Laboration report in Computational Statistics

Computer lab 1 block 1

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Contents

1 Assignment 3. Logistic regression and basis function expansion

1.1 Data

The data contains information about the onset of diabetes within 5 years in Pima Indians given medical details. The variables are:

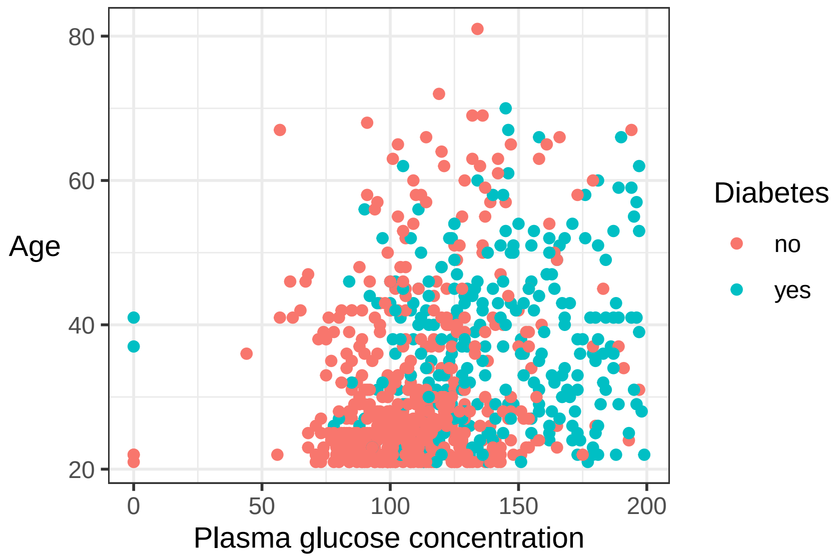
- Number of times pregnant
- Plasma glucose concentration a 2 hours in an oral glucose tolerance test.
- Diastolic blood pressure (mm Hg).
- Triceps skinfold thickness (mm).
- 2-Hour serum insulin (mu U/ml).
- Body mass index (weight in kg/(height in m)^2).
- Diabetes pedigree function.
- Age (years).
- Diabetes (0=no or 1=yes).

```
diabetes_df <- read.csv("pima-indians-diabetes.csv", header=FALSE)

colnames(diabetes_df) <- c("times_pregnant", "plasma_glucose_conc",
                          "diastolic_blood_pressure", "triceps_skinfold_thickness",
                          "serum_insulin","body_mass_index", "diabetes_pedigree",
                          "age", "diabetes")

diabetes_df$diabetes <- ifelse(diabetes_df$diabetes == 0, "no", "yes")
diabetes_df$diabetes <- as.factor(diabetes_df$diabetes)
```

1.2 3.1

Question: Make a scatterplot showing a Plasma glucose concentration on Age where observations are colored by Diabetes levels.

```
library(ggplot2)

ggplot(diabetes_df, aes(x = plasma_glucose_conc, y = age, color = diabetes)) +
  geom_point() +
  theme_bw() +
  theme(axis.title.y = element_text(angle = 0,vjust = 0.5)) +
  labs(colour = "Diabetes",
       x = "Plasma glucose concentration",
       y = "Age")
```



Question: Do you think that Diabetes is easy to classify by a standard logistic regression model that uses these two variables as features? Motivate your answer.

We don't think these two variables are good variables to classify Diabetes because there is no clear relationship between age, plasma glucose concentration with Diabetes.

1.3 3.2

Question:

Train a logistic regression model with y = Diabetes as target x_1 = Plasma glucose concentration and x_2 = Age as features and make a prediction for all observations by using $r = 0.5$ as the classification threshold. Report the probabilistic equation of the estimated model and compute also the training misclassification error.

The probabilistic equation:

$$$$

```
model <- glm(diabetes ~ plasma_glucose_conc + age, data = diabetes_df,
             family =  "binomial")

pred <- predict(model, newdata = diabetes_df, type = "response")

# Using 0.5 as the classification threshold
pred <- ifelse(pred > 0.5, "yes", "no")

confusion <- table(diabetes_df$diabetes, pred)
misclass_rate <- (confusion[1,2] + confusion[2,1]) / sum(confusion)


knitr::kable(as.data.frame(round(misclass_rate,2)), col.names = "Misclassification error",
             caption = "Misclassification error")
```

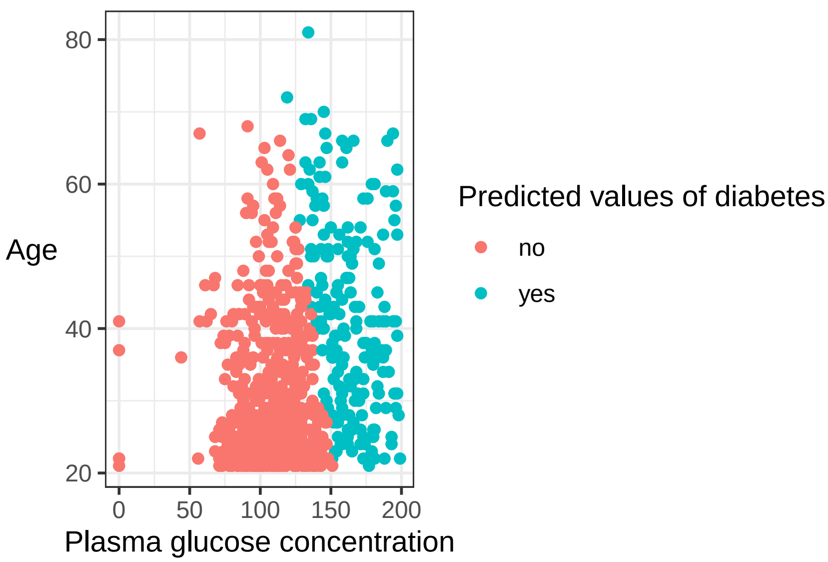
Table 1: Misclassification error

Misclassification error
0.26

Question:

Make a scatter plot of the same kind as in step 1 but showing the predicted values of Diabetes as a color instead.

```
diabetes_df_pred <- diabetes_df
diabetes_df_pred$pred <- pred

ggplot(diabetes_df_pred, aes(x = plasma_glucose_conc, y = age, color = pred)) +
  geom_point() +
  theme_bw() +
  theme(axis.title.y = element_text(angle = 0,vjust = 0.5)) +
  labs(colour = "Predicted values of diabetes",
       x = "Plasma glucose concentration",
       y = "Age")
```



Question:

Comment on the quality of the classification by using these results.

1.4 3.3

Question:

Use the model estimated in step 2 to a) report the equation of the decision boundary between the two classes b) add a curve showing this boundary to the scatter plot in step 2.

The decision boundary equation:

$$\beta_0 + \beta_1 \cdot \text{plasma glucos econc}$$

```
summary(model)
```

```
##
## Call:
## glm(formula = diabetes ~ plasma_glucose_conc + age, family = "binomial",
##     data = diabetes_df)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.3367  -0.7775  -0.5087   0.8367   3.1630
##
## Coefficients:
##                      Estimate Std. Error z value Pr(>|z|)
## (Intercept)         -5.912449   0.462620  -12.78  < 2e-16 ***
## plasma_glucose_conc  0.035644   0.003290   10.83  < 2e-16 ***
## age                  0.024778   0.007374    3.36 0.000778 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 993.48  on 767  degrees of freedom
## Residual deviance: 797.36  on 765  degrees of freedom
## AIC: 803.36
##
## Number of Fisher Scoring iterations: 4
```

```
slope <- coef(model)[2]/(-coef(model)[3])
intercept <- coef(model)[1]/(-coef(model)[3])


diabetes_df
```

```
##     times_pregnant plasma_glucose_conc diastolic_blood_pressure
## 1                6                 148                       72
## 2                1                  85                       66
## 3                8                 183                       64
## 4                1                  89                       66
## 5                0                 137                       40
## 6                5                 116                       74
## 7                3                  78                       50
```

```
## 8              10          115            0
## 9               2          197           70
## 10              8          125           96
## 11              4          110           92
## 12             10          168           74
## 13             10          139           80
## 14              1          189           60
## 15              5          166           72
## 16              7          100            0
## 17              0          118           84
## 18              7          107           74
## 19              1          103           30
## 20              1          115           70
## 21              3          126           88
## 22              8           99           84
## 23              7          196           90
## 24              9          119           80
## 25             11          143           94
## 26             10          125           70
## 27              7          147           76
## 28              1           97           66
## 29             13          145           82
## 30              5          117           92
## 31              5          109           75
## 32              3          158           76
## 33              3           88           58
## 34              6           92           92
## 35             10          122           78
## 36              4          103           60
## 37             11          138           76
## 38              9          102           76
## 39              2           90           68
## 40              4          111           72
## 41              3          180           64
## 42              7          133           84
## 43              7          106           92
## 44              9          171          110
## 45              7          159           64
## 46              0          180           66
## 47              1          146           56
## 48              2           71           70
## 49              7          103           66
## 50              7          105            0
## 51              1          103           80
## 52              1          101           50
## 53              5           88           66
## 54              8          176           90
## 55              7          150           66
## 56              1           73           50
```

```
## 57          7          187          68
## 58          0          100          88
## 59          0          146          82
## 60          0          105          64
## 61          2           84           0
## 62          8          133          72
## 63          5           44          62
## 64          2          141          58
## 65          7          114          66
## 66          5           99          74
## 67          0          109          88
## 68          2          109          92
## 69          1           95          66
## 70          4          146          85
## 71          2          100          66
## 72          5          139          64
## 73         13          126          90
## 74          4          129          86
## 75          1           79          75
## 76          1            0          48
## 77          7           62          78
## 78          5           95          72
## 79          0          131           0
## 80          2          112          66
## 81          3          113          44
## 82          2           74           0
## 83          7           83          78
## 84          0          101          65
## 85          5          137         108
## 86          2          110          74
## 87         13          106          72
## 88          2          100          68
## 89         15          136          70
## 90          1          107          68
## 91          1           80          55
## 92          4          123          80
## 93          7           81          78
## 94          4          134          72
## 95          2          142          82
## 96          6          144          72
## 97          2           92          62
## 98          1           71          48
## 99          6           93          50
## 100         1          122          90
## 101         1          163          72
## 102         1          151          60
## 103         0          125          96
## 104         1           81          72
## 105         2           85          65
```

```
## 106                 1                 126                      56
## 107                 1                  96                     122
## 108                 4                 144                      58
## 109                 3                  83                      58
## 110                 0                  95                      85
## 111                 3                 171                      72
## 112                 8                 155                      62
## 113                 1                  89                      76
## 114                 4                  76                      62
## 115                 7                 160                      54
## 116                 4                 146                      92
## 117                 5                 124                      74
## 118                 5                  78                      48
## 119                 4                  97                      60
## 120                 4                  99                      76
## 121                 0                 162                      76
## 122                 6                 111                      64
## 123                 2                 107                      74
## 124                 5                 132                      80
## 125                 0                 113                      76
## 126                 1                  88                      30
## 127                 3                 120                      70
## 128                 1                 118                      58
## 129                 1                 117                      88
## 130                 0                 105                      84
## 131                 4                 173                      70
## 132                 9                 122                      56
## 133                 3                 170                      64
## 134                 8                  84                      74
## 135                 2                  96                      68
## 136                 2                 125                      60
## 137                 0                 100                      70
## 138                 0                  93                      60
## 139                 0                 129                      80
## 140                 5                 105                      72
## 141                 3                 128                      78
## 142                 5                 106                      82
## 143                 2                 108                      52
## 144                10                 108                      66
## 145                 4                 154                      62
## 146                 0                 102                      75
## 147                 9                  57                      80
## 148                 2                 106                      64
## 149                 5                 147                      78
## 150                 2                  90                      70
## 151                 1                 136                      74
## 152                 4                 114                      65
## 153                 9                 156                      86
## 154                 1                 153                      82
```

```
## 155          8           188           78
## 156          7           152           88
## 157          2            99           52
## 158          1           109           56
## 159          2            88           74
## 160         17           163           72
## 161          4           151           90
## 162          7           102           74
## 163          0           114           80
## 164          2           100           64
## 165          0           131           88
## 166          6           104           74
## 167          3           148           66
## 168          4           120           68
## 169          4           110           66
## 170          3           111           90
## 171          6           102           82
## 172          6           134           70
## 173          2            87            0
## 174          1            79           60
## 175          2            75           64
## 176          8           179           72
## 177          6            85           78
## 178          0           129          110
## 179          5           143           78
## 180          5           130           82
## 181          6            87           80
## 182          0           119           64
## 183          1             0           74
## 184          5            73           60
## 185          4           141           74
## 186          7           194           68
## 187          8           181           68
## 188          1           128           98
## 189          8           109           76
## 190          5           139           80
## 191          3           111           62
## 192          9           123           70
## 193          7           159           66
## 194         11           135            0
## 195          8            85           55
## 196          5           158           84
## 197          1           105           58
## 198          3           107           62
## 199          4           109           64
## 200          4           148           60
## 201          0           113           80
## 202          1           138           82
## 203          0           108           68
```

```
## 204              2          99           70
## 205              6         103           72
## 206              5         111           72
## 207              8         196           76
## 208              5         162          104
## 209              1          96           64
## 210              7         184           84
## 211              2          81           60
## 212              0         147           85
## 213              7         179           95
## 214              0         140           65
## 215              9         112           82
## 216             12         151           70
## 217              5         109           62
## 218              6         125           68
## 219              5          85           74
## 220              5         112           66
## 221              0         177           60
## 222              2         158           90
## 223              7         119            0
## 224              7         142           60
## 225              1         100           66
## 226              1          87           78
## 227              0         101           76
## 228              3         162           52
## 229              4         197           70
## 230              0         117           80
## 231              4         142           86
## 232              6         134           80
## 233              1          79           80
## 234              4         122           68
## 235              3          74           68
## 236              4         171           72
## 237              7         181           84
## 238              0         179           90
## 239              9         164           84
## 240              0         104           76
## 241              1          91           64
## 242              4          91           70
## 243              3         139           54
## 244              6         119           50
## 245              2         146           76
## 246              9         184           85
## 247             10         122           68
## 248              0         165           90
## 249              9         124           70
## 250              1         111           86
## 251              9         106           52
## 252              2         129           84
```

```
## 253                 2                  90                   80
## 254                 0                  86                   68
## 255                12                  92                   62
## 256                 1                 113                   64
## 257                 3                 111                   56
## 258                 2                 114                   68
## 259                 1                 193                   50
## 260                11                 155                   76
## 261                 3                 191                   68
## 262                 3                 141                    0
## 263                 4                  95                   70
## 264                 3                 142                   80
## 265                 4                 123                   62
## 266                 5                  96                   74
## 267                 0                 138                    0
## 268                 2                 128                   64
## 269                 0                 102                   52
## 270                 2                 146                    0
## 271                10                 101                   86
## 272                 2                 108                   62
## 273                 3                 122                   78
## 274                 1                  71                   78
## 275                13                 106                   70
## 276                 2                 100                   70
## 277                 7                 106                   60
## 278                 0                 104                   64
## 279                 5                 114                   74
## 280                 2                 108                   62
## 281                 0                 146                   70
## 282                10                 129                   76
## 283                 7                 133                   88
## 284                 7                 161                   86
## 285                 2                 108                   80
## 286                 7                 136                   74
## 287                 5                 155                   84
## 288                 1                 119                   86
## 289                 4                  96                   56
## 290                 5                 108                   72
## 291                 0                  78                   88
## 292                 0                 107                   62
## 293                 2                 128                   78
## 294                 1                 128                   48
## 295                 0                 161                   50
## 296                 6                 151                   62
## 297                 2                 146                   70
## 298                 0                 126                   84
## 299                14                 100                   78
## 300                 8                 112                   72
## 301                 0                 167                    0
```

```
## 302          2         144          58
## 303          5          77          82
## 304          5         115          98
## 305          3         150          76
## 306          2         120          76
## 307         10         161          68
## 308          0         137          68
## 309          0         128          68
## 310          2         124          68
## 311          6          80          66
## 312          0         106          70
## 313          2         155          74
## 314          3         113          50
## 315          7         109          80
## 316          2         112          68
## 317          3          99          80
## 318          3         182          74
## 319          3         115          66
## 320          6         194          78
## 321          4         129          60
## 322          3         112          74
## 323          0         124          70
## 324         13         152          90
## 325          2         112          75
## 326          1         157          72
## 327          1         122          64
## 328         10         179          70
## 329          2         102          86
## 330          6         105          70
## 331          8         118          72
## 332          2          87          58
## 333          1         180           0
## 334         12         106          80
## 335          1          95          60
## 336          0         165          76
## 337          0         117           0
## 338          5         115          76
## 339          9         152          78
## 340          7         178          84
## 341          1         130          70
## 342          1          95          74
## 343          1           0          68
## 344          5         122          86
## 345          8          95          72
## 346          8         126          88
## 347          1         139          46
## 348          3         116           0
## 349          3          99          62
## 350          5           0          80
```

```
## 351           4          92          80
## 352           4         137          84
## 353           3          61          82
## 354           1          90          62
## 355           3          90          78
## 356           9         165          88
## 357           1         125          50
## 358          13         129           0
## 359          12          88          74
## 360           1         196          76
## 361           5         189          64
## 362           5         158          70
## 363           5         103         108
## 364           4         146          78
## 365           4         147          74
## 366           5          99          54
## 367           6         124          72
## 368           0         101          64
## 369           3          81          86
## 370           1         133         102
## 371           3         173          82
## 372           0         118          64
## 373           0          84          64
## 374           2         105          58
## 375           2         122          52
## 376          12         140          82
## 377           0          98          82
## 378           1          87          60
## 379           4         156          75
## 380           0          93         100
## 381           1         107          72
## 382           0         105          68
## 383           1         109          60
## 384           1          90          62
## 385           1         125          70
## 386           1         119          54
## 387           5         116          74
## 388           8         105         100
## 389           5         144          82
## 390           3         100          68
## 391           1         100          66
## 392           5         166          76
## 393           1         131          64
## 394           4         116          72
## 395           4         158          78
## 396           2         127          58
## 397           3          96          56
## 398           0         131          66
## 399           3          82          70
```

```
## 400        3      193      70
## 401        4       95      64
## 402        6      137      61
## 403        5      136      84
## 404        9       72      78
## 405        5      168      64
## 406        2      123      48
## 407        4      115      72
## 408        0      101      62
## 409        8      197      74
## 410        1      172      68
## 411        6      102      90
## 412        1      112      72
## 413        1      143      84
## 414        1      143      74
## 415        0      138      60
## 416        3      173      84
## 417        1       97      68
## 418        4      144      82
## 419        1       83      68
## 420        3      129      64
## 421        1      119      88
## 422        2       94      68
## 423        0      102      64
## 424        2      115      64
## 425        8      151      78
## 426        4      184      78
## 427        0       94       0
## 428        1      181      64
## 429        0      135      94
## 430        1       95      82
## 431        2       99       0
## 432        3       89      74
## 433        1       80      74
## 434        2      139      75
## 435        1       90      68
## 436        0      141       0
## 437       12      140      85
## 438        5      147      75
## 439        1       97      70
## 440        6      107      88
## 441        0      189     104
## 442        2       83      66
## 443        4      117      64
## 444        8      108      70
## 445        4      117      62
## 446        0      180      78
## 447        1      100      72
## 448        0       95      80
```

```
## 449     0    104     64
## 450     0    120     74
## 451     1     82     64
## 452     2    134     70
## 453     0     91     68
## 454     2    119      0
## 455     2    100     54
## 456    14    175     62
## 457     1    135     54
## 458     5     86     68
## 459    10    148     84
## 460     9    134     74
## 461     9    120     72
## 462     1     71     62
## 463     8     74     70
## 464     5     88     78
## 465    10    115     98
## 466     0    124     56
## 467     0     74     52
## 468     0     97     64
## 469     8    120      0
## 470     6    154     78
## 471     1    144     82
## 472     0    137     70
## 473     0    119     66
## 474     7    136     90
## 475     4    114     64
## 476     0    137     84
## 477     2    105     80
## 478     7    114     76
## 479     8    126     74
## 480     4    132     86
## 481     3    158     70
## 482     0    123     88
## 483     4     85     58
## 484     0     84     82
## 485     0    145      0
## 486     0    135     68
## 487     1    139     62
## 488     0    173     78
## 489     4     99     72
## 490     8    194     80
## 491     2     83     65
## 492     2     89     90
## 493     4     99     68
## 494     4    125     70
## 495     3     80      0
## 496     6    166     74
## 497     5    110     68
```

## 498	2	81	72
## 499	7	195	70
## 500	6	154	74
## 501	2	117	90
## 502	3	84	72
## 503	6	0	68
## 504	7	94	64
## 505	3	96	78
## 506	10	75	82
## 507	0	180	90
## 508	1	130	60
## 509	2	84	50
## 510	8	120	78
## 511	12	84	72
## 512	0	139	62
## 513	9	91	68
## 514	2	91	62
## 515	3	99	54
## 516	3	163	70
## 517	9	145	88
## 518	7	125	86
## 519	13	76	60
## 520	6	129	90
## 521	2	68	70
## 522	3	124	80
## 523	6	114	0
## 524	9	130	70
## 525	3	125	58
## 526	3	87	60
## 527	1	97	64
## 528	3	116	74
## 529	0	117	66
## 530	0	111	65
## 531	2	122	60
## 532	0	107	76
## 533	1	86	66
## 534	6	91	0
## 535	1	77	56
## 536	4	132	0
## 537	0	105	90
## 538	0	57	60
## 539	0	127	80
## 540	3	129	92
## 541	8	100	74
## 542	3	128	72
## 543	10	90	85
## 544	4	84	90
## 545	1	88	78
## 546	8	186	90

```
## 547           5          187            76
## 548           4          131            68
## 549           1          164            82
## 550           4          189           110
## 551           1          116            70
## 552           3           84            68
## 553           6          114            88
## 554           1           88            62
## 555           1           84            64
## 556           7          124            70
## 557           1           97            70
## 558           8          110            76
## 559          11          103            68
## 560          11           85            74
## 561           6          125            76
## 562           0          198            66
## 563           1           87            68
## 564           6           99            60
## 565           0           91            80
## 566           2           95            54
## 567           1           99            72
## 568           6           92            62
## 569           4          154            72
## 570           0          121            66
## 571           3           78            70
## 572           2          130            96
## 573           3          111            58
## 574           2           98            60
## 575           1          143            86
## 576           1          119            44
## 577           6          108            44
## 578           2          118            80
## 579          10          133            68
## 580           2          197            70
## 581           0          151            90
## 582           6          109            60
## 583          12          121            78
## 584           8          100            76
## 585           8          124            76
## 586           1           93            56
## 587           8          143            66
## 588           6          103            66
## 589           3          176            86
## 590           0           73             0
## 591          11          111            84
## 592           2          112            78
## 593           3          132            80
## 594           2           82            52
## 595           6          123            72
```

```
## 596     0   188    82
## 597     0    67    76
## 598     1    89    24
## 599     1   173    74
## 600     1   109    38
## 601     1   108    88
## 602     6    96     0
## 603     1   124    74
## 604     7   150    78
## 605     4   183     0
## 606     1   124    60
## 607     1   181    78
## 608     1    92    62
## 609     0   152    82
## 610     1   111    62
## 611     3   106    54
## 612     3   174    58
## 613     7   168    88
## 614     6   105    80
## 615    11   138    74
## 616     3   106    72
## 617     6   117    96
## 618     2    68    62
## 619     9   112    82
## 620     0   119     0
## 621     2   112    86
## 622     2    92    76
## 623     6   183    94
## 624     0    94    70
## 625     2   108    64
## 626     4    90    88
## 627     0   125    68
## 628     0   132    78
## 629     5   128    80
## 630     4    94    65
## 631     7   114    64
## 632     0   102    78
## 633     2   111    60
## 634     1   128    82
## 635    10    92    62
## 636    13   104    72
## 637     5   104    74
## 638     2    94    76
## 639     7    97    76
## 640     1   100    74
## 641     0   102    86
## 642     4   128    70
## 643     6   147    80
## 644     4    90     0
```

```
## 645                  3                   103                          72
## 646                  2                   157                          74
## 647                  1                   167                          74
## 648                  0                   179                          50
## 649                 11                   136                          84
## 650                  0                   107                          60
## 651                  1                    91                          54
## 652                  1                   117                          60
## 653                  5                   123                          74
## 654                  2                   120                          54
## 655                  1                   106                          70
## 656                  2                   155                          52
## 657                  2                   101                          58
## 658                  1                   120                          80
## 659                 11                   127                         106
## 660                  3                    80                          82
## 661                 10                   162                          84
## 662                  1                   199                          76
## 663                  8                   167                         106
## 664                  9                   145                          80
## 665                  6                   115                          60
## 666                  1                   112                          80
## 667                  4                   145                          82
## 668                 10                   111                          70
## 669                  6                    98                          58
## 670                  9                   154                          78
## 671                  6                   165                          68
## 672                  1                    99                          58
## 673                 10                    68                         106
## 674                  3                   123                         100
## 675                  8                    91                          82
## 676                  6                   195                          70
## 677                  9                   156                          86
## 678                  0                    93                          60
## 679                  3                   121                          52
## 680                  2                   101                          58
## 681                  2                    56                          56
## 682                  0                   162                          76
## 683                  0                    95                          64
## 684                  4                   125                          80
## 685                  5                   136                          82
## 686                  2                   129                          74
## 687                  3                   130                          64
## 688                  1                   107                          50
## 689                  1                   140                          74
## 690                  1                   144                          82
## 691                  8                   107                          80
## 692                 13                   158                         114
## 693                  2                   121                          70
```

```
## 694                     7                   129                        68
## 695                     2                    90                        60
## 696                     7                   142                        90
## 697                     3                   169                        74
## 698                     0                    99                         0
## 699                     4                   127                        88
## 700                     4                   118                        70
## 701                     2                   122                        76
## 702                     6                   125                        78
## 703                     1                   168                        88
## 704                     2                   129                         0
## 705                     4                   110                        76
## 706                     6                    80                        80
## 707                    10                   115                         0
## 708                     2                   127                        46
## 709                     9                   164                        78
## 710                     2                    93                        64
## 711                     3                   158                        64
## 712                     5                   126                        78
## 713                    10                   129                        62
## 714                     0                   134                        58
## 715                     3                   102                        74
## 716                     7                   187                        50
## 717                     3                   173                        78
## 718                    10                    94                        72
## 719                     1                   108                        60
## 720                     5                    97                        76
## 721                     4                    83                        86
## 722                     1                   114                        66
## 723                     1                   149                        68
## 724                     5                   117                        86
## 725                     1                   111                        94
## 726                     4                   112                        78
## 727                     1                   116                        78
## 728                     0                   141                        84
## 729                     2                   175                        88
## 730                     2                    92                        52
## 731                     3                   130                        78
## 732                     8                   120                        86
## 733                     2                   174                        88
## 734                     2                   106                        56
## 735                     2                   105                        75
## 736                     4                    95                        60
## 737                     0                   126                        86
## 738                     8                    65                        72
## 739                     2                    99                        60
## 740                     1                   102                        74
## 741                    11                   120                        80
## 742                     3                   102                        44
```

```
## 743              1                 109                       58
## 744              9                 140                       94
## 745             13                 153                       88
## 746             12                 100                       84
## 747              1                 147                       94
## 748              1                  81                       74
## 749              3                 187                       70
## 750              6                 162                       62
## 751              4                 136                       70
## 752              1                 121                       78
## 753              3                 108                       62
## 754              0                 181                       88
## 755              8                 154                       78
## 756              1                 128                       88
## 757              7                 137                       90
## 758              0                 123                       72
## 759              1                 106                       76
## 760              6                 190                       92
## 761              2                  88                       58
## 762              9                 170                       74
## 763              9                  89                       62
## 764             10                 101                       76
## 765              2                 122                       70
## 766              5                 121                       72
## 767              1                 126                       60
## 768              1                  93                       70
##     triceps_skinfold_thickness serum_insulin body_mass_index diabetes_pedigree
## 1                           35             0            33.6             0.627
## 2                           29             0            26.6             0.351
## 3                            0             0            23.3             0.672
## 4                           23            94            28.1             0.167
## 5                           35           168            43.1             2.288
## 6                            0             0            25.6             0.201
## 7                           32            88            31.0             0.248
## 8                            0             0            35.3             0.134
## 9                           45           543            30.5             0.158
## 10                           0             0             0.0             0.232
## 11                           0             0            37.6             0.191
## 12                           0             0            38.0             0.537
## 13                           0             0            27.1             1.441
## 14                          23           846            30.1             0.398
## 15                          19           175            25.8             0.587
## 16                           0             0            30.0             0.484
## 17                          47           230            45.8             0.551
## 18                           0             0            29.6             0.254
## 19                          38            83            43.3             0.183
## 20                          30            96            34.6             0.529
## 21                          41           235            39.3             0.704
## 22                           0             0            35.4             0.388
```

```
## 23                                 0          0          39.8             0.451
## 24                                35          0          29.0             0.263
## 25                                33        146          36.6             0.254
## 26                                26        115          31.1             0.205
## 27                                 0          0          39.4             0.257
## 28                                15        140          23.2             0.487
## 29                                19        110          22.2             0.245
## 30                                 0          0          34.1             0.337
## 31                                26          0          36.0             0.546
## 32                                36        245          31.6             0.851
## 33                                11         54          24.8             0.267
## 34                                 0          0          19.9             0.188
## 35                                31          0          27.6             0.512
## 36                                33        192          24.0             0.966
## 37                                 0          0          33.2             0.420
## 38                                37          0          32.9             0.665
## 39                                42          0          38.2             0.503
## 40                                47        207          37.1             1.390
## 41                                25         70          34.0             0.271
## 42                                 0          0          40.2             0.696
## 43                                18          0          22.7             0.235
## 44                                24        240          45.4             0.721
## 45                                 0          0          27.4             0.294
## 46                                39          0          42.0             1.893
## 47                                 0          0          29.7             0.564
## 48                                27          0          28.0             0.586
## 49                                32          0          39.1             0.344
## 50                                 0          0           0.0             0.305
## 51                                11         82          19.4             0.491
## 52                                15         36          24.2             0.526
## 53                                21         23          24.4             0.342
## 54                                34        300          33.7             0.467
## 55                                42        342          34.7             0.718
## 56                                10          0          23.0             0.248
## 57                                39        304          37.7             0.254
## 58                                60        110          46.8             0.962
## 59                                 0          0          40.5             1.781
## 60                                41        142          41.5             0.173
## 61                                 0          0           0.0             0.304
## 62                                 0          0          32.9             0.270
## 63                                 0          0          25.0             0.587
## 64                                34        128          25.4             0.699
## 65                                 0          0          32.8             0.258
## 66                                27          0          29.0             0.203
## 67                                30          0          32.5             0.855
## 68                                 0          0          42.7             0.845
## 69                                13         38          19.6             0.334
## 70                                27        100          28.9             0.189
## 71                                20         90          32.9             0.867
```

```
## 72                             35          140          28.6            0.411
## 73                              0            0          43.4            0.583
## 74                             20          270          35.1            0.231
## 75                             30            0          32.0            0.396
## 76                             20            0          24.7            0.140
## 77                              0            0          32.6            0.391
## 78                             33            0          37.7            0.370
## 79                              0            0          43.2            0.270
## 80                             22            0          25.0            0.307
## 81                             13            0          22.4            0.140
## 82                              0            0           0.0            0.102
## 83                             26           71          29.3            0.767
## 84                             28            0          24.6            0.237
## 85                              0            0          48.8            0.227
## 86                             29          125          32.4            0.698
## 87                             54            0          36.6            0.178
## 88                             25           71          38.5            0.324
## 89                             32          110          37.1            0.153
## 90                             19            0          26.5            0.165
## 91                              0            0          19.1            0.258
## 92                             15          176          32.0            0.443
## 93                             40           48          46.7            0.261
## 94                              0            0          23.8            0.277
## 95                             18           64          24.7            0.761
## 96                             27          228          33.9            0.255
## 97                             28            0          31.6            0.130
## 98                             18           76          20.4            0.323
## 99                             30           64          28.7            0.356
## 100                            51          220          49.7            0.325
## 101                             0            0          39.0            1.222
## 102                             0            0          26.1            0.179
## 103                             0            0          22.5            0.262
## 104                            18           40          26.6            0.283
## 105                             0            0          39.6            0.930
## 106                            29          152          28.7            0.801
## 107                             0            0          22.4            0.207
## 108                            28          140          29.5            0.287
## 109                            31           18          34.3            0.336
## 110                            25           36          37.4            0.247
## 111                            33          135          33.3            0.199
## 112                            26          495          34.0            0.543
## 113                            34           37          31.2            0.192
## 114                             0            0          34.0            0.391
## 115                            32          175          30.5            0.588
## 116                             0            0          31.2            0.539
## 117                             0            0          34.0            0.220
## 118                             0            0          33.7            0.654
## 119                            23            0          28.2            0.443
## 120                            15           51          23.2            0.223
```

```
## 121                              56          100          53.2          0.759
## 122                              39            0          34.2          0.260
## 123                              30          100          33.6          0.404
## 124                               0            0          26.8          0.186
## 125                               0            0          33.3          0.278
## 126                              42           99          55.0          0.496
## 127                              30          135          42.9          0.452
## 128                              36           94          33.3          0.261
## 129                              24          145          34.5          0.403
## 130                               0            0          27.9          0.741
## 131                              14          168          29.7          0.361
## 132                               0            0          33.3          1.114
## 133                              37          225          34.5          0.356
## 134                              31            0          38.3          0.457
## 135                              13           49          21.1          0.647
## 136                              20          140          33.8          0.088
## 137                              26           50          30.8          0.597
## 138                              25           92          28.7          0.532
## 139                               0            0          31.2          0.703
## 140                              29          325          36.9          0.159
## 141                               0            0          21.1          0.268
## 142                              30            0          39.5          0.286
## 143                              26           63          32.5          0.318
## 144                               0            0          32.4          0.272
## 145                              31          284          32.8          0.237
## 146                              23            0           0.0          0.572
## 147                              37            0          32.8          0.096
## 148                              35          119          30.5          1.400
## 149                               0            0          33.7          0.218
## 150                              17            0          27.3          0.085
## 151                              50          204          37.4          0.399
## 152                               0            0          21.9          0.432
## 153                              28          155          34.3          1.189
## 154                              42          485          40.6          0.687
## 155                               0            0          47.9          0.137
## 156                              44            0          50.0          0.337
## 157                              15           94          24.6          0.637
## 158                              21          135          25.2          0.833
## 159                              19           53          29.0          0.229
## 160                              41          114          40.9          0.817
## 161                              38            0          29.7          0.294
## 162                              40          105          37.2          0.204
## 163                              34          285          44.2          0.167
## 164                              23            0          29.7          0.368
## 165                               0            0          31.6          0.743
## 166                              18          156          29.9          0.722
## 167                              25            0          32.5          0.256
## 168                               0            0          29.6          0.709
## 169                               0            0          31.9          0.471
```

```
## 170                         12         78          28.4          0.495
## 171                          0          0          30.8          0.180
## 172                         23        130          35.4          0.542
## 173                         23          0          28.9          0.773
## 174                         42         48          43.5          0.678
## 175                         24         55          29.7          0.370
## 176                         42        130          32.7          0.719
## 177                          0          0          31.2          0.382
## 178                         46        130          67.1          0.319
## 179                          0          0          45.0          0.190
## 180                          0          0          39.1          0.956
## 181                          0          0          23.2          0.084
## 182                         18         92          34.9          0.725
## 183                         20         23          27.7          0.299
## 184                          0          0          26.8          0.268
## 185                          0          0          27.6          0.244
## 186                         28          0          35.9          0.745
## 187                         36        495          30.1          0.615
## 188                         41         58          32.0          1.321
## 189                         39        114          27.9          0.640
## 190                         35        160          31.6          0.361
## 191                          0          0          22.6          0.142
## 192                         44         94          33.1          0.374
## 193                          0          0          30.4          0.383
## 194                          0          0          52.3          0.578
## 195                         20          0          24.4          0.136
## 196                         41        210          39.4          0.395
## 197                          0          0          24.3          0.187
## 198                         13         48          22.9          0.678
## 199                         44         99          34.8          0.905
## 200                         27        318          30.9          0.150
## 201                         16          0          31.0          0.874
## 202                          0          0          40.1          0.236
## 203                         20          0          27.3          0.787
## 204                         16         44          20.4          0.235
## 205                         32        190          37.7          0.324
## 206                         28          0          23.9          0.407
## 207                         29        280          37.5          0.605
## 208                          0          0          37.7          0.151
## 209                         27         87          33.2          0.289
## 210                         33          0          35.5          0.355
## 211                         22          0          27.7          0.290
## 212                         54          0          42.8          0.375
## 213                         31          0          34.2          0.164
## 214                         26        130          42.6          0.431
## 215                         32        175          34.2          0.260
## 216                         40        271          41.8          0.742
## 217                         41        129          35.8          0.514
## 218                         30        120          30.0          0.464
```

```
## 219                                    22          0            29.0            1.224
## 220                                     0          0            37.8            0.261
## 221                                    29        478            34.6            1.072
## 222                                     0          0            31.6            0.805
## 223                                     0          0            25.2            0.209
## 224                                    33        190            28.8            0.687
## 225                                    15         56            23.6            0.666
## 226                                    27         32            34.6            0.101
## 227                                     0          0            35.7            0.198
## 228                                    38          0            37.2            0.652
## 229                                    39        744            36.7            2.329
## 230                                    31         53            45.2            0.089
## 231                                     0          0            44.0            0.645
## 232                                    37        370            46.2            0.238
## 233                                    25         37            25.4            0.583
## 234                                     0          0            35.0            0.394
## 235                                    28         45            29.7            0.293
## 236                                     0          0            43.6            0.479
## 237                                    21        192            35.9            0.586
## 238                                    27          0            44.1            0.686
## 239                                    21          0            30.8            0.831
## 240                                     0          0            18.4            0.582
## 241                                    24          0            29.2            0.192
## 242                                    32         88            33.1            0.446
## 243                                     0          0            25.6            0.402
## 244                                    22        176            27.1            1.318
## 245                                    35        194            38.2            0.329
## 246                                    15          0            30.0            1.213
## 247                                     0          0            31.2            0.258
## 248                                    33        680            52.3            0.427
## 249                                    33        402            35.4            0.282
## 250                                    19          0            30.1            0.143
## 251                                     0          0            31.2            0.380
## 252                                     0          0            28.0            0.284
## 253                                    14         55            24.4            0.249
## 254                                    32          0            35.8            0.238
## 255                                     7        258            27.6            0.926
## 256                                    35          0            33.6            0.543
## 257                                    39          0            30.1            0.557
## 258                                    22          0            28.7            0.092
## 259                                    16        375            25.9            0.655
## 260                                    28        150            33.3            1.353
## 261                                    15        130            30.9            0.299
## 262                                     0          0            30.0            0.761
## 263                                    32          0            32.1            0.612
## 264                                    15          0            32.4            0.200
## 265                                     0          0            32.0            0.226
## 266                                    18         67            33.6            0.997
## 267                                     0          0            36.3            0.933
```

```
## 268                    42          0         40.0          1.101
## 269                     0          0         25.1          0.078
## 270                     0          0         27.5          0.240
## 271                    37          0         45.6          1.136
## 272                    32         56         25.2          0.128
## 273                     0          0         23.0          0.254
## 274                    50         45         33.2          0.422
## 275                     0          0         34.2          0.251
## 276                    52         57         40.5          0.677
## 277                    24          0         26.5          0.296
## 278                    23        116         27.8          0.454
## 279                     0          0         24.9          0.744
## 280                    10        278         25.3          0.881
## 281                     0          0         37.9          0.334
## 282                    28        122         35.9          0.280
## 283                    15        155         32.4          0.262
## 284                     0          0         30.4          0.165
## 285                     0          0         27.0          0.259
## 286                    26        135         26.0          0.647
## 287                    44        545         38.7          0.619
## 288                    39        220         45.6          0.808
## 289                    17         49         20.8          0.340
## 290                    43         75         36.1          0.263
## 291                    29         40         36.9          0.434
## 292                    30         74         36.6          0.757
## 293                    37        182         43.3          1.224
## 294                    45        194         40.5          0.613
## 295                     0          0         21.9          0.254
## 296                    31        120         35.5          0.692
## 297                    38        360         28.0          0.337
## 298                    29        215         30.7          0.520
## 299                    25        184         36.6          0.412
## 300                     0          0         23.6          0.840
## 301                     0          0         32.3          0.839
## 302                    33        135         31.6          0.422
## 303                    41         42         35.8          0.156
## 304                     0          0         52.9          0.209
## 305                     0          0         21.0          0.207
## 306                    37        105         39.7          0.215
## 307                    23        132         25.5          0.326
## 308                    14        148         24.8          0.143
## 309                    19        180         30.5          1.391
## 310                    28        205         32.9          0.875
## 311                    30          0         26.2          0.313
## 312                    37        148         39.4          0.605
## 313                    17         96         26.6          0.433
## 314                    10         85         29.5          0.626
## 315                    31          0         35.9          1.127
## 316                    22         94         34.1          0.315
```

```
## 317                                  11          64          19.3          0.284
## 318                                   0           0          30.5          0.345
## 319                                  39         140          38.1          0.150
## 320                                   0           0          23.5          0.129
## 321                                  12         231          27.5          0.527
## 322                                  30           0          31.6          0.197
## 323                                  20           0          27.4          0.254
## 324                                  33          29          26.8          0.731
## 325                                  32           0          35.7          0.148
## 326                                  21         168          25.6          0.123
## 327                                  32         156          35.1          0.692
## 328                                   0           0          35.1          0.200
## 329                                  36         120          45.5          0.127
## 330                                  32          68          30.8          0.122
## 331                                  19           0          23.1          1.476
## 332                                  16          52          32.7          0.166
## 333                                   0           0          43.3          0.282
## 334                                   0           0          23.6          0.137
## 335                                  18          58          23.9          0.260
## 336                                  43         255          47.9          0.259
## 337                                   0           0          33.8          0.932
## 338                                   0           0          31.2          0.343
## 339                                  34         171          34.2          0.893
## 340                                   0           0          39.9          0.331
## 341                                  13         105          25.9          0.472
## 342                                  21          73          25.9          0.673
## 343                                  35           0          32.0          0.389
## 344                                   0           0          34.7          0.290
## 345                                   0           0          36.8          0.485
## 346                                  36         108          38.5          0.349
## 347                                  19          83          28.7          0.654
## 348                                   0           0          23.5          0.187
## 349                                  19          74          21.8          0.279
## 350                                  32           0          41.0          0.346
## 351                                   0           0          42.2          0.237
## 352                                   0           0          31.2          0.252
## 353                                  28           0          34.4          0.243
## 354                                  12          43          27.2          0.580
## 355                                   0           0          42.7          0.559
## 356                                   0           0          30.4          0.302
## 357                                  40         167          33.3          0.962
## 358                                  30           0          39.9          0.569
## 359                                  40          54          35.3          0.378
## 360                                  36         249          36.5          0.875
## 361                                  33         325          31.2          0.583
## 362                                   0           0          29.8          0.207
## 363                                  37           0          39.2          0.305
## 364                                   0           0          38.5          0.520
## 365                                  25         293          34.9          0.385
```

```
## 366                        28          83          34.0          0.499
## 367                         0           0          27.6          0.368
## 368                        17           0          21.0          0.252
## 369                        16          66          27.5          0.306
## 370                        28         140          32.8          0.234
## 371                        48         465          38.4          2.137
## 372                        23          89           0.0          1.731
## 373                        22          66          35.8          0.545
## 374                        40          94          34.9          0.225
## 375                        43         158          36.2          0.816
## 376                        43         325          39.2          0.528
## 377                        15          84          25.2          0.299
## 378                        37          75          37.2          0.509
## 379                         0           0          48.3          0.238
## 380                        39          72          43.4          1.021
## 381                        30          82          30.8          0.821
## 382                        22           0          20.0          0.236
## 383                         8         182          25.4          0.947
## 384                        18          59          25.1          1.268
## 385                        24         110          24.3          0.221
## 386                        13          50          22.3          0.205
## 387                        29           0          32.3          0.660
## 388                        36           0          43.3          0.239
## 389                        26         285          32.0          0.452
## 390                        23          81          31.6          0.949
## 391                        29         196          32.0          0.444
## 392                         0           0          45.7          0.340
## 393                        14         415          23.7          0.389
## 394                        12          87          22.1          0.463
## 395                         0           0          32.9          0.803
## 396                        24         275          27.7          1.600
## 397                        34         115          24.7          0.944
## 398                        40           0          34.3          0.196
## 399                         0           0          21.1          0.389
## 400                        31           0          34.9          0.241
## 401                         0           0          32.0          0.161
## 402                         0           0          24.2          0.151
## 403                        41          88          35.0          0.286
## 404                        25           0          31.6          0.280
## 405                         0           0          32.9          0.135
## 406                        32         165          42.1          0.520
## 407                         0           0          28.9          0.376
## 408                         0           0          21.9          0.336
## 409                         0           0          25.9          1.191
## 410                        49         579          42.4          0.702
## 411                        39           0          35.7          0.674
## 412                        30         176          34.4          0.528
## 413                        23         310          42.4          1.076
## 414                        22          61          26.2          0.256
```

```
## 415                                            35              167              34.6                0.534
## 416                                            33              474              35.7                0.258
## 417                                            21                0              27.2                1.095
## 418                                            32                0              38.5                0.554
## 419                                             0                0              18.2                0.624
## 420                                            29              115              26.4                0.219
## 421                                            41              170              45.3                0.507
## 422                                            18               76              26.0                0.561
## 423                                            46               78              40.6                0.496
## 424                                            22                0              30.8                0.421
## 425                                            32              210              42.9                0.516
## 426                                            39              277              37.0                0.264
## 427                                             0                0               0.0                0.256
## 428                                            30              180              34.1                0.328
## 429                                            46              145              40.6                0.284
## 430                                            25              180              35.0                0.233
## 431                                             0                0              22.2                0.108
## 432                                            16               85              30.4                0.551
## 433                                            11               60              30.0                0.527
## 434                                             0                0              25.6                0.167
## 435                                             8                0              24.5                1.138
## 436                                             0                0              42.4                0.205
## 437                                            33                0              37.4                0.244
## 438                                             0                0              29.9                0.434
## 439                                            15                0              18.2                0.147
## 440                                             0                0              36.8                0.727
## 441                                            25                0              34.3                0.435
## 442                                            23               50              32.2                0.497
## 443                                            27              120              33.2                0.230
## 444                                             0                0              30.5                0.955
## 445                                            12                0              29.7                0.380
## 446                                            63               14              59.4                2.420
## 447                                            12               70              25.3                0.658
## 448                                            45               92              36.5                0.330
## 449                                            37               64              33.6                0.510
## 450                                            18               63              30.5                0.285
## 451                                            13               95              21.2                0.415
## 452                                             0                0              28.9                0.542
## 453                                            32              210              39.9                0.381
## 454                                             0                0              19.6                0.832
## 455                                            28              105              37.8                0.498
## 456                                            30                0              33.6                0.212
## 457                                             0                0              26.7                0.687
## 458                                            28               71              30.2                0.364
## 459                                            48              237              37.6                1.001
## 460                                            33               60              25.9                0.460
## 461                                            22               56              20.8                0.733
## 462                                             0                0              21.8                0.416
## 463                                            40               49              35.3                0.705
```

```
## 464                          30          0          27.6            0.258
## 465                           0          0          24.0            1.022
## 466                          13        105          21.8            0.452
## 467                          10         36          27.8            0.269
## 468                          36        100          36.8            0.600
## 469                           0          0          30.0            0.183
## 470                          41        140          46.1            0.571
## 471                          40          0          41.3            0.607
## 472                          38          0          33.2            0.170
## 473                          27          0          38.8            0.259
## 474                           0          0          29.9            0.210
## 475                           0          0          28.9            0.126
## 476                          27          0          27.3            0.231
## 477                          45        191          33.7            0.711
## 478                          17        110          23.8            0.466
## 479                          38         75          25.9            0.162
## 480                          31          0          28.0            0.419
## 481                          30        328          35.5            0.344
## 482                          37          0          35.2            0.197
## 483                          22         49          27.8            0.306
## 484                          31        125          38.2            0.233
## 485                           0          0          44.2            0.630
## 486                          42        250          42.3            0.365
## 487                          41        480          40.7            0.536
## 488                          32        265          46.5            1.159
## 489                          17          0          25.6            0.294
## 490                           0          0          26.1            0.551
## 491                          28         66          36.8            0.629
## 492                          30          0          33.5            0.292
## 493                          38          0          32.8            0.145
## 494                          18        122          28.9            1.144
## 495                           0          0           0.0            0.174
## 496                           0          0          26.6            0.304
## 497                           0          0          26.0            0.292
## 498                          15         76          30.1            0.547
## 499                          33        145          25.1            0.163
## 500                          32        193          29.3            0.839
## 501                          19         71          25.2            0.313
## 502                          32          0          37.2            0.267
## 503                          41          0          39.0            0.727
## 504                          25         79          33.3            0.738
## 505                          39          0          37.3            0.238
## 506                           0          0          33.3            0.263
## 507                          26         90          36.5            0.314
## 508                          23        170          28.6            0.692
## 509                          23         76          30.4            0.968
## 510                           0          0          25.0            0.409
## 511                          31          0          29.7            0.297
## 512                          17        210          22.1            0.207
```

```
## 513                                0           0           24.2              0.200
## 514                                0           0           27.3              0.525
## 515                               19          86           25.6              0.154
## 516                               18         105           31.6              0.268
## 517                               34         165           30.3              0.771
## 518                                0           0           37.6              0.304
## 519                                0           0           32.8              0.180
## 520                                7         326           19.6              0.582
## 521                               32          66           25.0              0.187
## 522                               33         130           33.2              0.305
## 523                                0           0            0.0              0.189
## 524                                0           0           34.2              0.652
## 525                                0           0           31.6              0.151
## 526                               18           0           21.8              0.444
## 527                               19          82           18.2              0.299
## 528                               15         105           26.3              0.107
## 529                               31         188           30.8              0.493
## 530                                0           0           24.6              0.660
## 531                               18         106           29.8              0.717
## 532                                0           0           45.3              0.686
## 533                               52          65           41.3              0.917
## 534                                0           0           29.8              0.501
## 535                               30          56           33.3              1.251
## 536                                0           0           32.9              0.302
## 537                                0           0           29.6              0.197
## 538                                0           0           21.7              0.735
## 539                               37         210           36.3              0.804
## 540                               49         155           36.4              0.968
## 541                               40         215           39.4              0.661
## 542                               25         190           32.4              0.549
## 543                               32           0           34.9              0.825
## 544                               23          56           39.5              0.159
## 545                               29          76           32.0              0.365
## 546                               35         225           34.5              0.423
## 547                               27         207           43.6              1.034
## 548                               21         166           33.1              0.160
## 549                               43          67           32.8              0.341
## 550                               31           0           28.5              0.680
## 551                               28           0           27.4              0.204
## 552                               30         106           31.9              0.591
## 553                                0           0           27.8              0.247
## 554                               24          44           29.9              0.422
## 555                               23         115           36.9              0.471
## 556                               33         215           25.5              0.161
## 557                               40           0           38.1              0.218
## 558                                0           0           27.8              0.237
## 559                               40           0           46.2              0.126
## 560                                0           0           30.1              0.300
## 561                                0           0           33.8              0.121
```

```
## 562                          32          274          41.3          0.502
## 563                          34           77          37.6          0.401
## 564                          19           54          26.9          0.497
## 565                           0            0          32.4          0.601
## 566                          14           88          26.1          0.748
## 567                          30           18          38.6          0.412
## 568                          32          126          32.0          0.085
## 569                          29          126          31.3          0.338
## 570                          30          165          34.3          0.203
## 571                           0            0          32.5          0.270
## 572                           0            0          22.6          0.268
## 573                          31           44          29.5          0.430
## 574                          17          120          34.7          0.198
## 575                          30          330          30.1          0.892
## 576                          47           63          35.5          0.280
## 577                          20          130          24.0          0.813
## 578                           0            0          42.9          0.693
## 579                           0            0          27.0          0.245
## 580                          99            0          34.7          0.575
## 581                          46            0          42.1          0.371
## 582                          27            0          25.0          0.206
## 583                          17            0          26.5          0.259
## 584                           0            0          38.7          0.190
## 585                          24          600          28.7          0.687
## 586                          11            0          22.5          0.417
## 587                           0            0          34.9          0.129
## 588                           0            0          24.3          0.249
## 589                          27          156          33.3          1.154
## 590                           0            0          21.1          0.342
## 591                          40            0          46.8          0.925
## 592                          50          140          39.4          0.175
## 593                           0            0          34.4          0.402
## 594                          22          115          28.5          1.699
## 595                          45          230          33.6          0.733
## 596                          14          185          32.0          0.682
## 597                           0            0          45.3          0.194
## 598                          19           25          27.8          0.559
## 599                           0            0          36.8          0.088
## 600                          18          120          23.1          0.407
## 601                          19            0          27.1          0.400
## 602                           0            0          23.7          0.190
## 603                          36            0          27.8          0.100
## 604                          29          126          35.2          0.692
## 605                           0            0          28.4          0.212
## 606                          32            0          35.8          0.514
## 607                          42          293          40.0          1.258
## 608                          25           41          19.5          0.482
## 609                          39          272          41.5          0.270
## 610                          13          182          24.0          0.138
```

```
## 611                21    158    30.9    0.292
## 612                22    194    32.9    0.593
## 613                42    321    38.2    0.787
## 614                28      0    32.5    0.878
## 615                26    144    36.1    0.557
## 616                 0      0    25.8    0.207
## 617                 0      0    28.7    0.157
## 618                13     15    20.1    0.257
## 619                24      0    28.2    1.282
## 620                 0      0    32.4    0.141
## 621                42    160    38.4    0.246
## 622                20      0    24.2    1.698
## 623                 0      0    40.8    1.461
## 624                27    115    43.5    0.347
## 625                 0      0    30.8    0.158
## 626                47     54    37.7    0.362
## 627                 0      0    24.7    0.206
## 628                 0      0    32.4    0.393
## 629                 0      0    34.6    0.144
## 630                22      0    24.7    0.148
## 631                 0      0    27.4    0.732
## 632                40     90    34.5    0.238
## 633                 0      0    26.2    0.343
## 634                17    183    27.5    0.115
## 635                 0      0    25.9    0.167
## 636                 0      0    31.2    0.465
## 637                 0      0    28.8    0.153
## 638                18     66    31.6    0.649
## 639                32     91    40.9    0.871
## 640                12     46    19.5    0.149
## 641                17    105    29.3    0.695
## 642                 0      0    34.3    0.303
## 643                 0      0    29.5    0.178
## 644                 0      0    28.0    0.610
## 645                30    152    27.6    0.730
## 646                35    440    39.4    0.134
## 647                17    144    23.4    0.447
## 648                36    159    37.8    0.455
## 649                35    130    28.3    0.260
## 650                25      0    26.4    0.133
## 651                25    100    25.2    0.234
## 652                23    106    33.8    0.466
## 653                40     77    34.1    0.269
## 654                 0      0    26.8    0.455
## 655                28    135    34.2    0.142
## 656                27    540    38.7    0.240
## 657                35     90    21.8    0.155
## 658                48    200    38.9    1.162
## 659                 0      0    39.0    0.190
```

```
## 660                                31         70         34.2        1.292
## 661                                 0          0         27.7        0.182
## 662                                43          0         42.9        1.394
## 663                                46        231         37.6        0.165
## 664                                46        130         37.9        0.637
## 665                                39          0         33.7        0.245
## 666                                45        132         34.8        0.217
## 667                                18          0         32.5        0.235
## 668                                27          0         27.5        0.141
## 669                                33        190         34.0        0.430
## 670                                30        100         30.9        0.164
## 671                                26        168         33.6        0.631
## 672                                10          0         25.4        0.551
## 673                                23         49         35.5        0.285
## 674                                35        240         57.3        0.880
## 675                                 0          0         35.6        0.587
## 676                                 0          0         30.9        0.328
## 677                                 0          0         24.8        0.230
## 678                                 0          0         35.3        0.263
## 679                                 0          0         36.0        0.127
## 680                                17        265         24.2        0.614
## 681                                28         45         24.2        0.332
## 682                                36          0         49.6        0.364
## 683                                39        105         44.6        0.366
## 684                                 0          0         32.3        0.536
## 685                                 0          0          0.0        0.640
## 686                                26        205         33.2        0.591
## 687                                 0          0         23.1        0.314
## 688                                19          0         28.3        0.181
## 689                                26        180         24.1        0.828
## 690                                46        180         46.1        0.335
## 691                                 0          0         24.6        0.856
## 692                                 0          0         42.3        0.257
## 693                                32         95         39.1        0.886
## 694                                49        125         38.5        0.439
## 695                                 0          0         23.5        0.191
## 696                                24        480         30.4        0.128
## 697                                19        125         29.9        0.268
## 698                                 0          0         25.0        0.253
## 699                                11        155         34.5        0.598
## 700                                 0          0         44.5        0.904
## 701                                27        200         35.9        0.483
## 702                                31          0         27.6        0.565
## 703                                29          0         35.0        0.905
## 704                                 0          0         38.5        0.304
## 705                                20        100         28.4        0.118
## 706                                36          0         39.8        0.177
## 707                                 0          0          0.0        0.261
## 708                                21        335         34.4        0.176
```

```
## 709                               0          0          32.8          0.148
## 710                              32        160          38.0          0.674
## 711                              13        387          31.2          0.295
## 712                              27         22          29.6          0.439
## 713                              36          0          41.2          0.441
## 714                              20        291          26.4          0.352
## 715                               0          0          29.5          0.121
## 716                              33        392          33.9          0.826
## 717                              39        185          33.8          0.970
## 718                              18          0          23.1          0.595
## 719                              46        178          35.5          0.415
## 720                              27          0          35.6          0.378
## 721                              19          0          29.3          0.317
## 722                              36        200          38.1          0.289
## 723                              29        127          29.3          0.349
## 724                              30        105          39.1          0.251
## 725                               0          0          32.8          0.265
## 726                              40          0          39.4          0.236
## 727                              29        180          36.1          0.496
## 728                              26          0          32.4          0.433
## 729                               0          0          22.9          0.326
## 730                               0          0          30.1          0.141
## 731                              23         79          28.4          0.323
## 732                               0          0          28.4          0.259
## 733                              37        120          44.5          0.646
## 734                              27        165          29.0          0.426
## 735                               0          0          23.3          0.560
## 736                              32          0          35.4          0.284
## 737                              27        120          27.4          0.515
## 738                              23          0          32.0          0.600
## 739                              17        160          36.6          0.453
## 740                               0          0          39.5          0.293
## 741                              37        150          42.3          0.785
## 742                              20         94          30.8          0.400
## 743                              18        116          28.5          0.219
## 744                               0          0          32.7          0.734
## 745                              37        140          40.6          1.174
## 746                              33        105          30.0          0.488
## 747                              41          0          49.3          0.358
## 748                              41         57          46.3          1.096
## 749                              22        200          36.4          0.408
## 750                               0          0          24.3          0.178
## 751                               0          0          31.2          1.182
## 752                              39         74          39.0          0.261
## 753                              24          0          26.0          0.223
## 754                              44        510          43.3          0.222
## 755                              32          0          32.4          0.443
## 756                              39        110          36.5          1.057
## 757                              41          0          32.0          0.391
```

```
## 758                          0           0          36.3            0.258
## 759                          0           0          37.5            0.197
## 760                          0           0          35.5            0.278
## 761                         26          16          28.4            0.766
## 762                         31           0          44.0            0.403
## 763                          0           0          22.5            0.142
## 764                         48         180          32.9            0.171
## 765                         27           0          36.8            0.340
## 766                         23         112          26.2            0.245
## 767                          0           0          30.1            0.349
## 768                         31           0          30.4            0.315
##     age diabetes
## 1    50      yes
## 2    31       no
## 3    32      yes
## 4    21       no
## 5    33      yes
## 6    30       no
## 7    26      yes
## 8    29       no
## 9    53      yes
## 10   54      yes
## 11   30       no
## 12   34      yes
## 13   57       no
## 14   59      yes
## 15   51      yes
## 16   32      yes
## 17   31      yes
## 18   31      yes
## 19   33       no
## 20   32      yes
## 21   27       no
## 22   50       no
## 23   41      yes
## 24   29      yes
## 25   51      yes
## 26   41      yes
## 27   43      yes
## 28   22       no
## 29   57       no
## 30   38       no
## 31   60       no
## 32   28      yes
## 33   22       no
## 34   28       no
## 35   45       no
## 36   33       no
## 37   35       no
```

```
## 38   46        yes
## 39   27        yes
## 40   56        yes
## 41   26         no
## 42   37         no
## 43   48         no
## 44   54        yes
## 45   40         no
## 46   25        yes
## 47   29         no
## 48   22         no
## 49   31        yes
## 50   24         no
## 51   22         no
## 52   26         no
## 53   30         no
## 54   58        yes
## 55   42         no
## 56   21         no
## 57   41        yes
## 58   31         no
## 59   44         no
## 60   22         no
## 61   21         no
## 62   39        yes
## 63   36         no
## 64   24         no
## 65   42        yes
## 66   32         no
## 67   38        yes
## 68   54         no
## 69   25         no
## 70   27         no
## 71   28        yes
## 72   26         no
## 73   42        yes
## 74   23         no
## 75   22         no
## 76   22         no
## 77   41         no
## 78   27         no
## 79   26        yes
## 80   24         no
## 81   22         no
## 82   22         no
## 83   36         no
## 84   22         no
## 85   37        yes
## 86   27         no
```

```
## 87   45        no
## 88   26        no
## 89   43       yes
## 90   24        no
## 91   21        no
## 92   34        no
## 93   42        no
## 94   60       yes
## 95   21        no
## 96   40        no
## 97   24        no
## 98   22        no
## 99   23        no
## 100  31       yes
## 101  33       yes
## 102  22        no
## 103  21        no
## 104  24        no
## 105  27        no
## 106  21        no
## 107  27        no
## 108  37        no
## 109  25        no
## 110  24       yes
## 111  24       yes
## 112  46       yes
## 113  23        no
## 114  25        no
## 115  39       yes
## 116  61       yes
## 117  38       yes
## 118  25        no
## 119  22        no
## 120  21        no
## 121  25       yes
## 122  24        no
## 123  23        no
## 124  69        no
## 125  23       yes
## 126  26       yes
## 127  30        no
## 128  23        no
## 129  40       yes
## 130  62       yes
## 131  33       yes
## 132  33       yes
## 133  30       yes
## 134  39        no
## 135  26        no
```

```
## 136  31        no
## 137  21        no
## 138  22        no
## 139  29        no
## 140  28        no
## 141  55        no
## 142  38        no
## 143  22        no
## 144  42       yes
## 145  23        no
## 146  21        no
## 147  41        no
## 148  34        no
## 149  65        no
## 150  22        no
## 151  24        no
## 152  37        no
## 153  42       yes
## 154  23        no
## 155  43       yes
## 156  36       yes
## 157  21        no
## 158  23        no
## 159  22        no
## 160  47       yes
## 161  36        no
## 162  45        no
## 163  27        no
## 164  21        no
## 165  32       yes
## 166  41       yes
## 167  22        no
## 168  34        no
## 169  29        no
## 170  29        no
## 171  36       yes
## 172  29       yes
## 173  25        no
## 174  23        no
## 175  33        no
## 176  36       yes
## 177  42        no
## 178  26       yes
## 179  47        no
## 180  37       yes
## 181  32        no
## 182  23        no
## 183  21        no
## 184  27        no
```

```
## 185   40         no
## 186   41        yes
## 187   60        yes
## 188   33        yes
## 189   31        yes
## 190   25        yes
## 191   21         no
## 192   40         no
## 193   36        yes
## 194   40        yes
## 195   42         no
## 196   29        yes
## 197   21         no
## 198   23        yes
## 199   26        yes
## 200   29        yes
## 201   21         no
## 202   28         no
## 203   32         no
## 204   27         no
## 205   55         no
## 206   27         no
## 207   57        yes
## 208   52        yes
## 209   21         no
## 210   41        yes
## 211   25         no
## 212   24         no
## 213   60         no
## 214   24        yes
## 215   36        yes
## 216   38        yes
## 217   25        yes
## 218   32         no
## 219   32        yes
## 220   41        yes
## 221   21        yes
## 222   66        yes
## 223   37         no
## 224   61         no
## 225   26         no
## 226   22         no
## 227   26         no
## 228   24        yes
## 229   31         no
## 230   24         no
## 231   22        yes
## 232   46        yes
## 233   22         no
```

```
## 234  29         no
## 235  23         no
## 236  26        yes
## 237  51        yes
## 238  23        yes
## 239  32        yes
## 240  27         no
## 241  21         no
## 242  22         no
## 243  22        yes
## 244  33        yes
## 245  29         no
## 246  49        yes
## 247  41         no
## 248  23         no
## 249  34         no
## 250  23         no
## 251  42         no
## 252  27         no
## 253  24         no
## 254  25         no
## 255  44        yes
## 256  21        yes
## 257  30         no
## 258  25         no
## 259  24         no
## 260  51        yes
## 261  34         no
## 262  27        yes
## 263  24         no
## 264  63         no
## 265  35        yes
## 266  43         no
## 267  25        yes
## 268  24         no
## 269  21         no
## 270  28        yes
## 271  38        yes
## 272  21         no
## 273  40         no
## 274  21         no
## 275  52         no
## 276  25         no
## 277  29        yes
## 278  23         no
## 279  57         no
## 280  22         no
## 281  28        yes
## 282  39         no
```

```
## 283   37          no
## 284   47         yes
## 285   52         yes
## 286   51          no
## 287   34          no
## 288   29         yes
## 289   26          no
## 290   33          no
## 291   21          no
## 292   25         yes
## 293   31         yes
## 294   24         yes
## 295   65          no
## 296   28          no
## 297   29         yes
## 298   24          no
## 299   46         yes
## 300   58          no
## 301   30         yes
## 302   25         yes
## 303   35          no
## 304   28         yes
## 305   37          no
## 306   29          no
## 307   47         yes
## 308   21          no
## 309   25         yes
## 310   30         yes
## 311   41          no
## 312   22          no
## 313   27         yes
## 314   25          no
## 315   43         yes
## 316   26          no
## 317   30          no
## 318   29         yes
## 319   28          no
## 320   59         yes
## 321   31          no
## 322   25         yes
## 323   36         yes
## 324   43         yes
## 325   21          no
## 326   24          no
## 327   30         yes
## 328   37          no
## 329   23         yes
## 330   37          no
## 331   46          no
```

```
## 332  25         no
## 333  41        yes
## 334  44         no
## 335  22         no
## 336  26         no
## 337  44         no
## 338  44        yes
## 339  33        yes
## 340  41        yes
## 341  22         no
## 342  36         no
## 343  22         no
## 344  33         no
## 345  57         no
## 346  49         no
## 347  22         no
## 348  23         no
## 349  26         no
## 350  37        yes
## 351  29         no
## 352  30         no
## 353  46         no
## 354  24         no
## 355  21         no
## 356  49        yes
## 357  28        yes
## 358  44        yes
## 359  48         no
## 360  29        yes
## 361  29        yes
## 362  63         no
## 363  65         no
## 364  67        yes
## 365  30         no
## 366  30         no
## 367  29        yes
## 368  21         no
## 369  22         no
## 370  45        yes
## 371  25        yes
## 372  21         no
## 373  21         no
## 374  25         no
## 375  28         no
## 376  58        yes
## 377  22         no
## 378  22         no
## 379  32        yes
## 380  35         no
```

```
## 381  24        no
## 382  22        no
## 383  21        no
## 384  25        no
## 385  25        no
## 386  24        no
## 387  35       yes
## 388  45       yes
## 389  58       yes
## 390  28        no
## 391  42        no
## 392  27       yes
## 393  21        no
## 394  37        no
## 395  31       yes
## 396  25        no
## 397  39        no
## 398  22       yes
## 399  25        no
## 400  25       yes
## 401  31       yes
## 402  55        no
## 403  35       yes
## 404  38        no
## 405  41       yes
## 406  26        no
## 407  46       yes
## 408  25        no
## 409  39       yes
## 410  28       yes
## 411  28        no
## 412  25        no
## 413  22        no
## 414  21        no
## 415  21       yes
## 416  22       yes
## 417  22        no
## 418  37       yes
## 419  27        no
## 420  28       yes
## 421  26        no
## 422  21        no
## 423  21        no
## 424  21        no
## 425  36       yes
## 426  31       yes
## 427  25        no
## 428  38       yes
## 429  26        no
```

```
## 430  43        yes
## 431  23         no
## 432  38         no
## 433  22         no
## 434  29         no
## 435  36         no
## 436  29        yes
## 437  41         no
## 438  28         no
## 439  21         no
## 440  31         no
## 441  41        yes
## 442  22         no
## 443  24         no
## 444  33        yes
## 445  30        yes
## 446  25        yes
## 447  28         no
## 448  26         no
## 449  22        yes
## 450  26         no
## 451  23         no
## 452  23        yes
## 453  25         no
## 454  72         no
## 455  24         no
## 456  38        yes
## 457  62         no
## 458  24         no
## 459  51        yes
## 460  81         no
## 461  48         no
## 462  26         no
## 463  39         no
## 464  37         no
## 465  34         no
## 466  21         no
## 467  22         no
## 468  25         no
## 469  38        yes
## 470  27         no
## 471  28         no
## 472  22         no
## 473  22         no
## 474  50         no
## 475  24         no
## 476  59         no
## 477  29        yes
## 478  31         no
```

```
## 479   39          no
## 480   63          no
## 481   35         yes
## 482   29          no
## 483   28          no
## 484   23          no
## 485   31         yes
## 486   24         yes
## 487   21          no
## 488   58          no
## 489   28          no
## 490   67          no
## 491   24          no
## 492   42          no
## 493   33          no
## 494   45         yes
## 495   22          no
## 496   66          no
## 497   30          no
## 498   25          no
## 499   55         yes
## 500   39          no
## 501   21          no
## 502   28          no
## 503   41         yes
## 504   41          no
## 505   40          no
## 506   38          no
## 507   35         yes
## 508   21          no
## 509   21          no
## 510   64          no
## 511   46         yes
## 512   21          no
## 513   58          no
## 514   22          no
## 515   24          no
## 516   28         yes
## 517   53         yes
## 518   51          no
## 519   41          no
## 520   60          no
## 521   25          no
## 522   26          no
## 523   26          no
## 524   45         yes
## 525   24          no
## 526   21          no
## 527   21          no
```

```
## 528  24         no
## 529  22         no
## 530  31         no
## 531  22         no
## 532  24         no
## 533  29         no
## 534  31         no
## 535  24         no
## 536  23        yes
## 537  46         no
## 538  67         no
## 539  23         no
## 540  32        yes
## 541  43        yes
## 542  27        yes
## 543  56        yes
## 544  25         no
## 545  29         no
## 546  37        yes
## 547  53        yes
## 548  28         no
## 549  50         no
## 550  37         no
## 551  21         no
## 552  25         no
## 553  66         no
## 554  23         no
## 555  28         no
## 556  37         no
## 557  30         no
## 558  58         no
## 559  42         no
## 560  35         no
## 561  54        yes
## 562  28        yes
## 563  24         no
## 564  32         no
## 565  27         no
## 566  22         no
## 567  21         no
## 568  46         no
## 569  37         no
## 570  33        yes
## 571  39         no
## 572  21         no
## 573  22         no
## 574  22         no
## 575  23         no
## 576  25         no
```

```
## 577  35         no
## 578  21        yes
## 579  36         no
## 580  62        yes
## 581  21        yes
## 582  27         no
## 583  62         no
## 584  42         no
## 585  52        yes
## 586  22         no
## 587  41        yes
## 588  29         no
## 589  52        yes
## 590  25         no
## 591  45        yes
## 592  24         no
## 593  44        yes
## 594  25         no
## 595  34         no
## 596  22        yes
## 597  46         no
## 598  21         no
## 599  38        yes
## 600  26         no
## 601  24         no
## 602  28         no
## 603  30         no
## 604  54        yes
## 605  36        yes
## 606  21         no
## 607  22        yes
## 608  25         no
## 609  27         no
## 610  23         no
## 611  24         no
## 612  36        yes
## 613  40        yes
## 614  26         no
## 615  50        yes
## 616  27         no
## 617  30         no
## 618  23         no
## 619  50        yes
## 620  24        yes
## 621  28         no
## 622  28         no
## 623  45         no
## 624  21         no
## 625  21         no
```

```
## 626  29         no
## 627  21         no
## 628  21         no
## 629  45         no
## 630  21         no
## 631  34        yes
## 632  24         no
## 633  23         no
## 634  22         no
## 635  31         no
## 636  38        yes
## 637  48         no
## 638  23         no
## 639  32        yes
## 640  28         no
## 641  27         no
## 642  24         no
## 643  50        yes
## 644  31         no
## 645  27         no
## 646  30         no
## 647  33        yes
## 648  22        yes
## 649  42        yes
## 650  23         no
## 651  23         no
## 652  27         no
## 653  28         no
## 654  27         no
## 655  22         no
## 656  25        yes
## 657  22         no
## 658  41         no
## 659  51         no
## 660  27        yes
## 661  54         no
## 662  22        yes
## 663  43        yes
## 664  40        yes
## 665  40        yes
## 666  24         no
## 667  70        yes
## 668  40        yes
## 669  43         no
## 670  45         no
## 671  49         no
## 672  21         no
## 673  47         no
## 674  22         no
```

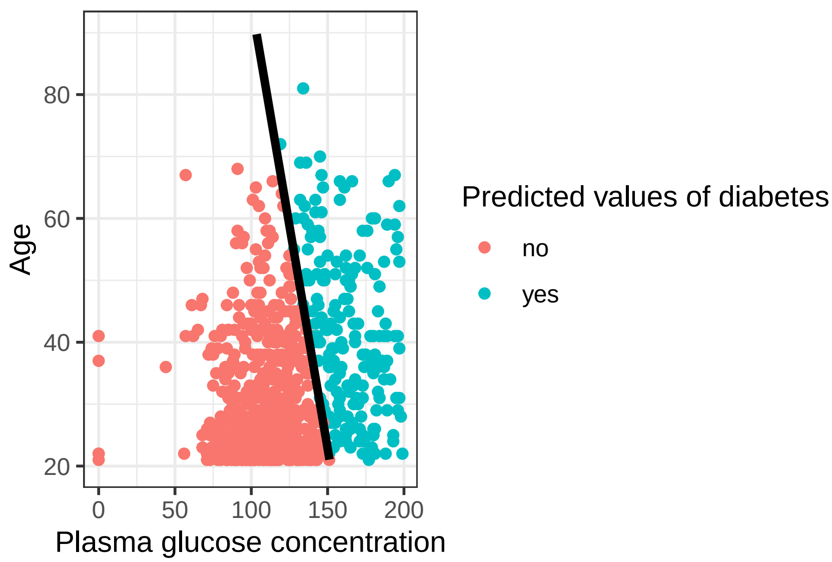
```
## 675  68        no
## 676  31       yes
## 677  53       yes
## 678  25        no
## 679  25       yes
## 680  23        no
## 681  22        no
## 682  26       yes
## 683  22        no
## 684  27       yes
## 685  69        no
## 686  25        no
## 687  22        no
## 688  29        no
## 689  23        no
## 690  46       yes
## 691  34        no
## 692  44       yes
## 693  23        no
## 694  43       yes
## 695  25        no
## 696  43       yes
## 697  31       yes
## 698  22        no
## 699  28        no
## 700  26        no
## 701  26        no
## 702  49       yes
## 703  52       yes
## 704  41        no
## 705  27        no
## 706  28        no
## 707  30       yes
## 708  22        no
## 709  45       yes
## 710  23       yes
## 711  24        no
## 712  40        no
## 713  38       yes
## 714  21        no
## 715  32        no
## 716  34       yes
## 717  31       yes
## 718  56        no
## 719  24        no
## 720  52       yes
## 721  34        no
## 722  21        no
## 723  42       yes
```

```
## 724  42        no
## 725  45        no
## 726  38        no
## 727  25        no
## 728  22        no
## 729  22        no
## 730  22        no
## 731  34       yes
## 732  22       yes
## 733  24       yes
## 734  22        no
## 735  53        no
## 736  28        no
## 737  21        no
## 738  42        no
## 739  21        no
## 740  42       yes
## 741  48       yes
## 742  26        no
## 743  22        no
## 744  45       yes
## 745  39        no
## 746  46        no
## 747  27       yes
## 748  32        no
## 749  36       yes
## 750  50       yes
## 751  22       yes
## 752  28        no
## 753  25        no
## 754  26       yes
## 755  45       yes
## 756  37       yes
## 757  39        no
## 758  52       yes
## 759  26        no
## 760  66       yes
## 761  22        no
## 762  43       yes
## 763  33        no
## 764  63        no
## 765  27        no
## 766  30        no
## 767  47       yes
## 768  23        no
```

```
 #coef(model)[1] + t(as.matrix(coef(model)[2:3])) %*% as.matrix(diabetes_df[,c("plasma_glucose_conc","ag

ggplot(diabetes_df_pred, aes(x = plasma_glucose_conc, y = age, color = pred)) +
```

```
  geom_point() +
  theme_bw() +
 stat_function(fun = ({function(x) (-coef(model)[1] - coef(model)[2]*x)/ coef(model)[3] }),
               size=1.5, color = "black") +
  ylim(20,90) +
  labs(colour = "Predicted values of diabetes",
       x = "Plasma glucose concentration",
       y = "Age")
```

```
## Warning: Removed 76 row(s) containing missing values (geom_path).
```



Question:

Comment whether the decision boundary seems to catch the data distribution well.

1.5 3.4

Question:

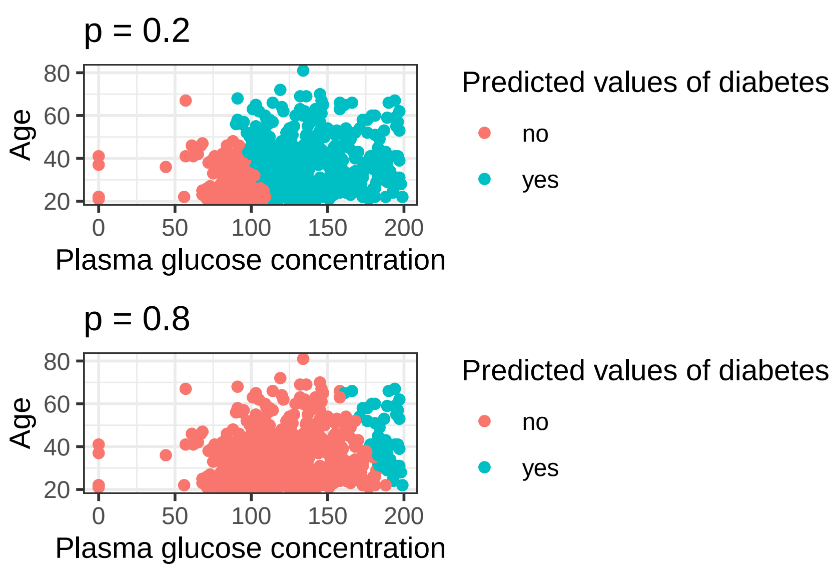
Make same kind of plots as in step 2 but use thresholds $r = 0.2$ and $r = 0.8$. By using these plots

```
library("ggpubr")
```

```
## Warning: package 'ggpubr' was built under R version 4.2.1
```

```
# Using 0.2 as the classification threshold
pred <- predict(model, newdata = diabetes_df, type = "response")
pred <- ifelse(pred > 0.2, "yes", "no")
diabetes_df_pred$pred <- pred
```

```r
p1 <- ggplot(diabetes_df_pred, aes(x = plasma_glucose_conc, y = age, color = pred)) +
      geom_point() +
      theme_bw() +
      labs(colour = "Predicted values of diabetes",
           x = "Plasma glucose concentration",
           y = "Age") +
      ggtitle("p = 0.2")


# Using 0.8 as the classification threshold
pred <- predict(model, newdata = diabetes_df, type = "response")
pred <- ifelse(pred > 0.8, "yes", "no")
diabetes_df_pred$pred <- pred


p2 <- ggplot(diabetes_df_pred, aes(x = plasma_glucose_conc, y = age, color = pred)) +
      geom_point() +
      theme_bw() +
      labs(colour = "Predicted values of diabetes",
           x = "Plasma glucose concentration",
           y = "Age") +
  ggtitle("p = 0.8")


ggarrange(p1, p2,  ncol = 1, nrow = 2)
```



Question:

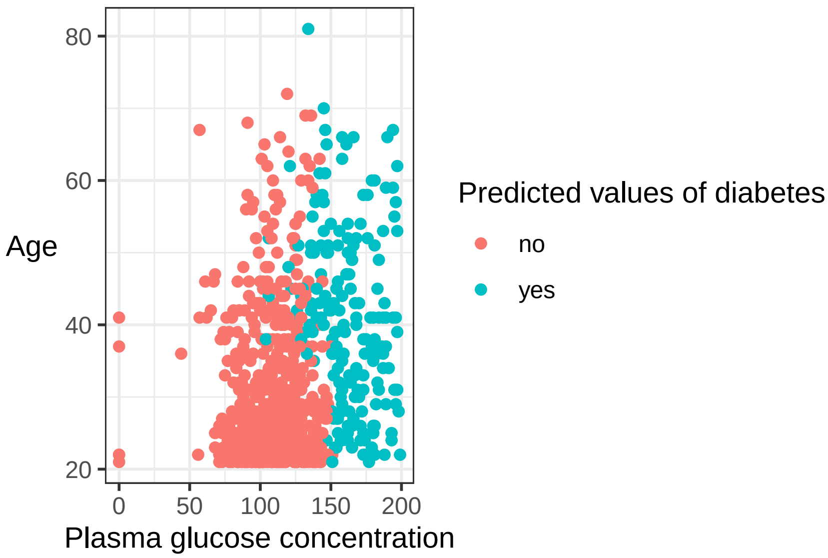
Comment on what happens with the prediction when r value changes.

1.6 3.5

Question:

Perform a basis function expansion trick by computing new features $z_1 = x_1^4$, $z_2 = x_1^3 x^2$, $z_3 = x_1^2 x_2^2$, $z_4 = x_1 x_2^3$, $z_5 = x_2^4$, adding them to the data set and then computing a logistic regression model with y as target and $x_1, x_2, z_1, ..., z_5$ as features. Create a scatterplot of the same kind as in step 2 for this model.

```
diabetes_df$z1  <- diabetes_df$times_pregnant^4
diabetes_df$z2  <- diabetes_df$times_pregnant^3 * diabetes_df$plasma_glucose_conc^2
diabetes_df$z3  <- diabetes_df$times_pregnant^2 * diabetes_df$plasma_glucose_conc^2
diabetes_df$z4  <- diabetes_df$times_pregnant * diabetes_df$plasma_glucose_conc^3
diabetes_df$z5  <- diabetes_df$plasma_glucose_conc^4


model <- glm(diabetes ~ plasma_glucose_conc + age + z1 + z2 + z3 + z4 + z5, data = diabetes_df,
             family =  "binomial")

pred <- predict(model, newdata = diabetes_df, type = "response")

# Using 0.5 as the classification threshold
pred <- ifelse(pred > 0.5, "yes", "no")

diabetes_df_pred <- diabetes_df
diabetes_df_pred$pred <- pred

ggplot(diabetes_df_pred, aes(x = plasma_glucose_conc, y = age, color = pred)) +
  geom_point() +
  theme_bw() +
  theme(axis.title.y = element_text(angle = 0,vjust = 0.5)) +
  labs(colour = "Predicted values of diabetes",
       x = "Plasma glucose concentration",
       y = "Age")
```



Question:

Compute the training misclassification rate. What can you say about the quality of this model compared to the previous logistic regression model? How have the basis expansion trick affected the shape of the decision boundary and the prediction accuracy?