     -7.6686038
## 577     -2.5543621
## 578    -34.7716724
## 579    -27.0362587
## 580     17.4857027
## 581     -0.3399883
## 582     -2.9028650
## 583      1.8710551
## 584     14.5547091
## 585     -8.3119830
## 586      3.2466551
## 587    -14.1110429
## 588    -11.2630678
## 589    -22.0285287
## 590     -1.5544674
## 591    -10.4582660
## 592     29.8566833
## 593    -35.0272558
## 594      0.2598512

```

```

mutate(atlaspc2, PCH_SUPERCPATH_16_20 = PCH_SUPERCPATH_16_20) |>
select(PCH_SUPERCPATH_16_20)

```

```

##      PCH_SUPERCPATH_16_20
## 1      16.51542505
## 2      30.54981677

```

## 3	-4.51649887
## 4	32.12377610
## 5	-5.92115393
## 6	-1.92494095
## 7	0.59436029
## 8	18.09955735
## 9	49.00777732
## 10	33.74694950
## 11	-1.90787691
## 12	31.69608572
## 13	64.47690782
## 14	23.66512341
## 15	89.58867061
## 16	-3.16023211
## 17	35.31056016
## 18	-13.20971755
## 19	-6.40979486
## 20	10.95609599
## 21	567.54347430
## 22	92.58425762
## 23	-1.43603143
## 24	30.44394000
## 25	19.98870770
## 26	9.66137132
## 27	346.87119355
## 28	325.34127127
## 29	215.81397807
## 30	95.06712065
## 31	102.22260608
## 32	24.73234801
## 33	95.50281670
## 34	46.63734878
## 35	190.07681339
## 36	305.26945323
## 37	123.40514910
## 38	60.93941465
## 39	177.55145833
## 40	135.16938323
## 41	62.77950999
## 42	49.81288812
## 43	116.28829617
## 44	138.79272719
## 45	43.10420427
## 46	399.35340109
## 47	1773.46942242
## 48	249.48537418
## 49	221.69197032
## 50	306.74409612
## 51	33.00936575
## 52	35.00772691
## 53	310.31074150
## 54	193.94906123
## 55	49.04134389
## 56	144.83175955

## 57	168.42058976
## 58	194.32160348
## 59	4.44343100
## 60	16.74251508
## 61	37.68500762
## 62	21.48024960
## 63	7.16505482
## 64	192.41127587
## 65	33.04785015
## 66	15.08952519
## 67	28.43111290
## 68	21.36386265
## 69	-11.27392788
## 70	26.89547608
## 71	137.45738479
## 72	36.34056064
## 73	73.62640163
## 74	192.15649991
## 75	43.01723630
## 76	34.43058025
## 77	43.55023377
## 78	-8.55883696
## 79	-6.54989257
## 80	16.90095834
## 81	33.01313076
## 82	23.29279818
## 83	61.29540657
## 84	10.26681794
## 85	14.87177561
## 86	24.11425091
## 87	1.65474660
## 88	25.56928760
## 89	6.46651972
## 90	46.61016980
## 91	60.49947209
## 92	163.96232960
## 93	32.16653106
## 94	35.65037799
## 95	-2.48036666
## 96	26.91032689
## 97	-3.07960166
## 98	73.97526719
## 99	30.16167979
## 100	5.79843026
## 101	19.99922847
## 102	33.17044726
## 103	44.33589728
## 104	13.07629841
## 105	0.31099242
## 106	28.39021179
## 107	-8.80033964
## 108	46.57028976
## 109	-4.54474777
## 110	55.39118651

## 111	55.29989586
## 112	5.07454305
## 113	92.18277418
## 114	-1.90053188
## 115	0.62183652
## 116	52.04218399
## 117	47.62119654
## 118	20.04894511
## 119	-5.04135705
## 120	-7.56839872
## 121	29.03687816
## 122	49.93280482
## 123	-10.35077596
## 124	50.07423015
## 125	46.79345784
## 126	388.30283162
## 127	77.96343233
## 128	195.87972434
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## 558	-0.04381015
## 559	2.30770850
## 560	9.40977859
## 561	-0.42163488
## 562	2.76302075
## 563	1.72321332
## 564	4.58960295
## 565	-1.43679571
## 566	7.93626833
## 567	4.83993959
## 568	1.80709374
## 569	8.78467274
## 570	5.27596140
## 571	10.87668324
## 572	4.91527748
## 573	11.44066525
## 574	-1.42818058
## 575	10.16794205
## 576	15.22427940
## 577	17.56909943
## 578	13.49627209
## 579	15.19492435
## 580	-3.50019121
## 581	14.49812126
## 582	12.04676342

```
## 583      4.78192759
## 584     38.39988327
## 585     -3.25179172
## 586     21.52538300
## 587     23.41023445
## 588      9.14954472
## 589     29.93756485
## 590     38.08540344
## 591     14.33442783
## 592     13.00773430
## 593      6.19929171
## 594     10.35099602
```

```
mutate(atlaspc2, PCH_WICSPH_16_22 = PCH_WICSPH_16_22) |>
select(PCH_WICSPH_16_22)
```

```
##      PCH_WICSPH_16_22
## 1      -20.4221193
## 2      -7.3536209
## 3      -8.1640348
## 4     -34.5263194
## 5      -8.1722998
## 6      -9.4945766
## 7      -7.1801952
## 8       7.6496762
## 9     -20.0199382
## 10     -32.7861114
## 11     -8.5869486
## 12     -15.8930975
## 13     -1.7831437
## 14     -26.7456184
## 15     -1.4275310
## 16     -11.6022071
## 17     -10.2723181
## 18     -24.3031316
## 19     -26.4731933
## 20     -12.4658904
## 21     -17.0874984
## 22     -10.7990828
## 23     -10.3705133
## 24     -13.6314882
## 25      30.3970784
## 26     -20.6059602
## 27     -8.1799080
## 28     -4.3049411
## 29     -1.7288408
## 30     -24.8182468
## 31      12.2546060
## 32     -25.3220013
## 33     -19.4325650
## 34      11.9569450
## 35     -23.9023974
## 36      5.7903069
## 37     -23.6267521
## 38     -25.1691741
```

## 39	-18.8563170
## 40	-4.6238955
## 41	-6.6699623
## 42	-12.2180480
## 43	-13.7512894
## 44	-19.7262975
## 45	-23.0055534
## 46	-27.8124180
## 47	-17.3367607
## 48	-7.4751179
## 49	-2.3502339
## 50	-18.5210284
## 51	3.4849237
## 52	-10.8249561
## 53	5.6181276
## 54	-22.6980320
## 55	-31.2346574
## 56	-14.7987851
## 57	-15.8901638
## 58	0.1361245
## 59	-17.1874592
## 60	21.3447799
## 61	-4.4718189
## 62	-2.4982407
## 63	-8.9209817
## 64	-6.7895506
## 65	-20.1742911
## 66	-17.0405231
## 67	-18.6584160
## 68	-31.9210923
## 69	-10.5179196
## 70	-32.1039874
## 71	-24.9729963
## 72	3.7231234
## 73	12.7254331
## 74	-4.9992657
## 75	-23.0374606
## 76	-11.5938078
## 77	-7.0881232
## 78	-29.4745175
## 79	-3.4519306
## 80	-13.3490972
## 81	-2.6879723
## 82	-14.0465377
## 83	-0.9719124
## 84	-10.0823423
## 85	-14.2272230
## 86	-3.6987875
## 87	-10.6534689
## 88	-12.7528924
## 89	-17.1202426
## 90	-8.4609084
## 91	1.1122162
## 92	-6.3084899

## 93	-3.8037481
## 94	-6.9135145
## 95	-22.9713689
## 96	-5.7710837
## 97	-19.0687122
## 98	-10.9398873
## 99	-1.4371387
## 100	-8.9101174
## 101	7.1295423
## 102	6.3356436
## 103	-2.1135510
## 104	-0.6587048
## 105	-11.0390044
## 106	-17.0507475
## 107	-28.4384005
## 108	-10.8685495
## 109	-30.2504501
## 110	-13.2485513
## 111	-8.0190461
## 112	-32.5103989
## 113	-8.1872208
## 114	-32.8839664
## 115	-42.1420799
## 116	7.5973787
## 117	-14.5104101
## 118	-15.1289581
## 119	-27.3911281
## 120	-7.9023466
## 121	-3.6860443
## 122	-10.9879980
## 123	-29.4494380
## 124	-13.1527423
## 125	-14.9857653
## 126	-10.8032866
## 127	-3.6255377
## 128	-5.5096663
## 129	-9.7850178
## 130	-28.1043415
## 131	-22.1792032
## 132	-24.4979925
## 133	-23.7773974
## 134	-10.6378029
## 135	6.0066849
## 136	-8.5670438
## 137	-4.1142259
## 138	29.9413915
## 139	-12.5973085
## 140	-31.4063007
## 141	5.6000737
## 142	-7.5076282
## 143	15.9705127
## 144	-6.3424638
## 145	0.8180667
## 146	-12.0890481

## 147	-8.3480825
## 148	-14.0310037
## 149	-26.5185429
## 150	-13.4487449
## 151	-5.1098478
## 152	-8.1931690
## 153	-8.9371413
## 154	-8.4307090
## 155	-44.3611400
## 156	-16.5922188
## 157	-30.7732077
## 158	-2.5144893
## 159	-16.7565567
## 160	-42.1996031
## 161	-34.9428053
## 162	-15.0293403
## 163	11.3661305
## 164	16.1069970
## 165	-10.9800811
## 166	-26.3828803
## 167	-20.4302773
## 168	3.2250090
## 169	-10.6568560
## 170	-18.2526122
## 171	-30.3475089
## 172	1.3583540
## 173	-17.8799963
## 174	-12.0333217
## 175	-17.4116102
## 176	-6.9356553
## 177	-21.3438002
## 178	-12.3528443
## 179	-18.5941830
## 180	-12.6438944
## 181	-2.3023836
## 182	-3.1529043
## 183	-1.3403693
## 184	2.5609325
## 185	-11.2248221
## 186	-11.1399716
## 187	-18.9034606
## 188	-27.4846053
## 189	-24.4531174
## 190	-23.0958039
## 191	-10.0137722
## 192	-22.3638904
## 193	-37.8843202
## 194	-3.6422569
## 195	13.4186632
## 196	5.5721200
## 197	-0.5139931
## 198	6.3379090
## 199	-39.5591501
## 200	-3.3769893

## 201	-22.7066265
## 202	-48.3068453
## 203	-56.5776638
## 204	33.0039985
## 205	-4.6225509
## 206	-14.5933258
## 207	-11.0357278
## 208	-20.0830154
## 209	-4.9951032
## 210	7.8077919
## 211	48.3277275
## 212	-12.4495139
## 213	-30.5066158
## 214	-35.9450060
## 215	-24.0094461
## 216	-1.6375315
## 217	-35.7148010
## 218	-31.1654229
## 219	-28.2415072
## 220	-22.5811276
## 221	-30.7637820
## 222	-31.0409547
## 223	-23.5955797
## 224	-22.2118965
## 225	-48.1862848
## 226	-11.0944708
## 227	-70.1067739
## 228	-0.9167754
## 229	-4.4963967
## 230	-14.1311536
## 231	-25.3938131
## 232	-25.1041631
## 233	-1.9233891
## 234	-4.0589086
## 235	6.5581414
## 236	-4.3227407
## 237	-23.2015850
## 238	-19.3085405
## 239	-25.0021205
## 240	-16.4991121
## 241	-46.1567398
## 242	-16.4532026
## 243	-43.1337607
## 244	-35.3365928
## 245	0.7723650
## 246	-54.3900509
## 247	-23.4569127
## 248	189.8107989
## 249	-31.5299224
## 250	-16.4667776
## 251	-18.2664648
## 252	-8.7020840
## 253	-6.4840129
## 254	74.1197307

## 255	-35.5682357
## 256	-9.4179498
## 257	4.1573688
## 258	-15.4473941
## 259	-44.8016733
## 260	-15.3345840
## 261	-19.4971403
## 262	-17.3862491
## 263	-26.0460021
## 264	-17.4968397
## 265	7.5896581
## 266	-2.4254463
## 267	3.0646214
## 268	-12.2723876
## 269	-17.8334035
## 270	-22.5613006
## 271	-18.6162551
## 272	-23.2508737
## 273	-2.4516326
## 274	31.6652651
## 275	-6.0630898
## 276	-7.4096101
## 277	-3.7905163
## 278	1802.4853341
## 279	-6.1235701
## 280	-11.8654207
## 281	7.5237464
## 282	-14.8720214
## 283	-58.1285108
## 284	-10.7767189
## 285	-4.5920957
## 286	24.6931679
## 287	-18.0636525
## 288	-20.3718943
## 289	-6.4997486
## 290	7.7979910
## 291	-2.8120316
## 292	-10.6219885
## 293	11.6088817
## 294	1.5399990
## 295	22.6711221
## 296	8.2882710
## 297	-26.7618831
## 298	-1.5164253
## 299	0.7724131
## 300	-21.5718944
## 301	-1.1338352
## 302	-5.5105316
## 303	-31.5102481
## 304	-33.5049782
## 305	-28.1553607
## 306	-23.2240547
## 307	-17.9336677
## 308	-8.4357344

## 309	22.4407898
## 310	-27.1684971
## 311	-18.7627545
## 312	-3.4753660
## 313	-28.4208803
## 314	-17.4962376
## 315	-14.7983323
## 316	-26.5732681
## 317	-9.1154873
## 318	-15.8752656
## 319	-18.8691548
## 320	-9.7793774
## 321	-25.2189972
## 322	-2.4093498
## 323	-1.4801279
## 324	-11.2706884
## 325	6.5126159
## 326	-7.5893246
## 327	-18.8655278
## 328	7.2850377
## 329	-4.9842812
## 330	-33.2317841
## 331	4.4791407
## 332	13.7225278
## 333	-12.4971142
## 334	-3.7542255
## 335	-0.3914167
## 336	-39.1248035
## 337	-17.0248421
## 338	-31.1085631
## 339	-13.8677429
## 340	-18.5745302
## 341	-21.0050436
## 342	3.8342841
## 343	-3.7999237
## 344	-18.7728587
## 345	-11.0796827
## 346	2.0976446
## 347	-0.6113997
## 348	-28.2582793
## 349	-2.4010831
## 350	2.6309016
## 351	10.2045068
## 352	-38.6649846
## 353	23.4531445
## 354	10.9130800
## 355	10.7535356
## 356	18.5877788
## 357	-24.3988505
## 358	-35.3201377
## 359	-9.2861258
## 360	-35.3733386
## 361	-26.9964876
## 362	-15.5424084

## 363	-35.2689074
## 364	-20.9698889
## 365	-7.5201315
## 366	-30.4371895
## 367	-20.4714419
## 368	-26.2457294
## 369	-20.9419350
## 370	-5.2956890
## 371	-17.0462404
## 372	-19.4388119
## 373	-14.7185312
## 374	-6.2923675
## 375	-15.6737037
## 376	-15.7200321
## 377	-4.2974481
## 378	-24.1650911
## 379	-12.1220147
## 380	-14.8945396
## 381	-3.7826368
## 382	-18.5718028
## 383	-39.8219297
## 384	37.9301282
## 385	-20.2268223
## 386	-41.6878767
## 387	-32.6983658
## 388	-23.3940229
## 389	-25.0089267
## 390	-14.7947205
## 391	-21.6005941
## 392	-24.5073748
## 393	-38.9788208
## 394	-7.6153404
## 395	-14.9731722
## 396	-5.9677414
## 397	-22.9850761
## 398	-13.2295936
## 399	-14.5389814
## 400	-18.5625317
## 401	-5.2163679
## 402	-23.0230300
## 403	-6.2421252
## 404	-8.8923382
## 405	-20.1982924
## 406	-36.0461201
## 407	-23.4908894
## 408	1.1105668
## 409	21.7907289
## 410	6.4987233
## 411	27.4839116
## 412	-8.5342244
## 413	-23.5433977
## 414	17.5528013
## 415	-19.5065624
## 416	4.4337301

## 417	-23.4963285
## 418	-18.7752131
## 419	1.0660517
## 420	-31.7623908
## 421	42.3172132
## 422	-26.6878253
## 423	-13.0464721
## 424	-18.4441077
## 425	-0.7353730
## 426	1.8337779
## 427	-28.1181147
## 428	-30.1477962
## 429	-16.9345633
## 430	-11.1802468
## 431	-24.2948689
## 432	-43.2923751
## 433	-3.3674884
## 434	-19.1134619
## 435	-49.6915872
## 436	0.3233212
## 437	-16.4871920
## 438	-5.9980260
## 439	-6.6716707
## 440	-28.7082172
## 441	-41.1047494
## 442	-21.2471400
## 443	-13.9198655
## 444	-32.7374622
## 445	4.9128275
## 446	-12.2098997
## 447	-27.3533164
## 448	-8.7485540
## 449	-61.0949450
## 450	-14.7748782
## 451	-21.5313392
## 452	-25.9894111
## 453	-6.4432703
## 454	-19.7025101
## 455	-19.8893325
## 456	-67.0771703
## 457	-0.6497115
## 458	-34.9997812
## 459	-17.6570543
## 460	-13.0119722
## 461	-17.5821257
## 462	5.3692621
## 463	-42.6491926
## 464	2.1716551
## 465	9.2296498
## 466	-20.4974881
## 467	-30.4600777
## 468	-16.3607394
## 469	-27.6516704
## 470	-15.7882020

## 471	-27.5833687
## 472	10.2341531
## 473	-21.0994933
## 474	-24.3906210
## 475	-31.3864385
## 476	9.6983483
## 477	37.4388421
## 478	-26.7036434
## 479	-7.3166677
## 480	-18.7896325
## 481	-8.8128370
## 482	-9.9103807
## 483	-9.6428975
## 484	1.5987930
## 485	-15.5466427
## 486	-10.7599140
## 487	-16.8919666
## 488	-21.4620613
## 489	-21.7260196
## 490	-28.7100538
## 491	23.7025801
## 492	-23.3568216
## 493	-16.1034330
## 494	-24.2297695
## 495	-17.9678940
## 496	-5.4547611
## 497	-6.8034913
## 498	-17.9617536
## 499	0.8137699
## 500	-35.4448537
## 501	1.1202804
## 502	-31.7060448
## 503	-5.6215420
## 504	-17.8777018
## 505	-7.0320231
## 506	-32.2028678
## 507	-1.3097447
## 508	-24.3182230
## 509	-18.0707283
## 510	9.1590629
## 511	-50.0740693
## 512	-17.8670400
## 513	13.5178761
## 514	-0.5629217
## 515	-6.8284330
## 516	-8.0145010
## 517	-34.5356153
## 518	11.1594635
## 519	-28.4659651
## 520	95.2618126
## 521	-81.8214841
## 522	-20.4472486
## 523	-3.2433083
## 524	2.1540418

## 525	0.2243176
## 526	-18.0566158
## 527	-11.3865776
## 528	-10.9287895
## 529	19.7105498
## 530	-58.7345299
## 531	-6.5195837
## 532	-17.0791126
## 533	-38.8053328
## 534	-26.0913660
## 535	-9.4758030
## 536	-21.6445523
## 537	-21.4601649
## 538	-20.7409331
## 539	-51.0942260
## 540	-93.1174968
## 541	-14.6367064
## 542	-83.4334605
## 543	-3.9257737
## 544	-20.9637872
## 545	-75.0305228
## 546	-48.3503154
## 547	-13.6824986
## 548	-0.3458292
## 549	-17.9039283
## 550	25.4707048
## 551	19.3770097
## 552	-7.6679263
## 553	-0.8155591
## 554	58.5184563
## 555	-8.0527070
## 556	-14.4104936
## 557	1.2963130
## 558	-15.0788147
## 559	-17.4337714
## 560	-7.0212684
## 561	-33.6785482
## 562	-23.2960715
## 563	-26.5417841
## 564	-25.9631039
## 565	-6.9547416
## 566	-33.5994251
## 567	-20.8866925
## 568	-16.4631565
## 569	-32.6366853
## 570	-29.7622049
## 571	-17.8080807
## 572	9.1796373
## 573	-20.6219749
## 574	15.5486284
## 575	43.3059606
## 576	-1.8019437
## 577	-8.9238678
## 578	-35.7238139

```
## 579      -23.2808495
## 580      -13.7302869
## 581      -31.6729437
## 582      -39.0105640
## 583       -4.6230280
## 584      -4.4907109
## 585     -34.6075321
## 586      -8.2796065
## 587       2.7841759
## 588     -14.3370808
## 589      -2.0032909
## 590      -8.2345708
## 591     -12.1077195
## 592      -9.2489424
## 593     -14.5287548
## 594     -12.8141307
```

```
mutate(atlaspc2, PCH_FFRPTH_16_20 = PCH_FFRPTH_16_20) |>
select(PCH_FFRPTH_16_20)
```

```
##      PCH_FFRPTH_16_20
## 1      -0.082217810
## 2       2.132723912
## 3     -3.050058848
## 4       7.466878513
## 5       2.554422868
## 6      15.238194594
## 7      17.360082207
## 8      16.087377144
## 9       3.753566313
## 10     4.968951206
## 11     2.681228625
## 12     8.989863453
## 13     2.541064523
## 14     3.002646973
## 15     1.787364216
## 16     14.021007239
## 17     3.472288658
## 18     -2.689679643
## 19     -5.736484480
## 20     6.109128374
## 21     10.810955199
## 22     10.048144227
## 23     0.910728405
## 24     4.465115866
## 25     2.902945071
## 26     -1.086177468
## 27     5.602449832
## 28     5.662300108
## 29     10.095634229
## 30     12.609730999
## 31    -12.439702858
## 32     6.567431904
## 33     6.181041657
## 34     13.135925782
```

## 35	7.374752446
## 36	6.678069422
## 37	-0.907198894
## 38	9.350406482
## 39	1.470980300
## 40	-0.299450654
## 41	7.448801563
## 42	8.570278337
## 43	7.981149232
## 44	3.106261952
## 45	3.591881005
## 46	11.394217192
## 47	-0.609887834
## 48	9.431873989
## 49	-0.337395156
## 50	9.239844993
## 51	4.663099865
## 52	-0.119679725
## 53	11.390203219
## 54	4.140427085
## 55	7.781310675
## 56	6.835674825
## 57	3.197974668
## 58	0.688972268
## 59	-0.271032142
## 60	-3.291362904
## 61	4.089286463
## 62	-6.382188282
## 63	6.510479839
## 64	-2.529572573
## 65	-3.993059228
## 66	-0.623798876
## 67	13.259303699
## 68	-4.740816067
## 69	0.371368146
## 70	17.930036780
## 71	15.551034010
## 72	3.798361650
## 73	-9.040265033
## 74	6.778013420
## 75	9.379964767
## 76	-4.601727518
## 77	1.769659620
## 78	-7.371289366
## 79	11.173397385
## 80	10.748271317
## 81	9.112338068
## 82	3.261448946
## 83	10.161334768
## 84	11.121589623
## 85	1.074750238
## 86	-11.918921398
## 87	-2.106477042
## 88	-0.648478633

## 89	7.953921524
## 90	4.134324852
## 91	4.001303890
## 92	-10.546095370
## 93	3.186491931
## 94	10.148590965
## 95	25.708904157
## 96	2.133551481
## 97	18.409531734
## 98	8.542556147
## 99	13.600940318
## 100	12.369761177
## 101	13.521993145
## 102	4.808733628
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select(PCH_FSRPTH_16_20)
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## 384	59.94291151
## 385	110.43478261
## 386	30.94629156
## 387	57.24020443
## 388	20.54140127
## 389	17.69759450
## 390	91.25248509
## 391	-15.89861751
## 392	8.88888889
## 393	-17.83625731
## 394	1.98412698
## 395	83.52534562
## 396	85.28006947
## 397	-16.01532567
## 398	0.11668611
## 399	253.20855615
## 400	35.20000000
## 401	0.07347539
## 402	59.80392157
## 403	-29.30374904
## 404	49.25531915

## 405	51.30568356
## 406	118.18181818
## 407	-17.43589744
## 408	139.72602740
## 409	316.92307692
## 410	492.43243243
## 411	-10.61007958
## 412	4.77732794
## 413	87.28787411
## 414	-40.90909091
## 415	-31.13207547
## 416	-5.94059406
## 417	87.55506608
## 418	166.32595116
## 419	302.03679369
## 420	39.35052531
## 421	6.13718412
## 422	76.52898422
## 423	-67.22365039
## 424	-2.23438212
## 425	-11.02871568
## 426	-39.76884686
## 427	941.95338513
## 428	35.33558075
## 429	812.59899208
## 430	157.52293578
## 431	69.00072939
## 432	145.20817935
## 433	-17.15145436
## 434	160.07822686
## 435	9.05644482
## 436	192.50197316
## 437	235.77981651
## 438	-38.46153846
## 439	294.94186047
## 440	1293.57541899
## 441	-70.58823529
## 442	76.93905817
## 443	56.44067797
## 444	124.87930480
## 445	17.26618705
## 446	435.37581699
## 447	65.86941927
## 448	71.24582870
## 449	162.22775358
## 450	-13.66711773
## 451	-0.08298755
## 452	103.50378788
## 453	27.52941176
## 454	232.37250554
## 455	21.72797263
## 456	94.44444444
## 457	-55.75268817
## 458	18.62999481

## 459	82.32356135
## 460	53.50877193
## 461	-23.82608696
## 462	51.95195195
## 463	-59.12698413
## 464	-2.25118483
## 465	-24.10714286
## 466	-30.57119871
## 467	79.26829268
## 468	-88.24101069
## 469	156.88073394
## 470	-7.81250000
## 471	17.20720721
## 472	280.43478261
## 473	37.47826087
## 474	-44.28571429
## 475	-53.54330709
## 476	169.76744186
## 477	21.94092827
## 478	631.49606299
## 479	-37.46556474
## 480	43.56617647
## 481	892.45283019
## 482	101.66666667
## 483	33.56643357
## 484	-25.96685083
## 485	46.34146341
## 486	128.92561983
## 487	110.52631579
## 488	101.98675497
## 489	10.73318216
## 490	-28.40375587
## 491	-48.00000000
## 492	-16.08695652
## 493	-53.40909091
## 494	-89.12037037
## 495	-31.46853147
## 496	-37.50000000
## 497	66.96035242
## 498	259.74025974
## 499	-62.87128713
## 500	29.57198444
## 501	4.16666667
## 502	-17.32673267
## 503	-41.05960265
## 504	76.21951220
## 505	131.39534884
## 506	-23.33333333
## 507	-31.84615385
## 508	978.24074074
## 509	200.65847234
## 510	-4.90797546
## 511	26.16279070
## 512	-61.90476190

## 513	80.17241379
## 514	694.52054795
## 515	-54.86284289
## 516	361.53846154
## 517	-46.22425629
## 518	38.29787234
## 519	129.50000000
## 520	-84.09090909
## 521	11.36363636
## 522	-45.45454545
## 523	-31.25000000
## 524	-44.56721915
## 525	614.04958678
## 526	-35.55555556
## 527	10.52631579
## 528	757.49385749
## 529	-48.25174825
## 530	7.14285714
## 531	-21.66666667
## 532	57.73710483
## 533	374.54545455
## 534	-34.79359730
## 535	126.28062361
## 536	-45.83602324
## 537	-32.57142857
## 538	37.43409490
## 539	63.93144638
## 540	52.54041570
## 541	705.93406593
## 542	55.69620253
## 543	395.36507937
## 544	17.71653543
## 545	-0.87209302
## 546	320.83333333
## 547	32.82442748
## 548	0.00000000
## 549	0.00000000
## 550	0.00000000
## 551	0.00000000
## 552	0.00000000
## 553	0.00000000
## 554	0.00000000
## 555	295.23809524
## 556	135.49883991
## 557	-1.65484634
## 558	199.51456311
## 559	28.95365504
## 560	-33.37378641
## 561	-40.49751244
## 562	74.87666034
## 563	13.08056872
## 564	94.13008990
## 565	174.49297972
## 566	147.46963563

```
## 567      -31.66157872
## 568       7.43398393
## 569     523.87706856
## 570      89.13043478
## 571      6.37989367
## 572    -50.66666667
## 573     14.14141414
## 574   -23.85321101
## 575     67.02127660
## 576     28.24175824
## 577     37.15549507
## 578     31.65938865
## 579    -8.41784990
## 580     14.47368421
## 581    103.63036304
## 582     77.35849057
## 583   -57.94947994
## 584   -11.79883946
## 585     70.45075125
## 586     30.90803260
## 587      9.24242424
## 588     84.75894246
## 589   -14.49399657
## 590     44.06229721
## 591     30.45454545
## 592     58.71559633
## 593    135.67839196
## 594    110.14492754
```

```
cor(atlaspc2)
```

```
##          PCH_LACCESS_POP_15_19 PCH_GROCPATH_16_20
## PCH_LACCESS_POP_15_19      1.000000000      -0.084206775
## PCH_GROCPATH_16_20      -0.084206775      1.000000000
## PCH_SUPERCPATH_16_20      0.018425037      0.008091590
## PCH_CONVSPTH_16_20      -0.001400242     -0.119616952
## PCH_SPECSPTH_16_20      0.006932067     -0.063737757
## PCH_SNAPSPATH_17_23     -0.004985344      0.098718445
## PCH_WICSPATH_16_22     -0.032020566     -0.005017603
## PCH_FFRPTH_16_20      -0.109084416      0.061274962
## PCH_FSRPTH_16_20       0.141752309      0.013515837
## PCH_PC_DIRSALES_12_17   -0.041513549      0.050895256
##          PCH_SUPERCPATH_16_20 PCH_CONVSPTH_16_20 PCH_SPECSPTH_16_20
## PCH_LACCESS_POP_15_19      0.018425037     -0.001400242      0.006932067
## PCH_GROCPATH_16_20      0.008091590     -0.119616952     -0.063737757
## PCH_SUPERCPATH_16_20      1.000000000      0.147948020     -0.007705825
## PCH_CONVSPTH_16_20      0.147948020      1.000000000      0.026224555
## PCH_SPECSPTH_16_20     -0.007705825      0.026224555      1.000000000
## PCH_SNAPSPATH_17_23      0.037958390     -0.007140006      0.040959877
## PCH_WICSPATH_16_22     -0.022902150      0.023093921     -0.039133197
## PCH_FFRPTH_16_20      -0.016784759     -0.043905615      0.034036418
## PCH_FSRPTH_16_20      -0.029449275      0.080128354      0.047073748
## PCH_PC_DIRSALES_12_17      0.067257365      0.020570372     -0.025135601
##          PCH_SNAPSPATH_17_23 PCH_WICSPATH_16_22 PCH_FFRPTH_16_20
## PCH_LACCESS_POP_15_19     -0.004985344     -0.032020566     -0.10908442
```

```
## PCH_GROCPATH_16_20      0.098718445      -0.005017603      0.06127496
## PCH_SUPERCPATH_16_20    0.037958390      -0.022902150      -0.01678476
## PCH_CONVSPATH_16_20     -0.007140006      0.023093921      -0.04390562
## PCH_SPECSPTH_16_20      0.040959877      -0.039133197      0.03403642
## PCH_SNAPSPATH_17_23     1.000000000      -0.020451183      0.02622866
## PCH_WICSPATH_16_22      -0.020451183      1.000000000      -0.02190272
## PCH_FFRPTH_16_20        0.026228664      -0.021902718      1.00000000
## PCH_FSRPTH_16_20        0.048516764      0.007131612      -0.08847977
## PCH_PC_DIRSALES_12_17   -0.048479520      -0.032939935      0.05535931
## PCH_FSRPTH_16_20 PCH_PC_DIRSALES_12_17
## PCH_LACCESS_POP_15_19   0.141752309      -0.04151355
## PCH_GROCPATH_16_20      0.013515837      0.05089526
## PCH_SUPERCPATH_16_20    -0.029449275      0.06725736
## PCH_CONVSPATH_16_20     0.080128354      0.02057037
## PCH_SPECSPTH_16_20      0.047073748      -0.02513560
## PCH_SNAPSPATH_17_23     0.048516764      -0.04847952
## PCH_WICSPATH_16_22      0.007131612      -0.03293993
## PCH_FFRPTH_16_20        -0.088479766      0.05535931
## PCH_FSRPTH_16_20        1.000000000      -0.03822234
## PCH_PC_DIRSALES_12_17   -0.038222337      1.00000000
```

```
mshapiro.test(t(atlaspc2[,1:9]))
```

```
##
## Shapiro-Wilk normality test
##
## data: Z
## W = 0.13286, p-value < 2.2e-16
```

```
atlaspc2_long <- atlaspc2 |>
```

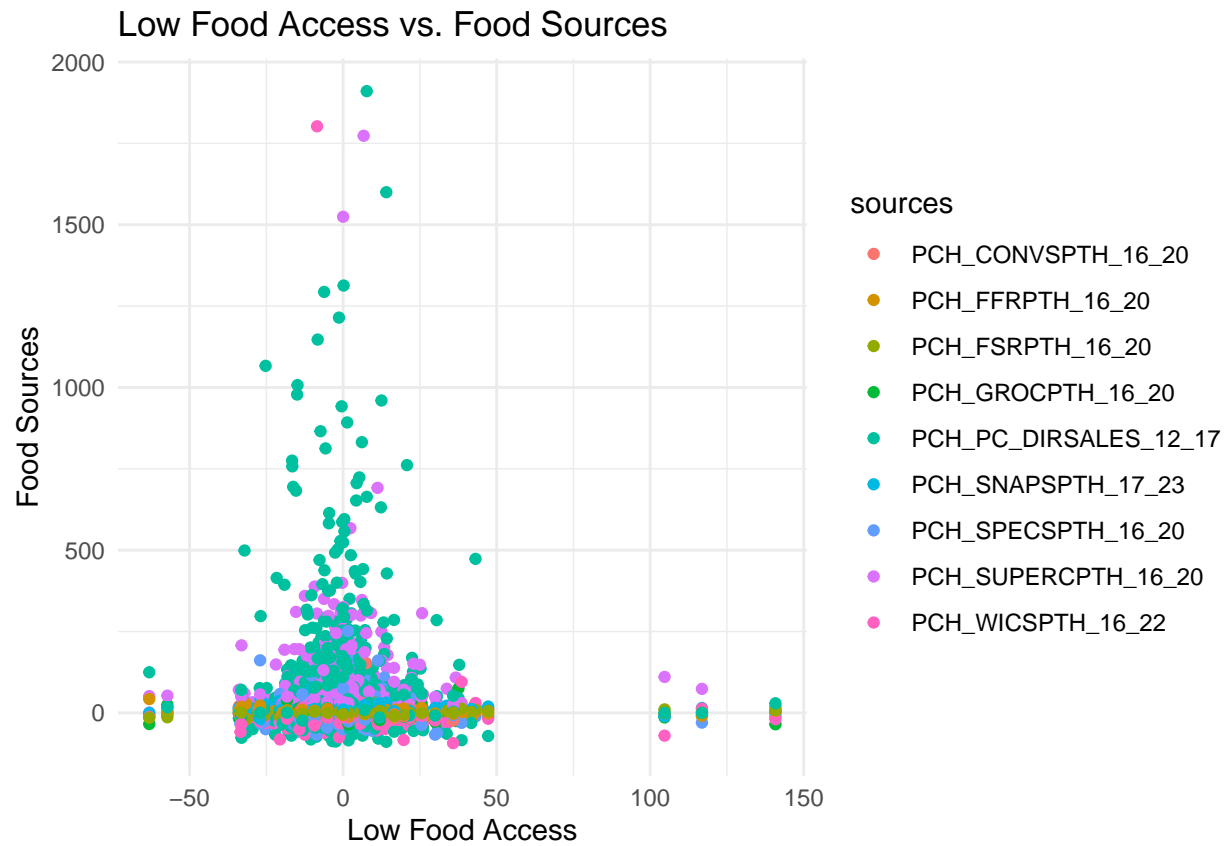
```
  pivot_longer(cols = c("PCH_GROCPATH_16_20", "PCH_SUPERCPATH_16_20", "PCH_CONVSPATH_16_20", "PCH_SPECSPTH_16_20",
    names_to = "sources",
    values_to = "food"))
```

```
atlaspc2_long
```

```
## # A tibble: 5,346 x 3
##   PCH_LACCESS_POP_15_19 sources      food
##   <dbl> <chr>      <dbl>
## 1 -1.32 PCH_GROCPATH_16_20 -9.38
## 2 -1.32 PCH_SUPERCPATH_16_20 16.5
## 3 -1.32 PCH_CONVSPATH_16_20 -9.38
## 4 -1.32 PCH_SPECSPTH_16_20 -2.66
## 5 -1.32 PCH_SNAPSPATH_17_23 3.40
## 6 -1.32 PCH_WICSPATH_16_22 -20.4
## 7 -1.32 PCH_FFRPTH_16_20 -0.0822
## 8 -1.32 PCH_FSRPTH_16_20 -5.54
## 9 -1.32 PCH_PC_DIRSALES_12_17 79.0
## 10 -8.19 PCH_GROCPATH_16_20 -2.09
## # i 5,336 more rows
```

```
options(repr.plot.width = NULL, repr.plot.height = NULL)
ggplot(atlaspc2_long, aes(x = PCH_LACCESS_POP_15_19, y = food, color = sources)) +
  geom_point() +
  labs(title = "Low Food Access vs. Food Sources",
    x = "Low Food Access",
    y = "Food Sources") +
```

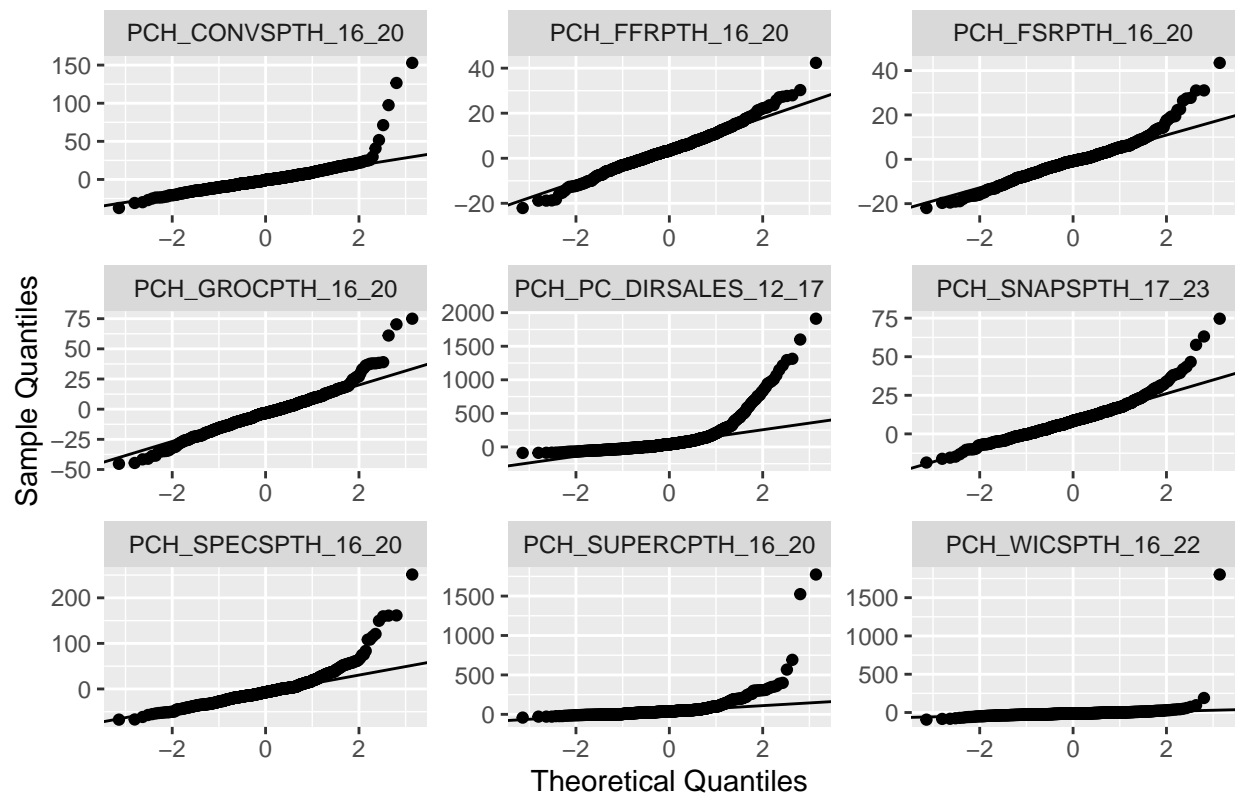
```
theme_minimal()
```



```
options(repr.plot.width = 8, repr.plot.height = 3)

ggplot(atlaspc2_long, aes(sample = food)) +
  stat_qq() +
  stat_qq_line() +
  facet_wrap(~sources, scales = "free") +
  labs(title = "Q-Q Plots for Food Sources",
       x = "Theoretical Quantiles", y = "Sample Quantiles")
```

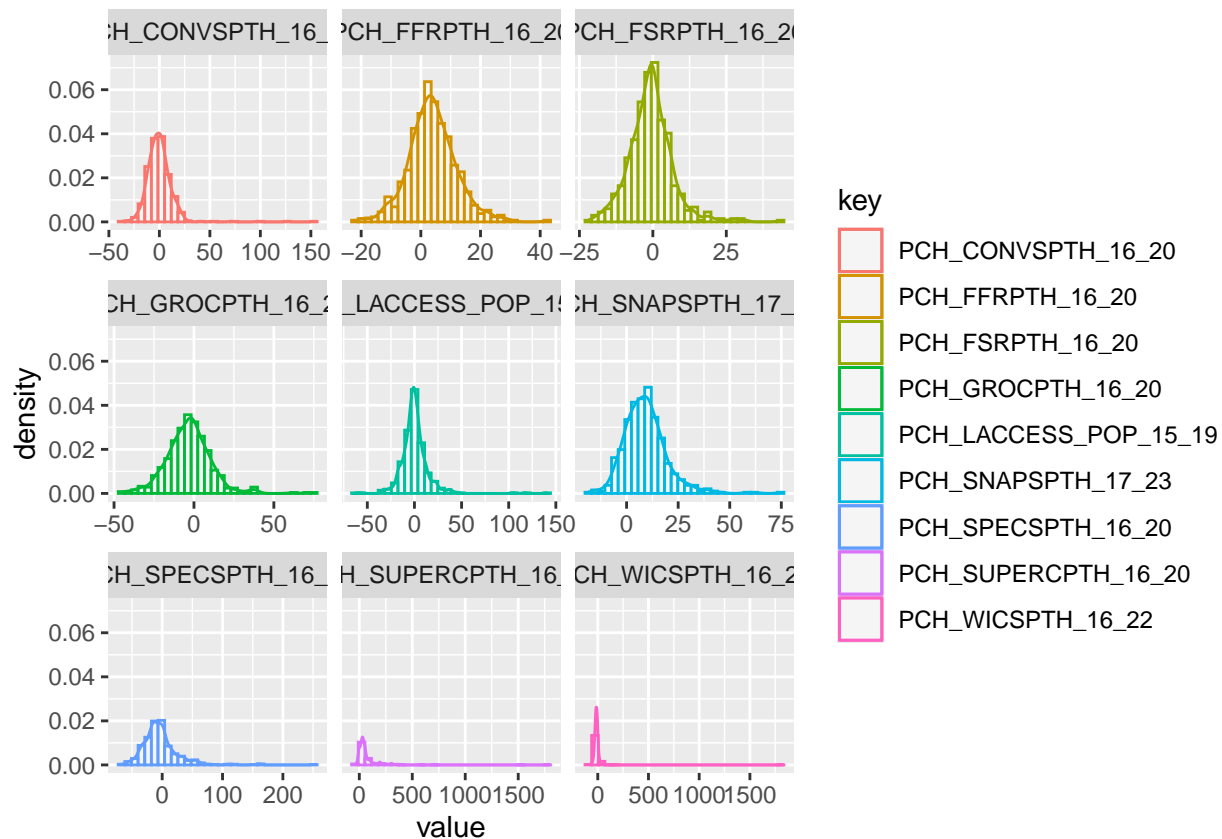
## Q-Q Plots for Food Sources



```
options(repr.plot.width = 8, repr.plot.height = 3)
```

```
d <- gather(atlaspc2[,c(1:9)])
ggplot(d, aes(x = value, color=key)) +
  facet_wrap(~key, scales = "free_x") +
  geom_histogram(aes(y=after_stat(density)), alpha=0.5,
    position="identity", fill="white")+
  geom_density(alpha=.2)
```

```
## `stat_bin()` using `bins = 30`. Pick better value `binwidth`.
```



```
pcmodel <- lm(PCH_LACCESS_POP_15_19 ~ ., data = atlaspc2)
pcmodel
```

```
##
## Call:
## lm(formula = PCH_LACCESS_POP_15_19 ~ ., data = atlaspc2)
##
## Coefficients:
##      (Intercept)      PCH_GROCPH_16_20      PCH_SUPERCPH_16_20
##           0.811170          -0.087606           0.003371
##      PCH_CONVSPH_16_20      PCH_SPECSPTH_16_20      PCH_SNAPSPH_17_23
##          -0.030915          -0.001288          -0.006356
##      PCH_WICSPH_16_22      PCH_FFRPTH_16_20      PCH_FSRPTH_16_20
##          -0.006885          -0.171426           0.275960
## PCH_PC_DIRSALES_12_17
##          -0.001984
```

```
predict(pcmodel, newdata=data.frame(PCH_GROCPH_16_20=1, PCH_SUPERCPH_16_20=1, PCH_CONVSPH_16_20=1, PCH_FFRPTH_16_20=1, PCH_FSRPTH_16_20=1, PCH_SNAPSPH_17_23=1, PCH_SPECSPTH_16_20=1, PCH_WICSPH_16_22=1, PCH_PC_DIRSALES_12_17=1))
```

```
##           1
## 0.7840411
```

```
summary(pcmodel)
```

```
##
## Call:
## lm(formula = PCH_LACCESS_POP_15_19 ~ ., data = atlaspc2)
##
```

```
## Residuals:
##      Min       1Q   Median       3Q      Max
## -55.850  -6.839  -1.093   4.933 135.044
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      0.811170   0.987088   0.822 0.411537
## PCH_GROCPATH_16_20 -0.087606   0.043835  -1.999 0.046120 *
## PCH_SUPERCPATH_16_20  0.003371   0.005105   0.660 0.509348
## PCH_CONVSPTH_16_20  -0.030915   0.044485  -0.695 0.487365
## PCH_SPECSPTH_16_20  -0.001288   0.019792  -0.065 0.948144
## PCH_SNAPSPTH_17_23  -0.006356   0.059314  -0.107 0.914704
## PCH_WICSPATH_16_22  -0.006885   0.007928  -0.868 0.385538
## PCH_FFRPTH_16_20    -0.171426   0.076598  -2.238 0.025598 *
## PCH_FSRPTH_16_20     0.275960   0.082413   3.348 0.000865 ***
## PCH_PC_DIRSALES_12_17 -0.001984   0.002735  -0.726 0.468319
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14.85 on 584 degrees of freedom
## Multiple R-squared:  0.03932,    Adjusted R-squared:  0.02451
## F-statistic: 2.656 on 9 and 584 DF,  p-value: 0.005046
```

```
confint(pcmodel)
```

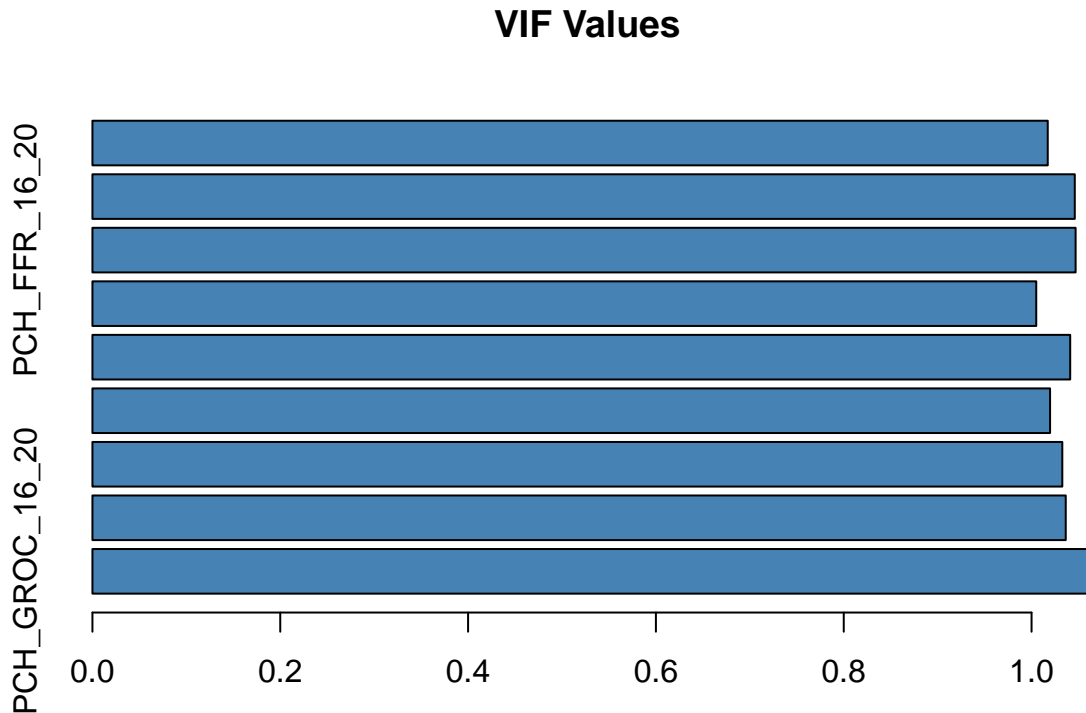
```
##              2.5 %      97.5 %
## (Intercept)   -1.127503890  2.749844070
## PCH_GROCPATH_16_20 -0.173699347 -0.001512995
## PCH_SUPERCPATH_16_20 -0.006655960  0.013397398
## PCH_CONVSPTH_16_20 -0.118284205  0.056455076
## PCH_SPECSPTH_16_20 -0.040160353  0.037584775
## PCH_SNAPSPTH_17_23 -0.122850914  0.110139426
## PCH_WICSPATH_16_22 -0.022456220  0.008686580
## PCH_FFRPTH_16_20   -0.321867890 -0.020984265
## PCH_FSRPTH_16_20    0.114097906  0.437821843
## PCH_PC_DIRSALES_12_17 -0.007355228  0.003386331
```

```
anova(pcmodel)
```

```
## Analysis of Variance Table
##
## Response: PCH_LACCESS_POP_15_19
##              Df Sum Sq Mean Sq F value    Pr(>F)
## PCH_GROCPATH_16_20      1      951    951.05   4.3105 0.0383149 *
## PCH_SUPERCPATH_16_20      1       49     48.97   0.2219 0.6377481
## PCH_CONVSPTH_16_20      1       29     28.54   0.1293 0.7192410
## PCH_SPECSPTH_16_20      1        1      0.54   0.0024 0.9607049
## PCH_SNAPSPTH_17_23      1        1      0.86   0.0039 0.9503561
## PCH_WICSPATH_16_22      1      133    133.48   0.6050 0.4369922
## PCH_FFRPTH_16_20        1     1485   1485.09   6.7309 0.0097133 **
## PCH_FSRPTH_16_20        1     2509   2508.65  11.3701 0.0007957 ***
## PCH_PC_DIRSALES_12_17    1      116    116.19   0.5266 0.4683191
## Residuals              584  128852    220.64
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Assumptions: testing linearity, independence, homoskedasticity, etc.

```
#create vector of VIF values
vif_values <- vif(model)
barplot(vif_values, main = "VIF Values", horiz = TRUE, col = "steelblue") #create horizontal bar chart
#add vertical line at 5 as after 5 there is severe correlation
abline(v = 5, lwd = 3, lty = 2)
```



```
# independent variables
data_x <- atlas2[,1:3]
# independent variables correlation matrix
var <- cor(data_x)
## or solve independent variables inverse correlation matrix
var_inv <- ginv(var)
# rename the row names and column names
colnames(var_inv) <- colnames(data_x)
rownames(var_inv) <- colnames(data_x)
var_inv
```

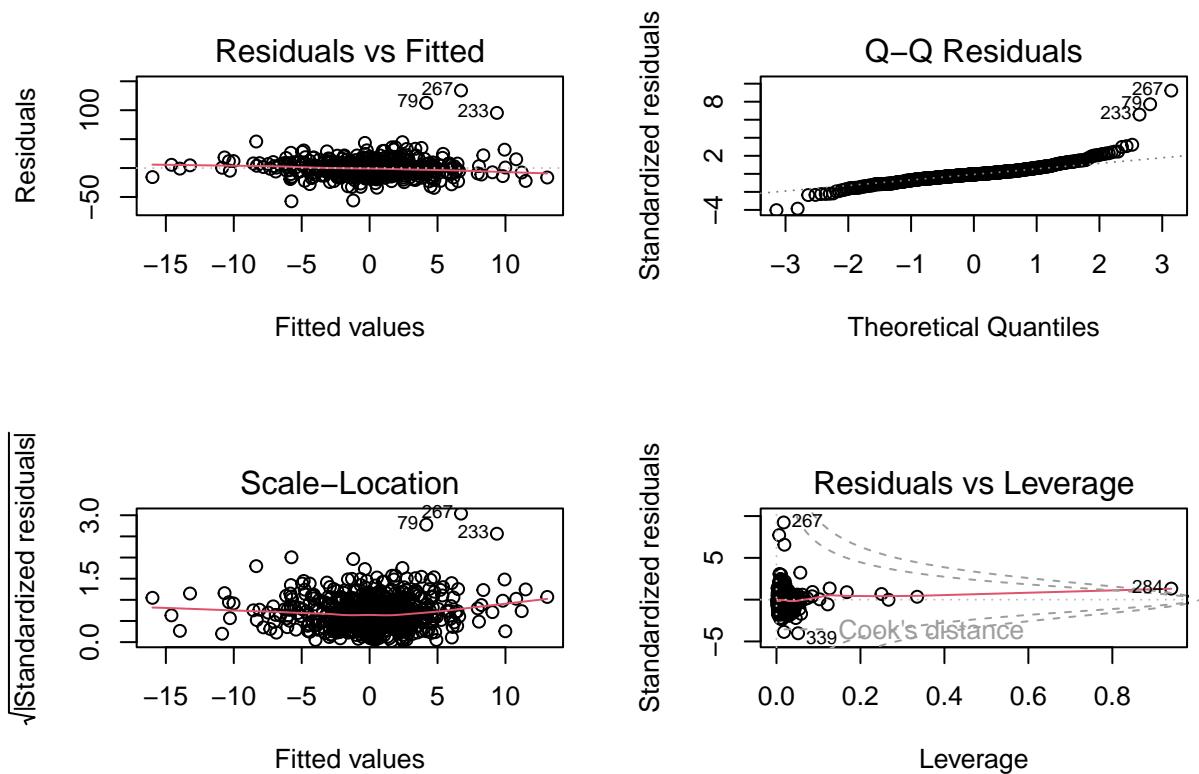
```
##               PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_SUPER_16_20
## PCH_LACCESS_POP_15_19             1.016762202    0.13018761   -0.006190331
## PCH_GROC_16_20                   0.130187605    1.01787972    0.034018141
## PCH_SUPER_16_20                  -0.006190331    0.03401814    1.001248013
```

```
model.arg <- augment(model, se_fit = TRUE)
head(model.arg)
```

```
## # A tibble: 6 x 17
```

```
## PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_SUPER_16_20 PCH_CONVS_16_20
## <dbl> <dbl> <dbl> <dbl>
## 1 -1.32 0 28.6 0
## 2 -8.19 0 33.3 2.82
## 3 -0.0797 5.61 -5.26 1.09
## 4 10.3 0 33.3 18.4
## 5 -3.73 -2.17 0 -7.83
## 6 -4.41 4.55 0 -9.46
## # i 13 more variables: PCH_SPECS_16_20 <dbl>, PCH_SNAPS_17_23 <dbl>,
## # PCH_WICS_16_22 <dbl>, PCH_FFR_16_20 <dbl>, PCH_FSR_16_20 <dbl>,
## # PCH_DIRSALES_12_17 <dbl>, .fitted <dbl>, .se.fit <dbl>, .resid <dbl>,
## # .hat <dbl>, .sigma <dbl>, .cooksd <dbl>, .std.resid <dbl>
```

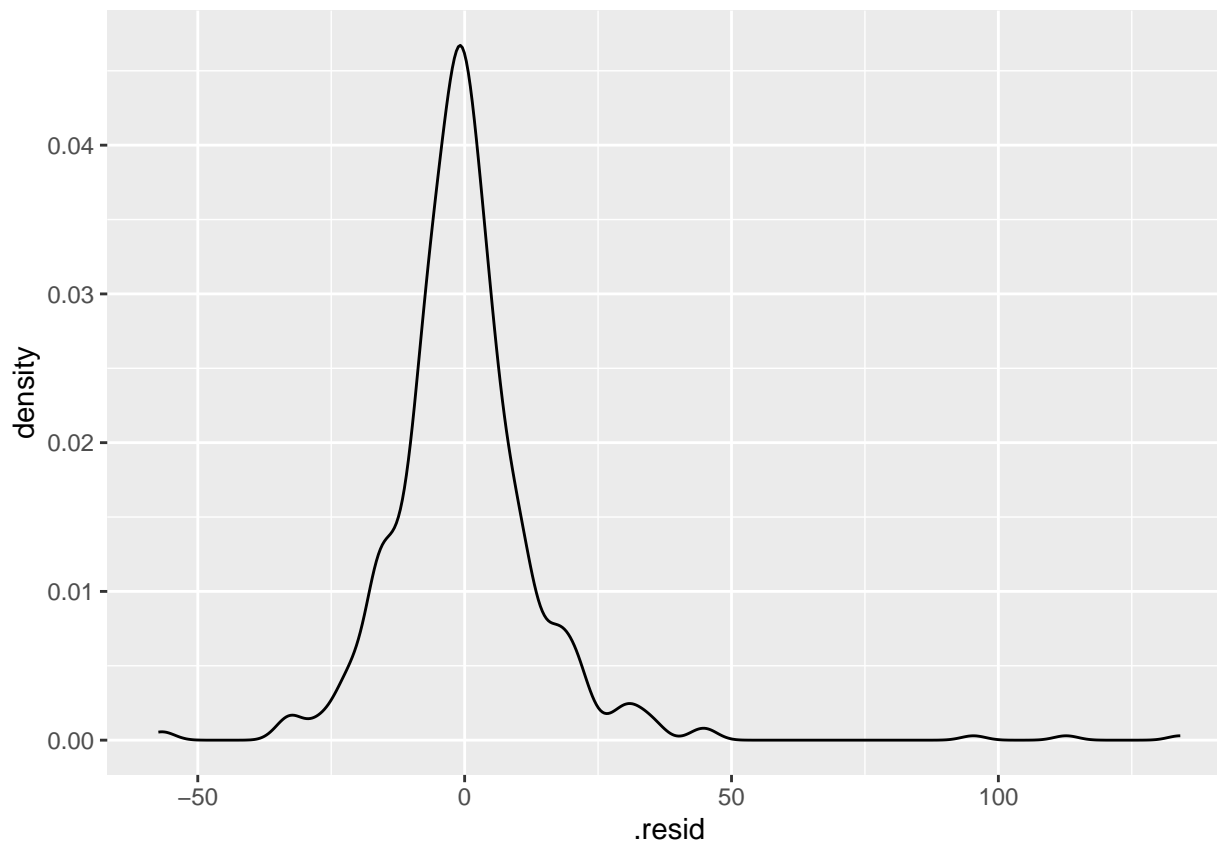
```
par(mfrow = c(2, 2))
plot(model)
```



```
mshapiro.test(t(model.arg$.resid))
```

```
##
## Shapiro-Wilk normality test
##
## data: Z
## W = 0.82313, p-value < 2.2e-16
```

```
ggplot(model.arg) +
  geom_density(aes(x=.resid))
```



```
# Add observations indices and
# drop some columns (.se.fit, .sigma) for simplification
model.arg %>%
  mutate(index = 1:nrow(model.arg)) %>%
  filter(index %in% c(6,76,131))

## # A tibble: 3 x 18
##   PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_SUPER_16_20 PCH_CONVS_16_20
##   <dbl> <dbl> <dbl> <dbl>
## 1 -4.41 4.55 0 -9.46
## 2 -0.875 -7.14 33.3 7.27
## 3 4.47 0 50 -1.69
## # i 14 more variables: PCH_SPECS_16_20 <dbl>, PCH_SNAPS_17_23 <dbl>,
## # PCH_WICS_16_22 <dbl>, PCH_FFR_16_20 <dbl>, PCH_FSR_16_20 <dbl>,
## # PCH_DIRSALES_12_17 <dbl>, .fitted <dbl>, .se.fit <dbl>, .resid <dbl>,
## # .hat <dbl>, .sigma <dbl>, .cooksd <dbl>, .std.resid <dbl>, index <int>

# again for model2
vif_values2 <- vif(model2)
barplot(vif_values2, main = "VIF Values", horiz = TRUE, col = "steelblue")
abline(v = 5, lwd = 3, lty = 2)
data_x2 <- atlas3[,1:3]
var2 <- cor(data_x2)
var_inv2 <- ginv(var2)
colnames(var_inv2) <- colnames(data_x2)
rownames(var_inv2) <- colnames(data_x2)
var_inv2
```

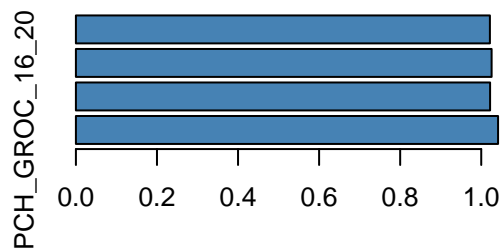
```
##           PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_CONVS_16_20
## PCH_LACCESS_POP_15_19           1.02068363      0.1373672      0.06337882
## PCH_GROC_16_20                 0.13736716      1.0289901      0.11154921
## PCH_CONVS_16_20                0.06337882      0.1115492      1.01443818
```

```
model2.arg <- augment(model2, se_fit = TRUE)
head(model2.arg)
```

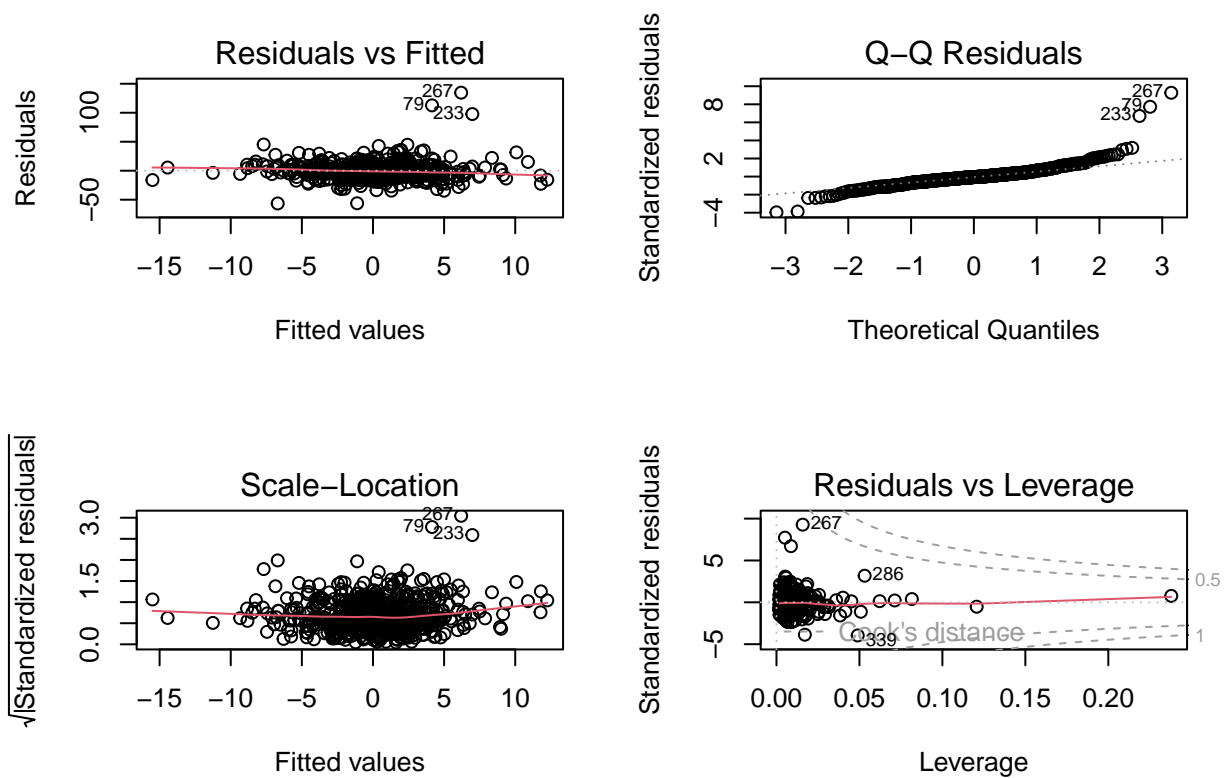
```
## # A tibble: 6 x 12
##   PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_CONVS_16_20 PCH_FFR_16_20
##           <dbl>           <dbl>           <dbl>           <dbl>
## 1          -1.32             0             0             10.3
## 2          -8.19             0             2.82            4.31
## 3         -0.0797            5.61            1.09           -3.81
## 4           10.3             0            18.4            8.45
## 5          -3.73            -2.17           -7.83            9.01
## 6          -4.41            4.55           -9.46           17.5
## # i 8 more variables: PCH_FSR_16_20 <dbl>, .fitted <dbl>, .se.fit <dbl>,
## #   .resid <dbl>, .hat <dbl>, .sigma <dbl>, .cooksd <dbl>, .std.resid <dbl>
```

```
par(mfrow = c(2, 2))
```

### VIF Values



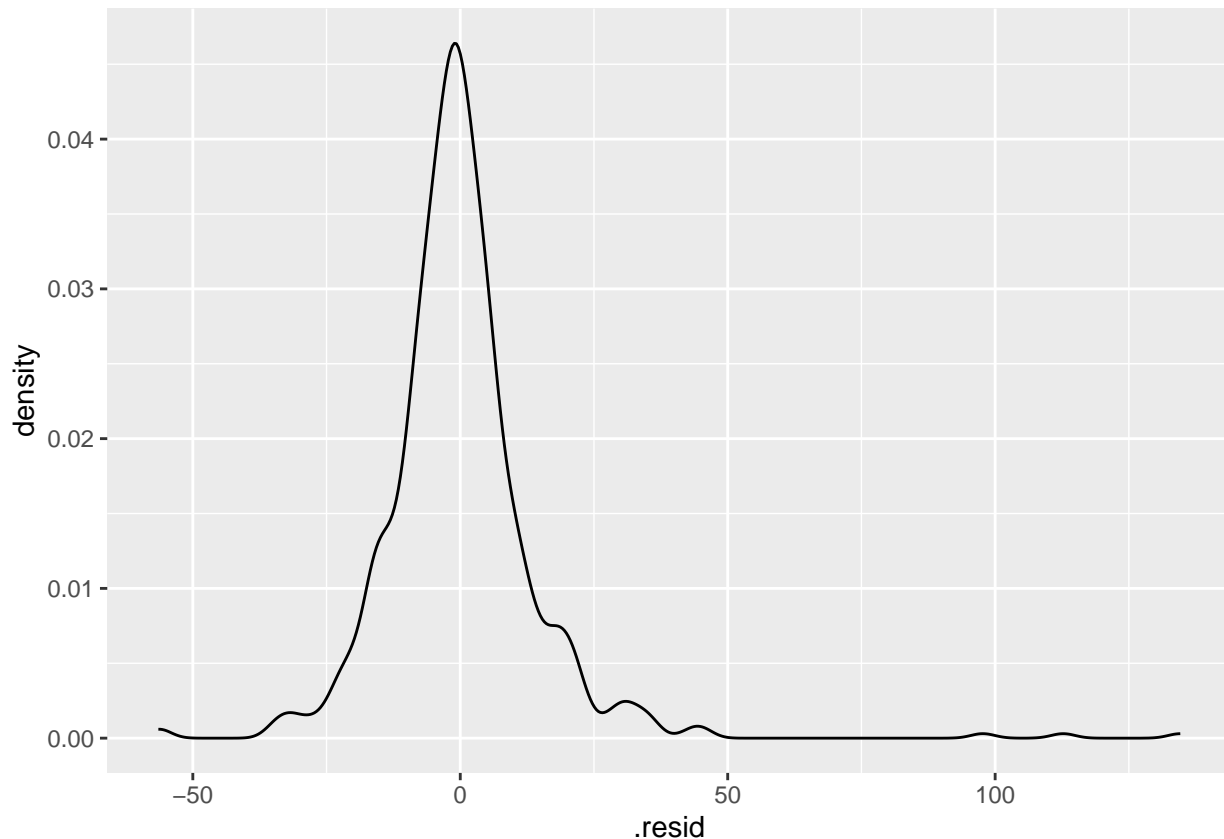
```
plot(model2)
```



```
mshapiro.test(t(model2.arg$resid))
```

```
##
##  Shapiro-Wilk normality test
##
## data:  Z
## W = 0.82107, p-value < 2.2e-16
```

```
ggplot(model2.arg) +
  geom_density(aes(x=.resid))
```



```
model2.arg %>%
  mutate(index = 1:nrow(model2.arg)) %>%
  filter(index %in% c(6,76,131))
```

```
## # A tibble: 3 x 13
##   PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_CONVS_16_20 PCH_FFR_16_20
##   <dbl> <dbl> <dbl> <dbl>
## 1 -4.41 4.55 -9.46 17.5
## 2 -0.875 -7.14 7.27 23.9
## 3 4.47 0 -1.69 19.2
## # i 9 more variables: PCH_FSR_16_20 <dbl>, .fitted <dbl>, .se.fit <dbl>,
## #   .resid <dbl>, .hat <dbl>, .sigma <dbl>, .cooksd <dbl>, .std.resid <dbl>,
## #   index <int>
```

```
# again for pmodel
pcvif_values <- vif(pmodel)
barplot(pcvif_values, main = "VIF Values", horiz = TRUE, col = "steelblue")
abline(v = 5, lwd = 3, lty = 2)
pcdata_x <- atlaspc2[,1:3]
pcvar <- cor(pcdata_x)
pcvar_inv <- ginv(pcvar)
colnames(pcvar_inv) <- colnames(pcdata_x)
rownames(pcvar_inv) <- colnames(pcdata_x)
pcvar_inv
```

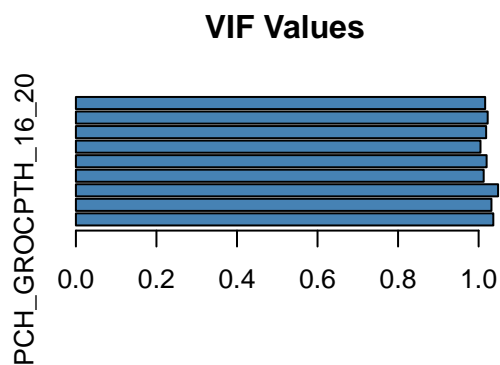
```
##               PCH_LACCESS_POP_15_19 PCH_GROCPH_16_20
## PCH_LACCESS_POP_15_19      1.00751187      0.084995097
```

```
## PCH_GROCPATH_16_20          0.08499510      1.007235782
## PCH_SUPERCPATH_16_20       -0.01925119      -0.009716176
##                PCH_SUPERCPATH_16_20
## PCH_LACCESS_POP_15_19      -0.019251188
## PCH_GROCPATH_16_20         -0.009716176
## PCH_SUPERCPATH_16_20        1.000433323
```

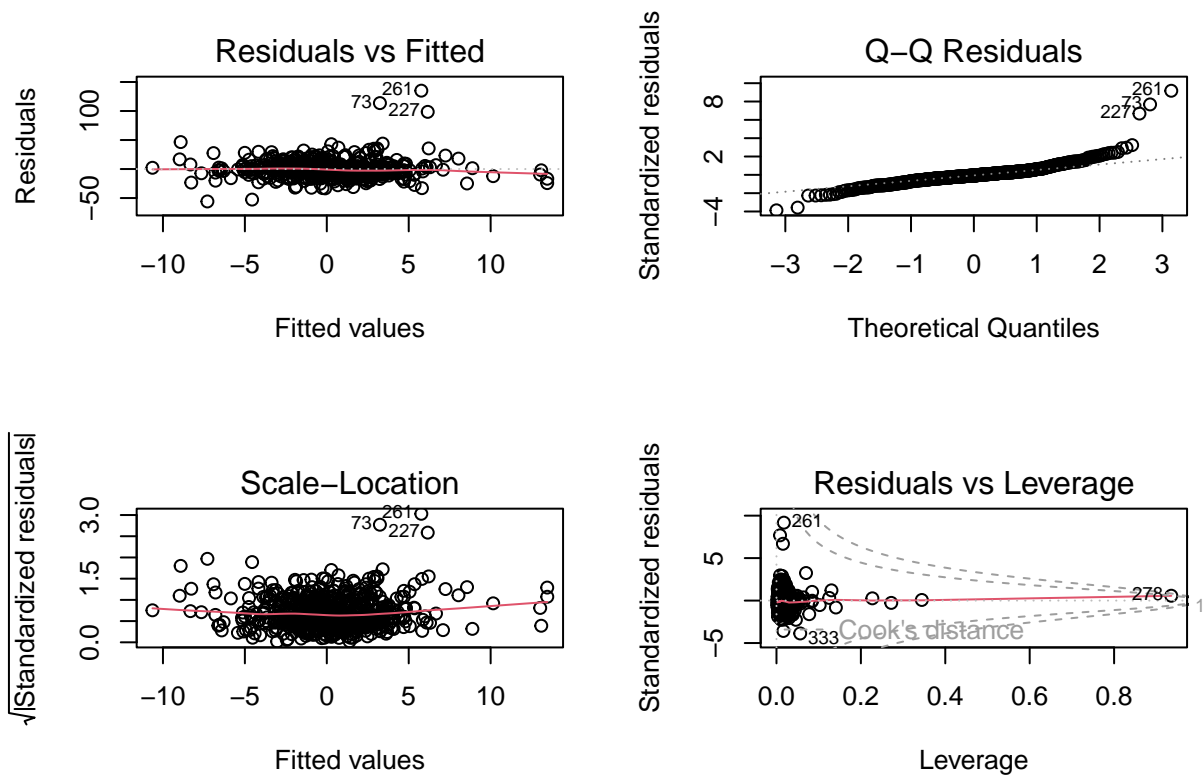
```
pcmodel.arg <- augment(pcmodel, se_fit = TRUE)
head(pcmodel.arg)
```

```
## # A tibble: 6 x 17
##   PCH_LACCESS_POP_15_19 PCH_GROCPATH_16_20 PCH_SUPERCPATH_16_20 PCH_CONVSPATH_16_20
##   <dbl>                <dbl>                <dbl>                <dbl>
## 1          -1.32          -9.38             16.5             -9.38
## 2          -8.19          -2.09             30.5              0.670
## 3         -0.0797          6.44             -4.52             1.89
## 4          10.3          -0.907            32.1             17.3
## 5          -3.73          -7.97             -5.92            -13.3
## 6          -4.41           2.53             -1.92            -11.2
## # i 13 more variables: PCH_SPECSPTH_16_20 <dbl>, PCH_SNAPSPATH_17_23 <dbl>,
## #   PCH_WICSPATH_16_22 <dbl>, PCH_FFRPTH_16_20 <dbl>, PCH_FSRPTH_16_20 <dbl>,
## #   PCH_PC_DIRSALES_12_17 <dbl>, .fitted <dbl>, .se.fit <dbl>, .resid <dbl>,
## #   .hat <dbl>, .sigma <dbl>, .cooksd <dbl>, .std.resid <dbl>
```

```
par(mfrow = c(2, 2))
```



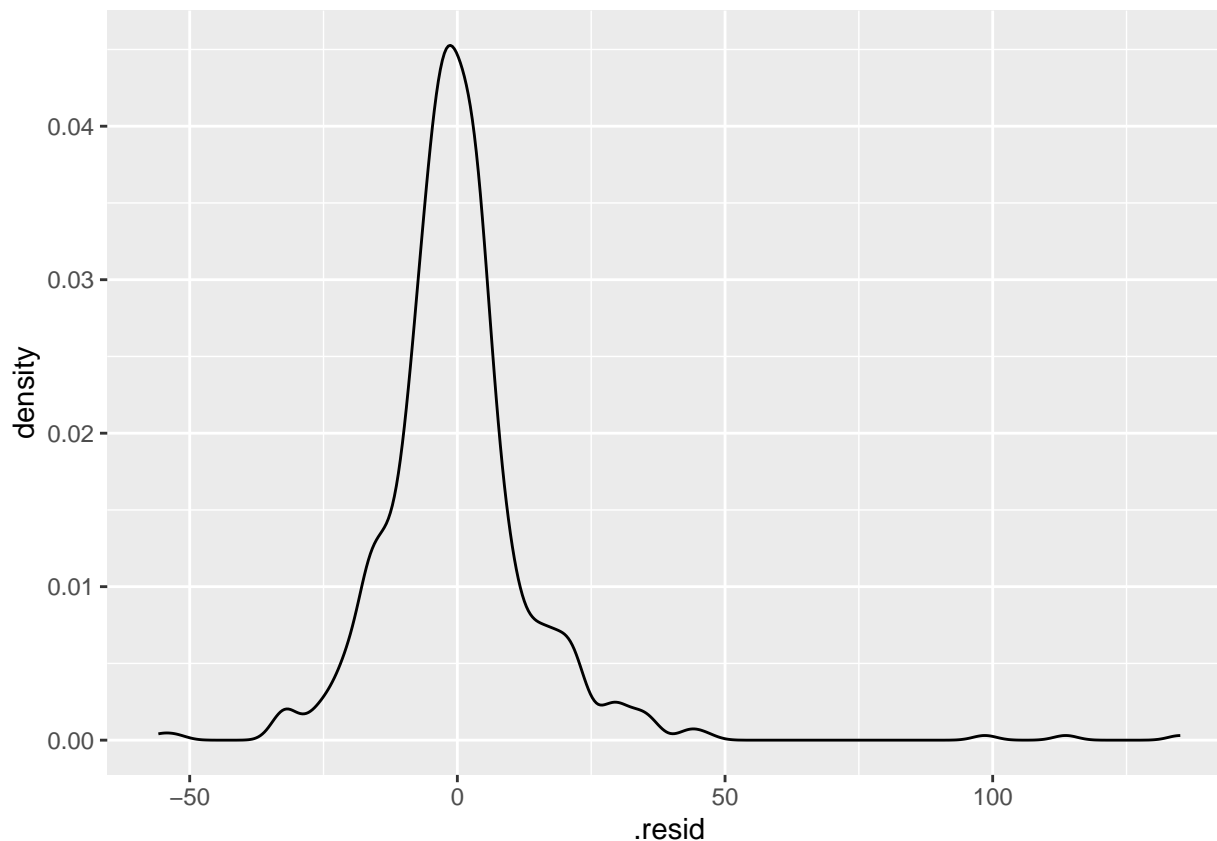
```
plot(pcmodel)
```



```
mshapiro.test(t(pcmmodel.arg$.resid))
```

```
##
##  Shapiro-Wilk normality test
##
## data:  Z
## W = 0.82102, p-value < 2.2e-16
```

```
ggplot(pcmmodel.arg) +
  geom_density(aes(x=.resid))
```



```
pcmodel.arg %>%
  mutate(index = 1:nrow(pcmodel.arg)) %>%
  filter(index %in% c(6,76,131))
```

```
## # A tibble: 3 x 18
##   PCH_LACCESS_POP_15_19 PCH_GROCPATH_16_20 PCH_SUPERCPATH_16_20 PCH_CONVSPATH_16_20
##   <dbl> <dbl> <dbl> <dbl>
## 1 -4.41 2.53 -1.92 -11.2
## 2 -2.67 -0.363 34.4 -3.20
## 3 -2.61 10.2 14.8 -2.18
## # i 14 more variables: PCH_SPECSPTH_16_20 <dbl>, PCH_SNAPSPTH_17_23 <dbl>,
## # PCH_WICSPATH_16_22 <dbl>, PCH_FFRPTH_16_20 <dbl>, PCH_FSRPTH_16_20 <dbl>,
## # PCH_PC_DIRSALES_12_17 <dbl>, .fitted <dbl>, .se.fit <dbl>, .resid <dbl>,
## # .hat <dbl>, .sigma <dbl>, .cooksd <dbl>, .std.resid <dbl>, index <int>
```

For models 1 and 2 and the per capita model, the VIF looks to be slightly higher than 1, suggesting moderate multicollinearity. The Residual v. Fitted Plot suggests linearity because there is a horizontal line without any distinct patterns. The Normal Q-Q Plot suggests that the residuals are normally distributed because they follow the red line. The Scale-Location suggests that we have homoscedasticity because there is a horizontal line with equally spread points.

Results, interpretation, and insights:

Comparing the first and second models, the first model's Shapiro-Wilk test had a W of 0.12859 with a significant p-value, so we cannot say that the data are multivariate normal. The second model's W is much closer to 1 at 0.74753 with a significant p-value, so we can say that the data are multivariate normal.

In the first model, the intercept for grocery stores was -.109 with a p-value of .00842, the intercept for

convenience stores was  $-.072$  with a p-value of  $.09752$ , the intercept for fast food was  $-.267$  with a p-value of  $8.33e-05$ , and the intercept for full-service restaurants was  $.140$  with a p-value of  $.06602$ . In the second model, the intercept for grocery stores was  $-.116$  with a p-value of  $.00442$ , the intercept for convenience stores was  $-.0737$  with a p-value of  $.08702$ , the intercept for fast food was  $-.275$  with a p-value of  $4.02e-05$ , and the intercept for full-service restaurants was  $.132$  with a p-value of  $.07825$ .

The first model had a residual standard error of  $14.65$  on  $590$  df, an adjusted  $R^2$  of  $.04206$ —very low. Its F-statistic was  $3.922$  with a p-value of  $7.339e-05$ . (Need to fix code for second model) The second model had a residual standard error of  $14.63$  on  $595$  df, an adjusted  $R^2$  of  $.04503$ —again, very low. Its F-statistic was  $8.061$  with a p-value of  $2.476e-06$ .

For the per capita variables, the model's Shapiro-Wilk test had a  $W$  of  $0.13286$  with a significant p-value, so we cannot say that the data are multivariate normal. The intercept for grocery stores was  $-.088$  with a p-value of  $.046$ , the intercept for fast food was  $-.171$  with a p-value of  $.026$ , and the intercept for full service restaurants was  $.276$  with a p-value of  $.000865$ . The first model had a residual standard error of  $14.85$  on  $584$  df, an adjusted  $R^2$  of  $.0245$ —even lower. Its F-statistic was  $2.656$  with a p-value of  $.005$ . I am deciding against using the per capita models for now.