STAT 170 Final Project Info

2023-11-15

## R Markdown

# Setting up data

insurance <- read.csv("~/Desktop/UC Riverside/2023-2024/STAT 170/Final Project/insurance.csv")  
# View(insurance)

library(tidyverse)

## ── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ──  
## ✔ dplyr 1.1.3 ✔ readr 2.1.4  
## ✔ forcats 1.0.0 ✔ stringr 1.5.0  
## ✔ ggplot2 3.4.4 ✔ tibble 3.2.1  
## ✔ lubridate 1.9.3 ✔ tidyr 1.3.0  
## ✔ purrr 1.0.2   
## ── Conflicts ────────────────────────────────────────── tidyverse\_conflicts() ──  
## ✖ dplyr::filter() masks stats::filter()  
## ✖ dplyr::lag() masks stats::lag()  
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors

insurance

## age sex bmi children smoker region charges  
## 1 19 female 27.900 0 yes southwest 16884.924  
## 2 18 male 33.770 1 no southeast 1725.552  
## 3 28 male 33.000 3 no southeast 4449.462  
## 4 33 male 22.705 0 no northwest 21984.471  
## 5 32 male 28.880 0 no northwest 3866.855  
## 6 31 female 25.740 0 no southeast 3756.622  
## 7 46 female 33.440 1 no southeast 8240.590  
## 8 37 female 27.740 3 no northwest 7281.506  
## 9 37 male 29.830 2 no northeast 6406.411  
## 10 60 female 25.840 0 no northwest 28923.137  
## 11 25 male 26.220 0 no northeast 2721.321  
## 12 62 female 26.290 0 yes southeast 27808.725  
## 13 23 male 34.400 0 no southwest 1826.843  
## 14 56 female 39.820 0 no southeast 11090.718  
## 15 27 male 42.130 0 yes southeast 39611.758  
## 16 19 male 24.600 1 no southwest 1837.237  
## 17 52 female 30.780 1 no northeast 10797.336  
## 18 23 male 23.845 0 no northeast 2395.172  
## 19 56 male 40.300 0 no southwest 10602.385  
## 20 30 male 35.300 0 yes southwest 36837.467  
## 21 60 female 36.005 0 no northeast 13228.847  
## 22 30 female 32.400 1 no southwest 4149.736  
## 23 18 male 34.100 0 no southeast 1137.011  
## 24 34 female 31.920 1 yes northeast 37701.877  
## 25 37 male 28.025 2 no northwest 6203.902  
## 26 59 female 27.720 3 no southeast 14001.134  
## 27 63 female 23.085 0 no northeast 14451.835  
## 28 55 female 32.775 2 no northwest 12268.632  
## 29 23 male 17.385 1 no northwest 2775.192  
## 30 31 male 36.300 2 yes southwest 38711.000  
## 31 22 male 35.600 0 yes southwest 35585.576  
## 32 18 female 26.315 0 no northeast 2198.190  
## 33 19 female 28.600 5 no southwest 4687.797  
## 34 63 male 28.310 0 no northwest 13770.098  
## 35 28 male 36.400 1 yes southwest 51194.559  
## 36 19 male 20.425 0 no northwest 1625.434  
## 37 62 female 32.965 3 no northwest 15612.193  
## 38 26 male 20.800 0 no southwest 2302.300  
## 39 35 male 36.670 1 yes northeast 39774.276  
## 40 60 male 39.900 0 yes southwest 48173.361  
## 41 24 female 26.600 0 no northeast 3046.062  
## 42 31 female 36.630 2 no southeast 4949.759  
## 43 41 male 21.780 1 no southeast 6272.477  
## 44 37 female 30.800 2 no southeast 6313.759  
## 45 38 male 37.050 1 no northeast 6079.672  
## 46 55 male 37.300 0 no southwest 20630.284  
## 47 18 female 38.665 2 no northeast 3393.356  
## 48 28 female 34.770 0 no northwest 3556.922  
## 49 60 female 24.530 0 no southeast 12629.897  
## 50 36 male 35.200 1 yes southeast 38709.176  
## 51 18 female 35.625 0 no northeast 2211.131  
## 52 21 female 33.630 2 no northwest 3579.829  
## 53 48 male 28.000 1 yes southwest 23568.272  
## 54 36 male 34.430 0 yes southeast 37742.576  
## 55 40 female 28.690 3 no northwest 8059.679  
## 56 58 male 36.955 2 yes northwest 47496.494  
## 57 58 female 31.825 2 no northeast 13607.369  
## 58 18 male 31.680 2 yes southeast 34303.167  
## 59 53 female 22.880 1 yes southeast 23244.790  
## 60 34 female 37.335 2 no northwest 5989.524  
## 61 43 male 27.360 3 no northeast 8606.217  
## 62 25 male 33.660 4 no southeast 4504.662  
## 63 64 male 24.700 1 no northwest 30166.618  
## 64 28 female 25.935 1 no northwest 4133.642  
## 65 20 female 22.420 0 yes northwest 14711.744  
## 66 19 female 28.900 0 no southwest 1743.214  
## 67 61 female 39.100 2 no southwest 14235.072  
## 68 40 male 26.315 1 no northwest 6389.378  
## 69 40 female 36.190 0 no southeast 5920.104  
## 70 28 male 23.980 3 yes southeast 17663.144  
## 71 27 female 24.750 0 yes southeast 16577.780  
## 72 31 male 28.500 5 no northeast 6799.458  
## 73 53 female 28.100 3 no southwest 11741.726  
## 74 58 male 32.010 1 no southeast 11946.626  
## 75 44 male 27.400 2 no southwest 7726.854  
## 76 57 male 34.010 0 no northwest 11356.661  
## 77 29 female 29.590 1 no southeast 3947.413  
## 78 21 male 35.530 0 no southeast 1532.470  
## 79 22 female 39.805 0 no northeast 2755.021  
## 80 41 female 32.965 0 no northwest 6571.024  
## 81 31 male 26.885 1 no northeast 4441.213  
## 82 45 female 38.285 0 no northeast 7935.291  
## 83 22 male 37.620 1 yes southeast 37165.164  
## 84 48 female 41.230 4 no northwest 11033.662  
## 85 37 female 34.800 2 yes southwest 39836.519  
## 86 45 male 22.895 2 yes northwest 21098.554  
## 87 57 female 31.160 0 yes northwest 43578.939  
## 88 56 female 27.200 0 no southwest 11073.176  
## 89 46 female 27.740 0 no northwest 8026.667  
## 90 55 female 26.980 0 no northwest 11082.577  
## 91 21 female 39.490 0 no southeast 2026.974  
## 92 53 female 24.795 1 no northwest 10942.132  
## 93 59 male 29.830 3 yes northeast 30184.937  
## 94 35 male 34.770 2 no northwest 5729.005  
## 95 64 female 31.300 2 yes southwest 47291.055  
## 96 28 female 37.620 1 no southeast 3766.884  
## 97 54 female 30.800 3 no southwest 12105.320  
## 98 55 male 38.280 0 no southeast 10226.284  
## 99 56 male 19.950 0 yes northeast 22412.648  
## 100 38 male 19.300 0 yes southwest 15820.699  
## 101 41 female 31.600 0 no southwest 6186.127  
## 102 30 male 25.460 0 no northeast 3645.089  
## 103 18 female 30.115 0 no northeast 21344.847  
## 104 61 female 29.920 3 yes southeast 30942.192  
## 105 34 female 27.500 1 no southwest 5003.853  
## 106 20 male 28.025 1 yes northwest 17560.380  
## 107 19 female 28.400 1 no southwest 2331.519  
## 108 26 male 30.875 2 no northwest 3877.304  
## 109 29 male 27.940 0 no southeast 2867.120  
## 110 63 male 35.090 0 yes southeast 47055.532  
## 111 54 male 33.630 1 no northwest 10825.254  
## 112 55 female 29.700 2 no southwest 11881.358  
## 113 37 male 30.800 0 no southwest 4646.759  
## 114 21 female 35.720 0 no northwest 2404.734  
## 115 52 male 32.205 3 no northeast 11488.317  
## 116 60 male 28.595 0 no northeast 30259.996  
## 117 58 male 49.060 0 no southeast 11381.325  
## 118 29 female 27.940 1 yes southeast 19107.780  
## 119 49 female 27.170 0 no southeast 8601.329  
## 120 37 female 23.370 2 no northwest 6686.431  
## 121 44 male 37.100 2 no southwest 7740.337  
## 122 18 male 23.750 0 no northeast 1705.624  
## 123 20 female 28.975 0 no northwest 2257.475  
## 124 44 male 31.350 1 yes northeast 39556.495  
## 125 47 female 33.915 3 no northwest 10115.009  
## 126 26 female 28.785 0 no northeast 3385.399  
## 127 19 female 28.300 0 yes southwest 17081.080  
## 128 52 female 37.400 0 no southwest 9634.538  
## 129 32 female 17.765 2 yes northwest 32734.186  
## 130 38 male 34.700 2 no southwest 6082.405  
## 131 59 female 26.505 0 no northeast 12815.445  
## 132 61 female 22.040 0 no northeast 13616.359  
## 133 53 female 35.900 2 no southwest 11163.568  
## 134 19 male 25.555 0 no northwest 1632.564  
## 135 20 female 28.785 0 no northeast 2457.211  
## 136 22 female 28.050 0 no southeast 2155.682  
## 137 19 male 34.100 0 no southwest 1261.442  
## 138 22 male 25.175 0 no northwest 2045.685  
## 139 54 female 31.900 3 no southeast 27322.734  
## 140 22 female 36.000 0 no southwest 2166.732  
## 141 34 male 22.420 2 no northeast 27375.905  
## 142 26 male 32.490 1 no northeast 3490.549  
## 143 34 male 25.300 2 yes southeast 18972.495  
## 144 29 male 29.735 2 no northwest 18157.876  
## 145 30 male 28.690 3 yes northwest 20745.989  
## 146 29 female 38.830 3 no southeast 5138.257  
## 147 46 male 30.495 3 yes northwest 40720.551  
## 148 51 female 37.730 1 no southeast 9877.608  
## 149 53 female 37.430 1 no northwest 10959.695  
## 150 19 male 28.400 1 no southwest 1842.519  
## 151 35 male 24.130 1 no northwest 5125.216  
## 152 48 male 29.700 0 no southeast 7789.635  
## 153 32 female 37.145 3 no northeast 6334.344  
## 154 42 female 23.370 0 yes northeast 19964.746  
## 155 40 female 25.460 1 no northeast 7077.189  
## 156 44 male 39.520 0 no northwest 6948.701  
## 157 48 male 24.420 0 yes southeast 21223.676  
## 158 18 male 25.175 0 yes northeast 15518.180  
## 159 30 male 35.530 0 yes southeast 36950.257  
## 160 50 female 27.830 3 no southeast 19749.383  
## 161 42 female 26.600 0 yes northwest 21348.706  
## 162 18 female 36.850 0 yes southeast 36149.484  
## 163 54 male 39.600 1 no southwest 10450.552  
## 164 32 female 29.800 2 no southwest 5152.134  
## 165 37 male 29.640 0 no northwest 5028.147  
## 166 47 male 28.215 4 no northeast 10407.086  
## 167 20 female 37.000 5 no southwest 4830.630  
## 168 32 female 33.155 3 no northwest 6128.797  
## 169 19 female 31.825 1 no northwest 2719.280  
## 170 27 male 18.905 3 no northeast 4827.905  
## 171 63 male 41.470 0 no southeast 13405.390  
## 172 49 male 30.300 0 no southwest 8116.680  
## 173 18 male 15.960 0 no northeast 1694.796  
## 174 35 female 34.800 1 no southwest 5246.047  
## 175 24 female 33.345 0 no northwest 2855.438  
## 176 63 female 37.700 0 yes southwest 48824.450  
## 177 38 male 27.835 2 no northwest 6455.863  
## 178 54 male 29.200 1 no southwest 10436.096  
## 179 46 female 28.900 2 no southwest 8823.279  
## 180 41 female 33.155 3 no northeast 8538.288  
## 181 58 male 28.595 0 no northwest 11735.879  
## 182 18 female 38.280 0 no southeast 1631.821  
## 183 22 male 19.950 3 no northeast 4005.423  
## 184 44 female 26.410 0 no northwest 7419.478  
## 185 44 male 30.690 2 no southeast 7731.427  
## 186 36 male 41.895 3 yes northeast 43753.337  
## 187 26 female 29.920 2 no southeast 3981.977  
## 188 30 female 30.900 3 no southwest 5325.651  
## 189 41 female 32.200 1 no southwest 6775.961  
## 190 29 female 32.110 2 no northwest 4922.916  
## 191 61 male 31.570 0 no southeast 12557.605  
## 192 36 female 26.200 0 no southwest 4883.866  
## 193 25 male 25.740 0 no southeast 2137.654  
## 194 56 female 26.600 1 no northwest 12044.342  
## 195 18 male 34.430 0 no southeast 1137.470  
## 196 19 male 30.590 0 no northwest 1639.563  
## 197 39 female 32.800 0 no southwest 5649.715  
## 198 45 female 28.600 2 no southeast 8516.829  
## 199 51 female 18.050 0 no northwest 9644.253  
## 200 64 female 39.330 0 no northeast 14901.517  
## 201 19 female 32.110 0 no northwest 2130.676  
## 202 48 female 32.230 1 no southeast 8871.152  
## 203 60 female 24.035 0 no northwest 13012.209  
## 204 27 female 36.080 0 yes southeast 37133.898  
## 205 46 male 22.300 0 no southwest 7147.105  
## 206 28 female 28.880 1 no northeast 4337.735  
## 207 59 male 26.400 0 no southeast 11743.299  
## 208 35 male 27.740 2 yes northeast 20984.094  
## 209 63 female 31.800 0 no southwest 13880.949  
## 210 40 male 41.230 1 no northeast 6610.110  
## 211 20 male 33.000 1 no southwest 1980.070  
## 212 40 male 30.875 4 no northwest 8162.716  
## 213 24 male 28.500 2 no northwest 3537.703  
## 214 34 female 26.730 1 no southeast 5002.783  
## 215 45 female 30.900 2 no southwest 8520.026  
## 216 41 female 37.100 2 no southwest 7371.772  
## 217 53 female 26.600 0 no northwest 10355.641  
## 218 27 male 23.100 0 no southeast 2483.736  
## 219 26 female 29.920 1 no southeast 3392.977  
## 220 24 female 23.210 0 no southeast 25081.768  
## 221 34 female 33.700 1 no southwest 5012.471  
## 222 53 female 33.250 0 no northeast 10564.885  
## 223 32 male 30.800 3 no southwest 5253.524  
## 224 19 male 34.800 0 yes southwest 34779.615  
## 225 42 male 24.640 0 yes southeast 19515.542  
## 226 55 male 33.880 3 no southeast 11987.168  
## 227 28 male 38.060 0 no southeast 2689.495  
## 228 58 female 41.910 0 no southeast 24227.337  
## 229 41 female 31.635 1 no northeast 7358.176  
## 230 47 male 25.460 2 no northeast 9225.256  
## 231 42 female 36.195 1 no northwest 7443.643  
## 232 59 female 27.830 3 no southeast 14001.287  
## 233 19 female 17.800 0 no southwest 1727.785  
## 234 59 male 27.500 1 no southwest 12333.828  
## 235 39 male 24.510 2 no northwest 6710.192  
## 236 40 female 22.220 2 yes southeast 19444.266  
## 237 18 female 26.730 0 no southeast 1615.767  
## 238 31 male 38.390 2 no southeast 4463.205  
## 239 19 male 29.070 0 yes northwest 17352.680  
## 240 44 male 38.060 1 no southeast 7152.671  
## 241 23 female 36.670 2 yes northeast 38511.628  
## 242 33 female 22.135 1 no northeast 5354.075  
## 243 55 female 26.800 1 no southwest 35160.135  
## 244 40 male 35.300 3 no southwest 7196.867  
## 245 63 female 27.740 0 yes northeast 29523.166  
## 246 54 male 30.020 0 no northwest 24476.479  
## 247 60 female 38.060 0 no southeast 12648.703  
## 248 24 male 35.860 0 no southeast 1986.933  
## 249 19 male 20.900 1 no southwest 1832.094  
## 250 29 male 28.975 1 no northeast 4040.558  
## 251 18 male 17.290 2 yes northeast 12829.455  
## 252 63 female 32.200 2 yes southwest 47305.305  
## 253 54 male 34.210 2 yes southeast 44260.750  
## 254 27 male 30.300 3 no southwest 4260.744  
## 255 50 male 31.825 0 yes northeast 41097.162  
## 256 55 female 25.365 3 no northeast 13047.332  
## 257 56 male 33.630 0 yes northwest 43921.184  
## 258 38 female 40.150 0 no southeast 5400.980  
## 259 51 male 24.415 4 no northwest 11520.100  
## 260 19 male 31.920 0 yes northwest 33750.292  
## 261 58 female 25.200 0 no southwest 11837.160  
## 262 20 female 26.840 1 yes southeast 17085.268  
## 263 52 male 24.320 3 yes northeast 24869.837  
## 264 19 male 36.955 0 yes northwest 36219.405  
## 265 53 female 38.060 3 no southeast 20462.998  
## 266 46 male 42.350 3 yes southeast 46151.124  
## 267 40 male 19.800 1 yes southeast 17179.522  
## 268 59 female 32.395 3 no northeast 14590.632  
## 269 45 male 30.200 1 no southwest 7441.053  
## 270 49 male 25.840 1 no northeast 9282.481  
## 271 18 male 29.370 1 no southeast 1719.436  
## 272 50 male 34.200 2 yes southwest 42856.838  
## 273 41 male 37.050 2 no northwest 7265.703  
## 274 50 male 27.455 1 no northeast 9617.662  
## 275 25 male 27.550 0 no northwest 2523.169  
## 276 47 female 26.600 2 no northeast 9715.841  
## 277 19 male 20.615 2 no northwest 2803.698  
## 278 22 female 24.300 0 no southwest 2150.469  
## 279 59 male 31.790 2 no southeast 12928.791  
## 280 51 female 21.560 1 no southeast 9855.131  
## 281 40 female 28.120 1 yes northeast 22331.567  
## 282 54 male 40.565 3 yes northeast 48549.178  
## 283 30 male 27.645 1 no northeast 4237.127  
## 284 55 female 32.395 1 no northeast 11879.104  
## 285 52 female 31.200 0 no southwest 9625.920  
## 286 46 male 26.620 1 no southeast 7742.110  
## 287 46 female 48.070 2 no northeast 9432.925  
## 288 63 female 26.220 0 no northwest 14256.193  
## 289 59 female 36.765 1 yes northeast 47896.791  
## 290 52 male 26.400 3 no southeast 25992.821  
## 291 28 female 33.400 0 no southwest 3172.018  
## 292 29 male 29.640 1 no northeast 20277.808  
## 293 25 male 45.540 2 yes southeast 42112.236  
## 294 22 female 28.820 0 no southeast 2156.752  
## 295 25 male 26.800 3 no southwest 3906.127  
## 296 18 male 22.990 0 no northeast 1704.568  
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## 304 28 female 33.000 2 no southeast 4349.462  
## 305 57 female 38.000 2 no southwest 12646.207  
## 306 29 male 33.345 2 no northwest 19442.354  
## 307 28 female 27.500 2 no southwest 20177.671  
## 308 30 female 33.330 1 no southeast 4151.029  
## 309 58 male 34.865 0 no northeast 11944.594  
## 310 41 female 33.060 2 no northwest 7749.156  
## 311 50 male 26.600 0 no southwest 8444.474  
## 312 19 female 24.700 0 no southwest 1737.376  
## 313 43 male 35.970 3 yes southeast 42124.515  
## 314 49 male 35.860 0 no southeast 8124.408  
## 315 27 female 31.400 0 yes southwest 34838.873  
## 316 52 male 33.250 0 no northeast 9722.770  
## 317 50 male 32.205 0 no northwest 8835.265  
## 318 54 male 32.775 0 no northeast 10435.065  
## 319 44 female 27.645 0 no northwest 7421.195  
## 320 32 male 37.335 1 no northeast 4667.608  
## 321 34 male 25.270 1 no northwest 4894.753  
## 322 26 female 29.640 4 no northeast 24671.663  
## 323 34 male 30.800 0 yes southwest 35491.640  
## 324 57 male 40.945 0 no northeast 11566.301  
## 325 29 male 27.200 0 no southwest 2866.091  
## 326 40 male 34.105 1 no northeast 6600.206  
## 327 27 female 23.210 1 no southeast 3561.889  
## 328 45 male 36.480 2 yes northwest 42760.502  
## 329 64 female 33.800 1 yes southwest 47928.030  
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## 332 52 male 27.360 0 yes northwest 24393.622  
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## 334 56 female 28.785 0 no northeast 11658.379  
## 335 43 female 35.720 2 no northeast 19144.577  
## 336 64 male 34.500 0 no southwest 13822.803  
## 337 60 male 25.740 0 no southeast 12142.579  
## 338 62 male 27.550 1 no northwest 13937.666  
## 339 50 male 32.300 1 yes northeast 41919.097  
## 340 46 female 27.720 1 no southeast 8232.639  
## 341 24 female 27.600 0 no southwest 18955.220  
## 342 62 male 30.020 0 no northwest 13352.100  
## 343 60 female 27.550 0 no northeast 13217.094  
## 344 63 male 36.765 0 no northeast 13981.850  
## 345 49 female 41.470 4 no southeast 10977.206  
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## 349 36 female 29.920 1 no southeast 5478.037  
## 350 19 male 27.835 0 no northwest 1635.734  
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## 352 50 female 25.600 0 no southwest 8932.084  
## 353 30 female 27.700 0 no southwest 3554.203  
## 354 33 male 35.245 0 no northeast 12404.879  
## 355 18 female 38.280 0 no southeast 14133.038  
## 356 46 male 27.600 0 no southwest 24603.048  
## 357 46 male 43.890 3 no southeast 8944.115  
## 358 47 male 29.830 3 no northwest 9620.331  
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## 360 18 female 20.790 0 no southeast 1607.510  
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## 362 35 male 30.500 1 no southwest 4751.070  
## 363 19 female 21.700 0 yes southwest 13844.506  
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## 367 56 female 32.300 3 no northeast 13430.265  
## 368 42 female 24.985 2 no northwest 8017.061  
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## 370 18 male 30.400 3 no northeast 3481.868  
## 371 61 female 21.090 0 no northwest 13415.038  
## 372 57 female 22.230 0 no northeast 12029.287  
## 373 42 female 33.155 1 no northeast 7639.417  
## 374 26 male 32.900 2 yes southwest 36085.219  
## 375 20 male 33.330 0 no southeast 1391.529  
## 376 23 female 28.310 0 yes northwest 18033.968  
## 377 39 female 24.890 3 yes northeast 21659.930  
## 378 24 male 40.150 0 yes southeast 38126.247  
## 379 64 female 30.115 3 no northwest 16455.708  
## 380 62 male 31.460 1 no southeast 27000.985  
## 381 27 female 17.955 2 yes northeast 15006.579  
## 382 55 male 30.685 0 yes northeast 42303.692  
## 383 55 male 33.000 0 no southeast 20781.489  
## 384 35 female 43.340 2 no southeast 5846.918  
## 385 44 male 22.135 2 no northeast 8302.536  
## 386 19 male 34.400 0 no southwest 1261.859  
## 387 58 female 39.050 0 no southeast 11856.412  
## 388 50 male 25.365 2 no northwest 30284.643  
## 389 26 female 22.610 0 no northwest 3176.816  
## 390 24 female 30.210 3 no northwest 4618.080  
## 391 48 male 35.625 4 no northeast 10736.871  
## 392 19 female 37.430 0 no northwest 2138.071  
## 393 48 male 31.445 1 no northeast 8964.061  
## 394 49 male 31.350 1 no northeast 9290.139  
## 395 46 female 32.300 2 no northeast 9411.005  
## 396 46 male 19.855 0 no northwest 7526.706  
## 397 43 female 34.400 3 no southwest 8522.003  
## 398 21 male 31.020 0 no southeast 16586.498  
## 399 64 male 25.600 2 no southwest 14988.432  
## 400 18 female 38.170 0 no southeast 1631.668  
## 401 51 female 20.600 0 no southwest 9264.797  
## 402 47 male 47.520 1 no southeast 8083.920  
## 403 64 female 32.965 0 no northwest 14692.669  
## 404 49 male 32.300 3 no northwest 10269.460  
## 405 31 male 20.400 0 no southwest 3260.199  
## 406 52 female 38.380 2 no northeast 11396.900  
## 407 33 female 24.310 0 no southeast 4185.098  
## 408 47 female 23.600 1 no southwest 8539.671  
## 409 38 male 21.120 3 no southeast 6652.529  
## 410 32 male 30.030 1 no southeast 4074.454  
## 411 19 male 17.480 0 no northwest 1621.340  
## 412 44 female 20.235 1 yes northeast 19594.810  
## 413 26 female 17.195 2 yes northeast 14455.644  
## 414 25 male 23.900 5 no southwest 5080.096  
## 415 19 female 35.150 0 no northwest 2134.901  
## 416 43 female 35.640 1 no southeast 7345.727  
## 417 52 male 34.100 0 no southeast 9140.951  
## 418 36 female 22.600 2 yes southwest 18608.262  
## 419 64 male 39.160 1 no southeast 14418.280  
## 420 63 female 26.980 0 yes northwest 28950.469  
## 421 64 male 33.880 0 yes southeast 46889.261  
## 422 61 male 35.860 0 yes southeast 46599.108  
## 423 40 male 32.775 1 yes northeast 39125.332  
## 424 25 male 30.590 0 no northeast 2727.395  
## 425 48 male 30.200 2 no southwest 8968.330  
## 426 45 male 24.310 5 no southeast 9788.866  
## 427 38 female 27.265 1 no northeast 6555.070  
## 428 18 female 29.165 0 no northeast 7323.735  
## 429 21 female 16.815 1 no northeast 3167.456  
## 430 27 female 30.400 3 no northwest 18804.752  
## 431 19 male 33.100 0 no southwest 23082.955  
## 432 29 female 20.235 2 no northwest 4906.410  
## 433 42 male 26.900 0 no southwest 5969.723  
## 434 60 female 30.500 0 no southwest 12638.195  
## 435 31 male 28.595 1 no northwest 4243.590  
## 436 60 male 33.110 3 no southeast 13919.823  
## 437 22 male 31.730 0 no northeast 2254.797  
## 438 35 male 28.900 3 no southwest 5926.846  
## 439 52 female 46.750 5 no southeast 12592.534  
## 440 26 male 29.450 0 no northeast 2897.323  
## 441 31 female 32.680 1 no northwest 4738.268  
## 442 33 female 33.500 0 yes southwest 37079.372  
## 443 18 male 43.010 0 no southeast 1149.396  
## 444 59 female 36.520 1 no southeast 28287.898  
## 445 56 male 26.695 1 yes northwest 26109.329  
## 446 45 female 33.100 0 no southwest 7345.084  
## 447 60 male 29.640 0 no northeast 12731.000  
## 448 56 female 25.650 0 no northwest 11454.022  
## 449 40 female 29.600 0 no southwest 5910.944  
## 450 35 male 38.600 1 no southwest 4762.329  
## 451 39 male 29.600 4 no southwest 7512.267  
## 452 30 male 24.130 1 no northwest 4032.241  
## 453 24 male 23.400 0 no southwest 1969.614  
## 454 20 male 29.735 0 no northwest 1769.532  
## 455 32 male 46.530 2 no southeast 4686.389  
## 456 59 male 37.400 0 no southwest 21797.000  
## 457 55 female 30.140 2 no southeast 11881.970  
## 458 57 female 30.495 0 no northwest 11840.775  
## 459 56 male 39.600 0 no southwest 10601.412  
## 460 40 female 33.000 3 no southeast 7682.670  
## 461 49 female 36.630 3 no southeast 10381.479  
## 462 42 male 30.000 0 yes southwest 22144.032  
## 463 62 female 38.095 2 no northeast 15230.324  
## 464 56 male 25.935 0 no northeast 11165.418  
## 465 19 male 25.175 0 no northwest 1632.036  
## 466 30 female 28.380 1 yes southeast 19521.968  
## 467 60 female 28.700 1 no southwest 13224.693  
## 468 56 female 33.820 2 no northwest 12643.378  
## 469 28 female 24.320 1 no northeast 23288.928  
## 470 18 female 24.090 1 no southeast 2201.097  
## 471 27 male 32.670 0 no southeast 2497.038  
## 472 18 female 30.115 0 no northeast 2203.472  
## 473 19 female 29.800 0 no southwest 1744.465  
## 474 47 female 33.345 0 no northeast 20878.784  
## 475 54 male 25.100 3 yes southwest 25382.297  
## 476 61 male 28.310 1 yes northwest 28868.664  
## 477 24 male 28.500 0 yes northeast 35147.528  
## 478 25 male 35.625 0 no northwest 2534.394  
## 479 21 male 36.850 0 no southeast 1534.304  
## 480 23 male 32.560 0 no southeast 1824.285  
## 481 63 male 41.325 3 no northwest 15555.189  
## 482 49 male 37.510 2 no southeast 9304.702  
## 483 18 female 31.350 0 no southeast 1622.188  
## 484 51 female 39.500 1 no southwest 9880.068  
## 485 48 male 34.300 3 no southwest 9563.029  
## 486 31 female 31.065 0 no northeast 4347.023  
## 487 54 female 21.470 3 no northwest 12475.351  
## 488 19 male 28.700 0 no southwest 1253.936  
## 489 44 female 38.060 0 yes southeast 48885.136  
## 490 53 male 31.160 1 no northwest 10461.979  
## 491 19 female 32.900 0 no southwest 1748.774  
## 492 61 female 25.080 0 no southeast 24513.091  
## 493 18 female 25.080 0 no northeast 2196.473  
## 494 61 male 43.400 0 no southwest 12574.049  
## 495 21 male 25.700 4 yes southwest 17942.106  
## 496 20 male 27.930 0 no northeast 1967.023  
## 497 31 female 23.600 2 no southwest 4931.647  
## 498 45 male 28.700 2 no southwest 8027.968  
## 499 44 female 23.980 2 no southeast 8211.100  
## 500 62 female 39.200 0 no southwest 13470.860  
## 501 29 male 34.400 0 yes southwest 36197.699  
## 502 43 male 26.030 0 no northeast 6837.369  
## 503 51 male 23.210 1 yes southeast 22218.115  
## 504 19 male 30.250 0 yes southeast 32548.340  
## 505 38 female 28.930 1 no southeast 5974.385  
## 506 37 male 30.875 3 no northwest 6796.863  
## 507 22 male 31.350 1 no northwest 2643.269  
## 508 21 male 23.750 2 no northwest 3077.095  
## 509 24 female 25.270 0 no northeast 3044.213  
## 510 57 female 28.700 0 no southwest 11455.280  
## 511 56 male 32.110 1 no northeast 11763.001  
## 512 27 male 33.660 0 no southeast 2498.414  
## 513 51 male 22.420 0 no northeast 9361.327  
## 514 19 male 30.400 0 no southwest 1256.299  
## 515 39 male 28.300 1 yes southwest 21082.160  
## 516 58 male 35.700 0 no southwest 11362.755  
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## 518 45 male 30.495 2 no northwest 8413.463  
## 519 35 female 31.000 1 no southwest 5240.765  
## 520 31 male 30.875 0 no northeast 3857.759  
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## 523 51 female 33.915 0 no northeast 9866.305  
## 524 38 female 37.730 0 no southeast 5397.617  
## 525 42 male 26.070 1 yes southeast 38245.593  
## 526 18 female 33.880 0 no southeast 11482.635  
## 527 19 female 30.590 2 no northwest 24059.680  
## 528 51 female 25.800 1 no southwest 9861.025  
## 529 46 male 39.425 1 no northeast 8342.909  
## 530 18 male 25.460 0 no northeast 1708.001  
## 531 57 male 42.130 1 yes southeast 48675.518  
## 532 62 female 31.730 0 no northeast 14043.477  
## 533 59 male 29.700 2 no southeast 12925.886  
## 534 37 male 36.190 0 no southeast 19214.706  
## 535 64 male 40.480 0 no southeast 13831.115  
## 536 38 male 28.025 1 no northeast 6067.127  
## 537 33 female 38.900 3 no southwest 5972.378  
## 538 46 female 30.200 2 no southwest 8825.086  
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## 541 34 female 38.000 3 no southwest 6196.448  
## 542 20 female 31.790 2 no southeast 3056.388  
## 543 63 female 36.300 0 no southeast 13887.204  
## 544 54 female 47.410 0 yes southeast 63770.428  
## 545 54 male 30.210 0 no northwest 10231.500  
## 546 49 male 25.840 2 yes northwest 23807.241  
## 547 28 male 35.435 0 no northeast 3268.847  
## 548 54 female 46.700 2 no southwest 11538.421  
## 549 25 female 28.595 0 no northeast 3213.622  
## 550 43 female 46.200 0 yes southeast 45863.205  
## 551 63 male 30.800 0 no southwest 13390.559  
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## 558 34 male 34.210 0 no southeast 3935.180  
## 559 35 female 34.105 3 yes northwest 39983.426  
## 560 19 male 35.530 0 no northwest 1646.430  
## 561 46 female 19.950 2 no northwest 9193.838  
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## 563 27 male 30.500 0 no southwest 2494.022  
## 564 50 male 44.770 1 no southeast 9058.730  
## 565 18 female 32.120 2 no southeast 2801.259  
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## 570 48 male 40.565 2 yes northwest 45702.022  
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## 574 62 female 36.860 1 no northeast 31620.001  
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## 577 22 male 26.840 0 no southeast 1665.000  
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## 583 39 male 45.430 2 no southeast 6356.271  
## 584 32 female 23.650 1 no southeast 17626.240  
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## 587 21 male 20.235 3 no northeast 3861.210  
## 588 34 female 30.210 1 yes northwest 43943.876  
## 589 61 female 35.910 0 no northeast 13635.638  
## 590 38 female 30.690 1 no southeast 5976.831  
## 591 58 female 29.000 0 no southwest 11842.442  
## 592 47 male 19.570 1 no northwest 8428.069  
## 593 20 male 31.130 2 no southeast 2566.471  
## 594 21 female 21.850 1 yes northeast 15359.104  
## 595 41 male 40.260 0 no southeast 5709.164  
## 596 46 female 33.725 1 no northeast 8823.986  
## 597 42 female 29.480 2 no southeast 7640.309  
## 598 34 female 33.250 1 no northeast 5594.846  
## 599 43 male 32.600 2 no southwest 7441.501  
## 600 52 female 37.525 2 no northwest 33471.972  
## 601 18 female 39.160 0 no southeast 1633.044  
## 602 51 male 31.635 0 no northwest 9174.136  
## 603 56 female 25.300 0 no southwest 11070.535  
## 604 64 female 39.050 3 no southeast 16085.128  
## 605 19 female 28.310 0 yes northwest 17468.984  
## 606 51 female 34.100 0 no southeast 9283.562  
## 607 27 female 25.175 0 no northeast 3558.620  
## 608 59 female 23.655 0 yes northwest 25678.778  
## 609 28 male 26.980 2 no northeast 4435.094  
## 610 30 male 37.800 2 yes southwest 39241.442  
## 611 47 female 29.370 1 no southeast 8547.691  
## 612 38 female 34.800 2 no southwest 6571.544  
## 613 18 female 33.155 0 no northeast 2207.697  
## 614 34 female 19.000 3 no northeast 6753.038  
## 615 20 female 33.000 0 no southeast 1880.070  
## 616 47 female 36.630 1 yes southeast 42969.853  
## 617 56 female 28.595 0 no northeast 11658.115  
## 618 49 male 25.600 2 yes southwest 23306.547  
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## 620 55 female 37.100 0 no southwest 10713.644  
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## 622 37 male 34.100 4 yes southwest 40182.246  
## 623 49 female 21.300 1 no southwest 9182.170  
## 624 18 male 33.535 0 yes northeast 34617.841  
## 625 59 male 28.785 0 no northwest 12129.614  
## 626 29 female 26.030 0 no northwest 3736.465  
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## 628 33 male 42.460 1 no southeast 11326.715  
## 629 58 male 38.000 0 no southwest 11365.952  
## 630 44 female 38.950 0 yes northwest 42983.459  
## 631 53 male 36.100 1 no southwest 10085.846  
## 632 24 male 29.300 0 no southwest 1977.815  
## 633 29 female 35.530 0 no southeast 3366.670  
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## 635 51 male 39.700 1 no southwest 9391.346  
## 636 64 male 38.190 0 no northeast 14410.932  
## 637 19 female 24.510 1 no northwest 2709.112  
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## 639 39 male 26.410 0 yes northeast 20149.323  
## 640 56 male 33.660 4 no southeast 12949.155  
## 641 33 male 42.400 5 no southwest 6666.243  
## 642 42 male 28.310 3 yes northwest 32787.459  
## 643 61 male 33.915 0 no northeast 13143.865  
## 644 23 female 34.960 3 no northwest 4466.621  
## 645 43 male 35.310 2 no southeast 18806.145  
## 646 48 male 30.780 3 no northeast 10141.136  
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## 655 59 female 35.200 0 no southeast 12244.531  
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## 672 29 female 31.160 0 no northeast 3943.595  
## 673 36 male 29.700 0 no southeast 4399.731  
## 674 41 female 31.020 0 no southeast 6185.321  
## 675 44 female 43.890 2 yes southeast 46200.985  
## 676 45 male 21.375 0 no northwest 7222.786  
## 677 55 female 40.810 3 no southeast 12485.801  
## 678 60 male 31.350 3 yes northwest 46130.526  
## 679 56 male 36.100 3 no southwest 12363.547  
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## 689 47 female 24.100 1 no southwest 26236.580  
## 690 27 male 31.130 1 yes southeast 34806.468  
## 691 21 male 27.360 0 no northeast 2104.113  
## 692 47 male 36.200 1 no southwest 8068.185  
## 693 20 male 32.395 1 no northwest 2362.229  
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## 695 27 female 34.800 1 no southwest 3577.999  
## 696 26 female 40.185 0 no northwest 3201.245  
## 697 53 female 32.300 2 no northeast 29186.482  
## 698 41 male 35.750 1 yes southeast 40273.645  
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## 886 32 male 28.930 1 yes southeast 19719.695  
## 887 57 male 28.975 0 yes northeast 27218.437  
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## 917 43 female 26.885 0 yes northwest 21774.322  
## 918 45 male 22.895 0 yes northeast 35069.375  
## 919 61 female 28.200 0 no southwest 13041.921  
## 920 35 female 34.210 1 no southeast 5245.227  
## 921 62 female 25.000 0 no southwest 13451.122  
## 922 62 female 33.200 0 no southwest 13462.520  
## 923 38 male 31.000 1 no southwest 5488.262  
## 924 34 male 35.815 0 no northwest 4320.411  
## 925 43 male 23.200 0 no southwest 6250.435  
## 926 50 male 32.110 2 no northeast 25333.333  
## 927 19 female 23.400 2 no southwest 2913.569  
## 928 57 female 20.100 1 no southwest 12032.326  
## 929 62 female 39.160 0 no southeast 13470.804  
## 930 41 male 34.210 1 no southeast 6289.755  
## 931 26 male 46.530 1 no southeast 2927.065  
## 932 39 female 32.500 1 no southwest 6238.298  
## 933 46 male 25.800 5 no southwest 10096.970  
## 934 45 female 35.300 0 no southwest 7348.142  
## 935 32 male 37.180 2 no southeast 4673.392  
## 936 59 female 27.500 0 no southwest 12233.828  
## 937 44 male 29.735 2 no northeast 32108.663  
## 938 39 female 24.225 5 no northwest 8965.796  
## 939 18 male 26.180 2 no southeast 2304.002  
## 940 53 male 29.480 0 no southeast 9487.644  
## 941 18 male 23.210 0 no southeast 1121.874  
## 942 50 female 46.090 1 no southeast 9549.565  
## 943 18 female 40.185 0 no northeast 2217.469  
## 944 19 male 22.610 0 no northwest 1628.471  
## 945 62 male 39.930 0 no southeast 12982.875  
## 946 56 female 35.800 1 no southwest 11674.130  
## 947 42 male 35.800 2 no southwest 7160.094  
## 948 37 male 34.200 1 yes northeast 39047.285  
## 949 42 male 31.255 0 no northwest 6358.776  
## 950 25 male 29.700 3 yes southwest 19933.458  
## 951 57 male 18.335 0 no northeast 11534.873  
## 952 51 male 42.900 2 yes southeast 47462.894  
## 953 30 female 28.405 1 no northwest 4527.183  
## 954 44 male 30.200 2 yes southwest 38998.546  
## 955 34 male 27.835 1 yes northwest 20009.634  
## 956 31 male 39.490 1 no southeast 3875.734  
## 957 54 male 30.800 1 yes southeast 41999.520  
## 958 24 male 26.790 1 no northwest 12609.887  
## 959 43 male 34.960 1 yes northeast 41034.221  
## 960 48 male 36.670 1 no northwest 28468.919  
## 961 19 female 39.615 1 no northwest 2730.108  
## 962 29 female 25.900 0 no southwest 3353.284  
## 963 63 female 35.200 1 no southeast 14474.675  
## 964 46 male 24.795 3 no northeast 9500.573  
## 965 52 male 36.765 2 no northwest 26467.097  
## 966 35 male 27.100 1 no southwest 4746.344  
## 967 51 male 24.795 2 yes northwest 23967.383  
## 968 44 male 25.365 1 no northwest 7518.025  
## 969 21 male 25.745 2 no northeast 3279.869  
## 970 39 female 34.320 5 no southeast 8596.828  
## 971 50 female 28.160 3 no southeast 10702.642  
## 972 34 female 23.560 0 no northeast 4992.376  
## 973 22 female 20.235 0 no northwest 2527.819  
## 974 19 female 40.500 0 no southwest 1759.338  
## 975 26 male 35.420 0 no southeast 2322.622  
## 976 29 male 22.895 0 yes northeast 16138.762  
## 977 48 male 40.150 0 no southeast 7804.160  
## 978 26 male 29.150 1 no southeast 2902.907  
## 979 45 female 39.995 3 no northeast 9704.668  
## 980 36 female 29.920 0 no southeast 4889.037  
## 981 54 male 25.460 1 no northeast 25517.114  
## 982 34 male 21.375 0 no northeast 4500.339  
## 983 31 male 25.900 3 yes southwest 19199.944  
## 984 27 female 30.590 1 no northeast 16796.412  
## 985 20 male 30.115 5 no northeast 4915.060  
## 986 44 female 25.800 1 no southwest 7624.630  
## 987 43 male 30.115 3 no northwest 8410.047  
## 988 45 female 27.645 1 no northwest 28340.189  
## 989 34 male 34.675 0 no northeast 4518.826  
## 990 24 female 20.520 0 yes northeast 14571.891  
## 991 26 female 19.800 1 no southwest 3378.910  
## 992 38 female 27.835 2 no northeast 7144.863  
## 993 50 female 31.600 2 no southwest 10118.424  
## 994 38 male 28.270 1 no southeast 5484.467  
## 995 27 female 20.045 3 yes northwest 16420.495  
## 996 39 female 23.275 3 no northeast 7986.475  
## 997 39 female 34.100 3 no southwest 7418.522  
## 998 63 female 36.850 0 no southeast 13887.969  
## 999 33 female 36.290 3 no northeast 6551.750  
## 1000 36 female 26.885 0 no northwest 5267.818  
## 1001 30 male 22.990 2 yes northwest 17361.766  
## 1002 24 male 32.700 0 yes southwest 34472.841  
## 1003 24 male 25.800 0 no southwest 1972.950  
## 1004 48 male 29.600 0 no southwest 21232.182  
## 1005 47 male 19.190 1 no northeast 8627.541  
## 1006 29 male 31.730 2 no northwest 4433.388  
## 1007 28 male 29.260 2 no northeast 4438.263  
## 1008 47 male 28.215 3 yes northwest 24915.221  
## 1009 25 male 24.985 2 no northeast 23241.475  
## 1010 51 male 27.740 1 no northeast 9957.722  
## 1011 48 female 22.800 0 no southwest 8269.044  
## 1012 43 male 20.130 2 yes southeast 18767.738  
## 1013 61 female 33.330 4 no southeast 36580.282  
## 1014 48 male 32.300 1 no northwest 8765.249  
## 1015 38 female 27.600 0 no southwest 5383.536  
## 1016 59 male 25.460 0 no northwest 12124.992  
## 1017 19 female 24.605 1 no northwest 2709.244  
## 1018 26 female 34.200 2 no southwest 3987.926  
## 1019 54 female 35.815 3 no northwest 12495.291  
## 1020 21 female 32.680 2 no northwest 26018.951  
## 1021 51 male 37.000 0 no southwest 8798.593  
## 1022 22 female 31.020 3 yes southeast 35595.590  
## 1023 47 male 36.080 1 yes southeast 42211.138  
## 1024 18 male 23.320 1 no southeast 1711.027  
## 1025 47 female 45.320 1 no southeast 8569.862  
## 1026 21 female 34.600 0 no southwest 2020.177  
## 1027 19 male 26.030 1 yes northwest 16450.895  
## 1028 23 male 18.715 0 no northwest 21595.382  
## 1029 54 male 31.600 0 no southwest 9850.432  
## 1030 37 female 17.290 2 no northeast 6877.980  
## 1031 46 female 23.655 1 yes northwest 21677.283  
## 1032 55 female 35.200 0 yes southeast 44423.803  
## 1033 30 female 27.930 0 no northeast 4137.523  
## 1034 18 male 21.565 0 yes northeast 13747.872  
## 1035 61 male 38.380 0 no northwest 12950.071  
## 1036 54 female 23.000 3 no southwest 12094.478  
## 1037 22 male 37.070 2 yes southeast 37484.449  
## 1038 45 female 30.495 1 yes northwest 39725.518  
## 1039 22 male 28.880 0 no northeast 2250.835  
## 1040 19 male 27.265 2 no northwest 22493.660  
## 1041 35 female 28.025 0 yes northwest 20234.855  
## 1042 18 male 23.085 0 no northeast 1704.700  
## 1043 20 male 30.685 0 yes northeast 33475.817  
## 1044 28 female 25.800 0 no southwest 3161.454  
## 1045 55 male 35.245 1 no northeast 11394.066  
## 1046 43 female 24.700 2 yes northwest 21880.820  
## 1047 43 female 25.080 0 no northeast 7325.048  
## 1048 22 male 52.580 1 yes southeast 44501.398  
## 1049 25 female 22.515 1 no northwest 3594.171  
## 1050 49 male 30.900 0 yes southwest 39727.614  
## 1051 44 female 36.955 1 no northwest 8023.135  
## 1052 64 male 26.410 0 no northeast 14394.558  
## 1053 49 male 29.830 1 no northeast 9288.027  
## 1054 47 male 29.800 3 yes southwest 25309.489  
## 1055 27 female 21.470 0 no northwest 3353.470  
## 1056 55 male 27.645 0 no northwest 10594.502  
## 1057 48 female 28.900 0 no southwest 8277.523  
## 1058 45 female 31.790 0 no southeast 17929.303  
## 1059 24 female 39.490 0 no southeast 2480.979  
## 1060 32 male 33.820 1 no northwest 4462.722  
## 1061 24 male 32.010 0 no southeast 1981.582  
## 1062 57 male 27.940 1 no southeast 11554.224  
## 1063 59 male 41.140 1 yes southeast 48970.248  
## 1064 36 male 28.595 3 no northwest 6548.195  
## 1065 29 female 25.600 4 no southwest 5708.867  
## 1066 42 female 25.300 1 no southwest 7045.499  
## 1067 48 male 37.290 2 no southeast 8978.185  
## 1068 39 male 42.655 0 no northeast 5757.413  
## 1069 63 male 21.660 1 no northwest 14349.854  
## 1070 54 female 31.900 1 no southeast 10928.849  
## 1071 37 male 37.070 1 yes southeast 39871.704  
## 1072 63 male 31.445 0 no northeast 13974.456  
## 1073 21 male 31.255 0 no northwest 1909.527  
## 1074 54 female 28.880 2 no northeast 12096.651  
## 1075 60 female 18.335 0 no northeast 13204.286  
## 1076 32 female 29.590 1 no southeast 4562.842  
## 1077 47 female 32.000 1 no southwest 8551.347  
## 1078 21 male 26.030 0 no northeast 2102.265  
## 1079 28 male 31.680 0 yes southeast 34672.147  
## 1080 63 male 33.660 3 no southeast 15161.534  
## 1081 18 male 21.780 2 no southeast 11884.049  
## 1082 32 male 27.835 1 no northwest 4454.403  
## 1083 38 male 19.950 1 no northwest 5855.903  
## 1084 32 male 31.500 1 no southwest 4076.497  
## 1085 62 female 30.495 2 no northwest 15019.760  
## 1086 39 female 18.300 5 yes southwest 19023.260  
## 1087 55 male 28.975 0 no northeast 10796.350  
## 1088 57 male 31.540 0 no northwest 11353.228  
## 1089 52 male 47.740 1 no southeast 9748.911  
## 1090 56 male 22.100 0 no southwest 10577.087  
## 1091 47 male 36.190 0 yes southeast 41676.081  
## 1092 55 female 29.830 0 no northeast 11286.539  
## 1093 23 male 32.700 3 no southwest 3591.480  
## 1094 22 female 30.400 0 yes northwest 33907.548  
## 1095 50 female 33.700 4 no southwest 11299.343  
## 1096 18 female 31.350 4 no northeast 4561.189  
## 1097 51 female 34.960 2 yes northeast 44641.197  
## 1098 22 male 33.770 0 no southeast 1674.632  
## 1099 52 female 30.875 0 no northeast 23045.566  
## 1100 25 female 33.990 1 no southeast 3227.121  
## 1101 33 female 19.095 2 yes northeast 16776.304  
## 1102 53 male 28.600 3 no southwest 11253.421  
## 1103 29 male 38.940 1 no southeast 3471.410  
## 1104 58 male 36.080 0 no southeast 11363.283  
## 1105 37 male 29.800 0 no southwest 20420.605  
## 1106 54 female 31.240 0 no southeast 10338.932  
## 1107 49 female 29.925 0 no northwest 8988.159  
## 1108 50 female 26.220 2 no northwest 10493.946  
## 1109 26 male 30.000 1 no southwest 2904.088  
## 1110 45 male 20.350 3 no southeast 8605.362  
## 1111 54 female 32.300 1 no northeast 11512.405  
## 1112 38 male 38.390 3 yes southeast 41949.244  
## 1113 48 female 25.850 3 yes southeast 24180.933  
## 1114 28 female 26.315 3 no northwest 5312.170  
## 1115 23 male 24.510 0 no northeast 2396.096  
## 1116 55 male 32.670 1 no southeast 10807.486  
## 1117 41 male 29.640 5 no northeast 9222.403  
## 1118 25 male 33.330 2 yes southeast 36124.574  
## 1119 33 male 35.750 1 yes southeast 38282.749  
## 1120 30 female 19.950 3 no northwest 5693.431  
## 1121 23 female 31.400 0 yes southwest 34166.273  
## 1122 46 male 38.170 2 no southeast 8347.164  
## 1123 53 female 36.860 3 yes northwest 46661.442  
## 1124 27 female 32.395 1 no northeast 18903.491  
## 1125 23 female 42.750 1 yes northeast 40904.200  
## 1126 63 female 25.080 0 no northwest 14254.608  
## 1127 55 male 29.900 0 no southwest 10214.636  
## 1128 35 female 35.860 2 no southeast 5836.520  
## 1129 34 male 32.800 1 no southwest 14358.364  
## 1130 19 female 18.600 0 no southwest 1728.897  
## 1131 39 female 23.870 5 no southeast 8582.302  
## 1132 27 male 45.900 2 no southwest 3693.428  
## 1133 57 male 40.280 0 no northeast 20709.020  
## 1134 52 female 18.335 0 no northwest 9991.038  
## 1135 28 male 33.820 0 no northwest 19673.336  
## 1136 50 female 28.120 3 no northwest 11085.587  
## 1137 44 female 25.000 1 no southwest 7623.518  
## 1138 26 female 22.230 0 no northwest 3176.288  
## 1139 33 male 30.250 0 no southeast 3704.354  
## 1140 19 female 32.490 0 yes northwest 36898.733  
## 1141 50 male 37.070 1 no southeast 9048.027  
## 1142 41 female 32.600 3 no southwest 7954.517  
## 1143 52 female 24.860 0 no southeast 27117.994  
## 1144 39 male 32.340 2 no southeast 6338.076  
## 1145 50 male 32.300 2 no southwest 9630.397  
## 1146 52 male 32.775 3 no northwest 11289.109  
## 1147 60 male 32.800 0 yes southwest 52590.829  
## 1148 20 female 31.920 0 no northwest 2261.569  
## 1149 55 male 21.500 1 no southwest 10791.960  
## 1150 42 male 34.100 0 no southwest 5979.731  
## 1151 18 female 30.305 0 no northeast 2203.736  
## 1152 58 female 36.480 0 no northwest 12235.839  
## 1153 43 female 32.560 3 yes southeast 40941.285  
## 1154 35 female 35.815 1 no northwest 5630.458  
## 1155 48 female 27.930 4 no northwest 11015.175  
## 1156 36 female 22.135 3 no northeast 7228.216  
## 1157 19 male 44.880 0 yes southeast 39722.746  
## 1158 23 female 23.180 2 no northwest 14426.074  
## 1159 20 female 30.590 0 no northeast 2459.720  
## 1160 32 female 41.100 0 no southwest 3989.841  
## 1161 43 female 34.580 1 no northwest 7727.253  
## 1162 34 male 42.130 2 no southeast 5124.189  
## 1163 30 male 38.830 1 no southeast 18963.172  
## 1164 18 female 28.215 0 no northeast 2200.831  
## 1165 41 female 28.310 1 no northwest 7153.554  
## 1166 35 female 26.125 0 no northeast 5227.989  
## 1167 57 male 40.370 0 no southeast 10982.501  
## 1168 29 female 24.600 2 no southwest 4529.477  
## 1169 32 male 35.200 2 no southwest 4670.640  
## 1170 37 female 34.105 1 no northwest 6112.353  
## 1171 18 male 27.360 1 yes northeast 17178.682  
## 1172 43 female 26.700 2 yes southwest 22478.600  
## 1173 56 female 41.910 0 no southeast 11093.623  
## 1174 38 male 29.260 2 no northwest 6457.843  
## 1175 29 male 32.110 2 no northwest 4433.916  
## 1176 22 female 27.100 0 no southwest 2154.361  
## 1177 52 female 24.130 1 yes northwest 23887.663  
## 1178 40 female 27.400 1 no southwest 6496.886  
## 1179 23 female 34.865 0 no northeast 2899.489  
## 1180 31 male 29.810 0 yes southeast 19350.369  
## 1181 42 female 41.325 1 no northeast 7650.774  
## 1182 24 female 29.925 0 no northwest 2850.684  
## 1183 25 female 30.300 0 no southwest 2632.992  
## 1184 48 female 27.360 1 no northeast 9447.382  
## 1185 23 female 28.490 1 yes southeast 18328.238  
## 1186 45 male 23.560 2 no northeast 8603.823  
## 1187 20 male 35.625 3 yes northwest 37465.344  
## 1188 62 female 32.680 0 no northwest 13844.797  
## 1189 43 female 25.270 1 yes northeast 21771.342  
## 1190 23 female 28.000 0 no southwest 13126.677  
## 1191 31 female 32.775 2 no northwest 5327.400  
## 1192 41 female 21.755 1 no northeast 13725.472  
## 1193 58 female 32.395 1 no northeast 13019.161  
## 1194 48 female 36.575 0 no northwest 8671.191  
## 1195 31 female 21.755 0 no northwest 4134.082  
## 1196 19 female 27.930 3 no northwest 18838.704  
## 1197 19 female 30.020 0 yes northwest 33307.551  
## 1198 41 male 33.550 0 no southeast 5699.837  
## 1199 40 male 29.355 1 no northwest 6393.603  
## 1200 31 female 25.800 2 no southwest 4934.705  
## 1201 37 male 24.320 2 no northwest 6198.752  
## 1202 46 male 40.375 2 no northwest 8733.229  
## 1203 22 male 32.110 0 no northwest 2055.325  
## 1204 51 male 32.300 1 no northeast 9964.060  
## 1205 18 female 27.280 3 yes southeast 18223.451  
## 1206 35 male 17.860 1 no northwest 5116.500  
## 1207 59 female 34.800 2 no southwest 36910.608  
## 1208 36 male 33.400 2 yes southwest 38415.474  
## 1209 37 female 25.555 1 yes northeast 20296.863  
## 1210 59 male 37.100 1 no southwest 12347.172  
## 1211 36 male 30.875 1 no northwest 5373.364  
## 1212 39 male 34.100 2 no southeast 23563.016  
## 1213 18 male 21.470 0 no northeast 1702.455  
## 1214 52 female 33.300 2 no southwest 10806.839  
## 1215 27 female 31.255 1 no northwest 3956.071  
## 1216 18 male 39.140 0 no northeast 12890.058  
## 1217 40 male 25.080 0 no southeast 5415.661  
## 1218 29 male 37.290 2 no southeast 4058.116  
## 1219 46 female 34.600 1 yes southwest 41661.602  
## 1220 38 female 30.210 3 no northwest 7537.164  
## 1221 30 female 21.945 1 no northeast 4718.204  
## 1222 40 male 24.970 2 no southeast 6593.508  
## 1223 50 male 25.300 0 no southeast 8442.667  
## 1224 20 female 24.420 0 yes southeast 26125.675  
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## 1226 33 female 39.820 1 no southeast 4795.657  
## 1227 38 male 16.815 2 no northeast 6640.545  
## 1228 42 male 37.180 2 no southeast 7162.012  
## 1229 56 male 34.430 0 no southeast 10594.226  
## 1230 58 male 30.305 0 no northeast 11938.256  
## 1231 52 male 34.485 3 yes northwest 60021.399  
## 1232 20 female 21.800 0 yes southwest 20167.336  
## 1233 54 female 24.605 3 no northwest 12479.709  
## 1234 58 male 23.300 0 no southwest 11345.519  
## 1235 45 female 27.830 2 no southeast 8515.759  
## 1236 26 male 31.065 0 no northwest 2699.568  
## 1237 63 female 21.660 0 no northeast 14449.854  
## 1238 58 female 28.215 0 no northwest 12224.351  
## 1239 37 male 22.705 3 no northeast 6985.507  
## 1240 25 female 42.130 1 no southeast 3238.436  
## 1241 52 male 41.800 2 yes southeast 47269.854  
## 1242 64 male 36.960 2 yes southeast 49577.662  
## 1243 22 female 21.280 3 no northwest 4296.271  
## 1244 28 female 33.110 0 no southeast 3171.615  
## 1245 18 male 33.330 0 no southeast 1135.941  
## 1246 28 male 24.300 5 no southwest 5615.369  
## 1247 45 female 25.700 3 no southwest 9101.798  
## 1248 33 male 29.400 4 no southwest 6059.173  
## 1249 18 female 39.820 0 no southeast 1633.962  
## 1250 32 male 33.630 1 yes northeast 37607.528  
## 1251 24 male 29.830 0 yes northeast 18648.422  
## 1252 19 male 19.800 0 no southwest 1241.565  
## 1253 20 male 27.300 0 yes southwest 16232.847  
## 1254 40 female 29.300 4 no southwest 15828.822  
## 1255 34 female 27.720 0 no southeast 4415.159  
## 1256 42 female 37.900 0 no southwest 6474.013  
## 1257 51 female 36.385 3 no northwest 11436.738  
## 1258 54 female 27.645 1 no northwest 11305.935  
## 1259 55 male 37.715 3 no northwest 30063.581  
## 1260 52 female 23.180 0 no northeast 10197.772  
## 1261 32 female 20.520 0 no northeast 4544.235  
## 1262 28 male 37.100 1 no southwest 3277.161  
## 1263 41 female 28.050 1 no southeast 6770.193  
## 1264 43 female 29.900 1 no southwest 7337.748  
## 1265 49 female 33.345 2 no northeast 10370.913  
## 1266 64 male 23.760 0 yes southeast 26926.514  
## 1267 55 female 30.500 0 no southwest 10704.470  
## 1268 24 male 31.065 0 yes northeast 34254.053  
## 1269 20 female 33.300 0 no southwest 1880.487  
## 1270 45 male 27.500 3 no southwest 8615.300  
## 1271 26 male 33.915 1 no northwest 3292.530  
## 1272 25 female 34.485 0 no northwest 3021.809  
## 1273 43 male 25.520 5 no southeast 14478.330  
## 1274 35 male 27.610 1 no southeast 4747.053  
## 1275 26 male 27.060 0 yes southeast 17043.341  
## 1276 57 male 23.700 0 no southwest 10959.330  
## 1277 22 female 30.400 0 no northeast 2741.948  
## 1278 32 female 29.735 0 no northwest 4357.044  
## 1279 39 male 29.925 1 yes northeast 22462.044  
## 1280 25 female 26.790 2 no northwest 4189.113  
## 1281 48 female 33.330 0 no southeast 8283.681  
## 1282 47 female 27.645 2 yes northwest 24535.699  
## 1283 18 female 21.660 0 yes northeast 14283.459  
## 1284 18 male 30.030 1 no southeast 1720.354  
## 1285 61 male 36.300 1 yes southwest 47403.880  
## 1286 47 female 24.320 0 no northeast 8534.672  
## 1287 28 female 17.290 0 no northeast 3732.625  
## 1288 36 female 25.900 1 no southwest 5472.449  
## 1289 20 male 39.400 2 yes southwest 38344.566  
## 1290 44 male 34.320 1 no southeast 7147.473  
## 1291 38 female 19.950 2 no northeast 7133.903  
## 1292 19 male 34.900 0 yes southwest 34828.654  
## 1293 21 male 23.210 0 no southeast 1515.345  
## 1294 46 male 25.745 3 no northwest 9301.894  
## 1295 58 male 25.175 0 no northeast 11931.125  
## 1296 20 male 22.000 1 no southwest 1964.780  
## 1297 18 male 26.125 0 no northeast 1708.926  
## 1298 28 female 26.510 2 no southeast 4340.441  
## 1299 33 male 27.455 2 no northwest 5261.469  
## 1300 19 female 25.745 1 no northwest 2710.829  
## 1301 45 male 30.360 0 yes southeast 62592.873  
## 1302 62 male 30.875 3 yes northwest 46718.163  
## 1303 25 female 20.800 1 no southwest 3208.787  
## 1304 43 male 27.800 0 yes southwest 37829.724  
## 1305 42 male 24.605 2 yes northeast 21259.378  
## 1306 24 female 27.720 0 no southeast 2464.619  
## 1307 29 female 21.850 0 yes northeast 16115.305  
## 1308 32 male 28.120 4 yes northwest 21472.479  
## 1309 25 female 30.200 0 yes southwest 33900.653  
## 1310 41 male 32.200 2 no southwest 6875.961  
## 1311 42 male 26.315 1 no northwest 6940.910  
## 1312 33 female 26.695 0 no northwest 4571.413  
## 1313 34 male 42.900 1 no southwest 4536.259  
## 1314 19 female 34.700 2 yes southwest 36397.576  
## 1315 30 female 23.655 3 yes northwest 18765.875  
## 1316 18 male 28.310 1 no northeast 11272.331  
## 1317 19 female 20.600 0 no southwest 1731.677  
## 1318 18 male 53.130 0 no southeast 1163.463  
## 1319 35 male 39.710 4 no northeast 19496.719  
## 1320 39 female 26.315 2 no northwest 7201.701  
## 1321 31 male 31.065 3 no northwest 5425.023  
## 1322 62 male 26.695 0 yes northeast 28101.333  
## 1323 62 male 38.830 0 no southeast 12981.346  
## 1324 42 female 40.370 2 yes southeast 43896.376  
## 1325 31 male 25.935 1 no northwest 4239.893  
## 1326 61 male 33.535 0 no northeast 13143.337  
## 1327 42 female 32.870 0 no northeast 7050.021  
## 1328 51 male 30.030 1 no southeast 9377.905  
## 1329 23 female 24.225 2 no northeast 22395.744  
## 1330 52 male 38.600 2 no southwest 10325.206  
## 1331 57 female 25.740 2 no southeast 12629.166  
## 1332 23 female 33.400 0 no southwest 10795.937  
## 1333 52 female 44.700 3 no southwest 11411.685  
## 1334 50 male 30.970 3 no northwest 10600.548  
## 1335 18 female 31.920 0 no northeast 2205.981  
## 1336 18 female 36.850 0 no southeast 1629.833  
## 1337 21 female 25.800 0 no southwest 2007.945  
## 1338 61 female 29.070 0 yes northwest 29141.360

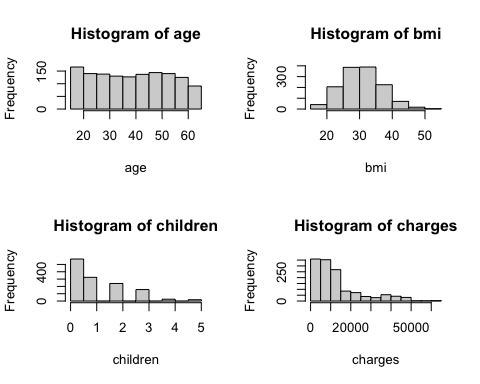
Setting variables in R

age <- insurance$age  
sex <- insurance$sex  
bmi <- insurance$bmi  
children <- insurance$children  
smoker <- insurance$smoker  
region <- insurance$region  
charges <- insurance$charges

# Plots of Data

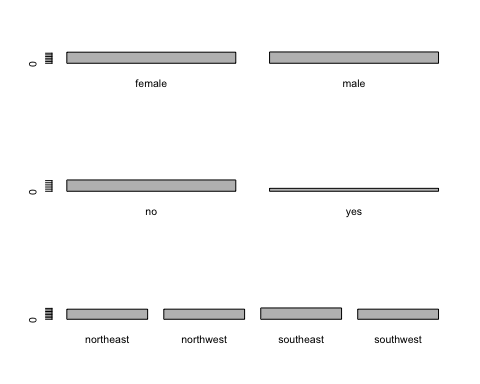
Numerical Data: Histograms

par(mfrow = c(2,2))  
hist1 <- hist(age)  
hist2 <- hist(bmi)  
hist3 <- hist(children)  
hist4 <- hist(charges)



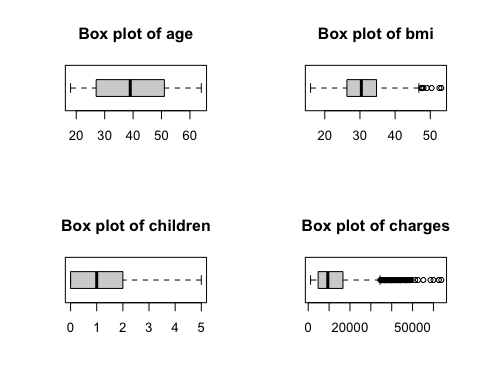
Categorical Data: Frequency tables

par(mfrow = c(3,1))  
table1 <- table(sex)  
table2 <- table(smoker)  
table3 <- table(region)  
  
barplot(table1)  
barplot(table2)  
barplot(table3)



Box Plots

par(mfrow = c(2,2))  
boxplot(age, main = "Box plot of age", horizontal = T)  
boxplot(bmi, main = "Box plot of bmi", horizontal = T)  
boxplot(children, main = "Box plot of children", horizontal = T)  
boxplot(charges, main = "Box plot of charges", horizontal = T)



# Summary Statistics

print("Age Summary")

## [1] "Age Summary"

print(summary(age))

## Min. 1st Qu. Median Mean 3rd Qu. Max.   
## 18.00 27.00 39.00 39.21 51.00 64.00

print("BMI Summary")

## [1] "BMI Summary"

print(summary(bmi))

## Min. 1st Qu. Median Mean 3rd Qu. Max.   
## 15.96 26.30 30.40 30.66 34.69 53.13

print("Children Summary")

## [1] "Children Summary"

print(summary(children))

## Min. 1st Qu. Median Mean 3rd Qu. Max.   
## 0.000 0.000 1.000 1.095 2.000 5.000

print("Charges Summary")

## [1] "Charges Summary"

print(summary(charges))

## Min. 1st Qu. Median Mean 3rd Qu. Max.   
## 1122 4740 9382 13270 16640 63770

# Pairwise Scatterplots + Coefficients of Correlation for all variables (Multicollinearity)

library("ggplot2")  
library("gridExtra")

##   
## Attaching package: 'gridExtra'

## The following object is masked from 'package:dplyr':  
##   
## combine

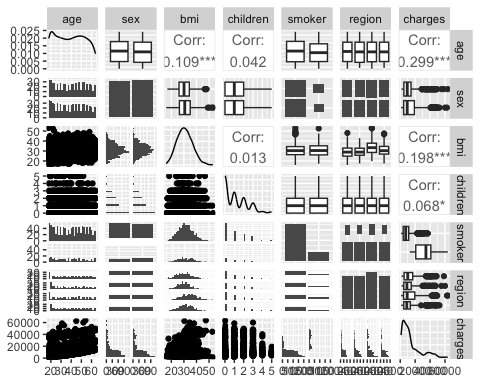
library("GGally")

## Registered S3 method overwritten by 'GGally':  
## method from   
## +.gg ggplot2

ggpairs(insurance) + theme()

## `stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

## `stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.  
## `stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.  
## `stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.  
## `stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.  
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## `stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.  
## `stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.  
## `stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.



Multicollinearity Correlation Values for predictors

# age, bmi, children, charges  
print("Correlation Coefficient of age ~ charges")

## [1] "Correlation Coefficient of age ~ charges"

print(cor(age, charges))

## [1] 0.2990082

print("Correlation Coefficient of bmi ~ charges")

## [1] "Correlation Coefficient of bmi ~ charges"

print(cor(bmi, charges))

## [1] 0.198341

print("Correlation Coefficient of children ~ charges")

## [1] "Correlation Coefficient of children ~ charges"

print(cor(children, charges))

## [1] 0.06799823

# Multicollinearity Summary of Linear Model

ins.mlr <- lm(charges~age+sex+bmi+children+smoker+region, data = insurance)  
summary(ins.mlr)

##   
## Call:  
## lm(formula = charges ~ age + sex + bmi + children + smoker +   
## region, data = insurance)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -11304.9 -2848.1 -982.1 1393.9 29992.8   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -11938.5 987.8 -12.086 < 2e-16 \*\*\*  
## age 256.9 11.9 21.587 < 2e-16 \*\*\*  
## sexmale -131.3 332.9 -0.394 0.693348   
## bmi 339.2 28.6 11.860 < 2e-16 \*\*\*  
## children 475.5 137.8 3.451 0.000577 \*\*\*  
## smokeryes 23848.5 413.1 57.723 < 2e-16 \*\*\*  
## regionnorthwest -353.0 476.3 -0.741 0.458769   
## regionsoutheast -1035.0 478.7 -2.162 0.030782 \*   
## regionsouthwest -960.0 477.9 -2.009 0.044765 \*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 6062 on 1329 degrees of freedom  
## Multiple R-squared: 0.7509, Adjusted R-squared: 0.7494   
## F-statistic: 500.8 on 8 and 1329 DF, p-value: < 2.2e-16

# Variance Inflation Factor (VIF)

# Using car Library  
# Used in Analysis  
library(car)

## Loading required package: carData

##   
## Attaching package: 'car'

## The following object is masked from 'package:dplyr':  
##   
## recode

## The following object is masked from 'package:purrr':  
##   
## some

vif(ins.mlr)

## GVIF Df GVIF^(1/(2\*Df))  
## age 1.016822 1 1.008376  
## sex 1.008900 1 1.004440  
## bmi 1.106630 1 1.051965  
## children 1.004011 1 1.002003  
## smoker 1.012074 1 1.006019  
## region 1.098893 3 1.015841

# Using rms library  
library(rms)

## Loading required package: Hmisc

##   
## Attaching package: 'Hmisc'

## The following objects are masked from 'package:dplyr':  
##   
## src, summarize

## The following objects are masked from 'package:base':  
##   
## format.pval, units

##   
## Attaching package: 'rms'

## The following objects are masked from 'package:car':  
##   
## Predict, vif

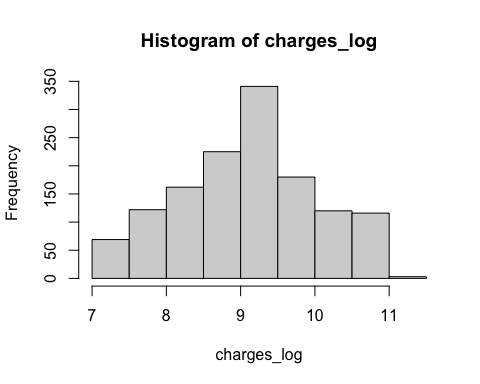
vif(ins.mlr)

## age sexmale bmi children smokeryes   
## 1.016822 1.008900 1.106630 1.004011 1.012074   
## regionnorthwest regionsoutheast regionsouthwest   
## 1.518823 1.652230 1.529411

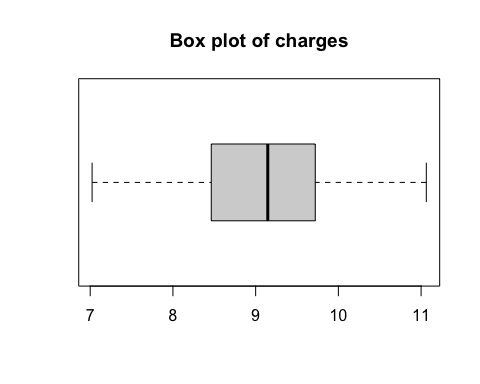
# ANALYSIS 2

## Transform the charges variable

# Log-transformed to make Charges variable more normal distributed  
charges\_log <- log(charges)  
hist(charges\_log)



boxplot(charges\_log, main = "Box plot of charges", horizontal = T)



# Residual Analysis for First-Order Predictors

## Residuals vs. Fitted Plot

# plot(log\_model)  
  
# ANOVA  
# anova(log\_model)

# Values for insurance dataset with log-transformed Charges data:

library(leaps)  
insurance\_all <- regsubsets(charges\_log ~ age+sex+bmi+children+smoker+region, data = insurance,  
 nbest = 1, nvmax = 5)  
summary(insurance\_all)$rsq # R^2

## [1] 0.4428978 0.7395465 0.7572654 0.7621566 0.7639274

summary(insurance\_all)$adjr2 # Adjusted R^2

## [1] 0.4424809 0.7391564 0.7567195 0.7614429 0.7630413

# Full Model Selection (Second Order Terms)

library(leaps)  
charges\_all <- regsubsets(charges\_log ~.^2 + I(age^2) + I(bmi^2) + I(children^2), data = insurance, nbest = 1, nvmax = 5)  
summary(charges\_all)$which

## (Intercept) age sexmale bmi children smokeryes regionnorthwest  
## 1 TRUE FALSE FALSE FALSE FALSE FALSE FALSE  
## 2 TRUE TRUE FALSE FALSE FALSE FALSE FALSE  
## 3 TRUE TRUE FALSE FALSE FALSE FALSE FALSE  
## 4 TRUE TRUE FALSE FALSE FALSE FALSE FALSE  
## 5 TRUE TRUE FALSE FALSE FALSE TRUE FALSE  
## regionsoutheast regionsouthwest charges I(age^2) I(bmi^2) I(children^2)  
## 1 FALSE FALSE TRUE FALSE FALSE FALSE  
## 2 FALSE FALSE TRUE FALSE FALSE FALSE  
## 3 FALSE FALSE TRUE FALSE FALSE FALSE  
## 4 FALSE FALSE TRUE FALSE FALSE FALSE  
## 5 FALSE FALSE TRUE FALSE FALSE FALSE  
## age:sexmale age:bmi age:children age:smokeryes age:regionnorthwest  
## 1 FALSE FALSE FALSE FALSE FALSE  
## 2 FALSE FALSE FALSE FALSE FALSE  
## 3 FALSE FALSE FALSE FALSE FALSE  
## 4 FALSE FALSE FALSE FALSE FALSE  
## 5 FALSE FALSE FALSE FALSE FALSE  
## age:regionsoutheast age:regionsouthwest age:charges sexmale:bmi  
## 1 FALSE FALSE FALSE FALSE  
## 2 FALSE FALSE FALSE FALSE  
## 3 FALSE FALSE TRUE FALSE  
## 4 FALSE FALSE TRUE FALSE  
## 5 FALSE FALSE TRUE FALSE  
## sexmale:children sexmale:smokeryes sexmale:regionnorthwest  
## 1 FALSE FALSE FALSE  
## 2 FALSE FALSE FALSE  
## 3 FALSE FALSE FALSE  
## 4 FALSE FALSE FALSE  
## 5 FALSE FALSE FALSE  
## sexmale:regionsoutheast sexmale:regionsouthwest sexmale:charges bmi:children  
## 1 FALSE FALSE FALSE FALSE  
## 2 FALSE FALSE FALSE FALSE  
## 3 FALSE FALSE FALSE FALSE  
## 4 FALSE FALSE FALSE FALSE  
## 5 FALSE FALSE FALSE FALSE  
## bmi:smokeryes bmi:regionnorthwest bmi:regionsoutheast bmi:regionsouthwest  
## 1 FALSE FALSE FALSE FALSE  
## 2 FALSE FALSE FALSE FALSE  
## 3 FALSE FALSE FALSE FALSE  
## 4 FALSE FALSE FALSE FALSE  
## 5 FALSE FALSE FALSE FALSE  
## bmi:charges children:smokeryes children:regionnorthwest  
## 1 FALSE FALSE FALSE  
## 2 FALSE FALSE FALSE  
## 3 FALSE FALSE FALSE  
## 4 TRUE FALSE FALSE  
## 5 FALSE FALSE FALSE  
## children:regionsoutheast children:regionsouthwest children:charges  
## 1 FALSE FALSE FALSE  
## 2 FALSE FALSE FALSE  
## 3 FALSE FALSE FALSE  
## 4 FALSE FALSE FALSE  
## 5 FALSE FALSE FALSE  
## smokeryes:regionnorthwest smokeryes:regionsoutheast smokeryes:regionsouthwest  
## 1 FALSE FALSE FALSE  
## 2 FALSE FALSE FALSE  
## 3 FALSE FALSE FALSE  
## 4 FALSE FALSE FALSE  
## 5 FALSE FALSE FALSE  
## smokeryes:charges regionnorthwest:charges regionsoutheast:charges  
## 1 FALSE FALSE FALSE  
## 2 FALSE FALSE FALSE  
## 3 FALSE FALSE FALSE  
## 4 FALSE FALSE FALSE  
## 5 TRUE FALSE FALSE  
## regionsouthwest:charges  
## 1 FALSE  
## 2 FALSE  
## 3 FALSE  
## 4 FALSE  
## 5 FALSE

summary(charges\_all)$adjr2

## [1] 0.7972334 0.8719057 0.9361297 0.9479134 0.9683719

# Step Model Selection

full\_model <- lm(charges\_log ~.^2 + I(age^2) + I(bmi^2) + I(children^2), data = insurance)  
null\_model <- lm(charges\_log ~ 1, data = insurance)  
step\_model1 <- step(null\_model, scope = list(lower = null\_model, upper = full\_model), direction = "both",test="F")

## Start: AIC=-223.51  
## charges\_log ~ 1  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + charges 1 901.42 229.05 -2357.55 5257.7881 < 2.2e-16 \*\*\*  
## + smoker 1 500.68 629.79 -1004.24 1062.1239 < 2.2e-16 \*\*\*  
## + age 1 314.96 815.51 -658.46 515.9771 < 2.2e-16 \*\*\*  
## + I(age^2) 1 293.08 837.39 -623.04 467.5871 < 2.2e-16 \*\*\*  
## + children 1 29.43 1101.05 -256.79 35.7047 2.941e-09 \*\*\*  
## + bmi 1 19.90 1110.58 -245.27 23.9365 1.117e-06 \*\*\*  
## + I(bmi^2) 1 17.64 1112.83 -242.55 21.1799 4.579e-06 \*\*\*  
## + I(children^2) 1 15.92 1114.55 -240.48 19.0828 1.348e-05 \*\*\*  
## <none> 1130.47 -223.51   
## + region 3 3.55 1126.92 -221.72 1.4020 0.2406   
## + sex 1 0.04 1130.44 -221.55 0.0424 0.8369   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2357.55  
## charges\_log ~ charges  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + age 1 84.46 144.59 -2971.08 779.818 < 2.2e-16 \*\*\*  
## + I(age^2) 1 71.94 157.11 -2860.01 611.348 < 2.2e-16 \*\*\*  
## + children 1 11.50 217.55 -2424.46 70.555 < 2.2e-16 \*\*\*  
## + I(children^2) 1 8.01 221.04 -2403.18 48.377 5.491e-12 \*\*\*  
## + smoker 1 4.18 224.87 -2380.18 24.796 7.204e-07 \*\*\*  
## + region 3 3.57 225.48 -2372.57 7.036 0.0001078 \*\*\*  
## + I(bmi^2) 1 2.64 226.41 -2371.05 15.556 8.424e-05 \*\*\*  
## + sex 1 2.35 226.70 -2369.36 13.844 0.0002068 \*\*\*  
## + bmi 1 2.32 226.73 -2369.20 13.685 0.0002249 \*\*\*  
## <none> 229.05 -2357.55   
## - charges 1 901.42 1130.47 -223.51 5257.788 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2971.08  
## charges\_log ~ charges + age  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + age:charges 1 72.55 72.04 -3901.2 1343.3935 < 2.2e-16 \*\*\*  
## + I(age^2) 1 13.76 130.83 -3102.9 140.3257 < 2.2e-16 \*\*\*  
## + children 1 10.10 134.49 -3066.0 100.1769 < 2.2e-16 \*\*\*  
## + I(children^2) 1 7.36 137.24 -3038.9 71.4950 < 2.2e-16 \*\*\*  
## + smoker 1 5.09 139.50 -3017.1 48.6936 4.701e-12 \*\*\*  
## + I(bmi^2) 1 4.20 140.39 -3008.5 39.8792 3.672e-10 \*\*\*  
## + bmi 1 4.07 140.52 -3007.3 38.6758 6.682e-10 \*\*\*  
## + region 3 2.81 141.78 -2991.4 8.8092 8.750e-06 \*\*\*  
## + sex 1 1.36 143.23 -2981.8 12.7011 0.0003783 \*\*\*  
## <none> 144.59 -2971.1   
## - age 1 84.46 229.05 -2357.6 779.8179 < 2.2e-16 \*\*\*  
## - charges 1 670.92 815.51 -658.5 6194.6079 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-3901.22  
## charges\_log ~ charges + age + charges:age  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + children 1 7.018 65.023 -4036.4 143.882 < 2.2e-16 \*\*\*  
## + I(children^2) 1 5.524 66.517 -4006.0 110.710 < 2.2e-16 \*\*\*  
## + I(bmi^2) 1 4.991 67.051 -3995.3 99.215 < 2.2e-16 \*\*\*  
## + bmi 1 4.878 67.164 -3993.0 96.816 < 2.2e-16 \*\*\*  
## + smoker 1 3.772 68.269 -3971.2 73.660 < 2.2e-16 \*\*\*  
## + region 3 2.315 69.726 -3938.9 14.733 1.931e-09 \*\*\*  
## + I(age^2) 1 1.833 70.209 -3933.7 34.803 4.618e-09 \*\*\*  
## + sex 1 1.314 70.727 -3923.8 24.769 7.307e-07 \*\*\*  
## <none> 72.042 -3901.2   
## - charges:age 1 72.549 144.591 -2971.1 1343.393 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-4036.36  
## charges\_log ~ charges + age + children + charges:age  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + I(bmi^2) 1 4.954 60.069 -4140.4 109.8511 < 2.2e-16 \*\*\*  
## + bmi 1 4.839 60.185 -4137.8 107.0855 < 2.2e-16 \*\*\*  
## + smoker 1 4.600 60.423 -4132.5 101.4032 < 2.2e-16 \*\*\*  
## + children:charges 1 3.788 61.235 -4114.7 82.4082 < 2.2e-16 \*\*\*  
## + age:children 1 2.582 62.441 -4088.6 55.0787 2.056e-13 \*\*\*  
## + region 3 2.331 62.692 -4079.2 16.4847 1.607e-10 \*\*\*  
## + sex 1 1.404 63.619 -4063.6 29.3898 7.019e-08 \*\*\*  
## + I(age^2) 1 0.357 64.666 -4041.7 7.3560 0.00677 \*\*   
## <none> 65.023 -4036.4   
## + I(children^2) 1 0.062 64.962 -4035.6 1.2633 0.26123   
## - children 1 7.018 72.042 -3901.2 143.8818 < 2.2e-16 \*\*\*  
## - charges:age 1 69.468 134.491 -3066.0 1424.1171 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-4140.39  
## charges\_log ~ charges + age + children + I(bmi^2) + charges:age  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + children:charges 1 3.587 56.482 -4220.8 84.5304 < 2.2e-16 \*\*\*  
## + smoker 1 2.712 57.357 -4200.2 62.9339 4.499e-15 \*\*\*  
## + age:children 1 2.291 57.778 -4190.4 52.7768 6.343e-13 \*\*\*  
## + sex 1 1.213 58.856 -4165.7 27.4265 1.895e-07 \*\*\*  
## + region 3 1.136 58.933 -4159.9 8.5395 1.283e-05 \*\*\*  
## + I(age^2) 1 0.271 59.799 -4144.4 6.0235 0.01424 \*   
## <none> 60.069 -4140.4   
## + I(children^2) 1 0.071 59.998 -4140.0 1.5836 0.20847   
## + bmi 1 0.002 60.067 -4138.4 0.0482 0.82618   
## - I(bmi^2) 1 4.954 65.023 -4036.4 109.8511 < 2.2e-16 \*\*\*  
## - children 1 6.982 67.051 -3995.3 154.8189 < 2.2e-16 \*\*\*  
## - charges:age 1 70.247 130.317 -3106.2 1557.6947 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-4220.78  
## charges\_log ~ charges + age + children + I(bmi^2) + charges:age +   
## charges:children  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + smoker 1 2.682 53.800 -4283.9 66.2927 8.859e-16 \*\*\*  
## + sex 1 1.162 55.320 -4246.6 27.9384 1.462e-07 \*\*\*  
## + region 3 1.245 55.237 -4244.6 9.9751 1.671e-06 \*\*\*  
## + age:children 1 0.989 55.493 -4242.4 23.7143 1.251e-06 \*\*\*  
## + I(age^2) 1 0.250 56.233 -4224.7 5.9019 0.01526 \*   
## + I(children^2) 1 0.218 56.264 -4223.9 5.1462 0.02346 \*   
## <none> 56.482 -4220.8   
## + bmi 1 0.001 56.481 -4218.8 0.0339 0.85397   
## - charges:children 1 3.587 60.069 -4140.4 84.5304 < 2.2e-16 \*\*\*  
## - I(bmi^2) 1 4.753 61.235 -4114.7 111.9951 < 2.2e-16 \*\*\*  
## - charges:age 1 65.480 121.962 -3192.8 1543.0317 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-4283.86  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## charges:age + charges:children  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + smoker:charges 1 27.931 25.870 -5261.6 1434.8796 < 2.2e-16 \*\*\*  
## + sex 1 1.344 52.456 -4315.7 34.0592 6.709e-09 \*\*\*  
## + region 3 1.481 52.320 -4315.2 12.5189 4.493e-08 \*\*\*  
## + age:children 1 1.022 52.779 -4307.5 25.7241 4.496e-07 \*\*\*  
## + age:smoker 1 0.449 53.351 -4293.1 11.1900 0.0008453 \*\*\*  
## + I(children^2) 1 0.220 53.581 -4287.3 5.4511 0.0197040 \*   
## + I(age^2) 1 0.133 53.668 -4285.2 3.2896 0.0699458 .   
## <none> 53.800 -4283.9   
## + children:smoker 1 0.048 53.752 -4283.1 1.1901 0.2755069   
## + bmi 1 0.041 53.760 -4282.9 1.0086 0.3154280   
## - smoker 1 2.682 56.482 -4220.8 66.2927 8.859e-16 \*\*\*  
## - I(bmi^2) 1 2.922 56.722 -4215.1 72.2339 < 2.2e-16 \*\*\*  
## - charges:children 1 3.557 57.357 -4200.2 87.9257 < 2.2e-16 \*\*\*  
## - charges:age 1 64.076 117.876 -3236.4 1584.0188 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5261.56  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## charges:age + charges:children + charges:smoker  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + I(age^2) 1 2.0224 23.847 -5368.5 112.6196 < 2.2e-16 \*\*\*  
## + age:children 1 1.3902 24.479 -5333.5 75.4201 < 2.2e-16 \*\*\*  
## + age:smoker 1 1.3266 24.543 -5330.0 71.7809 < 2.2e-16 \*\*\*  
## + region 3 0.8498 25.020 -5300.2 15.0130 1.298e-09 \*\*\*  
## + sex 1 0.7218 25.148 -5297.4 38.1166 8.838e-10 \*\*\*  
## + I(children^2) 1 0.3513 25.518 -5277.9 18.2810 2.042e-05 \*\*\*  
## + children:smoker 1 0.1273 25.742 -5266.2 6.5688 0.01049 \*   
## + bmi 1 0.1215 25.748 -5265.9 6.2660 0.01243 \*   
## <none> 25.870 -5261.6   
## - I(bmi^2) 1 0.1292 25.999 -5256.9 6.6388 0.01008 \*   
## - charges:children 1 3.6904 29.560 -5085.1 189.5864 < 2.2e-16 \*\*\*  
## - charges:smoker 1 27.9307 53.800 -4283.9 1434.8796 < 2.2e-16 \*\*\*  
## - charges:age 1 31.2124 57.082 -4204.6 1603.4673 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5368.47  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + charges:age + charges:children + charges:smoker  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + age:children 1 1.4712 22.376 -5451.7 87.2498 < 2.2e-16 \*\*\*  
## + region 3 0.8366 23.011 -5410.3 16.0574 2.950e-10 \*\*\*  
## + sex 1 0.6823 23.165 -5405.3 39.0880 5.450e-10 \*\*\*  
## + age:smoker 1 0.4947 23.353 -5394.5 28.1128 1.339e-07 \*\*\*  
## + children:smoker 1 0.1151 23.732 -5372.9 6.4366 0.01129 \*   
## + bmi 1 0.1148 23.733 -5372.9 6.4173 0.01142 \*   
## + I(children^2) 1 0.1032 23.744 -5372.3 5.7696 0.01644 \*   
## <none> 23.847 -5368.5   
## - I(bmi^2) 1 0.0735 23.921 -5366.4 4.0931 0.04326 \*   
## - I(age^2) 1 2.0224 25.870 -5261.6 112.6196 < 2.2e-16 \*\*\*  
## - charges:children 1 3.6386 27.486 -5180.5 202.6269 < 2.2e-16 \*\*\*  
## - charges:age 1 23.3279 47.175 -4457.7 1299.0724 < 2.2e-16 \*\*\*  
## - charges:smoker 1 29.8203 53.668 -4285.2 1660.6139 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5451.67  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + charges:age + charges:children + charges:smoker +   
## age:children  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + sex 1 0.7899 21.586 -5497.8 48.5190 5.136e-12 \*\*\*  
## + region 3 0.7792 21.597 -5493.1 15.9233 3.569e-10 \*\*\*  
## + age:smoker 1 0.3225 22.054 -5469.1 19.3893 1.152e-05 \*\*\*  
## + bmi 1 0.1407 22.235 -5458.1 8.3893 0.003836 \*\*   
## + I(children^2) 1 0.1368 22.239 -5457.9 8.1582 0.004354 \*\*   
## + children:smoker 1 0.0477 22.328 -5452.5 2.8314 0.092672 .   
## <none> 22.376 -5451.7   
## - I(bmi^2) 1 0.0460 22.422 -5450.9 2.7308 0.098668 .   
## - age:children 1 1.4712 23.847 -5368.5 87.2498 < 2.2e-16 \*\*\*  
## - I(age^2) 1 2.1033 24.479 -5333.5 124.7363 < 2.2e-16 \*\*\*  
## - charges:children 1 2.1295 24.506 -5332.0 126.2900 < 2.2e-16 \*\*\*  
## - charges:age 1 22.1679 44.544 -4532.5 1314.6508 < 2.2e-16 \*\*\*  
## - charges:smoker 1 30.2571 52.633 -4309.2 1794.3725 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5497.75  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + charges:age + charges:children + charges:smoker +   
## age:children  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + age:sex 1 1.1482 20.438 -5568.9 74.4399 < 2.2e-16 \*\*\*  
## + sex:charges 1 0.9510 20.635 -5556.0 61.0629 1.119e-14 \*\*\*  
## + region 3 0.7870 20.799 -5541.5 16.6875 1.208e-10 \*\*\*  
## + age:smoker 1 0.3061 21.280 -5514.9 19.0591 1.366e-05 \*\*\*  
## + sex:smoker 1 0.2480 21.338 -5511.2 15.3983 9.154e-05 \*\*\*  
## + sex:children 1 0.2265 21.360 -5509.9 14.0491 0.0001858 \*\*\*  
## + bmi 1 0.1469 21.439 -5504.9 9.0813 0.0026314 \*\*   
## + I(children^2) 1 0.1330 21.453 -5504.0 8.2154 0.0042192 \*\*   
## + children:smoker 1 0.0458 21.541 -5498.6 2.8161 0.0935578 .   
## <none> 21.586 -5497.8   
## - I(bmi^2) 1 0.0340 21.620 -5497.7 2.0869 0.1488042   
## - sex 1 0.7899 22.376 -5451.7 48.5190 5.136e-12 \*\*\*  
## - age:children 1 1.5787 23.165 -5405.3 96.9779 < 2.2e-16 \*\*\*  
## - charges:children 1 2.0574 23.644 -5377.9 126.3846 < 2.2e-16 \*\*\*  
## - I(age^2) 1 2.0632 23.649 -5377.6 126.7363 < 2.2e-16 \*\*\*  
## - charges:age 1 22.2998 43.886 -4550.4 1369.8295 < 2.2e-16 \*\*\*  
## - charges:smoker 1 29.5753 51.162 -4345.2 1816.7483 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5568.89  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + charges:age + charges:children + charges:smoker +   
## age:children + age:sex  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + region 3 0.7930 19.645 -5615.8 17.7883 2.540e-11 \*\*\*  
## + sex:charges 1 0.4642 19.974 -5597.6 30.7710 3.502e-08 \*\*\*  
## + sex:smoker 1 0.2762 20.162 -5585.1 18.1372 2.201e-05 \*\*\*  
## + age:smoker 1 0.2752 20.163 -5585.0 18.0691 2.280e-05 \*\*\*  
## + sex:children 1 0.1886 20.249 -5579.3 12.3299 0.0004607 \*\*\*  
## + I(children^2) 1 0.1392 20.299 -5576.0 9.0798 0.0026336 \*\*   
## + bmi 1 0.1344 20.304 -5575.7 8.7623 0.0031298 \*\*   
## + children:smoker 1 0.0447 20.393 -5569.8 2.9013 0.0887419 .   
## <none> 20.438 -5568.9   
## - I(bmi^2) 1 0.0399 20.478 -5568.3 2.5870 0.1079796   
## - age:sex 1 1.1482 21.586 -5497.8 74.4399 < 2.2e-16 \*\*\*  
## - age:children 1 1.5047 21.943 -5475.8 97.5522 < 2.2e-16 \*\*\*  
## - I(age^2) 1 1.9297 22.368 -5450.2 125.1055 < 2.2e-16 \*\*\*  
## - charges:children 1 2.1402 22.578 -5437.6 138.7493 < 2.2e-16 \*\*\*  
## - charges:age 1 22.7410 43.179 -4570.1 1474.2998 < 2.2e-16 \*\*\*  
## - charges:smoker 1 29.5921 50.030 -4373.1 1918.4544 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5615.84  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + charges:age + charges:children +   
## charges:smoker + age:children + age:sex  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + age:region 3 1.0966 18.548 -5686.7 25.9935 2.452e-16 \*\*\*  
## + region:charges 3 0.6441 19.001 -5654.4 14.9048 1.517e-09 \*\*\*  
## + sex:charges 1 0.4980 19.147 -5648.2 34.3592 5.781e-09 \*\*\*  
## + sex:smoker 1 0.3019 19.343 -5634.6 20.6162 6.123e-06 \*\*\*  
## + age:smoker 1 0.2505 19.395 -5631.0 17.0603 3.849e-05 \*\*\*  
## + sex:children 1 0.1810 19.464 -5626.2 12.2862 0.0004716 \*\*\*  
## + bmi 1 0.1444 19.501 -5623.7 9.7832 0.0017997 \*\*   
## + smoker:region 3 0.1987 19.446 -5623.4 4.4914 0.0038274 \*\*   
## + I(children^2) 1 0.1267 19.518 -5622.5 8.5720 0.0034722 \*\*   
## + children:region 3 0.1317 19.513 -5618.8 2.9672 0.0309983 \*   
## - I(bmi^2) 1 0.0002 19.645 -5617.8 0.0163 0.8985681   
## + sex:region 3 0.0943 19.551 -5616.3 2.1204 0.0958437 .   
## + children:smoker 1 0.0344 19.611 -5616.2 2.3161 0.1282814   
## <none> 19.645 -5615.8   
## - region 3 0.7930 20.438 -5568.9 17.7883 2.540e-11 \*\*\*  
## - age:sex 1 1.1542 20.799 -5541.5 77.6707 < 2.2e-16 \*\*\*  
## - age:children 1 1.4471 21.092 -5522.7 97.3791 < 2.2e-16 \*\*\*  
## - I(age^2) 1 1.9131 21.558 -5493.5 128.7377 < 2.2e-16 \*\*\*  
## - charges:children 1 2.2407 21.886 -5473.3 150.7891 < 2.2e-16 \*\*\*  
## - charges:age 1 22.6629 42.308 -4591.4 1525.0848 < 2.2e-16 \*\*\*  
## - charges:smoker 1 28.9329 48.578 -4406.5 1947.0207 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5686.69  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + charges:age + charges:children +   
## charges:smoker + age:children + age:sex + age:region  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + sex:charges 1 0.5211 18.027 -5722.8 38.0963 8.947e-10 \*\*\*  
## + sex:smoker 1 0.3042 18.244 -5706.8 21.9779 3.044e-06 \*\*\*  
## + age:smoker 1 0.2506 18.298 -5702.9 18.0484 2.305e-05 \*\*\*  
## + region:charges 3 0.2673 18.281 -5700.1 6.4149 0.0002591 \*\*\*  
## + smoker:region 3 0.2455 18.303 -5698.5 5.8832 0.0005475 \*\*\*  
## + bmi 1 0.1852 18.363 -5698.1 13.2945 0.0002766 \*\*\*  
## + sex:children 1 0.1739 18.375 -5697.3 12.4708 0.0004276 \*\*\*  
## + I(children^2) 1 0.1285 18.420 -5694.0 9.1969 0.0024716 \*\*   
## - I(bmi^2) 1 0.0005 18.549 -5688.7 0.0389 0.8436145   
## + children:region 3 0.1062 18.442 -5688.4 2.5255 0.0560976 .   
## + sex:region 3 0.0853 18.463 -5686.9 2.0275 0.1082111   
## <none> 18.548 -5686.7   
## + children:smoker 1 0.0185 18.530 -5686.0 1.3174 0.2512619   
## - age:region 3 1.0966 19.645 -5615.8 25.9935 2.452e-16 \*\*\*  
## - age:sex 1 1.1381 19.687 -5609.0 80.9325 < 2.2e-16 \*\*\*  
## - age:children 1 1.5117 20.060 -5583.9 107.4997 < 2.2e-16 \*\*\*  
## - I(age^2) 1 1.8794 20.428 -5559.6 133.6435 < 2.2e-16 \*\*\*  
## - charges:children 1 2.1863 20.735 -5539.6 155.4684 < 2.2e-16 \*\*\*  
## - charges:age 1 23.0423 41.591 -4608.3 1638.5650 < 2.2e-16 \*\*\*  
## - charges:smoker 1 28.4660 47.014 -4444.3 2024.2436 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5722.82  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + charges:age + charges:children +   
## charges:smoker + age:children + age:sex + age:region + charges:sex  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + age:smoker 1 0.2639 17.764 -5740.5 19.5637 1.053e-05 \*\*\*  
## + smoker:region 3 0.2402 17.787 -5734.8 5.9203 0.0005196 \*\*\*  
## + region:charges 3 0.2354 17.792 -5734.4 5.8003 0.0006151 \*\*\*  
## + bmi 1 0.1592 17.868 -5732.7 11.7325 0.0006331 \*\*\*  
## + sex:children 1 0.1475 17.880 -5731.8 10.8645 0.0010064 \*\*   
## + I(children^2) 1 0.1238 17.904 -5730.0 9.1076 0.0025944 \*\*   
## - I(bmi^2) 1 0.0009 18.028 -5724.7 0.0686 0.7933851   
## + children:region 3 0.0925 17.935 -5723.7 2.2613 0.0796388 .   
## + sex:region 3 0.0917 17.936 -5723.6 2.2403 0.0818735 .   
## <none> 18.027 -5722.8   
## + children:smoker 1 0.0196 18.008 -5722.3 1.4357 0.2310596   
## + sex:smoker 1 0.0065 18.021 -5721.3 0.4731 0.4916969   
## - charges:sex 1 0.5211 18.548 -5686.7 38.0963 8.947e-10 \*\*\*  
## - age:sex 1 0.6337 18.661 -5678.6 46.3284 1.514e-11 \*\*\*  
## - age:region 3 1.1197 19.147 -5648.2 27.2866 < 2.2e-16 \*\*\*  
## - age:children 1 1.5136 19.541 -5616.9 110.6616 < 2.2e-16 \*\*\*  
## - I(age^2) 1 1.8771 19.904 -5592.3 137.2334 < 2.2e-16 \*\*\*  
## - charges:children 1 2.3497 20.377 -5560.9 171.7856 < 2.2e-16 \*\*\*  
## - charges:age 1 22.6748 40.702 -4635.2 1657.7786 < 2.2e-16 \*\*\*  
## - charges:smoker 1 28.8972 46.925 -4444.8 2112.7022 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5740.55  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + charges:age + charges:children +   
## charges:smoker + age:children + age:sex + age:region + charges:sex +   
## age:smoker  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + region:charges 3 0.2726 17.491 -5755.2 6.8257 0.0001452 \*\*\*  
## + smoker:region 3 0.2508 17.513 -5753.6 6.2729 0.0003165 \*\*\*  
## + bmi 1 0.1548 17.609 -5750.3 11.5693 0.0006906 \*\*\*  
## + sex:children 1 0.1529 17.611 -5750.1 11.4255 0.0007457 \*\*\*  
## + I(children^2) 1 0.1165 17.647 -5747.3 8.6847 0.0032655 \*\*   
## + children:region 3 0.1130 17.651 -5743.1 2.8036 0.0386506 \*   
## + sex:region 3 0.1019 17.662 -5742.2 2.5275 0.0559501 .   
## - I(bmi^2) 1 0.0050 17.768 -5742.2 0.3693 0.5434689   
## <none> 17.764 -5740.5   
## + children:smoker 1 0.0218 17.742 -5740.2 1.6151 0.2040033   
## + sex:smoker 1 0.0064 17.757 -5739.0 0.4708 0.4927460   
## - age:smoker 1 0.2639 18.027 -5722.8 19.5637 1.053e-05 \*\*\*  
## - charges:sex 1 0.5344 18.298 -5702.9 39.6192 4.194e-10 \*\*\*  
## - age:sex 1 0.6073 18.371 -5697.6 45.0291 2.876e-11 \*\*\*  
## - age:region 3 1.1203 18.884 -5664.7 27.6871 < 2.2e-16 \*\*\*  
## - I(age^2) 1 1.2211 18.985 -5653.6 90.5341 < 2.2e-16 \*\*\*  
## - age:children 1 1.3505 19.114 -5644.5 100.1260 < 2.2e-16 \*\*\*  
## - charges:children 1 2.3521 20.116 -5576.2 174.3897 < 2.2e-16 \*\*\*  
## - charges:age 1 10.5657 28.329 -5118.0 783.3473 < 2.2e-16 \*\*\*  
## - charges:smoker 1 28.0711 45.835 -4474.3 2081.2154 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5755.24  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + charges:age + charges:children +   
## charges:smoker + age:children + age:sex + age:region + charges:sex +   
## age:smoker + charges:region  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + bmi 1 0.1736 17.317 -5766.6 13.1620 0.0002966 \*\*\*  
## + sex:children 1 0.1467 17.344 -5764.5 11.1075 0.0008838 \*\*\*  
## + I(children^2) 1 0.1195 17.371 -5762.4 9.0355 0.0026981 \*\*   
## + sex:region 3 0.1208 17.370 -5758.5 3.0403 0.0280843 \*   
## + children:region 3 0.1011 17.390 -5757.0 2.5403 0.0549992 .   
## + smoker:region 3 0.1001 17.391 -5756.9 2.5157 0.0568321 .   
## - I(bmi^2) 1 0.0085 17.499 -5756.6 0.6403 0.4237431   
## + children:smoker 1 0.0317 17.459 -5755.7 2.3867 0.1226118   
## <none> 17.491 -5755.2   
## + sex:smoker 1 0.0045 17.486 -5753.6 0.3384 0.5608406   
## - charges:region 3 0.2726 17.764 -5740.5 6.8257 0.0001452 \*\*\*  
## - age:smoker 1 0.3010 17.792 -5734.4 22.6136 2.199e-06 \*\*\*  
## - charges:sex 1 0.4984 17.989 -5719.6 37.4413 1.241e-09 \*\*\*  
## - age:sex 1 0.6255 18.116 -5710.2 46.9930 1.093e-11 \*\*\*  
## - age:region 3 0.7387 18.230 -5705.9 18.4989 9.322e-12 \*\*\*  
## - I(age^2) 1 1.2371 18.728 -5665.8 92.9349 < 2.2e-16 \*\*\*  
## - age:children 1 1.3573 18.848 -5657.2 101.9667 < 2.2e-16 \*\*\*  
## - charges:children 1 2.2354 19.726 -5596.3 167.9338 < 2.2e-16 \*\*\*  
## - charges:age 1 10.6725 28.163 -5119.9 801.7667 < 2.2e-16 \*\*\*  
## - charges:smoker 1 28.0138 45.505 -4477.9 2104.5275 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5766.58  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + bmi + charges:age + charges:children +   
## charges:smoker + age:children + age:sex + age:region + charges:sex +   
## age:smoker + charges:region  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + age:bmi 1 0.3018 17.016 -5788.1 23.2690 1.573e-06 \*\*\*  
## + sex:children 1 0.1363 17.181 -5775.2 10.4056 0.0012873 \*\*   
## + I(children^2) 1 0.1260 17.191 -5774.4 9.6157 0.0019704 \*\*   
## + bmi:smoker 1 0.0630 17.254 -5769.5 4.7887 0.0288223 \*   
## + sex:region 3 0.1122 17.205 -5769.3 2.8471 0.0364555 \*   
## + smoker:region 3 0.1012 17.216 -5768.4 2.5658 0.0531585 .   
## + children:region 3 0.1011 17.216 -5768.4 2.5643 0.0532701 .   
## + bmi:children 1 0.0471 17.270 -5768.2 3.5797 0.0587096 .   
## <none> 17.317 -5766.6   
## + children:smoker 1 0.0225 17.295 -5766.3 1.7105 0.1911554   
## + bmi:region 3 0.0711 17.246 -5766.1 1.8009 0.1451362   
## + bmi:charges 1 0.0177 17.300 -5766.0 1.3428 0.2467563   
## + sex:smoker 1 0.0072 17.310 -5765.1 0.5454 0.4603244   
## + sex:bmi 1 0.0028 17.314 -5764.8 0.2159 0.6422475   
## - I(bmi^2) 1 0.1588 17.476 -5756.4 12.0395 0.0005377 \*\*\*  
## - bmi 1 0.1736 17.491 -5755.2 13.1620 0.0002966 \*\*\*  
## - charges:region 3 0.2914 17.609 -5750.3 7.3638 6.791e-05 \*\*\*  
## - age:smoker 1 0.2981 17.615 -5745.7 22.6044 2.210e-06 \*\*\*  
## - charges:sex 1 0.4691 17.786 -5732.8 35.5642 3.168e-09 \*\*\*  
## - age:sex 1 0.6249 17.942 -5721.2 47.3765 9.050e-12 \*\*\*  
## - age:region 3 0.7558 18.073 -5715.4 19.1004 3.985e-12 \*\*\*  
## - I(age^2) 1 1.2325 18.550 -5676.6 93.4452 < 2.2e-16 \*\*\*  
## - age:children 1 1.3883 18.706 -5665.4 105.2579 < 2.2e-16 \*\*\*  
## - charges:children 1 2.1969 19.514 -5608.8 166.5722 < 2.2e-16 \*\*\*  
## - charges:age 1 10.6398 27.957 -5127.7 806.7079 < 2.2e-16 \*\*\*  
## - charges:smoker 1 28.1039 45.421 -4478.4 2130.8324 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5788.11  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + bmi + charges:age + charges:children +   
## charges:smoker + age:children + age:sex + age:region + charges:sex +   
## age:smoker + charges:region + age:bmi  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + sex:children 1 0.1483 16.867 -5797.8 11.5291 0.0007056 \*\*\*  
## + I(children^2) 1 0.1152 16.900 -5795.2 8.9375 0.0028458 \*\*   
## + bmi:smoker 1 0.0765 16.939 -5792.1 5.9211 0.0150936 \*   
## + children:region 3 0.1011 16.914 -5790.1 2.6080 0.0502480 .   
## + smoker:region 3 0.1007 16.915 -5790.1 2.5983 0.0509027 .   
## + sex:region 3 0.1005 16.915 -5790.0 2.5921 0.0513295 .   
## + bmi:children 1 0.0409 16.975 -5789.3 3.1612 0.0756412 .   
## <none> 17.016 -5788.1   
## + bmi:region 3 0.0760 16.940 -5788.1 1.9587 0.1183620   
## + children:smoker 1 0.0233 16.992 -5787.9 1.7985 0.1801249   
## + sex:smoker 1 0.0054 17.010 -5786.5 0.4156 0.5192432   
## + sex:bmi 1 0.0051 17.010 -5786.5 0.3962 0.5291590   
## + bmi:charges 1 0.0029 17.013 -5786.3 0.2205 0.6387389   
## - I(bmi^2) 1 0.2026 17.218 -5774.3 15.6225 8.145e-05 \*\*\*  
## - charges:region 3 0.3085 17.324 -5770.1 7.9284 3.055e-05 \*\*\*  
## - age:bmi 1 0.3018 17.317 -5766.6 23.2690 1.573e-06 \*\*\*  
## - age:smoker 1 0.4327 17.448 -5756.5 33.3655 9.525e-09 \*\*\*  
## - age:region 3 0.5220 17.538 -5753.7 13.4154 1.260e-08 \*\*\*  
## - charges:sex 1 0.4939 17.509 -5751.8 38.0805 9.029e-10 \*\*\*  
## - age:sex 1 0.5828 17.598 -5745.0 44.9340 3.018e-11 \*\*\*  
## - I(age^2) 1 1.1901 18.206 -5699.7 91.7634 < 2.2e-16 \*\*\*  
## - age:children 1 1.3601 18.376 -5687.2 104.8699 < 2.2e-16 \*\*\*  
## - charges:children 1 2.2169 19.232 -5626.2 170.9355 < 2.2e-16 \*\*\*  
## - charges:age 1 10.7999 27.815 -5132.5 832.7326 < 2.2e-16 \*\*\*  
## - charges:smoker 1 28.1536 45.169 -4483.8 2170.8113 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5797.82  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + bmi + charges:age + charges:children +   
## charges:smoker + age:children + age:sex + age:region + charges:sex +   
## age:smoker + charges:region + age:bmi + children:sex  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + I(children^2) 1 0.1270 16.740 -5805.9 9.9367 0.0016569 \*\*   
## + bmi:smoker 1 0.0661 16.801 -5801.1 5.1523 0.0233781 \*   
## + children:region 3 0.1139 16.753 -5800.9 2.9651 0.0310921 \*   
## + sex:region 3 0.0999 16.767 -5799.8 2.5983 0.0509062 .   
## + bmi:children 1 0.0411 16.826 -5799.1 3.1967 0.0740165 .   
## + smoker:region 3 0.0874 16.780 -5798.8 2.2717 0.0785541 .   
## + children:smoker 1 0.0279 16.839 -5798.0 2.1709 0.1408826   
## + bmi:region 3 0.0761 16.791 -5797.9 1.9755 0.1157955   
## <none> 16.867 -5797.8   
## + sex:bmi 1 0.0054 16.862 -5796.2 0.4174 0.5183270   
## + bmi:charges 1 0.0046 16.863 -5796.2 0.3559 0.5508699   
## + sex:smoker 1 0.0021 16.865 -5796.0 0.1644 0.6851743   
## - children:sex 1 0.1483 17.016 -5788.1 11.5291 0.0007056 \*\*\*  
## - I(bmi^2) 1 0.1915 17.059 -5784.7 14.8868 0.0001197 \*\*\*  
## - charges:region 3 0.3022 17.169 -5780.1 7.8299 3.512e-05 \*\*\*  
## - age:bmi 1 0.3138 17.181 -5775.2 24.3937 8.864e-07 \*\*\*  
## - age:smoker 1 0.4433 17.310 -5765.1 34.4523 5.527e-09 \*\*\*  
## - age:region 3 0.5141 17.381 -5763.6 13.3200 1.443e-08 \*\*\*  
## - charges:sex 1 0.4679 17.335 -5763.2 36.3671 2.122e-09 \*\*\*  
## - age:sex 1 0.5696 17.437 -5755.4 44.2685 4.195e-11 \*\*\*  
## - I(age^2) 1 1.1577 18.025 -5711.0 89.9855 < 2.2e-16 \*\*\*  
## - age:children 1 1.2699 18.137 -5702.7 98.7040 < 2.2e-16 \*\*\*  
## - charges:children 1 2.2734 19.141 -5630.6 176.6972 < 2.2e-16 \*\*\*  
## - charges:age 1 10.8664 27.734 -5134.5 844.5868 < 2.2e-16 \*\*\*  
## - charges:smoker 1 28.2391 45.106 -4483.7 2194.8745 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5805.93  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + bmi + I(children^2) + charges:age +   
## charges:children + charges:smoker + age:children + age:sex +   
## age:region + charges:sex + age:smoker + charges:region +   
## age:bmi + children:sex  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + children:region 3 0.1199 16.620 -5809.5 3.1427 0.0244430 \*   
## + bmi:smoker 1 0.0629 16.677 -5809.0 4.9354 0.0264818 \*   
## + sex:region 3 0.0998 16.640 -5807.9 2.6121 0.0499717 \*   
## + smoker:region 3 0.0977 16.643 -5807.8 2.5574 0.0537613 .   
## + children:smoker 1 0.0405 16.700 -5807.2 3.1715 0.0751640 .   
## + bmi:children 1 0.0395 16.701 -5807.1 3.0967 0.0786826 .   
## + bmi:region 3 0.0823 16.658 -5806.5 2.1521 0.0919429 .   
## <none> 16.740 -5805.9   
## + bmi:charges 1 0.0051 16.735 -5804.3 0.3997 0.5273299   
## + sex:bmi 1 0.0040 16.736 -5804.2 0.3105 0.5774879   
## + sex:smoker 1 0.0023 16.738 -5804.1 0.1782 0.6729753   
## - I(children^2) 1 0.1270 16.867 -5797.8 9.9367 0.0016569 \*\*   
## - children:sex 1 0.1601 16.900 -5795.2 12.5283 0.0004149 \*\*\*  
## - I(bmi^2) 1 0.1975 16.938 -5792.2 15.4514 8.908e-05 \*\*\*  
## - charges:region 3 0.3047 17.045 -5787.8 7.9492 2.967e-05 \*\*\*  
## - age:bmi 1 0.3028 17.043 -5783.9 23.6969 1.265e-06 \*\*\*  
## - age:smoker 1 0.4306 17.171 -5774.0 33.6927 8.087e-09 \*\*\*  
## - charges:sex 1 0.4619 17.202 -5771.5 36.1442 2.372e-09 \*\*\*  
## - age:region 3 0.5139 17.254 -5771.5 13.4062 1.277e-08 \*\*\*  
## - age:sex 1 0.5745 17.315 -5762.8 44.9580 2.985e-11 \*\*\*  
## - I(age^2) 1 0.9924 17.733 -5730.9 77.6571 < 2.2e-16 \*\*\*  
## - age:children 1 1.2989 18.039 -5707.9 101.6449 < 2.2e-16 \*\*\*  
## - charges:children 1 2.3526 19.093 -5632.0 184.1016 < 2.2e-16 \*\*\*  
## - charges:age 1 10.8207 27.561 -5140.8 846.7694 < 2.2e-16 \*\*\*  
## - charges:smoker 1 28.1626 44.903 -4487.7 2203.8511 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5809.55  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + bmi + I(children^2) + charges:age +   
## charges:children + charges:smoker + age:children + age:sex +   
## age:region + charges:sex + age:smoker + charges:region +   
## age:bmi + children:sex + children:region  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + bmi:smoker 1 0.0651 16.555 -5812.8 5.1318 0.0236539 \*   
## + sex:region 3 0.1024 16.518 -5811.8 2.6933 0.0448249 \*   
## + smoker:region 3 0.0935 16.527 -5811.1 2.4589 0.0612987 .   
## + children:smoker 1 0.0419 16.578 -5810.9 3.2984 0.0695758 .   
## + bmi:region 3 0.0809 16.539 -5810.1 2.1264 0.0950993 .   
## <none> 16.620 -5809.5   
## + bmi:children 1 0.0168 16.604 -5808.9 1.3214 0.2505528   
## + sex:bmi 1 0.0041 16.616 -5807.9 0.3258 0.5682376   
## + bmi:charges 1 0.0040 16.616 -5807.9 0.3133 0.5757313   
## + sex:smoker 1 0.0031 16.617 -5807.8 0.2409 0.6236552   
## - children:region 3 0.1199 16.740 -5805.9 3.1427 0.0244430 \*   
## - I(children^2) 1 0.1329 16.753 -5800.9 10.4541 0.0012543 \*\*   
## - children:sex 1 0.1729 16.793 -5797.7 13.5996 0.0002355 \*\*\*  
## - I(bmi^2) 1 0.1956 16.816 -5795.9 15.3786 9.255e-05 \*\*\*  
## - charges:region 3 0.2884 16.909 -5792.5 7.5600 5.148e-05 \*\*\*  
## - age:bmi 1 0.3052 16.926 -5787.2 23.9979 1.085e-06 \*\*\*  
## - charges:sex 1 0.4493 17.070 -5775.9 35.3295 3.566e-09 \*\*\*  
## - age:region 3 0.5037 17.124 -5775.6 13.2029 1.706e-08 \*\*\*  
## - age:smoker 1 0.4562 17.077 -5775.3 35.8718 2.720e-09 \*\*\*  
## - age:sex 1 0.5618 17.182 -5767.1 44.1807 4.385e-11 \*\*\*  
## - I(age^2) 1 0.9910 17.611 -5734.1 77.9334 < 2.2e-16 \*\*\*  
## - age:children 1 1.3433 17.964 -5707.6 105.6390 < 2.2e-16 \*\*\*  
## - charges:children 1 2.3985 19.019 -5631.2 188.6154 < 2.2e-16 \*\*\*  
## - charges:age 1 10.8680 27.488 -5138.4 854.6462 < 2.2e-16 \*\*\*  
## - charges:smoker 1 28.1939 44.814 -4484.4 2217.1277 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5812.8  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + bmi + I(children^2) + charges:age +   
## charges:children + charges:smoker + age:children + age:sex +   
## age:region + charges:sex + age:smoker + charges:region +   
## age:bmi + children:sex + children:region + smoker:bmi  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + bmi:charges 1 0.1653 16.390 -5824.2 13.1642 0.0002964 \*\*\*  
## + sex:region 3 0.0959 16.459 -5814.6 2.5299 0.0557733 .   
## + smoker:region 3 0.0862 16.469 -5813.8 2.2721 0.0785163 .   
## + children:smoker 1 0.0297 16.526 -5813.2 2.3418 0.1261883   
## <none> 16.555 -5812.8   
## + bmi:region 3 0.0713 16.484 -5812.6 1.8799 0.1310924   
## + bmi:children 1 0.0131 16.542 -5811.9 1.0347 0.3092502   
## + sex:smoker 1 0.0070 16.548 -5811.4 0.5555 0.4562007   
## + sex:bmi 1 0.0044 16.551 -5811.2 0.3495 0.5545079   
## - smoker:bmi 1 0.0651 16.620 -5809.5 5.1318 0.0236539 \*   
## - children:region 3 0.1221 16.677 -5809.0 3.2098 0.0223146 \*   
## - I(children^2) 1 0.1293 16.685 -5804.4 10.2010 0.0014372 \*\*   
## - children:sex 1 0.1622 16.718 -5801.8 12.7954 0.0003602 \*\*\*  
## - charges:region 3 0.2424 16.798 -5799.4 6.3731 0.0002750 \*\*\*  
## - I(bmi^2) 1 0.2103 16.766 -5797.9 16.5916 4.914e-05 \*\*\*  
## - age:bmi 1 0.3172 16.873 -5789.4 25.0235 6.435e-07 \*\*\*  
## - charges:sex 1 0.4392 16.995 -5779.8 34.6503 5.010e-09 \*\*\*  
## - age:region 3 0.5357 17.091 -5776.2 14.0871 4.859e-09 \*\*\*  
## - age:smoker 1 0.5039 17.059 -5774.7 39.7539 3.933e-10 \*\*\*  
## - age:sex 1 0.5852 17.141 -5768.3 46.1665 1.646e-11 \*\*\*  
## - I(age^2) 1 0.9974 17.553 -5736.5 78.6801 < 2.2e-16 \*\*\*  
## - age:children 1 1.3436 17.899 -5710.4 105.9890 < 2.2e-16 \*\*\*  
## - charges:children 1 2.4359 18.991 -5631.1 192.1616 < 2.2e-16 \*\*\*  
## - charges:age 1 10.7849 27.340 -5143.6 850.7880 < 2.2e-16 \*\*\*  
## - charges:smoker 1 16.5431 33.098 -4887.9 1305.0349 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5824.23  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + bmi + I(children^2) + charges:age +   
## charges:children + charges:smoker + age:children + age:sex +   
## age:region + charges:sex + age:smoker + charges:region +   
## age:bmi + children:sex + children:region + smoker:bmi + charges:bmi  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + smoker:region 3 0.0921 16.298 -5825.8 2.4532 0.0617681 .   
## + sex:region 3 0.0875 16.302 -5825.4 2.3306 0.0726785 .   
## + children:smoker 1 0.0275 16.362 -5824.5 2.1915 0.1390198   
## <none> 16.390 -5824.2   
## + bmi:children 1 0.0159 16.374 -5823.5 1.2624 0.2614078   
## + bmi:region 3 0.0574 16.333 -5822.9 1.5241 0.2064849   
## + sex:smoker 1 0.0082 16.382 -5822.9 0.6505 0.4200720   
## + sex:bmi 1 0.0022 16.388 -5822.4 0.1766 0.6743506   
## - children:region 3 0.1157 16.506 -5820.8 3.0698 0.0269839 \*   
## - I(bmi^2) 1 0.1026 16.493 -5817.9 8.1706 0.0043252 \*\*   
## - I(children^2) 1 0.1274 16.517 -5815.9 10.1467 0.0014798 \*\*   
## - children:sex 1 0.1607 16.551 -5813.2 12.7933 0.0003606 \*\*\*  
## - charges:bmi 1 0.1653 16.555 -5812.8 13.1642 0.0002964 \*\*\*  
## - charges:region 3 0.2540 16.644 -5809.7 6.7402 0.0001639 \*\*\*  
## - smoker:bmi 1 0.2264 16.616 -5807.9 18.0264 2.333e-05 \*\*\*  
## - charges:sex 1 0.3806 16.771 -5795.5 30.3003 4.451e-08 \*\*\*  
## - age:smoker 1 0.4676 16.858 -5788.6 37.2286 1.382e-09 \*\*\*  
## - age:bmi 1 0.4796 16.870 -5787.6 38.1874 8.574e-10 \*\*\*  
## - age:region 3 0.5379 16.928 -5787.0 14.2767 3.713e-09 \*\*\*  
## - age:sex 1 0.6069 16.997 -5777.6 48.3247 5.691e-12 \*\*\*  
## - I(age^2) 1 1.0473 17.437 -5743.4 83.3846 < 2.2e-16 \*\*\*  
## - age:children 1 1.3484 17.738 -5720.4 107.3629 < 2.2e-16 \*\*\*  
## - charges:children 1 2.3291 18.719 -5648.4 185.4444 < 2.2e-16 \*\*\*  
## - charges:age 1 10.3872 26.777 -5169.4 827.0464 < 2.2e-16 \*\*\*  
## - charges:smoker 1 16.7051 33.095 -4886.0 1330.0918 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5825.77  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + bmi + I(children^2) + charges:age +   
## charges:children + charges:smoker + age:children + age:sex +   
## age:region + charges:sex + age:smoker + charges:region +   
## age:bmi + children:sex + children:region + smoker:bmi + charges:bmi +   
## smoker:region  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + sex:region 3 0.0914 16.206 -5827.3 2.4432 0.0625968 .   
## + children:smoker 1 0.0386 16.259 -5826.9 3.0889 0.0790619 .   
## <none> 16.298 -5825.8   
## + bmi:children 1 0.0219 16.276 -5825.6 1.7515 0.1859248   
## + sex:smoker 1 0.0091 16.289 -5824.5 0.7288 0.3934174   
## - smoker:region 3 0.0921 16.390 -5824.2 2.4532 0.0617681 .   
## + sex:bmi 1 0.0019 16.296 -5823.9 0.1503 0.6983130   
## + bmi:region 3 0.0466 16.251 -5823.6 1.2408 0.2935227   
## - children:region 3 0.1084 16.406 -5822.9 2.8869 0.0345548 \*   
## - I(bmi^2) 1 0.1065 16.404 -5819.1 8.5055 0.0036014 \*\*   
## - charges:region 3 0.1558 16.454 -5819.0 4.1484 0.0061575 \*\*   
## - I(children^2) 1 0.1360 16.434 -5816.6 10.8666 0.0010055 \*\*   
## - children:sex 1 0.1498 16.448 -5815.5 11.9659 0.0005593 \*\*\*  
## - charges:bmi 1 0.1713 16.469 -5813.8 13.6852 0.0002252 \*\*\*  
## - smoker:bmi 1 0.2231 16.521 -5809.6 17.8251 2.590e-05 \*\*\*  
## - charges:sex 1 0.3755 16.673 -5797.3 29.9967 5.189e-08 \*\*\*  
## - age:region 3 0.4427 16.741 -5795.9 11.7901 1.272e-07 \*\*\*  
## - age:bmi 1 0.4820 16.780 -5788.8 38.5050 7.325e-10 \*\*\*  
## - age:smoker 1 0.4971 16.795 -5787.6 39.7138 4.016e-10 \*\*\*  
## - age:sex 1 0.6120 16.910 -5778.4 48.8891 4.316e-12 \*\*\*  
## - I(age^2) 1 1.0313 17.329 -5745.7 82.3849 < 2.2e-16 \*\*\*  
## - age:children 1 1.3723 17.670 -5719.6 109.6304 < 2.2e-16 \*\*\*  
## - charges:children 1 2.3059 18.604 -5650.7 184.2119 < 2.2e-16 \*\*\*  
## - charges:age 1 10.4290 26.727 -5165.9 833.1515 < 2.2e-16 \*\*\*  
## - charges:smoker 1 16.5323 32.830 -4890.7 1320.7318 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5827.3  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + bmi + I(children^2) + charges:age +   
## charges:children + charges:smoker + age:children + age:sex +   
## age:region + charges:sex + age:smoker + charges:region +   
## age:bmi + children:sex + children:region + smoker:bmi + charges:bmi +   
## smoker:region + sex:region  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + children:smoker 1 0.0393 16.167 -5828.5 3.1522 0.0760588 .   
## <none> 16.206 -5827.3   
## + bmi:children 1 0.0214 16.185 -5827.1 1.7152 0.1905459   
## + sex:bmi 1 0.0098 16.197 -5826.1 0.7885 0.3747110   
## + sex:smoker 1 0.0086 16.198 -5826.0 0.6862 0.4076170   
## - sex:region 3 0.0914 16.298 -5825.8 2.4432 0.0625968 .   
## - smoker:region 3 0.0960 16.302 -5825.4 2.5656 0.0531802 .   
## + bmi:region 3 0.0447 16.162 -5825.0 1.1946 0.3105072   
## - children:region 3 0.1109 16.317 -5824.2 2.9618 0.0312308 \*   
## - I(bmi^2) 1 0.1009 16.307 -5821.0 8.0912 0.0045179 \*\*   
## - charges:region 3 0.1563 16.363 -5820.5 4.1753 0.0059331 \*\*   
## - I(children^2) 1 0.1361 16.342 -5818.1 10.9081 0.0009835 \*\*\*  
## - children:sex 1 0.1496 16.356 -5817.0 11.9947 0.0005509 \*\*\*  
## - charges:bmi 1 0.1619 16.368 -5816.0 12.9778 0.0003271 \*\*\*  
## - smoker:bmi 1 0.2069 16.413 -5812.3 16.5828 4.939e-05 \*\*\*  
## - charges:sex 1 0.3749 16.581 -5798.7 30.0509 5.051e-08 \*\*\*  
## - age:region 3 0.4419 16.648 -5797.3 11.8064 1.243e-07 \*\*\*  
## - age:bmi 1 0.4612 16.668 -5791.8 36.9678 1.576e-09 \*\*\*  
## - age:smoker 1 0.5055 16.712 -5788.2 40.5207 2.692e-10 \*\*\*  
## - age:sex 1 0.6112 16.818 -5779.8 48.9897 4.113e-12 \*\*\*  
## - I(age^2) 1 1.0206 17.227 -5747.6 81.8031 < 2.2e-16 \*\*\*  
## - age:children 1 1.3770 17.583 -5720.2 110.3713 < 2.2e-16 \*\*\*  
## - charges:children 1 2.3203 18.527 -5650.3 185.9820 < 2.2e-16 \*\*\*  
## - charges:age 1 10.4866 26.693 -5161.6 840.5398 < 2.2e-16 \*\*\*  
## - charges:smoker 1 16.4440 32.650 -4892.1 1318.0406 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-5828.54  
## charges\_log ~ charges + age + children + I(bmi^2) + smoker +   
## I(age^2) + sex + region + bmi + I(children^2) + charges:age +   
## charges:children + charges:smoker + age:children + age:sex +   
## age:region + charges:sex + age:smoker + charges:region +   
## age:bmi + children:sex + children:region + smoker:bmi + charges:bmi +   
## smoker:region + sex:region + children:smoker  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## <none> 16.167 -5828.5   
## + sex:bmi 1 0.0097 16.157 -5827.3 0.7801 0.3772857   
## - children:smoker 1 0.0393 16.206 -5827.3 3.1522 0.0760588 .   
## + bmi:children 1 0.0084 16.159 -5827.2 0.6777 0.4105271   
## + sex:smoker 1 0.0077 16.159 -5827.2 0.6143 0.4333133   
## - sex:region 3 0.0921 16.259 -5826.9 2.4649 0.0608203 .   
## + bmi:region 3 0.0473 16.120 -5826.5 1.2659 0.2846196   
## - smoker:region 3 0.1072 16.274 -5825.7 2.8698 0.0353607 \*   
## - children:region 3 0.1124 16.280 -5825.3 3.0069 0.0293829 \*   
## - I(bmi^2) 1 0.0922 16.259 -5822.9 7.4053 0.0065901 \*\*   
## - charges:region 3 0.1706 16.338 -5820.5 4.5657 0.0034537 \*\*   
## - I(children^2) 1 0.1501 16.317 -5818.2 12.0516 0.0005345 \*\*\*  
## - children:sex 1 0.1563 16.323 -5817.7 12.5454 0.0004113 \*\*\*  
## - charges:bmi 1 0.1601 16.327 -5817.4 12.8541 0.0003492 \*\*\*  
## - smoker:bmi 1 0.1880 16.355 -5815.1 15.0920 0.0001076 \*\*\*  
## - charges:sex 1 0.3772 16.544 -5799.7 30.2874 4.484e-08 \*\*\*  
## - age:region 3 0.4283 16.595 -5799.6 11.4632 2.025e-07 \*\*\*  
## - age:bmi 1 0.4589 16.626 -5793.1 36.8474 1.674e-09 \*\*\*  
## - charges:children 1 0.4762 16.643 -5791.7 38.2309 8.403e-10 \*\*\*  
## - age:smoker 1 0.5065 16.674 -5789.3 40.6666 2.505e-10 \*\*\*  
## - age:sex 1 0.6076 16.775 -5781.2 48.7807 4.559e-12 \*\*\*  
## - I(age^2) 1 1.0195 17.187 -5748.7 81.8526 < 2.2e-16 \*\*\*  
## - age:children 1 1.2990 17.466 -5727.1 104.2885 < 2.2e-16 \*\*\*  
## - charges:age 1 10.5241 26.691 -5159.7 844.9392 < 2.2e-16 \*\*\*  
## - charges:smoker 1 15.8162 31.983 -4917.7 1269.8209 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

summary(step\_model1)

##   
## Call:  
## lm(formula = charges\_log ~ charges + age + children + I(bmi^2) +   
## smoker + I(age^2) + sex + region + bmi + I(children^2) +   
## charges:age + charges:children + charges:smoker + age:children +   
## age:sex + age:region + charges:sex + age:smoker + charges:region +   
## age:bmi + children:sex + children:region + smoker:bmi + charges:bmi +   
## smoker:region + sex:region + children:smoker, data = insurance)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.42113 -0.04216 -0.00314 0.03099 0.77202   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 6.901e+00 8.194e-02 84.222 < 2e-16 \*\*\*  
## charges 1.343e-04 3.391e-06 39.604 < 2e-16 \*\*\*  
## age 3.434e-02 2.151e-03 15.962 < 2e-16 \*\*\*  
## children 1.802e-01 1.221e-02 14.765 < 2e-16 \*\*\*  
## I(bmi^2) -1.766e-04 6.490e-05 -2.721 0.006590 \*\*   
## smokeryes 5.841e-01 9.469e-02 6.168 9.20e-10 \*\*\*  
## I(age^2) -1.970e-04 2.178e-05 -9.047 < 2e-16 \*\*\*  
## sexmale -2.279e-01 2.188e-02 -10.413 < 2e-16 \*\*\*  
## regionnorthwest -1.130e-01 2.924e-02 -3.863 0.000118 \*\*\*  
## regionsoutheast -2.388e-01 2.911e-02 -8.205 5.51e-16 \*\*\*  
## regionsouthwest -2.533e-01 2.985e-02 -8.486 < 2e-16 \*\*\*  
## bmi 3.497e-03 4.312e-03 0.811 0.417602   
## I(children^2) -6.689e-03 1.927e-03 -3.472 0.000534 \*\*\*  
## charges:age -1.078e-06 3.708e-08 -29.068 < 2e-16 \*\*\*  
## charges:children -2.712e-06 4.387e-07 -6.183 8.40e-10 \*\*\*  
## charges:smokeryes -5.143e-05 1.443e-06 -35.635 < 2e-16 \*\*\*  
## age:children -2.375e-03 2.325e-04 -10.212 < 2e-16 \*\*\*  
## age:sexmale 3.228e-03 4.621e-04 6.984 4.56e-12 \*\*\*  
## age:regionnorthwest 1.487e-03 7.236e-04 2.054 0.040152 \*   
## age:regionsoutheast 2.904e-03 7.276e-04 3.992 6.93e-05 \*\*\*  
## age:regionsouthwest 4.204e-03 7.566e-04 5.557 3.33e-08 \*\*\*  
## charges:sexmale 3.047e-06 5.536e-07 5.503 4.48e-08 \*\*\*  
## age:smokeryes 7.079e-03 1.110e-03 6.377 2.50e-10 \*\*\*  
## charges:regionnorthwest 8.394e-07 1.394e-06 0.602 0.547298   
## charges:regionsoutheast 4.684e-06 1.343e-06 3.489 0.000502 \*\*\*  
## charges:regionsouthwest 1.858e-06 1.478e-06 1.257 0.208944   
## age:bmi 2.826e-04 4.655e-05 6.070 1.67e-09 \*\*\*  
## children:sexmale 1.836e-02 5.184e-03 3.542 0.000411 \*\*\*  
## children:regionnorthwest 1.279e-02 7.591e-03 1.685 0.092196 .   
## children:regionsoutheast 2.193e-02 7.324e-03 2.994 0.002805 \*\*   
## children:regionsouthwest 1.231e-02 7.218e-03 1.706 0.088294 .   
## smokeryes:bmi 1.376e-02 3.543e-03 3.885 0.000108 \*\*\*  
## charges:bmi -3.545e-07 9.887e-08 -3.585 0.000349 \*\*\*  
## smokeryes:regionnorthwest 2.444e-02 3.740e-02 0.654 0.513537   
## smokeryes:regionsoutheast -6.014e-02 3.782e-02 -1.590 0.112075   
## smokeryes:regionsouthwest 5.814e-02 4.184e-02 1.390 0.164856   
## sexmale:regionnorthwest 1.104e-02 1.773e-02 0.623 0.533529   
## sexmale:regionsoutheast -1.943e-02 1.730e-02 -1.123 0.261479   
## sexmale:regionsouthwest -3.273e-02 1.774e-02 -1.844 0.065355 .   
## children:smokeryes -2.133e-02 1.202e-02 -1.775 0.076059 .   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.1116 on 1298 degrees of freedom  
## Multiple R-squared: 0.9857, Adjusted R-squared: 0.9853   
## F-statistic: 2294 on 39 and 1298 DF, p-value: < 2.2e-16

# Multicollinearity Analysis (on chosen model)

# Correlation Coefficients

# age, bmi, children, charges\_log  
print("Correlation Coefficient of age ~ charges\_log")

## [1] "Correlation Coefficient of age ~ charges\_log"

print(cor(age, charges\_log))

## [1] 0.527834

print("Correlation Coefficient of bmi ~ charges\_log")

## [1] "Correlation Coefficient of bmi ~ charges\_log"

print(cor(bmi, charges\_log))

## [1] 0.1326694

print("Correlation Coefficient of children ~ charges\_log")

## [1] "Correlation Coefficient of children ~ charges\_log"

print(cor(children, charges\_log))

## [1] 0.1613363

# Step-wise Regression

all\_possible\_data <- select(insurance, -charges)  
charges\_log <- log(insurance$charges)  
full\_model <- lm(charges\_log ~.^2 + I(age^2) + I(bmi^2) + I(children^2), data = all\_possible\_data)  
null\_model <- lm(charges\_log ~ 1, data = insurance)  
step\_model1 <- step(null\_model, scope = list(lower = null\_model, upper = full\_model), direction = "both",test="F")

## Start: AIC=-223.51  
## charges\_log ~ 1  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + smoker 1 500.68 629.79 -1004.24 1062.1239 < 2.2e-16 \*\*\*  
## + age 1 314.96 815.51 -658.46 515.9771 < 2.2e-16 \*\*\*  
## + I(age^2) 1 293.08 837.39 -623.04 467.5871 < 2.2e-16 \*\*\*  
## + children 1 29.43 1101.05 -256.79 35.7047 2.941e-09 \*\*\*  
## + bmi 1 19.90 1110.58 -245.27 23.9365 1.117e-06 \*\*\*  
## + I(bmi^2) 1 17.64 1112.83 -242.55 21.1799 4.579e-06 \*\*\*  
## + I(children^2) 1 15.92 1114.55 -240.48 19.0828 1.348e-05 \*\*\*  
## <none> 1130.47 -223.51   
## + region 3 3.55 1126.92 -221.72 1.4020 0.2406   
## + sex 1 0.04 1130.44 -221.55 0.0424 0.8369   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-1004.24  
## charges\_log ~ smoker  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + age 1 335.35 294.44 -2019.56 1520.5251 < 2.2e-16 \*\*\*  
## + I(age^2) 1 313.65 316.14 -1924.38 1324.4587 < 2.2e-16 \*\*\*  
## + children 1 27.59 602.20 -1062.19 61.1727 1.055e-14 \*\*\*  
## + bmi 1 19.16 610.63 -1043.57 41.8806 1.359e-10 \*\*\*  
## + I(children^2) 1 17.59 612.20 -1040.15 38.3656 7.796e-10 \*\*\*  
## + I(bmi^2) 1 16.34 613.45 -1037.42 35.5661 3.152e-09 \*\*\*  
## + sex 1 2.31 627.48 -1007.16 4.9140 0.02681 \*   
## <none> 629.79 -1004.24   
## + region 3 2.48 627.31 -1003.52 1.7546 0.15403   
## - smoker 1 500.68 1130.47 -223.51 1062.1239 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2019.56  
## charges\_log ~ smoker + age  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + age:smoker 1 42.38 252.06 -2225.49 224.2885 < 2.2e-16 \*\*\*  
## + children 1 20.03 274.41 -2111.83 97.3779 < 2.2e-16 \*\*\*  
## + I(children^2) 1 14.16 280.28 -2083.49 67.3849 5.214e-16 \*\*\*  
## + I(age^2) 1 6.57 287.87 -2047.75 30.4392 4.133e-08 \*\*\*  
## + bmi 1 5.70 288.73 -2043.72 26.3401 3.286e-07 \*\*\*  
## + I(bmi^2) 1 4.86 289.57 -2039.85 22.4117 2.435e-06 \*\*\*  
## + region 3 2.31 292.12 -2024.11 3.5158 0.01469 \*   
## + sex 1 1.37 293.06 -2023.81 6.2507 0.01253 \*   
## <none> 294.44 -2019.56   
## - age 1 335.35 629.79 -1004.24 1520.5251 < 2.2e-16 \*\*\*  
## - smoker 1 521.08 815.51 -658.46 2362.6176 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2225.49  
## charges\_log ~ smoker + age + smoker:age  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + children 1 21.101 230.96 -2340.5 121.7901 < 2.2e-16 \*\*\*  
## + I(children^2) 1 14.643 237.41 -2303.6 82.2154 < 2.2e-16 \*\*\*  
## + I(age^2) 1 6.551 245.51 -2258.7 35.5666 3.153e-09 \*\*\*  
## + bmi 1 4.991 247.07 -2250.2 26.9274 2.440e-07 \*\*\*  
## + I(bmi^2) 1 4.190 247.87 -2245.9 22.5323 2.289e-06 \*\*\*  
## + region 3 2.438 249.62 -2232.5 4.3341 0.004759 \*\*   
## + sex 1 1.274 250.78 -2230.3 6.7708 0.009369 \*\*   
## <none> 252.06 -2225.5   
## - smoker:age 1 42.379 294.44 -2019.6 224.2885 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2340.47  
## charges\_log ~ smoker + age + children + smoker:age  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + bmi 1 4.817 226.14 -2366.7 28.3750 1.172e-07 \*\*\*  
## + age:children 1 4.552 226.40 -2365.1 26.7798 2.630e-07 \*\*\*  
## + children:smoker 1 4.551 226.40 -2365.1 26.7766 2.634e-07 \*\*\*  
## + I(bmi^2) 1 4.030 226.93 -2362.0 23.6544 1.290e-06 \*\*\*  
## + region 3 2.695 228.26 -2350.2 5.2336 0.001360 \*\*   
## + I(age^2) 1 1.557 229.40 -2347.5 9.0400 0.002691 \*\*   
## + sex 1 1.460 229.50 -2347.0 8.4763 0.003658 \*\*   
## + I(children^2) 1 1.164 229.79 -2345.2 6.7453 0.009503 \*\*   
## <none> 230.96 -2340.5   
## - children 1 21.101 252.06 -2225.5 121.7901 < 2.2e-16 \*\*\*  
## - smoker:age 1 43.450 274.40 -2111.8 250.7765 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2366.68  
## charges\_log ~ smoker + age + children + bmi + smoker:age  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + bmi:smoker 1 20.864 205.27 -2494.2 135.2824 < 2.2e-16 \*\*\*  
## + age:children 1 5.002 221.14 -2394.6 30.1067 4.890e-08 \*\*\*  
## + children:smoker 1 4.429 221.71 -2391.1 26.5872 2.900e-07 \*\*\*  
## + region 3 4.435 221.70 -2387.2 8.8618 8.123e-06 \*\*\*  
## + I(age^2) 1 1.763 224.38 -2375.2 10.4573 0.001252 \*\*   
## + sex 1 1.734 224.40 -2375.0 10.2842 0.001374 \*\*   
## + I(bmi^2) 1 1.644 224.49 -2374.4 9.7472 0.001835 \*\*   
## + I(children^2) 1 1.086 225.05 -2371.1 6.4235 0.011376 \*   
## <none> 226.14 -2366.7   
## + age:bmi 1 0.256 225.88 -2366.2 1.5072 0.219783   
## + bmi:children 1 0.001 226.14 -2364.7 0.0042 0.948291   
## - bmi 1 4.817 230.96 -2340.5 28.3750 1.172e-07 \*\*\*  
## - children 1 20.928 247.07 -2250.2 123.2689 < 2.2e-16 \*\*\*  
## - smoker:age 1 42.738 268.88 -2137.1 251.7328 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2494.19  
## charges\_log ~ smoker + age + children + bmi + smoker:age + smoker:bmi  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + age:children 1 4.935 200.34 -2524.8 32.7649 1.284e-08 \*\*\*  
## + region 3 4.854 200.42 -2520.2 10.7213 5.788e-07 \*\*\*  
## + children:smoker 1 4.223 201.05 -2520.0 27.9350 1.465e-07 \*\*\*  
## + sex 1 2.393 202.88 -2507.9 15.6843 7.881e-05 \*\*\*  
## + I(age^2) 1 1.863 203.41 -2504.4 12.1808 0.0004986 \*\*\*  
## + I(bmi^2) 1 1.862 203.41 -2504.4 12.1737 0.0005005 \*\*\*  
## + I(children^2) 1 0.838 204.44 -2497.7 5.4534 0.0196779 \*   
## <none> 205.27 -2494.2   
## + bmi:children 1 0.109 205.16 -2492.9 0.7094 0.3998014   
## + age:bmi 1 0.104 205.17 -2492.9 0.6710 0.4128665   
## - smoker:bmi 1 20.864 226.14 -2366.7 135.2824 < 2.2e-16 \*\*\*  
## - children 1 21.478 226.75 -2363.1 139.2628 < 2.2e-16 \*\*\*  
## - smoker:age 1 46.981 252.25 -2220.4 304.6266 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2524.76  
## charges\_log ~ smoker + age + children + bmi + smoker:age + smoker:bmi +   
## age:children  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + children:smoker 1 4.470 195.87 -2552.9 30.3263 4.378e-08 \*\*\*  
## + region 3 4.743 195.60 -2550.8 10.7251 5.757e-07 \*\*\*  
## + sex 1 2.725 197.61 -2541.1 18.3261 1.995e-05 \*\*\*  
## + I(bmi^2) 1 1.980 198.36 -2536.1 13.2685 0.0002803 \*\*\*  
## + I(age^2) 1 1.758 198.58 -2534.6 11.7640 0.0006224 \*\*\*  
## + I(children^2) 1 1.137 199.20 -2530.4 7.5840 0.0059692 \*\*   
## <none> 200.34 -2524.8   
## + age:bmi 1 0.074 200.26 -2523.2 0.4899 0.4840998   
## + bmi:children 1 0.000 200.34 -2522.8 0.0021 0.9637911   
## - age:children 1 4.935 205.27 -2494.2 32.7649 1.284e-08 \*\*\*  
## - smoker:bmi 1 20.797 221.14 -2394.6 138.0686 < 2.2e-16 \*\*\*  
## - smoker:age 1 46.249 246.59 -2248.8 307.0384 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2552.94  
## charges\_log ~ smoker + age + children + bmi + smoker:age + smoker:bmi +   
## age:children + smoker:children  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + region 3 4.768 191.10 -2579.9 11.0290 3.738e-07 \*\*\*  
## + sex 1 2.519 193.35 -2568.3 17.3047 3.388e-05 \*\*\*  
## + I(children^2) 1 1.781 194.09 -2563.2 12.1830 0.0004981 \*\*\*  
## + I(age^2) 1 1.741 194.13 -2562.9 11.9067 0.0005769 \*\*\*  
## + I(bmi^2) 1 1.702 194.17 -2562.6 11.6438 0.0006635 \*\*\*  
## <none> 195.87 -2552.9   
## + age:bmi 1 0.069 195.80 -2551.4 0.4659 0.4950100   
## + bmi:children 1 0.011 195.86 -2551.0 0.0758 0.7831570   
## - smoker:children 1 4.470 200.34 -2524.8 30.3263 4.378e-08 \*\*\*  
## - age:children 1 5.182 201.05 -2520.0 35.1611 3.864e-09 \*\*\*  
## - smoker:bmi 1 20.584 216.45 -2421.2 139.6667 < 2.2e-16 \*\*\*  
## - smoker:age 1 43.940 239.81 -2284.1 298.1360 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2579.92  
## charges\_log ~ smoker + age + children + bmi + region + smoker:age +   
## smoker:bmi + age:children + smoker:children  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + sex 1 2.546 188.56 -2595.9 17.8906 2.501e-05 \*\*\*  
## + I(age^2) 1 1.770 189.33 -2590.4 12.3900 0.0004463 \*\*\*  
## + I(bmi^2) 1 1.695 189.41 -2589.8 11.8576 0.0005922 \*\*\*  
## + I(children^2) 1 1.652 189.45 -2589.5 11.5549 0.0006958 \*\*\*  
## + age:region 3 2.125 188.98 -2588.9 4.9587 0.0019971 \*\*   
## + bmi:region 3 1.527 189.57 -2584.7 3.5523 0.0139807 \*   
## <none> 191.10 -2579.9   
## + smoker:region 3 0.739 190.36 -2579.1 1.7111 0.1628475   
## + age:bmi 1 0.071 191.03 -2578.4 0.4931 0.4826698   
## + children:region 3 0.607 190.49 -2578.2 1.4053 0.2395874   
## + bmi:children 1 0.013 191.09 -2578.0 0.0873 0.7677086   
## - region 3 4.768 195.87 -2552.9 11.0290 3.738e-07 \*\*\*  
## - smoker:children 1 4.495 195.60 -2550.8 31.1922 2.832e-08 \*\*\*  
## - age:children 1 5.065 196.17 -2546.9 35.1430 3.901e-09 \*\*\*  
## - smoker:bmi 1 20.988 212.09 -2442.5 145.6286 < 2.2e-16 \*\*\*  
## - smoker:age 1 43.820 234.92 -2305.7 304.0583 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2595.87  
## charges\_log ~ smoker + age + children + bmi + region + sex +   
## smoker:age + smoker:bmi + age:children + smoker:children  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + I(age^2) 1 1.746 186.81 -2606.3 12.3740 0.0004501 \*\*\*  
## + I(bmi^2) 1 1.718 186.84 -2606.1 12.1717 0.0005011 \*\*\*  
## + age:sex 1 1.634 186.92 -2605.5 11.5727 0.0006892 \*\*\*  
## + age:region 3 2.175 186.38 -2605.4 5.1415 0.0015472 \*\*   
## + I(children^2) 1 1.608 186.95 -2605.3 11.3869 0.0007610 \*\*\*  
## + bmi:region 3 1.373 187.18 -2599.7 3.2335 0.0216029 \*   
## + sex:smoker 1 0.601 187.95 -2598.1 4.2305 0.0398995 \*   
## <none> 188.56 -2595.9   
## + smoker:region 3 0.791 187.76 -2595.5 1.8566 0.1350746   
## + children:region 3 0.623 187.93 -2594.3 1.4618 0.2232641   
## + age:bmi 1 0.054 188.50 -2594.2 0.3785 0.5385350   
## + sex:bmi 1 0.052 188.50 -2594.2 0.3671 0.5446856   
## + sex:children 1 0.039 188.52 -2594.2 0.2756 0.5997070   
## + bmi:children 1 0.014 188.54 -2594.0 0.0985 0.7537449   
## + sex:region 3 0.116 188.44 -2590.7 0.2721 0.8455389   
## - sex 1 2.546 191.10 -2579.9 17.8906 2.501e-05 \*\*\*  
## - region 3 4.795 193.35 -2568.3 11.2314 2.804e-07 \*\*\*  
## - smoker:children 1 4.287 192.84 -2567.8 30.1288 4.839e-08 \*\*\*  
## - age:children 1 5.383 193.94 -2560.2 37.8304 1.020e-09 \*\*\*  
## - smoker:bmi 1 21.676 210.23 -2452.3 152.3197 < 2.2e-16 \*\*\*  
## - smoker:age 1 43.766 232.32 -2318.6 307.5498 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2606.31  
## charges\_log ~ smoker + age + children + bmi + region + sex +   
## I(age^2) + smoker:age + smoker:bmi + age:children + smoker:children  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + I(bmi^2) 1 1.685 185.12 -2616.4 12.0425 0.0005367 \*\*\*  
## + age:region 3 2.224 184.59 -2616.3 5.3043 0.0012324 \*\*   
## + age:sex 1 1.537 185.27 -2615.4 10.9735 0.0009492 \*\*\*  
## + I(children^2) 1 1.055 185.75 -2611.9 7.5147 0.0062020 \*\*   
## + bmi:region 3 1.366 185.44 -2610.1 3.2438 0.0213014 \*   
## + sex:smoker 1 0.573 186.24 -2608.4 4.0697 0.0438611 \*   
## + smoker:region 3 0.840 185.97 -2606.3 1.9884 0.1138639   
## <none> 186.81 -2606.3   
## + sex:bmi 1 0.044 186.76 -2604.6 0.3088 0.5785238   
## + sex:children 1 0.026 186.78 -2604.5 0.1854 0.6668137   
## + children:region 3 0.578 186.23 -2604.5 1.3657 0.2516686   
## + bmi:children 1 0.016 186.79 -2604.4 0.1118 0.7381240   
## + age:bmi 1 0.010 186.80 -2604.4 0.0677 0.7947113   
## + sex:region 3 0.110 186.70 -2601.1 0.2591 0.8548735   
## - I(age^2) 1 1.746 188.56 -2595.9 12.3740 0.0004501 \*\*\*  
## - sex 1 2.521 189.33 -2590.4 17.8704 2.527e-05 \*\*\*  
## - region 3 4.824 191.63 -2578.2 11.3974 2.215e-07 \*\*\*  
## - smoker:children 1 4.273 191.08 -2578.1 30.2841 4.475e-08 \*\*\*  
## - age:children 1 5.273 192.08 -2571.1 37.3699 1.283e-09 \*\*\*  
## - smoker:bmi 1 21.771 208.58 -2460.8 154.3034 < 2.2e-16 \*\*\*  
## - smoker:age 1 43.664 230.47 -2327.3 309.4666 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2616.44  
## charges\_log ~ smoker + age + children + bmi + region + sex +   
## I(age^2) + I(bmi^2) + smoker:age + smoker:bmi + age:children +   
## smoker:children  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + age:region 3 2.411 182.71 -2628.0 5.8060 0.0006101 \*\*\*  
## + age:sex 1 1.497 183.63 -2625.3 10.7798 0.0010529 \*\*   
## + I(children^2) 1 1.088 184.04 -2622.3 7.8129 0.0052624 \*\*   
## + sex:smoker 1 0.448 184.68 -2617.7 3.2060 0.0735968 .   
## <none> 185.12 -2616.4   
## + smoker:region 3 0.762 184.36 -2615.9 1.8178 0.1420182   
## + sex:bmi 1 0.107 185.02 -2615.2 0.7664 0.3815061   
## + children:region 3 0.581 184.54 -2614.6 1.3855 0.2455479   
## + sex:children 1 0.012 185.11 -2614.5 0.0886 0.7660527   
## + bmi:children 1 0.005 185.12 -2614.5 0.0336 0.8544964   
## + age:bmi 1 0.002 185.12 -2614.4 0.0131 0.9089810   
## + bmi:region 3 0.486 184.64 -2613.9 1.1577 0.3246795   
## + sex:region 3 0.118 185.01 -2611.3 0.2814 0.8388227   
## - I(bmi^2) 1 1.685 186.81 -2606.3 12.0425 0.0005367 \*\*\*  
## - I(age^2) 1 1.713 186.84 -2606.1 12.2447 0.0004821 \*\*\*  
## - sex 1 2.544 187.67 -2600.2 18.1803 2.152e-05 \*\*\*  
## - smoker:children 1 3.981 189.10 -2590.0 28.4527 1.128e-07 \*\*\*  
## - region 3 4.816 189.94 -2588.1 11.4720 1.992e-07 \*\*\*  
## - age:children 1 5.390 190.51 -2580.0 38.5197 7.239e-10 \*\*\*  
## - smoker:bmi 1 22.015 207.14 -2468.1 157.3318 < 2.2e-16 \*\*\*  
## - smoker:age 1 43.937 229.06 -2333.5 313.9998 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2627.98  
## charges\_log ~ smoker + age + children + bmi + region + sex +   
## I(age^2) + I(bmi^2) + smoker:age + smoker:bmi + age:children +   
## smoker:children + age:region  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + age:sex 1 1.472 181.24 -2636.8 10.7094 0.0010935 \*\*   
## + I(children^2) 1 1.076 181.64 -2633.9 7.8127 0.0052633 \*\*   
## + sex:smoker 1 0.434 182.28 -2629.2 3.1410 0.0765760 .   
## + smoker:region 3 0.888 181.82 -2628.5 2.1435 0.0929803 .   
## <none> 182.71 -2628.0   
## + sex:bmi 1 0.147 182.57 -2627.1 1.0622 0.3028937   
## + bmi:region 3 0.681 182.03 -2627.0 1.6424 0.1777701   
## + age:bmi 1 0.108 182.60 -2626.8 0.7790 0.3775989   
## + children:region 3 0.592 182.12 -2626.3 1.4271 0.2331738   
## + sex:children 1 0.008 182.71 -2626.0 0.0582 0.8093963   
## + bmi:children 1 0.003 182.71 -2626.0 0.0245 0.8756841   
## + sex:region 3 0.124 182.59 -2622.9 0.2985 0.8264984   
## - I(age^2) 1 1.762 184.47 -2617.1 12.7301 0.0003727 \*\*\*  
## - age:region 3 2.411 185.12 -2616.4 5.8060 0.0006101 \*\*\*  
## - I(bmi^2) 1 1.873 184.59 -2616.3 13.5280 0.0002445 \*\*\*  
## - sex 1 2.597 185.31 -2611.1 18.7633 1.592e-05 \*\*\*  
## - smoker:children 1 3.696 186.41 -2603.2 26.7006 2.741e-07 \*\*\*  
## - age:children 1 5.586 188.30 -2589.7 40.3546 2.909e-10 \*\*\*  
## - smoker:bmi 1 22.486 205.20 -2474.7 162.4466 < 2.2e-16 \*\*\*  
## - smoker:age 1 44.519 227.23 -2338.2 321.6238 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2636.8  
## charges\_log ~ smoker + age + children + bmi + region + sex +   
## I(age^2) + I(bmi^2) + smoker:age + smoker:bmi + age:children +   
## smoker:children + age:region + age:sex  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + I(children^2) 1 1.093 180.15 -2642.9 7.9941 0.0047640 \*\*   
## + sex:smoker 1 0.469 180.77 -2638.3 3.4206 0.0646099 .   
## + smoker:region 3 0.908 180.33 -2637.5 2.2084 0.0853788 .   
## <none> 181.24 -2636.8   
## + age:bmi 1 0.142 181.10 -2635.8 1.0333 0.3095644   
## + bmi:region 3 0.662 180.58 -2635.7 1.6087 0.1855256   
## + sex:bmi 1 0.061 181.18 -2635.2 0.4453 0.5046979   
## + sex:children 1 0.002 181.24 -2634.8 0.0113 0.9152391   
## + bmi:children 1 0.001 181.24 -2634.8 0.0082 0.9277158   
## + children:region 3 0.522 180.72 -2634.7 1.2679 0.2839365   
## + sex:region 3 0.131 181.11 -2631.8 0.3168 0.8132776   
## - age:sex 1 1.472 182.71 -2628.0 10.7094 0.0010935 \*\*   
## - I(age^2) 1 1.668 182.91 -2626.5 12.1385 0.0005101 \*\*\*  
## - I(bmi^2) 1 1.830 183.07 -2625.4 13.3145 0.0002736 \*\*\*  
## - age:region 3 2.385 183.63 -2625.3 5.7862 0.0006273 \*\*\*  
## - smoker:children 1 3.798 185.04 -2611.1 27.6370 1.706e-07 \*\*\*  
## - age:children 1 5.499 186.74 -2598.8 40.0216 3.433e-10 \*\*\*  
## - smoker:bmi 1 22.926 204.17 -2479.4 166.8429 < 2.2e-16 \*\*\*  
## - smoker:age 1 45.346 226.59 -2340.0 330.0084 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2642.89  
## charges\_log ~ smoker + age + children + bmi + region + sex +   
## I(age^2) + I(bmi^2) + I(children^2) + smoker:age + smoker:bmi +   
## age:children + smoker:children + age:region + age:sex  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + sex:smoker 1 0.454 179.69 -2644.3 3.3287 0.0683083 .   
## + smoker:region 3 0.943 179.21 -2643.9 2.3058 0.0750884 .   
## <none> 180.15 -2642.9   
## + bmi:region 3 0.706 179.44 -2642.1 1.7239 0.1602156   
## + age:bmi 1 0.162 179.99 -2642.1 1.1838 0.2767840   
## + sex:bmi 1 0.047 180.10 -2641.2 0.3457 0.5566739   
## + sex:children 1 0.009 180.14 -2640.9 0.0628 0.8020986   
## + bmi:children 1 0.004 180.15 -2640.9 0.0310 0.8601772   
## + children:region 3 0.347 179.80 -2639.5 0.8456 0.4689159   
## + sex:region 3 0.102 180.05 -2637.6 0.2476 0.8630726   
## - I(children^2) 1 1.093 181.24 -2636.8 7.9941 0.0047640 \*\*   
## - I(age^2) 1 1.122 181.27 -2636.6 8.2078 0.0042373 \*\*   
## - age:sex 1 1.488 181.64 -2633.9 10.8891 0.0009932 \*\*\*  
## - age:region 3 2.372 182.52 -2631.4 5.7855 0.0006279 \*\*\*  
## - I(bmi^2) 1 1.866 182.01 -2631.1 13.6522 0.0002290 \*\*\*  
## - smoker:children 1 4.250 184.40 -2613.7 31.0914 2.983e-08 \*\*\*  
## - age:children 1 5.835 185.98 -2602.2 42.6927 9.127e-11 \*\*\*  
## - smoker:bmi 1 22.581 202.73 -2486.9 165.2089 < 2.2e-16 \*\*\*  
## - smoker:age 1 45.462 225.61 -2343.8 332.6106 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2644.27  
## charges\_log ~ smoker + age + children + bmi + region + sex +   
## I(age^2) + I(bmi^2) + I(children^2) + smoker:age + smoker:bmi +   
## age:children + smoker:children + age:region + age:sex + smoker:sex  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## + smoker:region 3 0.915 178.78 -2645.1 2.2419 0.0817012 .   
## <none> 179.69 -2644.3   
## + bmi:region 3 0.681 179.01 -2643.3 1.6667 0.1723485   
## + age:bmi 1 0.143 179.55 -2643.3 1.0467 0.3064573   
## - smoker:sex 1 0.454 180.15 -2642.9 3.3287 0.0683083 .   
## + sex:bmi 1 0.049 179.65 -2642.6 0.3586 0.5493625   
## + sex:children 1 0.010 179.69 -2642.3 0.0713 0.7895074   
## + bmi:children 1 0.008 179.69 -2642.3 0.0612 0.8046225   
## + children:region 3 0.324 179.37 -2640.7 0.7910 0.4989409   
## + sex:region 3 0.109 179.59 -2639.1 0.2648 0.8507763   
## - I(children^2) 1 1.078 180.77 -2638.3 7.8983 0.0050213 \*\*   
## - I(age^2) 1 1.105 180.80 -2638.1 8.1006 0.0044935 \*\*   
## - age:sex 1 1.523 181.22 -2635.0 11.1618 0.0008584 \*\*\*  
## - I(bmi^2) 1 1.730 181.43 -2633.4 12.6824 0.0003823 \*\*\*  
## - age:region 3 2.356 182.05 -2632.8 5.7556 0.0006548 \*\*\*  
## - smoker:children 1 4.427 184.12 -2613.7 32.4494 1.507e-08 \*\*\*  
## - age:children 1 5.904 185.60 -2603.0 43.2683 6.866e-11 \*\*\*  
## - smoker:bmi 1 21.443 201.14 -2495.4 157.1612 < 2.2e-16 \*\*\*  
## - smoker:age 1 45.228 224.92 -2345.9 331.4801 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Step: AIC=-2645.1  
## charges\_log ~ smoker + age + children + bmi + region + sex +   
## I(age^2) + I(bmi^2) + I(children^2) + smoker:age + smoker:bmi +   
## age:children + smoker:children + age:region + age:sex + smoker:sex +   
## smoker:region  
##   
## Df Sum of Sq RSS AIC F value Pr(>F)   
## <none> 178.78 -2645.1   
## - smoker:region 3 0.915 179.69 -2644.3 2.2419 0.0817012 .   
## + age:bmi 1 0.129 178.65 -2644.1 0.9470 0.3306560   
## + bmi:region 3 0.661 178.12 -2644.1 1.6229 0.1822296   
## - smoker:sex 1 0.427 179.21 -2643.9 3.1350 0.0768601 .   
## + sex:bmi 1 0.061 178.72 -2643.6 0.4482 0.5033211   
## + sex:children 1 0.005 178.78 -2643.1 0.0361 0.8493773   
## + bmi:children 1 0.002 178.78 -2643.1 0.0146 0.9038061   
## + children:region 3 0.344 178.44 -2641.7 0.8415 0.4711416   
## + sex:region 3 0.109 178.67 -2639.9 0.2655 0.8502822   
## - I(children^2) 1 1.116 179.90 -2638.8 8.1988 0.0042584 \*\*   
## - I(age^2) 1 1.144 179.92 -2638.6 8.4111 0.0037914 \*\*   
## - age:sex 1 1.541 180.32 -2635.6 11.3227 0.0007877 \*\*\*  
## - I(bmi^2) 1 1.637 180.42 -2634.9 12.0297 0.0005405 \*\*\*  
## - age:region 3 2.485 181.26 -2632.6 6.0884 0.0004103 \*\*\*  
## - smoker:children 1 4.570 183.35 -2613.3 33.5870 8.522e-09 \*\*\*  
## - age:children 1 5.844 184.62 -2604.1 42.9557 8.022e-11 \*\*\*  
## - smoker:bmi 1 18.603 197.38 -2514.7 136.7304 < 2.2e-16 \*\*\*  
## - smoker:age 1 44.286 223.06 -2351.0 325.4926 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

# Multicollinearity Summary

log\_model <- lm(charges\_log ~ age+sex+bmi+children+smoker+region, data = insurance)  
summary(log\_model)

##   
## Call:  
## lm(formula = charges\_log ~ age + sex + bmi + children + smoker +   
## region, data = insurance)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -1.07186 -0.19835 -0.04917 0.06598 2.16636   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 7.0305581 0.0723960 97.112 < 2e-16 \*\*\*  
## age 0.0345816 0.0008721 39.655 < 2e-16 \*\*\*  
## sexmale -0.0754164 0.0244012 -3.091 0.002038 \*\*   
## bmi 0.0133748 0.0020960 6.381 2.42e-10 \*\*\*  
## children 0.1018568 0.0100995 10.085 < 2e-16 \*\*\*  
## smokeryes 1.5543228 0.0302795 51.333 < 2e-16 \*\*\*  
## regionnorthwest -0.0637876 0.0349057 -1.827 0.067860 .   
## regionsoutheast -0.1571967 0.0350828 -4.481 8.08e-06 \*\*\*  
## regionsouthwest -0.1289522 0.0350271 -3.681 0.000241 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.4443 on 1329 degrees of freedom  
## Multiple R-squared: 0.7679, Adjusted R-squared: 0.7666   
## F-statistic: 549.8 on 8 and 1329 DF, p-value: < 2.2e-16

# VIF on Chosen Model

# Using car Library  
vif(step\_model1)

## smokeryes age children   
## 34.157349 54.054564 18.582374   
## bmi regionnorthwest regionsoutheast   
## 60.276225 13.888416 14.310440   
## regionsouthwest sexmale I(age^2)   
## 14.337453 9.205687 49.664942   
## I(bmi^2) I(children^2) smokeryes:age   
## 60.212620 7.267806 9.171773   
## smokeryes:bmi age:children smokeryes:children   
## 28.602274 10.854914 2.243045   
## age:regionnorthwest age:regionsoutheast age:regionsouthwest   
## 13.909060 14.184378 14.212561   
## age:sexmale smokeryes:sexmale smokeryes:regionnorthwest   
## 9.803471 2.722109 2.237333   
## smokeryes:regionsoutheast smokeryes:regionsouthwest   
## 3.071270 2.278194