Lab 9

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11:59PM May 10, 2021

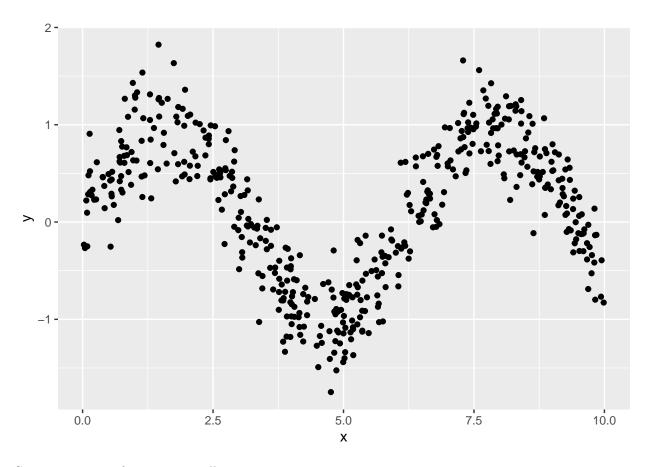
Here we will learn about trees, bagged trees and random forests. You can use the YARF package if it works, otherwise, use the randomForest package (the standard).

Let's take a look at the simulated sine curve data from practice lecture 12. Below is the code for the data generating process:

```
rm(list = ls())
n = 500
sigma = 0.3
x_min = 0
x_max = 10
f_x = function(x){sin(x)}
y_x = function(x, sigma){f_x(x) + rnorm(n, 0, sigma)}
x_train = runif(n, x_min, x_max)
y_train = y_x(x_train, sigma)
```

Plot an example dataset of size 500:

```
pacman::p_load(ggplot2)
ggplot(data.frame(x=x_train, y=y_train))+
  geom_point(aes(x=x,y=y))
```



Create a test set of size 500 as well

```
x_test=runif(n, x_min, x_max)
y_test=y_x(x_test,sigma)
```

Locate the optimal node size hyperparameter for the regression tree model. I believe you can use randomForest here by setting ntree = 1, replace = FALSE, sampsize = n (mtry is already set to be 1 because there is only one feature) and then you can set nodesize. Plot node size by out of sample SE.

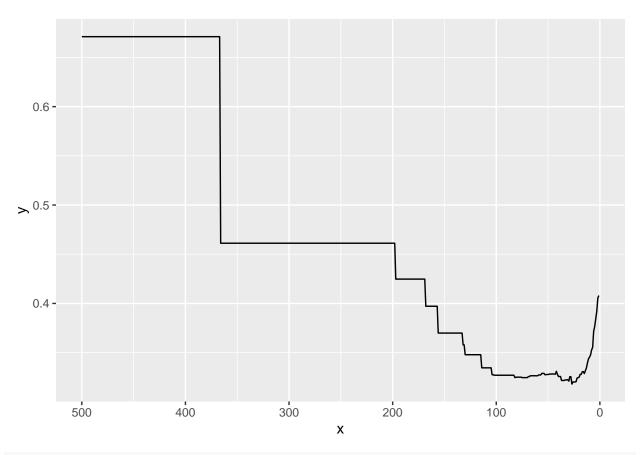
```
pacman::p_load(randomForest)

node_sizes=1:n

SE_by_node_sizes = array(NA, length(node_sizes))

for (i in 1:length(node_sizes)){
    rf_mod = randomForest(data.frame(x=x_train), y=y_train, ntree=1, replace=FALSE, sampsize=n, nodesize=:
    y_hat_test=predict(rf_mod,data.frame(x=x_test))
    SE_by_node_sizes[i]=sd(y_test - y_hat_test)
}

ggplot(data.frame(x=node_sizes, y=SE_by_node_sizes))+
    geom_line(aes(x=x, y=y))+
    scale_x_reverse()
```



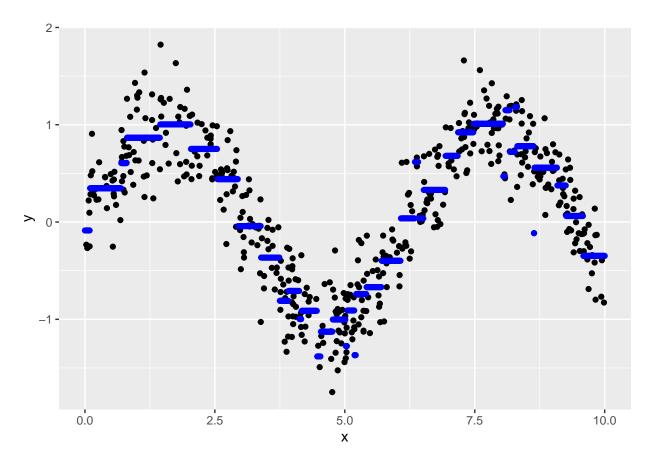
which.min(SE_by_node_sizes)

[1] 27

Plot the regression tree model with the optimal node size.

```
rf_mod = randomForest(data.frame(x=x_train), y=y_train, ntree=1, replace=FALSE, sampsize=n, nodesize=no
resolution = 0.01
x_grid = seq(from = x_min, to = x_max, by=resolution)
g_x = predict(rf_mod,data.frame(x=x_grid))

ggplot(data.frame(x=x_grid, y=g_x))+
    aes(x=x, y=y)+
    geom_point(data=data.frame(x=x_train, y=y_train))+
    geom_point(color= "blue")
```



Provide the bias-variance decomposition of this DGP fit with this model. It is a lot of code, but it is in the practice lectures. If your three numbers don't add up within two significant digits, increase your resolution.

```
#SKIP
```

```
rm(list = ls())
```

Take a sample of n = 2000 observations from the diamonds data.

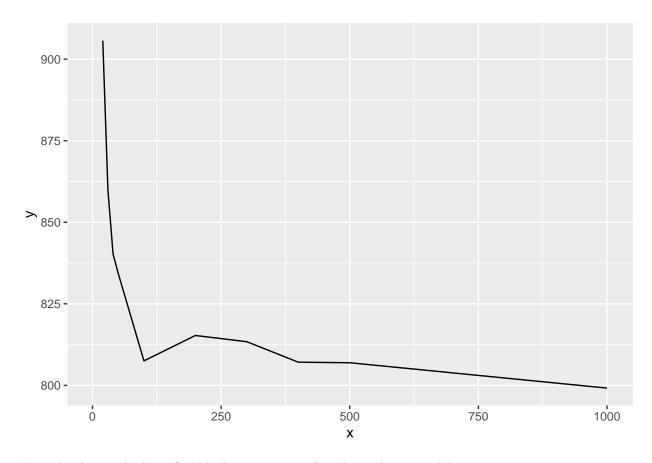
```
pacman::p_load(dplyr)
diamonds_samp = diamonds %>%
sample_n(2000)
```

find the bootstrap s_e for a RF model using 1, 2, 5, 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000 trees. If you are using the randomForest package, you can calculate oob residuals via e_oob = y_train - rf_mod\$predicted. Plot it.

```
num_trees = c(1, 2, 5, 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000)
oob_SE_by_num_trees = array(NA, length(num_trees))
for (i in 1:length(num_trees)){
    rf_mod= randomForest(price ~. , data=diamonds_samp, ntree=num_trees[i])
    oob_SE_by_num_trees[i]=sd(diamonds_samp$price - rf_mod$predicted)
}

ggplot(data.frame(x=num_trees, y=oob_SE_by_num_trees))+
    geom_line(aes(x=x, y=y))
```

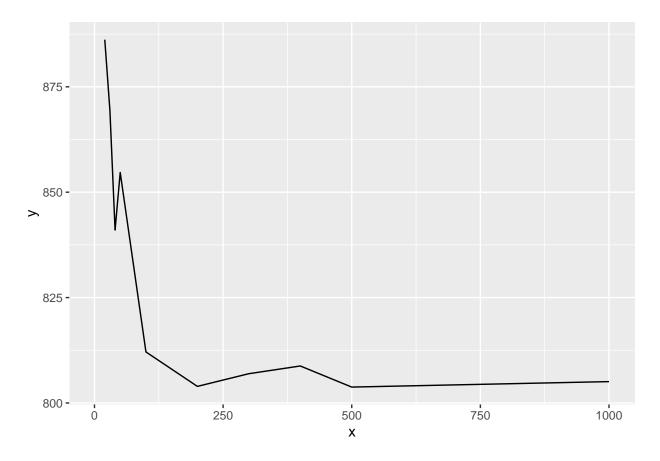
Warning: Removed 4 row(s) containing missing values (geom_path).



Using the diamonds data, find the bootstrap s_e for a bagged-tree model using 1, 2, 5, 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000 trees. If you are using the randomForest package, you can create the bagged tree model via setting an argument within the RF constructor function.

```
num_trees = c(1, 2, 5, 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000)
oob_SE_by_num_trees_bag = array(NA, length(num_trees))
for (i in 1:length(num_trees)){
    rf_mod= randomForest(price ~. , data=diamonds_samp, ntree=num_trees[i], ntry=ncol(diamonds_samp)-1)
    oob_SE_by_num_trees_bag[i]=sd(diamonds_samp$price - rf_mod$predicted)
}
ggplot(data.frame(x=num_trees, y=oob_SE_by_num_trees_bag))+
    geom_line(aes(x=x, y=y))
```

Warning: Removed 4 row(s) containing missing values (geom_path).



What is the percentage gain / loss in performance of the RF model vs bagged trees model?

(oob_SE_by_num_trees - oob_SE_by_num_trees_bag) /oob_SE_by_num_trees_bag*100

```
## [1] NA NA NA NA 2.19762278 -1.08829663
## [7] -0.09378487 -2.38001572 -0.56427312 1.41305068 0.79903839 -0.20599729
## [13] 0.39474267 -0.73180346
```

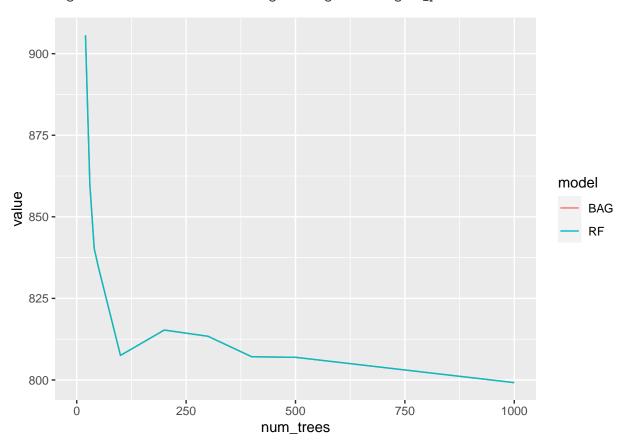
Plot bootstrap s_e by number of trees for both RF and bagged trees.

rbind(data.frame(num_trees=num_trees, value=oob_SE_by_num_trees, model="RF"))

```
##
      num_trees
                     value model
## 1
               1
                        NA
                              RF
## 2
               2
                        NA
                              RF
## 3
               5
                        NA
                              RF
## 4
              10
                        NA
                              RF
## 5
              20 905.6555
                              RF
              30 859.8445
## 6
                              RF
## 7
              40 840.2471
                              RF
## 8
              50 834.3429
                              RF
## 9
             100 807.5180
                              RF
             200 815.2941
## 10
                              RF
             300 813.3921
## 11
                              RF
## 12
             400 807.1078
                              RF
## 13
             500 806.9433
                              RF
## 14
            1000 799.1765
                              RF
```

```
ggplot(rbind(data.frame(num_trees=num_trees, value=oob_SE_by_num_trees, model="RF"), data.frame(num_tre
geom_line(aes(x=num_trees, y=value, color=model))
```

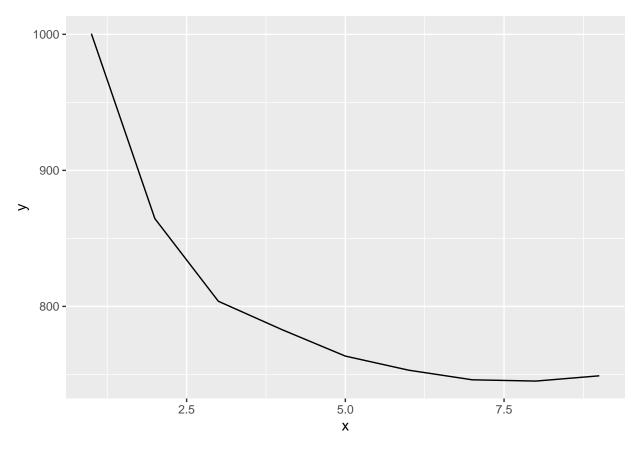
Warning: Removed 8 row(s) containing missing values (geom_path).



Build RF models for 500 trees using different mtry values: 1, 2, ... the maximum. That maximum will be the number of features assuming that we do not binarize categorical features if you are using randomForest or the number of features assuming binarization of the categorical features if you are using YARF. Calculate oob_s_e for all mtry values.

```
mtrys = 1:(ncol(diamonds_samp)-1)
oob_SE_by_mtrys = array(NA, length(mtrys))
for (i in 1:length(mtrys)){
   rf_mod= randomForest(price ~. , data=diamonds_samp, mtry=mtrys[i])
   oob_SE_by_mtrys[i]=sd(diamonds_samp$price - rf_mod$predicted)
}

ggplot(data.frame(x=mtrys, y=oob_SE_by_mtrys))+
   geom_line(aes(x=x, y=y))
```



```
rm(list = ls())
```

Take a sample of n = 2000 observations from the adult data.

```
pacman::p_load_gh("coatless/ucidata")
data(adult)
adult = na.omit(adult)

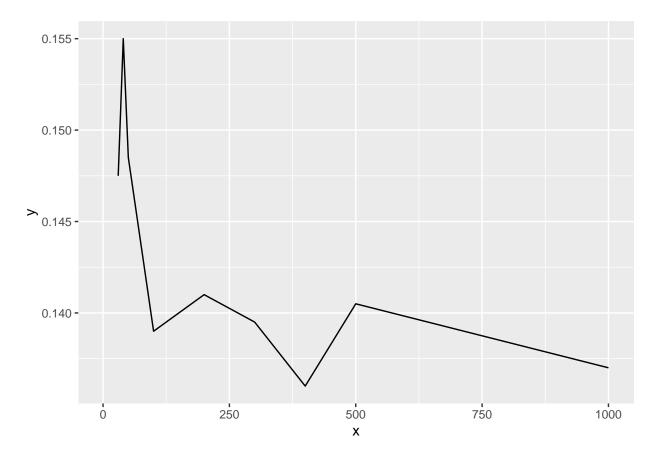
adult_samp = adult %>%
   sample_n(2000)
```

Using the adult data, find the bootstrap misclassification error for an RF model using 1, 2, 5, 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000 trees.

```
num_trees = c(1, 2, 5, 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000)
oob_ME_by_num_trees = array(NA, length(num_trees))
for (i in 1:length(num_trees)){
    rf_mod= randomForest(income ~. , data=adult_samp, ntree=num_trees[i])
    oob_ME_by_num_trees[i]= mean(adult_samp$income != rf_mod$predicted)
}

ggplot(data.frame(x=num_trees, y=oob_ME_by_num_trees))+
    geom_line(aes(x=x, y=y))
```

Warning: Removed 5 row(s) containing missing values (geom_path).

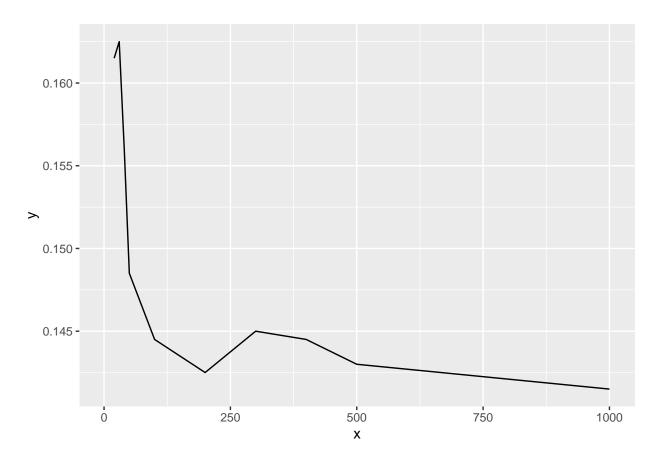


Using the adult data, find the bootstrap misclassification error for a bagged-tree model using 1, 2, 5, 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000 trees.

```
oob_ME_by_num_trees_bag = array(NA, length(num_trees))
for (i in 1:length(num_trees)){
   rf_mod= randomForest(income ~. , data=adult_samp, ntree=num_trees[i], mtry=ncol(adult)-1)
   oob_ME_by_num_trees_bag[i]= mean(adult_samp$income != rf_mod$predicted)
}

ggplot(data.frame(x=num_trees, y=oob_ME_by_num_trees_bag))+
   geom_line(aes(x=x, y=y))
```

Warning: Removed 4 row(s) containing missing values (geom_path).



What is the percentage gain / loss in performance of the RF model vs bagged trees model?

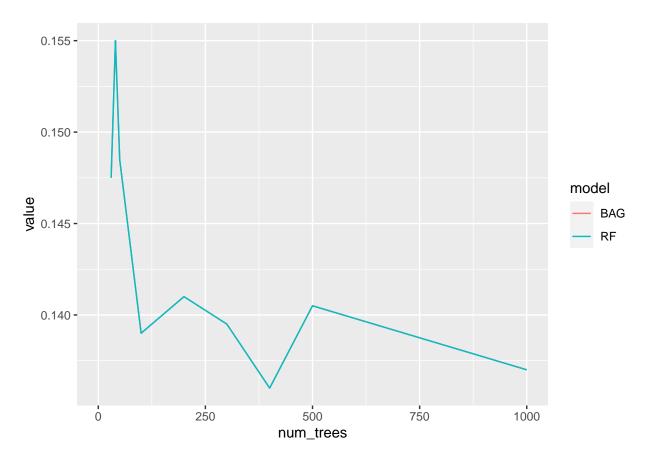
(oob_ME_by_num_trees - oob_ME_by_num_trees_bag)/ oob_ME_by_num_trees_bag*100

```
## [1] NA NA NA NA NA -9.2307692
## [7] -0.6410256 0.0000000 -3.8062284 -1.0526316 -3.7931034 -5.8823529
## [13] -1.7482517 -3.1802120
```

Plot bootstrap misclassification error by number of trees for both RF and bagged trees.

```
ggplot(rbind(data.frame(num_trees=num_trees, value=oob_ME_by_num_trees, model="RF"), data.frame(num_tre
geom_line(aes(x=num_trees, y=value, color=model))
```

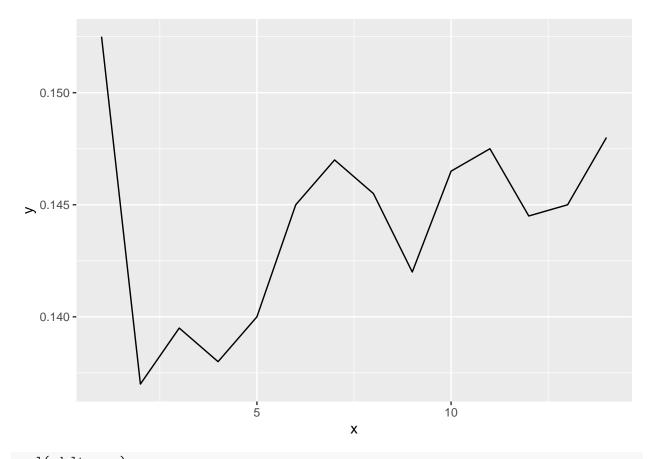
Warning: Removed 10 row(s) containing missing values (geom_path).



Build RF models for 500 trees using different mtry values: 1, 2, ... the maximum (see above as maximum is defined by the specific RF algorithm implementation).

```
mtrys = 1:(ncol(adult_samp)-1)
oob_ME_by_mtrys = array(NA, length(mtrys))
for (i in 1:length(mtrys)){
    rf_mod= randomForest(income ~. , data=adult_samp, mtry=mtrys[i])
    oob_ME_by_mtrys[i]=mean(adult_samp$income != rf_mod$predicted)
}

ggplot(data.frame(x=mtrys, y=oob_ME_by_mtrys))+
    geom_line(aes(x=x, y=y))
```



```
ncol(adult_samp)
```

```
## [1] 15
rm(list = ls())
```

Write a function random_bagged_ols which takes as its arguments X and y with further arguments num_ols_models defaulted to 100 and mtry defaulted to NULL which then gets set within the function to be 50% of available features. This argument builds an OLS on a bootstrap sample of the data and uses only mtry < p of the available features. The function then returns all the lm models as a list with size num_ols_models.

#T0-D0

Load up the Boston Housing Data and separate into X and y.

```
pacman::p_load(MASS)
y=Boston$medv
X=Boston[,1:13]
```

Similar to lab 1, write a function that takes a matrix and punches holes (i.e. sets entries equal to NA) randomly with an argument prob_missing.

```
punch_hole= function(X, prob_missing){
  nr = nrow(X)
  nc = ncol(X)
  M = matrix(rbinom(nr*nc,1,prob_missing),nrow=nr,ncol=nc)
  X[M==1] = NA
  X
}
```

Xmiss = punch_hole(X, 0.10)
Xmiss

шш				J	-1					- د د	4	.		h]l-
## ##	1	crim 0.00632		indus 2.31		Λ	nox	rm 6.575	age 65.2	4.0900		296	ptratio	396.90
##		0.00032	0.0	7.07				6.421	78.9	4.9671		242		396.90
##		0.02731	0.0	7.07			4690	NA	61.1	4.9671		242		392.83
##		0.02729	0.0	2.18			4580	NA NA	45.8	6.0622		222		394.63
##		0.03237						NA NA		6.0622	3			396.90
##		0.00905	0.0	NA O 10			4580	6.430	54.2 58.7		3			394.12
##			0.0	2.18		υ.	4560 NA		66.6	NA E EGOE		311		395.60
		0.08829		7.87	NA	^	5240	NA NA		5.5605				
	8	0.14455		7.87				NA E 631	96.1	5.9505	5			396.90
##	9 10	0.21124		7.87				5.631		6.0821	5	NA 311		386.63 386.71
		0.17004	NA 10 E	7.87				6.004	85.9	6.5921		311		
	11	0.22489		7.87				6.377	94.3	6.3467				392.52
##	12	0.11747		7.87				6.009	82.9	6.2267		311		396.90
	13	0.09378		7.87				5.889	39.0	NA		311		390.50
	14	NA	0.0	8.14				5.949	61.8	NA		307		396.90
	15	0.63796	0.0	8.14				6.096	84.5	4.4619		307		380.02
	16	0.62739	0.0	8.14				5.834	56.5	NA		307	21.0	NA
##	17	1.05393	0.0	8.14				5.935	29.3	4.4986		307		386.85
##	18	0.78420	0.0	8.14				5.990	81.7	4.2579		307		386.75
	19	NA	0.0	8.14				5.456	36.6	3.7965		307		288.99
##	20	0.72580	0.0	8.14				5.727	69.5	3.7965		307		390.95
##	21	1.25179	0.0	8.14				5.570	98.1	3.7979		307		376.57
##	22	0.85204	0.0	8.14			5380	NA	89.2	4.0123		307		392.53
##	23	1.23247	0.0	NA		0.		6.142	91.7	3.9769		307		396.90
##	24	0.98843	0.0	8.14	0		NA		100.0	NA		307		394.54
	25	0.75026	0.0	8.14				5.924	94.1	4.3996		307	21.0	NA
	26	0.84054	0.0	8.14		0.		5.599	NA	4.4546		307		303.42
	27	0.67191	0.0	8.14	0			5.813	90.3	4.6820	4	NA		376.88
	28	0.95577	0.0	NA				6.047	88.8	4.4534		307		306.38
	29	0.77299	0.0	8.14				6.495	94.4	4.4547		307		387.94
	30	1.00245	0.0	8.14				6.674	87.3	4.2390		307		380.23
##		1.13081	0.0	8.14				5.713	94.1	4.2330		307	21.0	NA
##		1.35472	0.0	8.14				6.072		4.1750		307		376.73
	33	1.38799	0.0	8.14				5.950	82.0	3.9900		307		232.60
##		1.15172	0.0	8.14				5.701	95.0	3.7872		307		358.77
	35	1.61282	NA	8.14				6.096	96.9	NA		307		248.31
##		0.06417	0.0	5.96				5.933	68.2	3.3603		279		396.90
	37	NA		5.96	0			5.841		3.3779		279	19.2	
	38	0.08014		5.96				5.850		3.9342		279		396.90
	39	0.17505		5.96				5.966		3.8473		NA	NA	
	40	0.02763		2.95				6.595	21.8	5.4011		252		395.63
	41	0.03359		2.95				7.024		5.4011		252		395.62
	42	0.12744		6.91				6.770	2.9	5.7209		NA		385.41
	43	NA		NA				6.169	6.6	5.7209		233	17.9	
	44	0.15936	0.0	6.91				6.211	6.5	5.7209		233		394.46
##		NA	0.0	6.91				6.069	40.0	5.7209		233		389.39
	46	0.17142	NA	6.91		Ο.		5.682		5.1004		233		396.90
	47	0.18836	0.0	6.91	NA			5.786	33.3	NA		233		396.90
	48	0.22927	0.0	6.91			4480		85.5	5.6894		233		392.74
##	49	0.25387	NA	6.91	0	0.	4480	5.399	NA	5.8700	3	233	17.9	396.90

```
## 50
        0.21977 0.0 6.91
                                0 0.4480 5.602
                                                 62.0 6.0877
                                                                 3 233
                                                                          17.9 396.90
## 51
             NA 21.0
                      5.64
                                0 0.4390 5.963
                                                 45.7
                                                                NA 243
                                                                          16.8 395.56
                                                       6.8147
        0.04337 21.0
                                0 0.4390 6.115
                                                       6.8147
## 52
                       5.64
                                                 63.0
                                                                 4 243
                                                                          16.8 393.97
## 53
        0.05360 21.0
                       5.64
                                0 0.4390 6.511
                                                 21.1
                                                       6.8147
                                                                 4 243
                                                                            NA 396.90
## 54
        0.04981 21.0
                       5.64
                                0 0.4390 5.998
                                                 21.4
                                                       6.8147
                                                                 4 243
                                                                          16.8 396.90
        0.01360 75.0
                                0 0.4100 5.888
                                                 47.6
                                                                          21.1 396.90
## 55
                         NA
                                                           NA
                                                                 3
                                                                   NA
                                0 0.4030 7.249
                                                                          17.9 395.93
## 56
        0.01311 90.0
                      1.22
                                                 21.9
                                                       8.6966
                                                                 5 226
                       0.74
                                0 0.4100 6.383
## 57
        0.02055 85.0
                                                 35.7
                                                           NA
                                                                 2 313
                                                                          17.3
                                                                                    NA
## 58
        0.01432
                  NA
                       1.32
                                0 0.4110 6.816
                                                 40.5
                                                       8.3248
                                                                 5 256
                                                                          15.1 392.90
## 59
        0.15445 25.0
                       5.13
                                0 0.4530 6.145
                                                 29.2
                                                       7.8148
                                                                 8 284
                                                                          19.7 390.68
## 60
        0.10328 25.0
                       5.13
                                0 0.4530 5.927
                                                 47.2
                                                       6.9320
                                                                 8 284
                                                                          19.7 396.90
## 61
        0.14932 25.0
                       5.13
                                0 0.4530 5.741
                                                       7.2254
                                                                 8 284
                                                                          19.7 395.11
                                                 66.2
## 62
        0.17171 25.0
                       5.13
                                0 0.4530 5.966
                                                 93.4
                                                       6.8185
                                                                 8 284
                                                                          19.7 378.08
        0.11027 25.0
                                      NA 6.456
                                                 67.8
                                                       7.2255
                                                                 8 284
## 63
                         NA
                                                                          19.7
                                                                                    NA
## 64
        0.12650
                                0 0.4530 6.762
                                                       7.9809
                                                                 8 284
                                                                          19.7 395.58
                   NA
                       5.13
                                                   NA
## 65
        0.01951 17.5
                       1.38
                                0 0.4161 7.104
                                                 59.5
                                                       9.2229
                                                                 3 216
                                                                          18.6 393.24
## 66
             NA 80.0
                       3.37
                                0 0.3980 6.290
                                                       6.6115
                                                                 4 337
                                                                          16.1 396.90
                                                 17.8
## 67
        0.04379 80.0
                       3.37
                                0 0.3980 5.787
                                                 31.1
                                                       6.6115
                                                                 4 337
                                                                          16.1 396.90
## 68
                       6.07
        0.05789 12.5
                                0 0.4090 5.878
                                                       6.4980
                                                 21.4
                                                                 4 345
                                                                          18.9 396.21
## 69
        0.13554 12.5
                       6.07
                                0 0.4090 5.594
                                                 36.8
                                                           NA
                                                                 4 345
                                                                          18.9 396.90
## 70
        0.12816 12.5
                       6.07
                                0 0.4090 5.885
                                                 33.0
                                                       6.4980
                                                                 4 345
                                                                          18.9 396.90
## 71
        0.08826
                  NA 10.81
                                0 0.4130 6.417
                                                       5.2873
                                                                 4 305
                                                                            NA 383.73
                                                  6.6
## 72
        0.15876
                  NA 10.81
                                0 0.4130 5.961
                                                                          19.2 376.94
                                                  NA
                                                           NA
                                                                 4
                                                                   NA
## 73
        0.09164
                 0.0 10.81
                                0 0.4130 6.065
                                                                 4 305
                                                                          19.2 390.91
                                                  7.8
                                                           NA
        0.19539
## 74
                  NA
                         NΑ
                                0 0.4130 6.245
                                                  6.2
                                                       5.2873
                                                                 4
                                                                   NΑ
                                                                          19.2 377.17
## 75
             NA
                  0.0 12.83
                                0 0.4370 6.273
                                                  NA
                                                       4.2515
                                                                 5 398
                                                                          18.7 394.92
## 76
        0.09512
                  0.0 12.83
                                0 0.4370 6.286
                                                       4.5026
                                                                 5 398
                                                                          18.7 383.23
                                                   NA
                                0 0.4370 6.279
                                                       4.0522
                                                                          18.7 373.66
## 77
        0.10153
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                                                   NA
                                                                 5 398
## 78
                 0.0 12.83
                                0 0.4370 6.140
                                                       4.0905
                                                                 5 398
                                                                          18.7 386.96
             NA
                                                 45.8
## 79
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                  0.0 12.83
                                0 0.4370 6.232
                                                 53.7
                                                       5.0141
                                                                 5 398
                                                                          18.7 386.40
## 80
             NA
                 0.0 12.83
                                0 0.4370 5.874
                                                 36.6
                                                       4.5026
                                                                 5
                                                                  398
                                                                          18.7 396.06
## 81
             NA 25.0
                      4.86
                                0 0.4260 6.727
                                                 33.5
                                                       5.4007
                                                                 4
                                                                   NA
                                                                          19.0 396.90
## 82
        0.04462 25.0
                       4.86
                                0 0.4260 6.619
                                                   NA
                                                       5.4007
                                                                 4 281
                                                                          19.0 395.63
## 83
        0.03659 25.0
                       4.86
                                0 0.4260 6.302
                                                       5.4007
                                                                          19.0 396.90
                                                 32.2
                                                                NA 281
## 84
        0.03551 25.0
                         NA
                                      NA 6.167
                                                 46.7
                                                       5.4007
                                                                 4 281
                                                                            NA
                                                                                    NA
                                0
## 85
        0.05059
                 0.0
                      4.49
                                0 0.4490 6.389
                                                       4.7794
                                                                          18.5 396.90
                                                  NA
                                                                 3 247
## 86
        0.05735
                 0.0
                       4.49
                               NA 0.4490 6.630
                                                 56.1
                                                       4.4377
                                                                NA 247
                                                                          18.5 392.30
## 87
        0.05188
                 0.0
                       4.49
                                0 0.4490 6.015
                                                 45.1
                                                       4.4272
                                                                 3 247
                                                                          18.5
                                                                                    ΝA
## 88
        0.07151
                 0.0
                         NA
                                0 0.4490 6.121
                                                 56.8
                                                       3.7476
                                                                 3 247
                                                                          18.5 395.15
                       3.41
## 89
        0.05660
                 0.0
                                0 0.4890 7.007
                                                                 2 270
                                                                          17.8 396.90
                                                   NA
                                                           NA
## 90
        0.05302
                              NA 0.4890 7.079
                                                                 2 270
                 0.0
                       3.41
                                                 63.1
                                                           NA
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## 91
        0.04684
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                                0 0.4890
                                                 66.1
                                                       3.0923
                                                                   NΑ
                                                                          17.8 392.18
                         NA
                                            NA
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## 92
        0.03932
                  NA 3.41
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                                      NA 6.405
                                                 73.9
                                                       3.0921
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                                                                          17.8 393.55
        0.04203 28.0 15.04
                                                       3.6659
                                                                          18.2 395.01
## 93
                                0 0.4640 6.442
                                                 53.6
                                                                 4 270
## 94
        0.02875 28.0 15.04
                                0
                                      NA 6.211
                                                 28.9
                                                           NA
                                                                 4 270
                                                                          18.2
                                                                                    NA
## 95
             NA 28.0 15.04
                              NA 0.4640 6.249
                                                 77.3
                                                       3.6150
                                                                          18.2 396.90
                                                                 4
                                                                   NA
## 96
        0.12204
                  0.0
                       2.89
                                0 0.4450 6.625
                                                 57.8
                                                       3.4952
                                                                 2 276
                                                                          18.0 357.98
## 97
        0.11504
                                0 0.4450 6.163
                                                                 2 276
                                                                          18.0 391.83
                  NA
                       2.89
                                                 69.6
                                                       3.4952
## 98
        0.12083
                  0.0
                       2.89
                                0
                                      NA 8.069
                                                  NA
                                                       3.4952
                                                                 2 276
                                                                          18.0
                                                                                    NA
## 99
             NA
                  0.0
                       2.89
                                0 0.4450 7.820
                                                 36.9
                                                       3.4952
                                                                 2 276
                                                                          18.0 393.53
## 100
        0.06860
                       2.89
                                0 0.4450 7.416
                                                 62.5
                                                       3.4952
                                                                          18.0 396.90
                  NA
                                                                 2
                                                                  NA
## 101
        0.14866
                 0.0
                       8.56
                                0 0.5200 6.727
                                                  NA
                                                       2.7778
                                                                 5 384
                                                                          20.9 394.76
                                                                          20.9 395.58
## 102
        0.11432
                 0.0
                       8.56
                                0 0.5200 6.781
                                                       2.8561
                                                                 5 384
                                                  NA
## 103
       0.22876 0.0
                         NA
                                0 0.5200 6.405 85.4 2.7147
                                                                 5 384
                                                                          20.9 70.80
```

```
## 104 0.21161 0.0 8.56
                              0
                                    NA
                                           NA 87.4 2.7147
                                                               5 384
                                                                        20.9 394.47
## 105
       0.13960
                0.0 8.56
                              0 0.5200 6.167
                                                              5 384
                                                                        20.9
                                               90.0
                                                         NA
                                                                                 NΑ
                      8.56
                             NA 0.5200 5.851
## 106
       0.13262
                0.0
                                               96.7
                                                         NA
                                                              5 384
                                                                        20.9 394.05
       0.17120
                              0 0.5200
## 107
                 0.0
                        NA
                                                     2.2110
                                                              5 NA
                                                                        20.9 395.67
                                           NA
                                                 NA
## 108
       0.13117
                 0.0
                      8.56
                              0 0.5200 6.127
                                                 NA
                                                     2.1224
                                                              5 384
                                                                        20.9 387.69
## 109
       0.12802 0.0 8.56
                              0 0.5200 6.474
                                                     2.4329
                                                              5 384
                                                                        20.9 395.24
                                               97.1
       0.26363
                 0.0 8.56
                              0 0.5200 6.229
                                                                        20.9 391.23
## 110
                                               91.2
                                                     2.5451
                                                               5 384
       0.10793
                                                               5 384
                                                                        20.9 393.49
## 111
                0.0 8.56
                              0 0.5200
                                           NA
                                               54.4
                                                     2.7778
## 112
       0.10084
                 0.0 10.01
                              0 0.5470 6.715
                                               81.6
                                                     2.6775
                                                               6 432
                                                                        17.8 395.59
       0.12329
                 0.0 10.01
                              0 0.5470 5.913
                                               92.9
                                                               6 432
## 113
                                                     2.3534
                                                                        17.8 394.95
## 114
       0.22212 0.0 10.01
                              0 0.5470 6.092
                                               95.4
                                                     2.5480
                                                               6 432
                                                                        17.8 396.90
       0.14231
                 0.0 10.01
                              0 0.5470 6.254
                                               84.2
                                                     2.2565
                                                               6 432
                                                                        17.8 388.74
## 115
## 116
       0.17134
                 0.0 10.01
                              0 0.5470 5.928
                                               88.2
                                                     2.4631
                                                               6 432
                                                                        17.8 344.91
       0.13158 0.0
                        NA
                              0 0.5470 6.176
                                               72.5
                                                               6 432
## 117
                                                         NA
                                                                        17.8 393.30
       0.15098
                 0.0 10.01
                             NA 0.5470 6.021
                                               82.6
                                                     2.7474
                                                               6 432
                                                                        17.8 394.51
## 118
## 119
        0.13058
                 0.0 10.01
                              0 0.5470
                                           NA
                                               73.1
                                                     2.4775
                                                               6
                                                                NA
                                                                        17.8 338.63
## 120
                 0.0 10.01
                             NA 0.5470 5.731
                                               65.2
                                                     2.7592
                                                               6 432
                                                                        17.8 391.50
             NA
## 121
       0.06899
                 0.0
                        NA
                              0 0.5810 5.870
                                               69.7
                                                     2.2577
                                                               2 188
                                                                        19.1
                                                                                 NA
                                                                        19.1 377.67
## 122
       0.07165
                              0 0.5810 6.004
                                               84.1
                                                     2.1974
                 0.0 25.65
                                                               2 188
## 123
             NA
                 0.0 25.65
                              0 0.5810 5.961
                                               92.9
                                                     2.0869
                                                               2 188
                                                                        19.1 378.09
       0.15038
## 124
                 0.0 25.65
                             NA 0.5810 5.856
                                               97.0
                                                     1.9444
                                                               2 188
                                                                        19.1 370.31
## 125
       0.09849
                 0.0
                        NA
                              0 0.5810 5.879
                                               95.8
                                                     2.0063
                                                               2 188
                                                                        19.1 379.38
       0.16902
                 0.0 25.65
                              0 0.5810 5.986
                                                     1.9929
                                                               2 188
                                                                        19.1 385.02
## 126
                                                 NA
       0.38735
                 0.0 25.65
                             NA 0.5810
                                               95.6
                                                                        19.1 359.29
## 127
                                           NA
                                                         NA
                                                               2 188
                 0.0 21.89
       0.25915
                              0 0.6240 5.693
                                                                        21.2 392.11
## 128
                                               96.0
                                                    1.7883
                                                               4 437
## 129
             NA
                 0.0
                        NA
                              0 0.6240
                                           NA
                                               98.8
                                                     1.8125
                                                               4 437
                                                                        21.2 396.90
## 130
             NA
                 0.0 21.89
                              0 0.6240 5.637
                                                     1.9799
                                                               4 NA
                                                                        21.2 396.90
                                                 NA
       0.34006
                 0.0 21.89
                                                                        21.2 395.04
## 131
                              0 0.6240 6.458
                                               98.9
                                                     2.1185
                                                               4 437
       1.19294
## 132
                        NA
                              0 0.6240 6.326
                                               97.7
                                                     2.2710
                                                               4 437
                                                                        21.2 396.90
                 0.0
## 133
       0.59005
                 0.0 21.89
                              0 0.6240 6.372
                                               97.9
                                                     2.3274
                                                               4 437
                                                                        NA 385.76
## 134
       0.32982
                 0.0 21.89
                              0 0.6240 5.822
                                               95.4
                                                     2.4699
                                                               4 437
                                                                        21.2 388.69
## 135
       0.97617
                 0.0 21.89
                              0 0.6240 5.757
                                               98.4
                                                     2.3460
                                                               4 437
                                                                        21.2 262.76
                 0.0 21.89
## 136
       0.55778
                              0 0.6240 6.335
                                               98.2
                                                     2.1107
                                                               4 437
                                                                        21.2 394.67
## 137
       0.32264
                 0.0 21.89
                              0 0.6240
                                               93.5
                                                     1.9669
                                                               4 437
                                                                         NA 378.25
                                          NA
                                                             NA 437
## 138
       0.35233
                 0.0 21.89
                              0 NA 6.454
                                               98.4
                                                     1.8498
                                                                        21.2 394.08
## 139
       0.24980
                 0.0 21.89
                              0 0.6240 5.857
                                               98.2
                                                     1.6686
                                                              4 437
                                                                        21.2 392.04
## 140
        0.54452
                 0.0 21.89
                              0 0.6240 6.151
                                               97.9
                                                     1.6687
                                                               4 437
                                                                        21.2
## 141
                  NA 21.89
                              0 0.6240 6.174 93.6
                                                     1.6119
                                                               4 437
                                                                        21.2 388.08
             NA
## 142
       1.62864
                 0.0 21.89
                              0 0.6240 5.019 100.0
                                                         NA
                                                               4 437
                                                                        21.2 396.90
                 0.0 19.58
## 143
       3.32105
                              1 0.8710 5.403 100.0 1.3216
                                                              5 NA
                                                                        14.7 396.90
       4.09740
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                                                     1.4118
                                                               5 403
                                                                        14.7 396.90
## 144
                        NA
## 145
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                              0 0.8710 4.903 97.8
                                                    1.3459
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       2.37934
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## 146
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                                                                        14.7 172.91
        2.15505
                                                               5 403
## 147
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                                                     1.5166
                                                                        14.7 169.27
       2.36862
                 0.0 19.58
                             NA 0.8710 4.926
                                                               5 403
## 148
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                                                                        14.7 391.71
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                                                     1.5296
                                                               5 403
                                                                        14.7
                                                                                 NA
## 149
                 0.0 19.58
## 150
       2.73397
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                                                     1.5257
                                                               5 403
                                                                        14.7 351.85
        1.65660
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                                                               5 403
                                                                        14.7 372.80
## 151
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                        NA
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## 152
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## 153
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                                                     1.6102
                                                              5 403
                                                                        14.7 343.28
                 0.0 19.58
## 154
        2.14918
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                                               98.5
                                                     1.6232
                                                              5 403
                                                                        14.7 261.95
## 155
       1.41385 0.0 19.58
                              1 0.8710 6.129
                                               96.0
                                                    1.7494
                                                              5 403
                                                                        14.7 321.02
## 156
       3.53501 0.0 19.58
                              1 0.8710 6.152
                                               82.6 1.7455
                                                              5 NA
                                                                         NA 88.01
                                                                        14.7 88.63
## 157 2.44668 0.0 19.58
                              0 0.8710
                                           NA 94.0
                                                         NA
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```

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## 158
        1.22358 0.0 19.58
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## 159
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                                                                          14.7 353.89
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## 160
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## 161
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## 162
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                                                                          14.7 389.61
## 163
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## 164
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                                                                          14.7 395.11
## 165
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## 166
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                                                                          14.7
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                                                96.2
## 167
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                                                               NA 403
                                                                          14.7 369.30
## 168
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                                                                          14.7 297.09
## 169
                                                96.1
## 170
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                                                94.6
                                                                          14.7 292.29
## 171
                 0.0
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## 172
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                                                      2.3887
                                                               NA 403
                                                                            NA
                                                                                   NA
## 173
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                               0 0.5100 5.572
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                                                                          16.6 396.90
## 174
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                                                                          16.6 395.50
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                                                68.7
## 175
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                                                                5
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                                                                          16.6 393.23
                       4.05
                               0 0.5100 6.546
                                                33.1
                                                      3.1323
                                                                5 296
## 176
             NA
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## 177
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                                                                          16.6 393.23
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## 178
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                                                74.4
                                                      2.9153
                                                                5 296
                                                                          16.6 391.27
## 179
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                               0 0.4880
                                                58.4
                                                      2.8290
                                                                          17.8 396.90
## 180
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        0.06588
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                                                      2.7410
                                                                          17.8 395.56
## 181
                  NA
                                                                3 193
        0.06888
                                                      2.5979
## 182
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                         NA
                               0 0.4880 6.144
                                                62.2
                                                                3 193
                                                                          17.8 396.90
## 183
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                               0 0.4880 7.155
                                                92.2
                                                      2.7006
                                                                3 193
                                                                          17.8 394.12
## 184
        0.10008
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                                                95.6
                                                      2.8470
                                                                3 193
                                                                          17.8 396.90
                               0
        0.08308 0.0
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## 185
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                                                                3
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## 186
                       2.46
                               0 0.4880 6.153
                                                68.8
                                                      3.2797
                                                                3 193
                                                                          17.8
                                                                                   NA
## 187
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                         NA
                               0 0.4880
                                                53.6
                                                      3.1992
                                                                3 193
                                                                          17.8 392.63
                                            NA
## 188
        0.07875 45.0
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                                     NA 6.782
                                                41.1
                                                      3.7886
                                                                5 398
                                                                          15.2 393.87
## 189
        0.12579 45.0
                       3.44
                               0 0.4370 6.556
                                                29.1
                                                      4.5667
                                                                5 398
                                                                            NA
                                                                                   NA
## 190
        0.08370 45.0
                       3.44
                              NA
                                     NA 7.185
                                                38.9
                                                      4.5667
                                                                5 398
                                                                          15.2 396.90
        0.09068 45.0
                       3.44
                               0 0.4370 6.951
                                                      6.4798
                                                                5 398
                                                                          15.2 377.68
## 191
                                                21.5
## 192
        0.06911 45.0
                       3.44
                               0 0.4370 6.739
                                                30.8
                                                      6.4798
                                                                5
                                                                  398
                                                                            NA
                                                                                   NA
## 193
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                               0 0.4370 7.178
                                                26.3
                                                      6.4798
                                                               NA 398
                                                                            NA 390.49
## 194
        0.02187 60.0
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                               0 0.4010 6.800
                                                 9.9
                                                      6.2196
                                                                1 265
                                                                          15.6 393.37
## 195
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                               0 0.4010 6.604
                                                18.8
                                                      6.2196
                                                                1 265
                                                                          15.6 376.70
                         NA
## 196
             NA 80.0
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                               0 0.4220 7.875
                                                32.0
                                                      5.6484
                                                                4 255
                                                                          14.4 394.23
## 197
        0.04011 80.0
                      1.52
                               0 0.4040 7.287
                                                34.1
                                                      7.3090
                                                                2 329
                                                                          12.6
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                                                      7.3090
                                                                          12.6 354.31
## 198
                                                36.6
                                                               NA 329
## 199
        0.03768 80.0
                         NA
                              NA 0.4040 7.274
                                                38.3
                                                      7.3090
                                                               NA 329
                                                                          12.6 392.20
        0.03150 95.0 1.47
                               0 0.4030 6.975
                                                                          17.0 396.90
  200
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                                                      7.6534
                                                                3 402
        0.01778 95.0
                      1.47
                               0 0.4030 7.135
                                                      7.6534
## 201
                                                13.9
                                                                3 402
                                                                          17.0 384.30
        0.03445 82.5
                                                      6.2700
                                                                          14.7 393.77
## 202
                       2.03
                               0 0.4150 6.162
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                                                                2 348
        0.02177 82.5
                                     NA 7.610
                                                      6.2700
                                                                          14.7 395.38
## 203
                       2.03
                                                15.7
                                                                2
                               0
                                                                  NA
## 204
        0.03510 95.0 2.68
                               0 0.4161 7.853
                                                33.2
                                                      5.1180
                                                                4 224
                                                                          14.7
                                                                                   NA
        0.02009 95.0 2.68
                               0 0.4161 8.034
## 205
                                                31.9
                                                      5.1180
                                                                4 224
                                                                          14.7 390.55
## 206
        0.13642
                 0.0 10.59
                               0 0.4890 5.891
                                                22.3
                                                      3.9454
                                                                4 277
                                                                          18.6 396.90
        0.22969
## 207
                 0.0 10.59
                               0 0.4890
                                            NA
                                                52.5
                                                      4.3549
                                                                4 277
                                                                          18.6 394.87
## 208
        0.25199
                              NA 0.4890 5.783
                                                72.7
                                                      4.3549
                                                                          18.6 389.43
                  NA
                         NA
                                                                4
                                                                  NA
## 209
        0.13587
                 0.0 10.59
                               1 0.4890 6.064
                                                59.1
                                                           NA
                                                                4
                                                                  NΑ
                                                                          18.6 381.32
## 210
        0.43571
                 0.0 10.59
                               1 0.4890 5.344
                                                      3.8750
                                                                4 277
                                                                          18.6 396.90
                                                  NA
## 211
             NA
                 0.0 10.59
                               1 0.4890 5.960 92.1 3.8771
                                                                4 277
                                                                          18.6 393.25
```

```
## 212
             NA
                 0.0 10.59
                              NA 0.4890 5.404
                                                88.6
                                                      3.6650
                                                                 4 277
                                                                          18.6 395.24
        0.21719
                  0.0 10.59
                               1
                                                       3.6526
                                                                 4 277
                                                                          18.6 390.94
## 213
                                      NA 5.807
                                                53.8
## 214
        0.14052
                  0.0 10.59
                               0 0.4890
                                            NA
                                                   NA
                                                       3.9454
                                                                 4 277
                                                                          18.6 385.81
        0.28955
                               0 0.4890 5.412
## 215
                                                       3.5875
                                                               NA 277
                                                                          18.6 348.93
                  NA
                         NA
                                                 9.8
## 216
        0.19802
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                               0 0.4890 6.182
                                                42.4
                                                       3.9454
                                                                 4 277
                                                                          18.6 393.63
## 217
        0.04560
                 0.0 13.89
                                      NA 5.888
                                                56.0
                                                       3.1121
                                                                          16.4 392.80
                                                                 5 276
                               1
        0.07013
                                                                          16.4 392.78
## 218
                  0.0 13.89
                               0 0.5500 6.642
                                                85.1
                                                       3.4211
                                                                 5 276
## 219
        0.11069
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                              NA
                                      NA 5.951
                                                93.8
                                                       2.8893
                                                                 5 276
                                                                          16.4 396.90
## 220
        0.11425
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                               1 0.5500 6.373
                                                92.4
                                                       3.3633
                                                                 5 276
                                                                          16.4 393.74
## 221
                      6.20
             NA
                  0.0
                               1 0.5070 6.951
                                                88.5
                                                       2.8617
                                                                 8 307
                                                                            NA 391.70
## 222
        0.40771
                  0.0
                       6.20
                               1 0.5070 6.164
                                                91.3
                                                       3.0480
                                                                 8
                                                                   NA
                                                                          17.4 395.24
        0.62356
## 223
                       6.20
                               1 0.5070 6.879
                                                       3.2721
                                                                  307
                                                                          17.4 390.39
                  0.0
                                                   NA
                                                                 8
## 224
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                 0.0
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                                                80.8
                                                       3.2721
                                                                 8 307
                                                                          17.4 396.90
        0.31533
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                               0 0.5040 8.266
                                                78.3
                                                       2.8944
                                                                          17.4 385.05
## 225
                 0.0
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                                                                  307
## 226
                       6.20
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                                                 83.0
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                                                                  307
                                                                          17.4 382.00
             NA
                  0.0
                                                                 8
## 227
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                               0 0.5040 8.040
                                                 86.5
                                                           NA
                                                                 8
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                                                                          17.4 387.38
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                               0 0.5040 7.163
## 228
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                                                       3.2157
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                                                                   NA
                                                                          17.4 372.08
## 229
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                               0 0.5040 7.686
                                                 17.0
                                                       3.3751
                                                                 8
                                                                  307
                                                                          17.4 377.51
## 230
        0.44178
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                               0 0.5040 6.552
                                                21.4
                                                       3.3751
                                                                 8 307
                                                                          17.4 380.34
                 0.0
## 231
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                                                 68.1
                                                       3.6715
                                                                 8 307
                                                                          17.4 378.35
## 232
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                               0
                                      NA 7.412
                                                76.9
                                                       3.6715
                                                                 8 307
                                                                          17.4 376.14
## 233
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                               0 0.5070 8.337
                                                 73.3
                                                       3.8384
                                                                 8 307
                                                                          17.4 385.91
                 0.0
                                                 70.4
## 234
        0.33147
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                               0 0.5070 8.247
                                                                 8 307
                                                                          17.4 378.95
                 0.0
                                                       3.6519
        0.44791
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                                      NA 6.726
                                                                 8 307
                                                                          17.4 360.20
## 235
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                                                 66.5
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                       6.20
                               0 0.5070 6.086
## 236
        0.33045
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                                                61.5
                                                           NA
                                                                 8 307
                                                                          17.4 376.75
## 237
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                         NA
                               1 0.5070 6.631
                                                76.5
                                                       4.1480
                                                                 8 307
                                                                          17.4 388.45
## 238
        0.51183
                 0.0
                       6.20
                               0 0.5070 7.358
                                                71.6
                                                       4.1480
                                                                 8 307
                                                                          17.4 390.07
                       4.93
                               0 0.4280 6.481
                                                                          16.6 379.41
##
  239
        0.08244 30.0
                                                18.5
                                                       6.1899
                                                                 6 300
                       4.93
## 240
        0.09252 30.0
                               0 0.4280 6.606
                                                42.2
                                                                 6 300
                                                                            NA 383.78
                                                           NA
## 241
        0.11329 30.0
                       4.93
                               0 0.4280 6.897
                                                 54.3
                                                           NA
                                                                 6
                                                                  300
                                                                          16.6 391.25
## 242
        0.10612 30.0
                       4.93
                               0 0.4280 6.095
                                                 65.1
                                                       6.3361
                                                                 6
                                                                  300
                                                                          16.6 394.62
## 243
        0.10290 30.0
                       4.93
                               0 0.4280 6.358
                                                 52.9
                                                       7.0355
                                                               NA 300
                                                                          16.6 372.75
                       4.93
## 244
        0.12757 30.0
                               0 0.4280 6.393
                                                 7.8
                                                       7.0355
                                                                 6 300
                                                                          16.6 374.71
        0.20608 22.0
                       5.86
                               0 0.4310 5.593
                                                76.5
                                                       7.9549
                                                                 7 330
                                                                            NA 372.49
## 245
## 246
        0.19133 22.0
                       5.86
                               0 0.4310 5.605
                                                 70.2
                                                       7.9549
                                                                 7 330
                                                                          19.1 389.13
## 247
        0.33983 22.0
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                               0 0.4310
                                                34.9
                                                       8.0555
                                                                7 330
                                            NA
                                                                          19.1
                                                                                   NA
## 248
        0.19657 22.0
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                               NA
                                      NA 6.226
                                                79.2
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                                                                 7 330
                                                                          19.1 376.14
## 249
        0.16439 22.0
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                                      NA 6.433
                                                       7.8265
                                                                 7 330
                                                                          19.1 374.71
                                                   NA
## 250
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                                                17.5
                                                       7.8265
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                                                                          19.1 393.74
## 251
             NA 22.0
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                                      NA 6.487
                                                13.0
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                                                                 7 330
                                                                          19.1 396.28
                               0
        0.21409 22.0
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                               0 0.4310 6.438
## 252
                                                 8.9
                                                       7.3967
                                                                 7 330
                                                                          19.1
                                                                                    ΝA
## 253
        0.08221 22.0
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                                                       8.9067
                                                                 7 330
                                                                          19.1 386.09
                                                 6.8
##
  254
        0.36894 22.0
                       5.86
                               0 0.4310 8.259
                                                 8.4
                                                           NA
                                                                 7 330
                                                                          19.1 396.90
                       3.64
##
  255
        0.04819 80.0
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                                                       9.2203
                                                                 1 315
                                                                          16.4 392.89
                                                   NA
                       3.64
## 256
        0.03548 80.0
                               0 0.3920 5.876
                                                19.1
                                                       9.2203
                                                                 1 315
                                                                          16.4 395.18
                       3.75
## 257
        0.01538 90.0
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                                                       6.3361
                                                                 3 244
                                                                          15.9 386.34
                                                   NA
## 258
        0.61154 20.0
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                               0 0.6470 8.704
                                                86.9
                                                           NA
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                                                                          13.0 389.70
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                              NA 0.6470
                                            NA 100.0
                                                                 5 264
                                                                          13.0 383.29
## 259
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                                                       1.8946
## 260
        0.65665 20.0
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                                                                   NA
                                                                          13.0 391.93
                                                                 5
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                                                       2.1121
                                                                 5 264
                                                                          13.0 392.80
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                               0 0.6470
                                                89.4
                                                                5 264
                                                                          13.0 388.37
## 262
                                            NA
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                                                91.5
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                                                                          13.0
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## 264
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                                                       2.0788
                                                                5 264
                                                                          13.0 393.42
                                                  NA
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## 265
        0.55007 20.0 3.97
                                                                5 264
                                                                          13.0 387.89
```

```
## 266
             NA 20.0 3.97
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                                     NA 5.560
                                                62.8 1.9865
                                                               NA 264
                                                                         13.0 392.40
## 267
                                     NA 7.014
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                                                                5 264
                                                                         13.0 384.07
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## 268
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                                     NA
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                                                67.0
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                                                                         13.0
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                               0 0.5750 7.470
## 269
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                         NA
                                                52.6
                                                      2.8720
                                                                5 264
                                                                         13.0 390.30
## 270
        0.09065 20.0
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                               1 0.4640 5.920
                                                61.5
                                                      3.9175
                                                                3 223
                                                                           NA 391.34
## 271
        0.29916 20.0
                      6.96
                              NA 0.4640 5.856
                                                42.1
                                                      4.4290
                                                                3 223
                                                                         18.6 388.65
                      6.96
                                                                         18.6 396.90
## 272
        0.16211 20.0
                               0 0.4640 6.240
                                                16.3
                                                      4.4290
                                                                3 223
                      6.96
## 273
        0.11460 20.0
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                                                58.7
                                                      3.9175
                                                                3 223
                                                                         18.6 394.96
## 274
        0.22188 20.0
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                               1 0.4640 7.691
                                                  NA
                                                      4.3665
                                                                3 223
                                                                         18.6 390.77
## 275
                      6.41
                              NA 0.4470 6.758
                                                                         17.6 396.90
             NA
                  NA
                                                32.9
                                                      4.0776
                                                                4 254
## 276
        0.09604 40.0
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                               0
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                                                                4 254
                                                                         17.6 396.90
## 277
        0.10469 40.0
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                               1 0.4470 7.267
                                                49.0
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                                                                           NA 389.25
                                                                4 254
## 278
        0.06127
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                               1 0.4470 6.826
                                                27.6
                                                      4.8628
                                                                4 254
                                                                         17.6 393.45
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        0.07978 40.0
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                                                                4 254
                                                                         17.6 396.90
                                                  NA
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                                                                5 216
                                                                         14.9 396.90
## 281
             NA 20.0
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                               0 0.4429 7.820
                                                64.5
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                                                                5 216
                                                                         14.9 387.31
## 282
        0.03705 20.0
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                              NA 0.4429 6.968
                                                                5 216
                                                  NA
                                                          NA
                                                                         14.9 392.23
## 283
        0.06129 20.0
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                              NA 0.4429 7.645
                                                49.7
                                                          NA
                                                                5 NA
                                                                         14.9 377.07
## 284
        0.01501 90.0
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                                                24.8
                                                      5.8850
                                                                         13.6 395.52
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                                                                1 198
                               1
##
  285
        0.00906 90.0
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                               0 0.4000 7.088
                                                  NA
                                                      7.3073
                                                                1 285
                                                                         15.3 394.72
##
  286
        0.01096 55.0
                      2.25
                               0 0.3890 6.453
                                                31.9
                                                      7.3073
                                                                1 300
                                                                         15.3 394.72
  287
        0.01965 80.0
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                               0 0.3850 6.230
                                                31.5
                                                      9.0892
                                                               NA 241
                                                                         18.2 341.60
                               0 0.4050 6.209
## 288
        0.03871 52.5
                      5.32
                                                                6 293
                                                                         16.6 396.90
                                                31.3
                                                      7.3172
        0.04590 52.5
                      5.32
                               0 0.4050
                                                                6 293
                                                                         16.6 396.90
## 289
                                            NA
                                                  NA
                                                          NA
        0.04297 52.5
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                               0 0.4050 6.565
## 290
                                                22.9
                                                          NA
                                                                6 293
                                                                         16.6 371.72
## 291
        0.03502 80.0
                         NA
                               0
                                     NA 6.861
                                                27.9
                                                      5.1167
                                                                4 245
                                                                         19.2 396.90
## 292
        0.07886 80.0 4.95
                               0 0.4110 7.148
                                                27.7
                                                      5.1167
                                                                4 245
                                                                         19.2 396.90
        0.03615 80.0 4.95
                               0 0.4110 6.630
##
  293
                                                23.4
                                                      5.1167
                                                                4 245
                                                                         19.2
                                                                                   NA
## 294
        0.08265 0.0 13.92
                               0 0.4370 6.127
                                                18.4
                                                      5.5027
                                                                4 289
                                                                         16.0 396.90
## 295
        0.08199 0.0 13.92
                               0 0.4370 6.009
                                                42.3
                                                      5.5027
                                                                4 289
                                                                         16.0 396.90
## 296
        0.12932
                 0.0 13.92
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                                                31.1
                                                      5.9604
                                                                4 289
                                                                           NA
                                                                                   NA
## 297
        0.05372 0.0 13.92
                               0 0.4370 6.549
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                                                                4 289
                                                                         16.0 392.85
        0.14103 0.0 13.92
##
  298
                               0 0.4370 5.790
                                                58.0
                                                      6.3200
                                                                4 289
                                                                         16.0 396.90
        0.06466 70.0 2.24
                               0 0.4000 6.345
                                                20.1
                                                      7.8278
                                                                5 358
                                                                         14.8 368.24
## 299
##
   300
        0.05561 70.0
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                               0 0.4000 7.041
                                                10.0
                                                      7.8278
                                                                5 358
                                                                         14.8
                                                                                   NA
        0.04417 70.0
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                                                47.4
                                                      7.8278
                                                                5 358
                                                                         14.8 390.86
##
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## 302
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                                                40.4
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                                                                7 329
                                                                         16.1 395.75
## 303
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                               0 0.4330 6.495
                                                18.4
                                                      5.4917
                                                                7 329
                                                                         16.1 383.61
## 304
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                               0 0.4330 6.982
                                                17.7
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                                                                7 329
                                                                         16.1 390.43
## 305
        0.05515 33.0
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                                                      4.0220
                                                                7 222
                                                                         18.4 393.68
                                                41.1
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                               0 0.4720 6.616
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                                                                           NA 393.36
  306
                                                58.1
                                                                7 222
## 307
        0.07503 33.0
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                                                71.9
                                                      3.0992
                                                                7 222
                                                                         18.4 396.90
        0.04932 33.0
                               0 0.4720 6.849
##
  308
                      2.18
                                                70.3
                                                      3.1827
                                                               NA 222
                                                                         18.4 396.90
        0.49298 0.0
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## 309
                               0 0.5440 6.635
                                                82.5
                                                      3.3175
                                                                4 304
                                                                         18.4 396.90
        0.34940
                              NA 0.5440 5.972
                                                      3.1025
## 310
                 0.0
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                                                76.7
                                                                4 304
                                                                         18.4 396.24
        2.63548
                               0 0.5440 4.973
                                                37.8
                 0.0
                      9.90
                                                      2.5194
                                                                4 304
                                                                         18.4 350.45
## 311
## 312
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                                                  NA
                                                      2.6403
                                                                4
                                                                  NA
                                                                         18.4 396.90
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                      9.90
                               0 0.5440 6.023
                                                      2.8340
                                                                4 304
                                                                         18.4 396.30
## 313
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                                                90.4
## 314
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                                                82.8
                                                      3.2628
                                                                4
                                                                  NA
                                                                         18.4 393.39
## 315
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                 0.0
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                               0 0.5440 6.567
                                                87.3
                                                      3.6023
                                                                4
                                                                   NA
                                                                         18.4 395.69
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                      9.90
                               0 0.5440 5.705
                                                77.7
                                                      3.9450
                                                               NA 304
                                                                         18.4 396.42
## 316
                 0.0
## 317
        0.31827
                 0.0
                      9.90
                               0 0.5440 5.914
                                                83.2
                                                      3.9986
                                                                4 304
                                                                         18.4 390.70
## 318
        0.24522
                 0.0
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                               0 0.5440 5.782
                                                71.7
                                                      4.0317
                                                                4 304
                                                                         18.4 396.90
## 319
             NA
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                               0 0.5440 6.382 67.2 3.5325
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```
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                                                                         19.6 396.90
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                                                                         17.9 392.43
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                                                                         18.3 370.78
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```
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                                               94.8
                                                                        20.2 43.06
                                                         NA
                                                              24 666
## 447
        6.28807
                 0.0 18.10
                               0 0.7400 6.341
                                               96.4
                                                     2.0720
                                                              24 666
                                                                          NA 318.01
## 448
             NA
                 0.0 18.10
                               0
                                    NA 6.251
                                               96.6
                                                     2.1980
                                                              24 666
                                                                        20.2 388.52
## 449
        9.32909
                 0.0
                               0 0.7130
                                               98.7
                                                     2.2616
                                                                        20.2 396.90
                        NΑ
                                           NA
                                                              24 666
                               0 0.7130 6.417
        7.52601
                 0.0 18.10
                                                     2.1850
                                                                        20.2 304.21
## 450
                                               98.3
                                                              NA 666
        6.71772
                 0.0 18.10
                               0 0.7130 6.749
                                               92.6
                                                     2.3236
                                                                        20.2 0.32
## 451
                                                              24 666
                               0 0.7130 6.655
## 452
        5.44114
                0.0 18.10
                                               98.2
                                                     2.3552
                                                              24 666
                                                                        20.2 355.29
## 453
        5.09017
                 0.0 18.10
                               0 0.7130 6.297
                                               91.8
                                                     2.3682
                                                              24 666
                                                                        20.2 385.09
## 454
        8.24809
                 0.0 18.10
                               0 0.7130 7.393
                                               99.3
                                                     2.4527
                                                              24 666
                                                                        20.2 375.87
        9.51363
                               0 0.7130 6.728
                                                     2.4961
## 455
                 0.0 18.10
                                               94.1
                                                              24
                                                                 NA
                                                                        20.2
                                                                              6.68
        4.75237
                 0.0 18.10
                               0 0.7130 6.525
                                               86.5
                                                     2.4358
                                                              24 666
                                                                        20.2 50.92
## 456
## 457
        4.66883
                 0.0 18.10
                               0 0.7130 5.976
                                               87.9
                                                     2.5806
                                                              24 666
                                                                        20.2 10.48
## 458
             NA
                 0.0 18.10
                               0 0.7130 5.936
                                               80.3
                                                     2.7792
                                                              24 666
                                                                        20.2
                                                                              3.50
## 459
             NA
                 0.0 18.10
                               0 0.7130 6.301
                                               83.7
                                                     2.7831
                                                              24 666
                                                                        20.2 272.21
## 460
        6.80117
                 0.0 18.10
                                     NA 6.081
                                               84.4
                                                     2.7175
                                                              24 666
                                                                        20.2 396.90
                                               90.0
        4.81213
                 0.0 18.10
                               0 0.7130 6.701
                                                     2.5975
                                                                        20.2 255.23
## 461
                                                              24 666
## 462
             NA
                 0.0 18.10
                             NA 0.7130
                                           NA
                                               88.4
                                                     2.5671
                                                              24 666
                                                                        20.2
                                                                                 NA
## 463
                                                              24 666
        6.65492
                 0.0 18.10
                               0 0.7130 6.317
                                               83.0
                                                     2.7344
                                                                        20.2 396.90
## 464
        5.82115
                 0.0 18.10
                               0 0.7130 6.513
                                               89.9
                                                     2.8016
                                                              24 666
                                                                        20.2 393.82
## 465
        7.83932
                 0.0 18.10
                               0 0.6550 6.209
                                                     2.9634
                                                              24 666
                                                                        20.2 396.90
                                                 NA
        3.16360
                 0.0 18.10
                               0 0.6550
                                               48.2
                                                     3.0665
                                                              24 666
                                                                        20.2 334.40
## 466
                                           NA
                               0 0.6550
        3.77498
                0.0 18.10
                                           NA
                                               84.7
                                                     2.8715
                                                              24 666
                                                                        20.2 22.01
## 467
       4.42228
                                                     2.5403
                                                                        20.2 331.29
## 468
                 0.0 18.10
                             NA
                                     NA 6.003
                                               94.5
                                                              24 666
## 469 15.57570
                 0.0 18.10
                               0 0.5800 5.926
                                               71.0
                                                     2.9084
                                                                        20.2
                                                                                 NA
                                                              NA 666
                               0 0.5800
## 470 13.07510
                 0.0
                        NA
                                           NA
                                               56.7
                                                     2.8237
                                                              24 666
                                                                        20.2 396.90
                                                              24 666
                                                                          NA 396.90
## 471
        4.34879
                  NA 18.10
                               0 0.5800 6.167
                                               84.0
                                                     3.0334
        4.03841
                                                                        20.2 395.33
## 472
                 0.0 18.10
                               0 0.5320 6.229
                                                 NA
                                                         NA
                                                              24
                                                                NA
## 473
        3.56868
                        NA
                             NA 0.5800 6.437
                                               75.0
                                                     2.8965
                                                              24 666
                                                                         NA 393.37
                 0.0
## 474
        4.64689
                 0.0 18.10
                             NA 0.6140 6.980
                                               67.6
                                                         NA
                                                              24 666
                                                                        20.2 374.68
        8.05579
                 0.0 18.10
                               0 0.5840
                                                              24 666
                                                                        20.2 352.58
## 475
                                           NA
                                               95.4
                                                     2.4298
                                                              24 666
## 476
        6.39312
                 0.0 18.10
                               0 0.5840 6.162
                                               97.4
                                                     2.2060
                                                                        20.2 302.76
## 477
        4.87141
                  NA 18.10
                               0 0.6140 6.484
                                               93.6
                                                     2.3053
                                                              24 666
                                                                        20.2 396.21
## 478 15.02340
                 0.0 18.10
                               0 0.6140 5.304
                                               97.3
                                                     2.1007
                                                                        20.2 349.48
                                                              NA 666
## 479 10.23300 0.0 18.10
                               0 0.6140 6.185
                                               96.7
                                                     2.1705
                                                              24 666
                                                                        20.2 379.70
## 480 14.33370 0.0 18.10
                               0 0.6140 6.229
                                               88.0 1.9512
                                                              24 666
                                                                        20.2 383.32
## 481 5.82401 0.0
                        NA
                               0 0.5320 6.242
                                               64.7
                                                         NA
                                                              24 666
                                                                        20.2
```

```
## 482 5.70818
                  NA 18.10
                               0 0.5320 6.750
                                               74.9 3.3317
                                                               24 666
                                                                           NA 393.07
                                                77.0
## 483
        5.73116
                 0.0 18.10
                               0 0.5320 7.061
                                                      3.4106
                                                               24
                                                                   NA
                                                                         20.2 395.28
                               0 0.5320 5.762
## 484
        2.81838
                 0.0 18.10
                                                40.3
                                                      4.0983
                                                               24
                                                                   NA
                                                                         20.2 392.92
        2.37857
                 0.0 18.10
                               0 0.5830 5.871
                                                      3.7240
                                                                         20.2 370.73
## 485
                                                               24 666
                                                  NA
## 486
        3.67367
                 0.0 18.10
                               0 0.5830 6.312
                                                51.9
                                                           NA
                                                               24 666
                                                                         20.2 388.62
        5.69175
                 0.0 18.10
                               0 0.5830 6.114
                                                79.8
                                                      3.5459
                                                               24 666
                                                                         20.2
                                                                                   NA
##
  487
        4.83567
                 0.0 18.10
                              NA 0.5830 5.905
                                                      3.1523
                                                               24 666
                                                                           NA 388.22
## 488
                                                53.2
                 0.0 27.74
                              NA 0.6090 5.454
## 489
        0.15086
                                                92.7
                                                      1.8209
                                                                4 711
                                                                         20.1
                                                                                   NA
## 490
        0.18337
                 0.0 27.74
                               0 0.6090
                                            NA
                                                98.3
                                                      1.7554
                                                                4 711
                                                                          20.1 344.05
        0.20746
                 0.0 27.74
                               0 0.6090 5.093
                                                      1.8226
## 491
                                                98.0
                                                                4 711
                                                                         20.1 318.43
## 492
        0.10574
                 0.0 27.74
                               0 0.6090 5.983
                                                98.8
                                                           NA
                                                                4 711
                                                                          20.1 390.11
        0.11132
                               0 0.6090 5.983
## 493
                 0.0 27.74
                                                      2.1099
                                                                4 711
                                                                         20.1
                                                                                   NA
                                                  NA
                               0 0.5850
                                                      2.3817
## 494
        0.17331
                 0.0 9.69
                                            NA
                                                54.0
                                                                6 391
                                                                         19.2 396.90
                               0 0.5850 5.926
        0.27957
                       9.69
                                                42.6
                                                      2.3817
                                                                         19.2 396.90
## 495
                 0.0
                                                                6 391
## 496
        0.17899
                 0.0
                         NA
                               0 0.5850 5.670
                                                28.8
                                                      2.7986
                                                                6 391
                                                                         19.2 393.29
## 497
             NA
                  NA
                         NA
                               0 0.5850 5.390
                                                72.9
                                                      2.7986
                                                                6 391
                                                                         19.2 396.90
        0.26838
                       9.69
                                                      2.8927
                                                                6 NA
                                                                           NA 396.90
## 498
                 0.0
                               0
                                     NA
                                            NA
                                                70.6
        0.23912
## 499
                 0.0
                       9.69
                               0 0.5850 6.019
                                                65.3
                                                      2.4091
                                                                6 391
                                                                         19.2 396.90
        0.17783
                 0.0 9.69
                                     NA 5.569
                                                73.5
                                                      2.3999
                                                                6 391
                                                                         19.2 395.77
## 500
                               0
                                                                         19.2 396.90
## 501
        0.22438
                 0.0 9.69
                               0 0.5850 6.027
                                                79.7
                                                      2.4982
                                                                6
                                                                  NA
                                                                         21.0 391.99
## 502
        0.06263
                 0.0 11.93
                               0 0.5730 6.593
                                                69.1
                                                      2.4786
                                                                1 273
## 503
        0.04527
                 0.0 11.93
                               0 0.5730 6.120
                                                76.7
                                                      2.2875
                                                                1 273
                                                                         21.0 396.90
## 504
                               0 0.5730 6.976
                                                      2.1675
                                                                1 273
                                                                           NA 396.90
             NA
                  NA 11.93
                                                91.0
## 505
        0.10959
                  NA 11.93
                              NA 0.5730 6.794
                                                89.3
                                                      2.3889
                                                                1 273
                                                                         21.0 393.45
## 506
                                                                           NA 396.90
       0.04741 0.0
                        NA
                               0 0.5730 6.030
                                                80.8 2.5050
                                                                1 NA
##
       lstat
## 1
          NA
## 2
        9.14
## 3
        4.03
## 4
        2.94
## 5
        5.33
## 6
        5.21
## 7
       12.43
## 8
       19.15
## 9
       29.93
## 10
       17.10
## 11
       20.45
## 12
          NA
## 13
       15.71
## 14
          NA
## 15
       10.26
## 16
        8.47
## 17
          NA
          NA
## 18
       11.69
## 19
       11.28
## 20
## 21
          NA
## 22
       13.83
## 23
       18.72
## 24
       19.88
## 25
       16.30
## 26
       16.51
## 27
       14.81
## 28
          NA
```

```
## 29 12.80
## 30
       11.98
## 31
       22.60
## 32
       13.04
## 33
       27.71
## 34
          NA
## 35
       20.34
## 36
          NA
## 37
          NA
## 38
        8.77
## 39
       10.13
## 40
        4.32
## 41
        1.98
## 42
        4.84
## 43
          NA
        7.44
## 44
## 45
        9.55
## 46
       10.21
## 47
       14.15
## 48
       18.80
## 49
       30.81
## 50
       16.20
## 51
       13.45
## 52
        9.43
## 53
        5.28
## 54
        8.43
## 55
       14.80
## 56
        4.81
## 57
        5.77
## 58
        3.95
## 59
        6.86
## 60
        9.22
## 61
       13.15
       14.44
## 62
## 63
        6.73
## 64
        9.50
## 65
        8.05
## 66
        4.67
       10.24
## 67
## 68
        8.10
## 69
       13.09
## 70
        8.79
## 71
        6.72
## 72
          NA
## 73
        5.52
## 74
        7.54
## 75
          NA
## 76
        8.94
## 77
       11.97
## 78
       10.27
## 79
       12.34
## 80
        9.10
## 81
        5.29
## 82
        7.22
```

```
## 83
        6.72
## 84
        7.51
## 85
        9.62
## 86
        6.53
## 87
       12.86
## 88
        8.44
## 89
          NA
## 90
        5.70
## 91
        8.81
## 92
        8.20
## 93
        8.16
## 94
        6.21
## 95
       10.59
## 96
          NA
## 97
          NA
## 98
        4.21
## 99
        3.57
## 100
       6.19
## 101 9.42
## 102
          NA
## 103 10.63
## 104 13.44
## 105 12.33
## 106 16.47
## 107 18.66
## 108 14.09
## 109 12.27
## 110 15.55
## 111 13.00
## 112 10.16
## 113
          NA
## 114 17.09
## 115 10.45
## 116
          NA
## 117 12.04
## 118 10.30
## 119
## 120 13.61
## 121 14.37
## 122 14.27
## 123 17.93
## 124
          NA
## 125 17.58
## 126 14.81
## 127 27.26
## 128 17.19
## 129 15.39
## 130 18.34
## 131 12.60
## 132 12.26
## 133 11.12
## 134 15.03
## 135 17.31
## 136
          NA
```

```
## 137 16.90
## 138 14.59
## 139
         NA
## 140 18.46
## 141 24.16
## 142 34.41
## 143 26.82
## 144 26.42
## 145 29.29
## 146 27.80
## 147 16.65
## 148 29.53
## 149 28.32
## 150 21.45
## 151 14.10
## 152 13.28
## 153 12.12
## 154 15.79
## 155 15.12
## 156 15.02
## 157
         NA
## 158
          NA
## 159 6.43
## 160
         NA
## 161
          NA
## 162 1.73
## 163
       1.92
## 164 3.32
## 165 11.64
## 166 9.81
## 167 3.70
## 168 12.14
## 169 11.10
## 170 11.32
## 171 14.43
## 172 12.03
## 173 14.69
## 174 9.04
## 175 9.64
## 176 5.33
## 177 10.11
## 178 6.29
## 179 6.92
## 180 5.04
## 181 7.56
## 182 9.45
## 183
       4.82
## 184 5.68
## 185 13.98
## 186
         NA
## 187
       4.45
## 188 6.68
## 189 4.56
## 190 5.39
```

```
## 191 5.10
## 192
         NA
## 193
          NA
## 194
       5.03
## 195
        4.38
## 196
       2.97
## 197
       4.08
## 198 8.61
## 199
        6.62
## 200
       4.56
## 201
       4.45
## 202
        7.43
## 203
        3.11
## 204 3.81
## 205 2.88
## 206 10.87
## 207 10.97
## 208
## 209 14.66
## 210 23.09
## 211 17.27
## 212 23.98
## 213 16.03
## 214 9.38
## 215 29.55
## 216 9.47
## 217 13.51
## 218 9.69
## 219 17.92
## 220 10.50
## 221 9.71
## 222 21.46
## 223 9.93
## 224 7.60
## 225
        4.14
## 226
       4.63
## 227
          NA
## 228 6.36
## 229
        3.92
## 230 3.76
## 231 11.65
## 232 5.25
## 233
        2.47
## 234
        3.95
## 235
        8.05
## 236
          NA
## 237
        9.54
## 238
        4.73
## 239
       6.36
## 240 7.37
## 241 11.38
## 242 12.40
## 243
          NA
```

244 5.19

```
## 245 12.50
## 246 18.46
## 247 9.16
## 248 10.15
## 249 9.52
## 250 6.56
## 251
       5.90
## 252
       3.59
## 253
       3.53
## 254
       3.54
## 255
       6.57
## 256
       9.25
## 257
       3.11
## 258
       5.12
## 259
       7.79
## 260
       6.90
## 261
       9.59
## 262 7.26
## 263 5.91
## 264 11.25
## 265 8.10
## 266 10.45
## 267 14.79
## 268 7.44
## 269 3.16
## 270 13.65
## 271
         NA
## 272
       6.59
## 273 7.73
## 274
       6.58
## 275
       3.53
## 276
       2.98
## 277
       6.05
## 278
       4.16
## 279
       7.19
## 280
       4.85
## 281
       3.76
## 282
       4.59
## 283
          NA
## 284
          NA
## 285
       7.85
## 286
         NA
## 287 12.93
## 288 7.14
## 289 7.60
## 290 9.51
## 291
       3.33
## 292
       3.56
## 293
       4.70
## 294
       8.58
## 295 10.40
## 296 6.27
## 297 7.39
## 298 15.84
```

```
## 299 4.97
## 300 4.74
## 301
       6.07
## 302
       9.50
## 303
       8.67
## 304
       4.86
## 305
       6.93
## 306 8.93
## 307
       6.47
## 308 7.53
## 309 4.54
## 310 9.97
## 311 12.64
## 312
         NA
## 313 11.72
## 314 7.90
## 315 9.28
## 316 11.50
## 317 18.33
## 318 15.94
## 319 10.36
## 320 12.73
## 321 7.20
## 322 6.87
## 323 7.70
## 324 11.74
## 325 6.12
## 326 5.08
## 327 6.15
## 328 12.79
## 329 9.97
## 330 7.34
## 331 9.09
## 332 12.43
## 333 7.83
## 334
         NA
## 335 6.75
## 336 8.01
## 337 9.80
## 338 10.56
## 339 8.51
## 340 9.74
## 341
       9.29
## 342 5.49
## 343 8.65
## 344 7.18
## 345 4.61
## 346 10.53
## 347 12.67
## 348 6.36
## 349 5.99
## 350 5.89
## 351 5.98
```

352 5.49

```
## 353 7.79
## 354 4.50
## 355 8.05
## 356 5.57
## 357 17.60
## 358 13.27
## 359 11.48
## 360 12.67
## 361 7.79
## 362 14.19
## 363 10.19
## 364 14.64
## 365 5.29
## 366 7.12
## 367
         NA
## 368 13.33
## 369 3.26
## 370 3.73
## 371 2.96
## 372 9.53
## 373 8.88
## 374 34.77
## 375 37.97
## 376 13.44
## 377 23.24
## 378 21.24
## 379 23.69
## 380 21.78
## 381 17.21
## 382 21.08
## 383 23.60
## 384 24.56
## 385 30.63
## 386 30.81
## 387 28.28
## 388 31.99
## 389 30.62
## 390 20.85
## 391 17.11
## 392 18.76
## 393 25.68
## 394 15.17
## 395 16.35
## 396
         NA
## 397 19.37
## 398 19.92
## 399 30.59
## 400 29.97
## 401 26.77
## 402 20.32
## 403 20.31
## 404 19.77
## 405 27.38
## 406 22.98
```

- ## 407 23.34
- ## 408 12.13
- ## 409 26.40
- ## 410 19.78
- ## 411 10.11
- ## 412 21.22
- ## 413 34.37
- ## 414 20.08
- ## 415 NA
- ## 416 29.05
- ... 110 20.00
- ## 417 25.79
- ## 418 26.64
- ## 419 20.62
- ## 420 22.74
- ## 421 15.02
- ## 422 15.70
- ## 423 14.10
- ## 424 23.29
- ## 425 17.16
- ## 426 24.39
- ## 427 15.69
- ## 428 14.52
- ## 429 21.52
- ## 423 21.32
- ## 430 24.08 ## 431 17.64
- ## 432 19.69
- ## 433 12.03
- ## 434 16.22
- ## 435 15.17
- ## 436 23.27
- ## 437 18.05
- ## 438 26.45
- ## 439 34.02
- ## 440 22.88
- ## 441 22.11
- ## 442 19.52
- ## 443 16.59
- ## 444 NA
- ## 445 NA
- ## 446 23.98 ## 447 17.79
- ## 448 16.44
- ## 449 18.13
- ## 450 19.31
- ## 451 17.44
- ## 452 17.73
- ## 453 17.27
- ## 454 16.74
- ## 455 NA
- ## 456 18.13
- ## 457 19.01 ## 458 16.94
- ## 459 16.23
- ## 460 14.70

```
## 461 16.42
## 462 14.65
## 463
## 464 10.29
## 465 13.22
## 466 14.13
## 467 17.15
## 468 21.32
## 469 18.13
## 470 14.76
## 471 16.29
## 472 12.87
## 473 14.36
## 474 11.66
## 475 18.14
## 476 24.10
## 477 18.68
## 478 24.91
## 479 18.03
## 480 13.11
## 481 10.74
## 482
       7.74
## 483
          NA
## 484 10.42
## 485 13.34
## 486 10.58
## 487 14.98
## 488 11.45
## 489
          NA
## 490 23.97
## 491 29.68
## 492 18.07
## 493 13.35
## 494 12.01
## 495 13.59
## 496 17.60
## 497 21.14
## 498 14.10
## 499 12.92
## 500
          NA
## 501 14.33
## 502
          NA
## 503
        9.08
## 504
        5.64
## 505
          NA
        7.88
## 506
```

Use a random forest modeling procedure to iteratively fill in the NA's by predicting each feature of X using every other feature of X. You need to start by filling in the holes to use RF. So fill them in with the average of the feature.

```
Xj_bars=colMeans(Xmiss, na.rm=TRUE)
XimputeRF = Xmiss
for (j in 1:ncol(Xmiss)){
  for(i in 1:nrow(Xmiss)){
```

```
if(is.na(Xmiss[i,j])){
    XimputeRF[i,j]=Xj_bars[j]
  }
}
```