Untitled

2024-11-17

```r
# install.packages('catdata')
```

```r
library(catdata)
```

```
## Loading required package: MASS
```

```r
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following object is masked from 'package:MASS':
##
##     select

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```r
library(ggplot2)
```

```r
data(aids)
```

```r
unique_person = unique(aids$person)
unique_person
```

```
##   [1] 10002 10005 10029 10039 10048 10052 10079 10088 10092 10131 10132 10135
##  [13] 10145 10171 10173 10175 10191 10196 10204 10213 10221 10222 10259 10263
##  [25] 10273 10290 10302 10304 10323 10343 10344 10350 10360 10361 10362 10372
##  [37] 10388 10396 10401 10403 10416 10419 10424 10425 10432 10433 10437 10444
##  [49] 10453 10473 10526 10527 10538 10557 10564 10569 10579 10587 10591 10642
##  [61] 10662 10669 10675 10678 10700 10770 10773 10806 10865 10878 10915 10916
##  [73] 10949 10954 10956 10968 11005 11048 11062 11076 11088 11100 11106 11118
##  [85] 11131 11142 11143 11165 11172 11175 11199 11200 20003 20013 20014 20032
##  [97] 20042 20057 20066 20072 20082 20086 20089 20111 20143 20147 20158 20175
## [109] 20199 20205 20232 20240 20284 20305 20323 20324 20332 20344 20348 20362
## [121] 20363 20374 20393 20395 20397 20404 20417 20421 20439 20476 20477 20492
## [133] 20498 20523 20537 20567 20568 20571 20583 20584 20591 20595 20604 20605
## [145] 20616 20664 20678 20713 20723 20736 20748 20749 20768 20776 20777 20779
## [157] 20837 20839 20850 20851 20852 20891 20906 21029 21058 21083 21087 21090
## [169] 21093 21136 21194 30007 30010 30018 30024 30038 30046 30048 30049 30050
## [181] 30051 30069 30075 30083 30101 30119 30122 30132 30133 30135 30148 30173
## [193] 30177 30179 30183 30193 30216 30225 30239 30262 30281 30301 30306 30310
## [205] 30324 30372 30376 30382 30388 30392 30405 30412 30420 30428 30454 30485
## [217] 30489 30490 30498 30503 30504 30508 30515 30531 30536 30548 30562 30599
## [229] 30654 30663 30673 30677 30692 30693 30698 30699 30702 30713 30735 30777
## [241] 30798 30820 30827 30835 30840 30864 30868 30871 30881 30882 30913 30931
## [253] 30933 30953 30960 30995 30999 31036 31054 31062 40012 40014 40043 40121
## [265] 40132 40175 40217 40224 40249 40286 40327 40337 40340 40362 40363 40372
## [277] 40374 40375 40378 40390 40399 40401 40402 40419 40438 40445 40464 40499
## [289] 40508 40520 40534 40553 40555 40562 40571 40624 40661 40672 40681 40693
## [301] 40702 40738 40759 40774 40791 40795 40807 40867 40873 40901 40904 40942
## [313] 40959 40967 40970 40973 41032 41045 41061 41062 41082 41108 41142 41157
## [325] 41158 41163 41165 41185 41194 41221 41243 41253 41261 41265 41289 41305
## [337] 41314 41325 41328 41395 41402 41406 41407 41411 41414 41416 41452 41474
## [349] 41475 41521 41549 41566 41620 41621 41628 41646 41656 41658 41659 41687
## [361] 41691 41692 41717 41725 41728 41741 41820 41829 41844
```

```r
set.seed(666)
randint = sample(unique_person,50)
training_data = aids %>%
  filter(person %in% randint)
training_data
```

```
##     cd4      time drugs partners packs cesd  age person
## 1   561 -1.253936     1        5     0    0 4.40  10145
## 2  1102 -0.755647     1        5     0    0 4.40  10145
## 3  1620 -0.240931     1       -1     0   -7 4.40  10145
## 4   697  0.238193     1       -1     0   -4 4.40  10145
## 5   538  0.766598     1       -4     0   -4 4.40  10145
## 6   811  1.284052     1       -4     0   -5 4.40  10145
## 7   592  1.779603     1       -4     0   -2 4.40  10145
## 8   568  2.277892     1       -3     0   -6 4.40  10145
## 9   384  2.795346     1       -4     0   -3 4.40  10145
## 10  431  3.293634     1        1     0   -7 4.40  10145
## 11  544  3.772758     1       -3     0   -5 4.40  10145
## 12  677  4.290212     1       -3     0   -7 4.40  10145
## 13  587 -1.667351     0        5     0    1 0.63  10304
## 14  638 -1.193703     1        5     0    2 0.63  10304
## 15  583 -0.673511     1        5     0   10 0.63  10304
## 16  479 -0.249144     1        5     0   17 0.63  10304
## 17  588  1.152635     0        5     0    2 0.63  10304
## 18  826  1.401780     1        5     0    7 0.63  10304
## 19  273  1.911020     0        5     0    4 0.63  10304
## 20  324  2.737851     0       -2     0    1 0.63  10304
## 21  515  3.236140     0        0     0    2 0.63  10304
## 22 1472 -1.604381     1        5     4   26 8.78  10343
## 23 1589 -0.254620     1       -1     3   24 8.78  10343
## 24  739  1.519507     1       -3     3   -1 8.78  10343
## 25 1697 -2.726899     1        5     3   14 6.50  10350
## 26 1416 -2.228611     1        5     3    4 6.50  10350
## 27  803 -1.749487     1        5     3   -1 6.50  10350
## 28  713  0.766598     1        1     2   -5 6.50  10350
## 29  599  2.031485     1       -4     2    4 6.50  10350
## 30  556  2.502396     1       -3     2    0 6.50  10350
## 31  668  0.246407     1        5     0   10 3.56  10361
## 32  405  0.744695     1        3     0    9 3.56  10361
## 33  400  1.262149     1       -4     0    5 3.56  10361
## 34  259  1.741273     1       -4     0    7 3.56  10361
## 35  558  2.321697     1        2     0    4 3.56  10361
## 36   488  2.789870     1        5     0    2  3.56  10361
## 37   307  3.288159     1        5     0    0  3.56  10361
## 38   307  3.786448     1        5     0    7  3.56  10361
## 39   326  4.284737     1        5     0   11  3.56  10361
## 40   293  4.802190     1        2     0   24  3.56  10361
## 41   343  5.289528     1        5     0   36  3.56  10361
## 42   631 -1.292266     0       -3     0   -1 -1.12  10473
## 43   558 -0.747433     0       -2     0    6 -1.12  10473
## 44   934 -0.229979     0       -2     0    2 -1.12  10473
## 45   200  0.229979     1       -3     0    8 -1.12  10473
## 46   314  2.338125     0       -4     0    2 -1.12  10473
## 47   149  2.839151     0       -4     0    7 -1.12  10473
## 48   855 -2.699521     1       -3     2   -4  6.20  10587
## 49  1264 -2.193018     1        0     2   -4  6.20  10587
## 50  1259 -1.675565     1        5     1   -5  6.20  10587
## 51   519 -1.256673     1       -3     1   -6  6.20  10587
## 52  1103  0.711841     1       -4     1   -5  6.20  10587
## 53  1082  1.708419     1       -4     1   -4  6.20  10587
## 54   779  2.225873     1       -4     1   -5  6.20  10587
## 55  1245 -1.697467     1        1     0   16  0.36  10669
## 56  1103 -1.199179     1        3     0   11  0.36  10669
## 57  1260 -0.260096     1        3     0    2  0.36  10669
## 58   478  1.316906     1       -5     0   15  0.36  10669
## 59   385  1.891855     1       -4     0   15  0.36  10669
## 60  1236 -2.466804     1        0     0    0  0.36  10773
## 61   942  2.464066     0        0     0   -3  0.36  10773
## 62   950  2.981519     0       -3     0    0  0.36  10773
## 63  1077 -1.248460     1        5     0   11  0.08  10806
## 64  1220 -0.747433     1        3     0    8  0.08  10806
## 65   756 -0.249144     1        5     0   19  0.08  10806
## 66   551  0.249144     0        2     0   28  0.08  10806
## 67   676  0.747433     0        1     0   18  0.08  10806
## 68  1206 -0.240931     1        5     0    1 -0.18  10878
## 69   691  0.240931     0       -2     0   -1 -0.18  10878
## 70   596 -0.758385     1        1     0    8 -3.17  10916
## 71   616 -0.240931     1       -3     0   -3 -3.17  10916
## 72   496  0.240931     1       -1     0   -2 -3.17  10916
## 73   672  0.700890     1       -2     0   -3 -3.17  10916
## 74   359  1.215606     1       -4     0   -2 -3.17  10916
## 75   660  1.771389     1       -2     0   -5 -3.17  10916
## 76   257  2.308008     1       -2     0   -1 -3.17  10916
## 77   383  2.825462     1       -4     0   20 -3.17  10916
## 78   940 -1.097878     0       -2     0    0 23.06  11076
## 79   570 -0.240931     1        0     0    3 23.06  11076
## 80   799 -1.341547     1       -2     1   11  1.79  20014
## 81   913 -0.347707     1       -2     0    3  1.79  20014
## 82   269  0.826831     1       -3     0   11  1.79  20014
## 83   276  1.382615     1       -3     0    1  1.79  20014
## 84   224  1.872690     1       -4     0    6  1.79  20014
## 85  1075 -1.563313     1       -2     0   10  4.51  20032
## 86   865 -0.867899     1       -3     0    4  4.51  20032
## 87   988 -0.720055     1       -3     0   10  4.51  20032
## 88   940 -0.336756     1        0     0   11  4.51  20032
## 89   900  0.336756     1       -1     0   -5  4.51  20032
## 90   556  0.878850     1       -4     0    5  4.51  20032
## 91   754 -2.882957     0       -2     0   -4 13.71  20082
## 92   814 -2.349076     0        3     0    0 13.71  20082
## 93   936 -0.758385     0        5     0   -5 13.71  20082
## 94   796 -0.224504     0        5     0   30 13.71  20082
## 95   770  0.224504     0        4     0   -2 13.71  20082
## 96   676  0.511978     0        1     0   -2 13.71  20082
## 97   811  1.029432     0        5     0   -7 13.71  20082
## 98   662  1.492129     0        0     0   -4 13.71  20082
## 99   780  2.023272     0        5     0   -4 13.71  20082
## 100  857 -2.787132     1        5     0   -4  4.42  20240
## 101  375 -2.422998     1        5     0    3  4.42  20240
## 102  543 -2.078029     1        5     0   -3  4.42  20240
## 103  530 -1.382615     1        5     0   10  4.42  20240
## 104  525 -0.900753     1        5     0    5  4.42  20240
## 105  633 -0.251882     1        5     0   17  4.42  20240
## 106  908 -0.262834     0        5     0   -6 -2.37  20393
## 107  250  0.262834     1        3     0   -7 -2.37  20393
## 108  307  0.818617     1        3     0   -6 -2.37  20393
## 109  605  1.330595     1       -1     0   -3 -2.37  20393
## 110  546  1.796030     1        0     0   -7 -2.37  20393
## 111  372  2.255989     1       -3     0   -4 -2.37  20393
## 112  339  2.852840     1        1     0   -7 -2.37  20393
## 113  311  3.175907     1        1     0   -2 -2.37  20393
## 114  319  3.466119     1        1     0   -7 -2.37  20393
## 115  492  4.000000     1        0     0   -4 -2.37  20393
## 116  350  4.536619     1       -1     0   -2 -2.37  20393
## 117  442  5.103354     1        5     0    2 -2.37  20393
## 118  838 -2.603696     1       -1     0   -2 -1.35  20404
## 119  412 -1.555099     1       -1     0    0 -1.35  20404
## 120  888 -0.678987     1        0     1   -6 -1.35  20404
## 121  724 -0.268309     1        1     1   -5 -1.35  20404
## 122  721  0.268309     1       -2     1   -7 -1.35  20404
## 123  690 -0.506502     1        5     0   -5 -7.76  20417
## 124 1025  0.511978     1       -3     0   -5 -7.76  20417
## 125  483  0.966461     1       -4     0    1 -7.76  20417
## 126  935 -0.763860     1        0     0    3  3.35  20421
## 127  816 -0.260096     1       -2     0    3  3.35  20421
## 128 1119  0.251882     1       -1     0    0  3.35  20421
## 129  902  0.799452     1       -4     0   -3  3.35  20421
## 130  809  1.286790     1       -4     0    3  3.35  20421
## 131  374  1.785079     1       -4     0    3  3.35  20421
## 132  684  2.321697     1       -4     0    3  3.35  20421
## 133  725  3.687885     0       -4     0   24  3.35  20421
## 134  892 -2.776181     1        0     0   -3 -9.52  20477
## 135 1110 -2.280630     1        0     0    4 -9.52  20477
## 136  740 -0.117728     1       -2     0   -4 -9.52  20477
## 137  472  0.117728     1       -3     0    2 -9.52  20477
## 138  755  0.481862     1        1     0   -1 -9.52  20477
## 139  701  1.018481     1        2     0    1 -9.52  20477
## 140   37  1.555099     1        5     0   -1 -9.52  20477
## 141  470  2.072553     1        1     0   16 -9.52  20477
## 142  957 -1.839836     1       -2     1   -7  3.36  20567
## 143 1006 -1.234771     1       -4     0   -3  3.36  20567
## 144  936 -0.802190     1        -4    0    -7  3.36  20567
## 145  492  0.717317     1        -4    0    -7  3.36  20567
## 146 1629  1.314168     1        -4    0    -7  3.36  20567
## 147 1203  1.615332     1        -4    0     3  3.36  20567
## 148 1397  2.439425     1        -4    0    -1  3.36  20567
## 149  424 -1.535934     1        -1    0    11 20.66  20571
## 150  553 -1.152635     1        -1    0     8 20.66  20571
## 151  734 -0.769336     1        -1    0    11 20.66  20571
## 152  405 -0.328542     1         0    0     9 20.66  20571
## 153  596  0.328542     1         1    0     8 20.66  20571
## 154  396  0.884326     1        -5    0    11 20.66  20571
## 155  831 -1.259411     1         0    2     4 -1.57  20584
## 156  753 -0.761123     1         3    2    -6 -1.57  20584
## 157  508 -0.260096     1        -3    2     3 -1.57  20584
## 158  406  1.366188     1        -4    1    -7 -1.57  20584
## 159  175  1.809719     1        -4    2    -6 -1.57  20584
## 160  108  2.598220     1        -4    2    -7 -1.57  20584
## 161 1292 -1.459274     1         5    3    -7  0.46  20595
## 162  884 -1.040383     1         5    3    -7  0.46  20595
## 163  785 -0.747433     1         5    3    -7  0.46  20595
## 164 1243 -0.268309     1         5    3    -7  0.46  20595
## 165  789  0.268309     1         5    3    -5  0.46  20595
## 166  517  0.769336     1         5    0     0  0.46  20595
## 167 1022 -0.281999     1        -4    2     2 -6.90  20678
## 168  800 -1.270363     1         5    0    -2  4.47  20713
## 169  743 -0.763860     1         5    0    14  4.47  20713
## 170  719 -0.251882     1        -2    0    11  4.47  20713
## 171  481  1.223819     0        -4    0    10  4.47  20713
## 172  348  1.971253     0        -4    0    -7  4.47  20713
## 173  392  2.362765     0        -4    0    -6  4.47  20713
## 174 1451 -0.254620     1         5    0    -3  1.93  20749
## 175 1684  0.249144     1         5    0     0  1.93  20749
## 176  797  0.744695     1         1    0    -6  1.93  20749
## 177  916  1.289528     1         3    0    -2  1.93  20749
## 178  918  1.897331     1         4    0    -2  1.93  20749
## 179 1345  2.247776     1         2    0    -4  1.93  20749
## 180  821  3.110198     1         5    0    -5  1.93  20749
## 181  759 -0.210815     1         5    1    12  4.37  20852
## 182  969  0.210815     1         5    1     6  4.37  20852
## 183  664  1.171800     1         2    1    14  4.37  20852
## 184  587  1.664613     1         1    1    12  4.37  20852
## 185  499  2.469541     1         5    1    17  4.37  20852
## 186  486  3.011636     1        -4    1    10  4.37  20852
## 187  805  3.493498     1        -4    1     9  4.37  20852
## 188  400  3.972621     1        -1    1    18  4.37  20852
## 189  567  4.583162     1        -1    1     7  4.37  20852
## 190  926 -0.221766     0         5    0    -2 29.08  20891
## 191  354  0.221766     1        -2    0     0 29.08  20891
## 192  899  0.550308     0        -4    0    -3 29.08  20891
## 193  675  1.081451     0        -4    0    -2 29.08  20891
## 194  524  1.585216     0        -4    0    -6 29.08  20891
## 195 1082  2.045175     0        -4    0    -7 29.08  20891
## 196  590  2.521561     0        -4    0    -7 29.08  20891
## 197  861  2.825462     0        -4    0    -7 29.08  20891
## 198  786  3.252567     0       -4     0   -6 29.08  20891
## 199  728  3.822040     0       -4     0   -4 29.08  20891
## 200  764  4.262834     0       -4     0   -6 29.08  20891
## 201  768 -0.832307     1        0     3    0 -6.44  30075
## 202  656 -0.238193     1        5     3    4 -6.44  30075
## 203  511  0.238193     1       -4     3   12 -6.44  30075
## 204  710  0.698152     1       -4     4   21 -6.44  30075
## 205  641  1.070500     1       -4     3    3 -6.44  30075
## 206  916  2.425736     1       -3     4    0 -6.44  30075
## 207  875 -1.549623     1        0     0    2  4.17  30083
## 208  972 -0.621492     1        5     0   -1  4.17  30083
## 209  609  0.621492     1       -3     0   10  4.17  30083
## 210  504 -2.532512     1        5     0   -2 -0.62  30132
## 211  695 -2.110883     1       -1     0    8 -0.62  30132
## 212  900 -1.708419     1        4     0    0 -0.62  30132
## 213  665 -1.248460     1        0     0    0 -0.62  30132
## 214 1166 -0.249144     1        5     0   10 -0.62  30132
## 215  274  0.249144     1        0     0   -1 -0.62  30132
## 216  995 -0.249144     1       -3     3   -7 -2.53  30376
## 217  975  0.249144     1       -4     3    0 -2.53  30376
## 218  782  0.824093     1       -2     3    0 -2.53  30376
## 219 2534 -2.433949     1        5     4   25 13.25  30503
## 220  394  2.433949     1        5     3    8 13.25  30503
## 221  748 -2.466804     1        5     0   25  2.55  30735
## 222  685 -1.968515     1        5     0   21  2.55  30735
## 223  684 -1.546886     1        5     0   19  2.55  30735
## 224  711 -1.144422     1        5     0   25  2.55  30735
## 225  837 -0.703628     1        5     0   22  2.55  30735
## 226  897 -0.224504     1        5     0   17  2.55  30735
## 227  606  0.435318     1        0     0   22  2.55  30735
## 228  431  0.952772     1        1     0   22  2.55  30735
## 229  473  1.467488     1        5     0   18  2.55  30735
## 230  370  1.965777     1        5     0   16  2.55  30735
## 231  303 -0.249144     0        5     0   17 11.53  30827
## 232  451  0.249144     1        0     0   -5 11.53  30827
## 233  297  0.673511     1       -2     0   17 11.53  30827
## 234  233  1.040383     0       -3     0    2 11.53  30827
## 235  290  1.620808     0       -2     0   -1 11.53  30827
## 236  184  1.908282     0       -4     0   -4 11.53  30827
## 237  505  2.417522     0       -2     0   -6 11.53  30827
## 238  301  2.915811     0       -3     0   -4 11.53  30827
## 239  101  3.436003     0       -3     0   -5 11.53  30827
## 240 1585 -0.763860     0        0     3   15 -6.17  31054
## 241 1731 -0.227242     1        1     3   16 -6.17  31054
## 242 1466  0.227242     1        5     3    9 -6.17  31054
## 243 1224  0.610541     1        0     3    1 -6.17  31054
## 244 1482  1.108830     1       -4     3    0 -6.17  31054
## 245 1376  1.694730     1       -4     0   -3 -6.17  31054
## 246 1245  2.088980     0       -4     0   -2 -6.17  31054
## 247 1159  2.748802     1       -4     3   -6 -6.17  31054
## 248  916  3.400411     1       -4     3   -5 -6.17  31054
## 249  803 -0.325804     1        5     4    1 11.22  40224
## 250  664  0.325804     1        0     3    1 11.22  40224
## 251  539  0.804928     0       -2     3   -4 11.22  40224
## 252  311  1.648186     0        -4    3    1 11.22  40224
## 253  735 -1.694730     1         5    0    9  7.55  40372
## 254  966 -1.067762     1         5    0   -7  7.55  40372
## 255  772 -0.665298     1         1    0   -3  7.55  40372
## 256  749 -0.260096     1        -1    0   -6  7.55  40372
## 257  423  1.979466     1        -3    0    8  7.55  40372
## 258  446  2.554415     1        -4    0    0  7.55  40372
## 259  605  3.088296     1         0    0   -5  7.55  40372
## 260  534  3.493498     1         0    0   -2  7.55  40372
## 261  387  4.062971     1        -2    0    5  7.55  40372
## 262  903 -1.700205     1         5    3   -5  5.74  40402
## 263  426  2.198494     1        -4    2   -3  5.74  40402
## 264  942 -2.910335     1         5    3   -7 11.59  40499
## 265  699 -2.422998     1         5    3   -5 11.59  40499
## 266  907 -1.957563     1         4    3   -7 11.59  40499
## 267  734 -1.552361     1        -2    3   -7 11.59  40499
## 268 1000 -0.295688     0         0    3   13  0.71  40738
## 269  480  0.295688     1         2    3   -1  0.71  40738
## 270  449  0.835045     1        -2    3    8  0.71  40738
## 271  407  1.448323     1        -2    3   22  0.71  40738
## 272  360  1.946612     1        -3    2    5  0.71  40738
## 273  325  3.457906     1        -5    2    1  0.71  40738
## 274  382  4.881588     1        -4    2   -3  0.71  40738
## 275  882 -0.334018     1         5    3    3 18.14  40774
## 276  713  0.334018     1         0    0    3 18.14  40774
## 277  512  0.835045     1        -2    3    3 18.14  40774
## 278  389  1.349760     1        -4    3    4 18.14  40774
## 279 1157 -2.521561     1         2    4   33 -4.55  40795
## 280  972 -2.099931     1         5    4   33 -4.55  40795
## 281 1350 -1.661875     1         5    4   39 -4.55  40795
## 282 1290 -1.182752     1         5    4   39 -4.55  40795
## 283 1246 -0.240931     1         5    4   48 -4.55  40795
## 284  530  0.240931     1         5    4   48 -4.55  40795
## 285  546  1.259411     1         5    4   40 -4.55  40795
## 286  394  2.291581     1         5    4   39 -4.55  40795
## 287  906 -1.853525     1         5    0   -1 15.23  41062
## 288 1212 -1.125257     1         5    0   -6 15.23  41062
## 289 1459 -0.703628     1         5    0   -1 15.23  41062
## 290 1538 -0.235455     1         0    0   -7 15.23  41062
## 291 1362  0.235455     1         0    0   -5 15.23  41062
## 292  624  1.396304     1        -2    0   -5 15.23  41062
## 293  170  2.354552     1        -4    0   -5 15.23  41062
## 294  277  2.819986     1        -5    0   -2 15.23  41062
## 295  980 -0.821355     1        -3    0    0  7.67  41158
## 296 1174 -0.251882     1         1    0   -7  7.67  41158
## 297 1008  0.251882     1        -1    0   -4  7.67  41158
## 298  931  0.750171     1        -2    0   -6  7.67  41158
## 299  910  1.763176     1        -2    0   -3  7.67  41158
## 300  327  2.702259     1        -1    0   -4  7.67  41158
## 301  295  3.200547     1        -4    0   -1  7.67  41158
## 302   83  3.698836     1        -3    0   -2  7.67  41158
## 303  819 -2.647502     0         5    0    1  0.67  41474
## 304  970 -2.242300     0         5    0    0  0.67  41474
## 305  647 -1.760438     0         5    0    2  0.67  41474
## 306  828 -1.264887     0       -2     0    4  0.67  41474
## 307  647  0.268309     0       -3     0    6  0.67  41474
## 308  624  0.783025     0       -4     0    8  0.67  41474
## 309  547  1.347023     0        5     0    8  0.67  41474
## 310  628  1.768652     0        1     0    2  0.67  41474
## 311  532 -1.779603     1        5     0   21  2.49  41691
## 312  464 -1.284052     1        5     0   16  2.49  41691
## 313  780 -0.766598     1        3     0   33  2.49  41691
## 314  633 -0.369610     1        5     0   31  2.49  41691
## 315  540  1.377139     1        5     0   38  2.49  41691
```

```r
bandwidths <- seq(15, 40, length.out = 100)
```

```r
x = training_data$time
y = training_data$cd4
smoother = ksmooth(x,y, kernel = "normal", bandwidth = 2, x.points = unique(x))
smoothed_values = smoother$y
  smoothed_full = smoothed_values[match(x, unique(x))]
  residuals = y - smoothed_full
noise_variance = var(residuals)
noise_variance
```

```
## [1] 142819.3
```

#b

```r
cp_values <- numeric(length(bandwidths))
for (i in 1:length(bandwidths)) {
  bandwidth <- bandwidths[i]
  smoother = ksmooth(x,y, kernel = "normal", bandwidth = bandwidth, x.points = unique(x))
  smoothed_values = smoother$y
  smoothed_full = smoothed_values[match(x, unique(x))]
  residuals = y - smoothed_full
  rss = sum(residuals^2)
  noise_variance = var(residuals)
  n = length(x)
  kernel_weights <- exp(-0.5 * (outer(x, x, "-") / bandwidth)^2)
  smoother_matrix_diag <- diag(kernel_weights)
  trace_S_lambda = sum(smoother_matrix_diag)
  cp =  1/n * (rss + 2 * noise_variance * trace_S_lambda)
  cp_values[i] <- cp
}
```

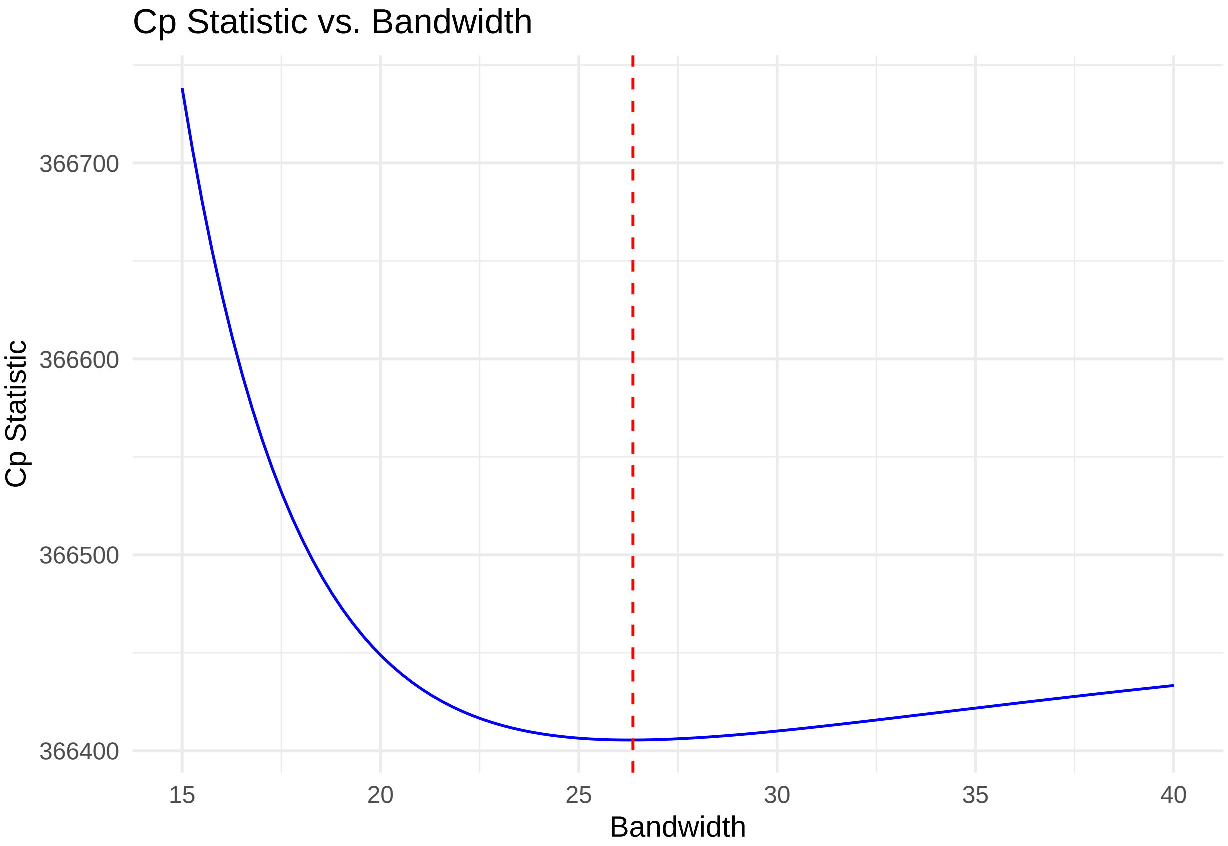
```r
cp_values
```

```
##   [1] 366738.2 366707.9 366680.2 366655.0 366632.1 366611.1 366592.0 366574.6
##   [9] 366558.6 366544.1 366530.8 366518.7 366507.7 366497.6 366488.4 366480.0
##  [17] 366472.3 366465.3 366459.0 366453.2 366447.9 366443.1 366438.7 366434.8
##  [25] 366431.2 366428.0 366425.1 366422.4 366420.1 366417.9 366416.1 366414.4
##  [33] 366412.9 366411.6 366410.4 366409.4 366408.6 366407.8 366407.2 366406.7
##  [41] 366406.3 366406.0 366405.8 366405.6 366405.5 366405.5 366405.6 366405.7
##  [49] 366405.8 366406.0 366406.3 366406.5 366406.9 366407.2 366407.6 366408.0
##  [57] 366408.4 366408.9 366409.4 366409.9 366410.4 366410.9 366411.5 366412.0
##  [65] 366412.6 366413.2 366413.7 366414.3 366414.9 366415.5 366416.1 366416.8
##  [73] 366417.4 366418.0 366418.6 366419.2 366419.8 366420.4 366421.1 366421.7
##  [81] 366422.3 366422.9 366423.5 366424.1 366424.7 366425.3 366425.9 366426.5
##  [89] 366427.1 366427.7 366428.3 366428.9 366429.4 366430.0 366430.6 366431.1
##  [97] 366431.7 366432.2 366432.8 366433.3
```

```
optimal_bandwidth_idx <- which.min(cp_values)
optimal_bandwidth <- bandwidths[optimal_bandwidth_idx]
smoother = ksmooth(x,y, kernel = "normal", bandwidth = optimal_bandwidth, x.points = unique(x))
smoothed_values = smoother$y
smoothed_full = smoothed_values[match(x, unique(x))]
residuals = y - smoothed_full
rss = sum(residuals^2)
training_error = rss/length(x)
training_error
```

```
## [1] 121876.9
```

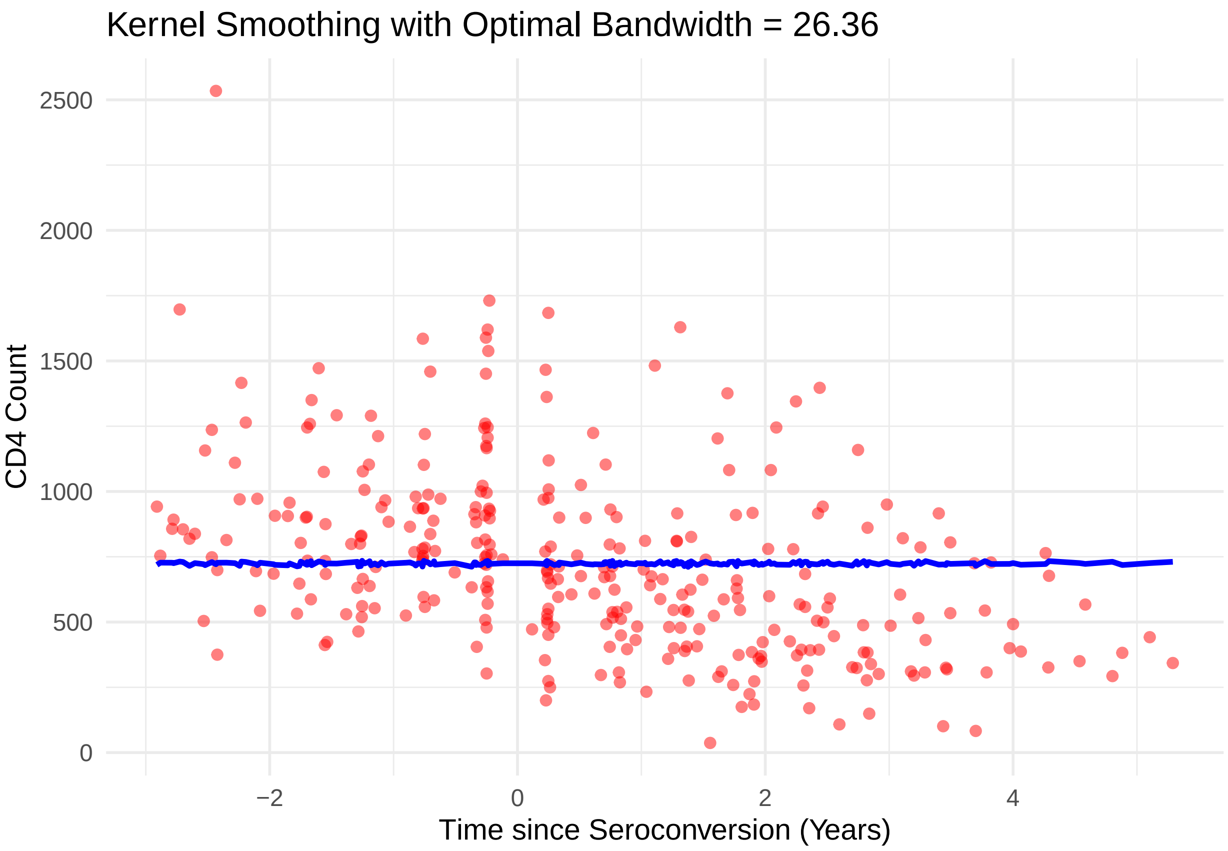
```
cp_plot <- ggplot(data.frame(bandwidths, cp_values), aes(x = bandwidths, y = cp_values)) +
  geom_line(color = "blue") +
  geom_vline(xintercept = optimal_bandwidth, color = "red", linetype = "dashed") +
  labs(title = "Cp Statistic vs. Bandwidth", x = "Bandwidth", y = "Cp Statistic") +
  theme_minimal()

print(cp_plot)
```



```
fitted_plot <- ggplot(data.frame(x, y), aes(x = x, y = y)) +
  geom_point(color = "red", alpha = 0.5) +
  geom_line(aes(x = x, y = smoothed_full), color = "blue", size = 1) +
  labs(title = paste("Kernel Smoothing with Optimal Bandwidth =", round(optimal_bandwidth, 2)),
       x = "Time since Seroconversion (Years)", y = "CD4 Count") +
  theme_minimal()
```

```
## Warning: Using `size` aesthetic for lines was deprecated in ggplot2 3.4.0.
## i Please use `linewidth` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```

```
print(fitted_plot)
```



#c

```
bootstrapped_loo <- function(x, y, bandwidth, n_bootstrap = 100) {

  n <- length(x)
  bootstrap_errors <- numeric(n_bootstrap)
  for (i in 1:n_bootstrap) {
    bootstrap_indices <- sample(1:n, size = n, replace = TRUE)
    x_bootstrap <- x[bootstrap_indices]
    y_bootstrap <- y[bootstrap_indices]
    loo_errors <- numeric(n)
    for (j in 1:n) {
      x_train <- x_bootstrap[-j]
      y_train <- y_bootstrap[-j]
      smoother_train <- ksmooth(x_train, y_train, kernel = "normal", bandwidth = bandwidth, x.points = u
      smoothed_train_values <- smoother_train$y
      prediction <- smoothed_train_values[match(x[j], unique(x))]
      loo_errors[j] <- (y[j] - prediction)^2
    }
    bootstrap_errors[i] <- mean(loo_errors)
  }
  mean_bootstrap_error <- mean(bootstrap_errors)
  return(mean_bootstrap_error)
}

n_bootstrap <- 100

bootstrap_error <- bootstrapped_loo(x, y, optimal_bandwidth, n_bootstrap)

print(paste("Bootstrap Estimated Prediction Error:", bootstrap_error))
```

```
## [1] "Bootstrap Estimated Prediction Error: 122290.173021034"
```

#d

```
estimator_632 =  0.368 * training_error + 0.632 * bootstrap_error
estimator_632
```

```
## [1] 122138.1
```

```
training_error
```

```
## [1] 121876.9
```

```
bootstrap_error
```

```
## [1] 122290.2
```

We can tell that the .632 estimator is living between training_error and bootstrap_error

#e

```
testing_data = aids %>%
  filter(!(person %in% randint))
unique_person = unique(testing_data$person)

mean_errors = numeric(1000)
compute_mean_error <- function(x_test, y_test, bandwidth) {
  smoothed_values <- smoother$y[match(x_test, unique(x_test))]
  mean_squared_error <- mean((y_test - smoothed_values)^2)
  return(mean_squared_error)
}
smoother = ksmooth(x,y, kernel = "normal", bandwidth = optimal_bandwidth, x.points = unique(x))
for (i in 1:1000) {
  randint = sample(unique_person,5)
  testing = testing_data %>%
  filter(person %in% randint)
  x_test_sample <- testing$time
  y_test_sample <- testing$cd4
  mean_errors[i] <- compute_mean_error(x_test_sample, y_test_sample, optimal_bandwidth)
}

average_mean_squared_error = mean(mean_errors)
average_mean_squared_error
```

```
## [1] 164957.4
```

The prediction error is a bit higher than the training error but acceptable.