UKBiobank Breast Cancer Analysis

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Contents

1 Breast Cancer, PRS, and Environmental Variables Summary

We first took unrelated female subjects from the UK Biobank study. Then we selected and derived 9 classical risk factors including age, parity, age at first birth, alcohol, height, BMI, age at menopause (for post-menopause women), age at menarche, and use of oral contraceptive pill. There was no information on breast cancer family history and so we did not include it into the mode. In addition, for post-menopause women, we included HRT use. We also included the top 10 PCs (code 22009). All the data was extracted from /dcl01/arking/data/UK_Biobank/static/Phenotype/Downloads/tab_delim/ukb45830.tab and /dcl01/arking/data/UK_Biobank/active/pheno/ukbPheno_032022.rds. Age at menopause was extracted from DNAnexus as it was not found in the above two files.

For breast cancer data, we used ICD9 (code 40013) and ICD10 (code 40006) in UK Biobank data. To find incident breast cancer data, we compared the age at cancer diagnosis (code 40008) with the age at recruitment. In particular, from previous publications, bilateral breast cancer and breast cancer in situ (stage 0 breast cancer) should be excluded from the study. There was no information on bilateral breast cancer and given that they are highly rare, we only excluded breast cancer in situ. For this work, we used incident breast cancer patients.

Next we selected geographical data and social economic data. The assessment centre at which a participant consented was assigned a numerical code (field 54 in the UK Biobank data). In analyses adjusted for

assessment centre, these codes were treated as factor variables. Participants who were born in the United Kingdom were asked to name their place of birth during a verbal interview at study assessment centres. These answers were used to derive approximate North and East co-ordinates (rounded values, recorded on a metre grid scale from an origin South-West of the UK, fields 129 and 130 in the UK Biobank data). Values less than zero were coded as missing for both variables (Haworth et al. Nature Communications 2019). We also selected education data and household-income to include in the study.

```
#For our analysis, select: 1. european; 2. post-menopause/pre-menopause; 3. age by category; 4. see the
dat0=dat0[which(dat0$race=="White"),]
table(dat0$breast_cancer)  # 0 is control; 1 is breast cancer; 2 is breast cancer in situ
```

```
##
##      0      1      2
## 193511  10681   1802
```

```
#add age by category
dat0$agegroups<-cut(dat0$age, breaks=c( 40, 50,60,70,80), right = FALSE)
table(dat0$oral.contraceptive.ever)
```

```
##
##     -1     -3      0      1
##    213    201  36372 169206
```

```
dat0$oral.contraceptive.ever[which(dat0$oral.contraceptive.ever=="-3" | dat0$oral.contraceptive.ever=="
dat0$age.start.oc[which(dat0$age.start.oc=="-3" | dat0$age.start.oc=="-1")]=NA
dat0$age.last.oc[which(dat0$age.last.oc=="-3" | dat0$age.last.oc=="-1")]=NA
dat0$oral.contraceptive.current=dat0$oral.contraceptive.ever
dat0$oral.contraceptive.current[which(dat0$age.last.oc=="-11")]="current"
dat0$oral.contraceptive.current[which(dat0$oral.contraceptive.current=="0")]="never"
dat0$oral.contraceptive.current[which(dat0$oral.contraceptive.current=="1")]="former"
dat0$age.last.oc[which(dat0$age.last.oc=="-11")]=dat0$age[which(dat0$age.last.oc=="-11")]
dat0$length.oc=as.numeric(as.character(dat0$age.last.oc))-as.numeric(as.character(dat0$age.start.oc))
dat0$length.oc[which(dat0$oral.contraceptive.ever==0)]=0
dat0$oc.cate=NA
dat0$oc.cate[which(dat0$oral.contraceptive.ever==0 | dat0$length.oc<10)]=0
dat0$oc.cate[which( dat0$length.oc>=10)]=1
table(dat0$menopause,dat0$breast_cancer)
```

```
##
##                      0      1      2
##   No             45964   1097    268
##   Yes           116965   7881   1289
##   Hysterectomy   22242   1144    198
```

```
table(dat0$menopause,dat0$breast_cancer,dat0$breast_cancer_incident)
```

```
## , ,  = 0
##
##
##                      0      1      2
##   No             45964    245     74
```

```
##   Yes          116965   5219    783
##   Hysterectomy  22242    675    112
##
## , ,  = 1
##
##
##                     0      1      2
##   No                0    852    194
##   Yes               0   2662    506
##   Hysterectomy      0    469     86
```

```
dat0=dat0[which(dat0$breast_cancer!=2),] #exclude in situ bc
dat0=dat0[-which(dat0$breast_cancer==1 & dat0$breast_cancer_incident!=1),] #exclude non-incident bc
```

1.1 PRS

We used the PRS calculator provided by PGSCatalog based on 313 SNPs (Polygenic Score (PGS) ID: PGS000004). The genome build is hg19. After matching with our data and data cleaning, 276 SNPs were used for the calculation. The OR per SD change for breast cancer in UKBiobank is 1.58 for all women; 1.56 for post-menopause women and 1.63 for pre-menopause women. This result is close to the reported OR 1.61 in the manuscript by Mavaddat N et al. Am J Hum Genet (2018).

```
dat0$prs_scaled=scale(dat0$prs_bc,center = T,scale = T)
fit <- glm(breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC9+PC10, data=dat0,family = binomia
summary(fit)
```

```
##
## Call:
## glm(formula = breast_cancer ~ prs_scaled + PC1 + PC2 + PC3 +
##     PC4 + PC5 + PC6 + PC7 + PC8 + PC9 + PC10, family = binomial(),
##     data = dat0, model = FALSE, x = FALSE, y = FALSE)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.5354  -0.2269  -0.1943  -0.1668   3.2774
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -3.997383   0.054401 -73.480   <2e-16 ***
## prs_scaled   0.454500   0.015714  28.922   <2e-16 ***
## PC1         -0.006366   0.005225  -1.218   0.2232
## PC2         -0.005165   0.005085  -1.016   0.3097
## PC3         -0.003332   0.006609  -0.504   0.6141
## PC4         -0.001378   0.003423  -0.403   0.6872
## PC5          0.003738   0.002162   1.729   0.0838 .
## PC6         -0.012590   0.006796  -1.853   0.0639 .
## PC7         -0.004379   0.003746  -1.169   0.2424
## PC8         -0.001246   0.004842  -0.257   0.7970
## PC9         -0.005860   0.003388  -1.730   0.0837 .
## PC10         0.005301   0.006622   0.800   0.4235
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 40433  on 197680  degrees of freedom
## Residual deviance: 39579  on 197669  degrees of freedom
## AIC: 39603
##
## Number of Fisher Scoring iterations: 7
```

```
exp(0.4545)
```

```
## [1] 1.575385
```

```
dat0_postmeno_bc=dat0[which(dat0$menopause=="Yes" ),]
table(dat0_postmeno_bc$breast_cancer)
```

```
##
##      0      1
## 116965   2662
```

```
dat0_postmeno_bc$prs_scaled=scale(dat0_postmeno_bc$prs_bc,center = T,scale = T)
fit <- glm(breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC9+PC10, data=dat0_postmeno_bc,fami
summary(fit)
```

```
##
## Call:
## glm(formula = breast_cancer ~ prs_scaled + PC1 + PC2 + PC3 +
##     PC4 + PC5 + PC6 + PC7 + PC8 + PC9 + PC10, family = binomial(),
##     data = dat0_postmeno_bc, model = FALSE, x = FALSE, y = FALSE)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.7087  -0.2333  -0.2000  -0.1731   3.2468
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -3.934293   0.072114 -54.557   <2e-16 ***
## prs_scaled   0.441668   0.019705  22.415   <2e-16 ***
## PC1         -0.006631   0.007031  -0.943   0.3457
## PC2         -0.008839   0.006483  -1.363   0.1727
## PC3         -0.007072   0.008211  -0.861   0.3891
## PC4         -0.001218   0.004379  -0.278   0.7810
## PC5          0.004617   0.002699   1.710   0.0872 .
## PC6         -0.015641   0.008785  -1.780   0.0750 .
## PC7         -0.008708   0.004858  -1.793   0.0730 .
## PC8          0.003905   0.006221   0.628   0.5302
## PC9         -0.007549   0.004138  -1.824   0.0681 .
## PC10         0.008745   0.008448   1.035   0.3006
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
```

```
##
##     Null deviance: 25524  on 119626  degrees of freedom
## Residual deviance: 25003  on 119615  degrees of freedom
## AIC: 25027
##
## Number of Fisher Scoring iterations: 7
```

```
exp(0.441668)
```

```
## [1] 1.555299
```

```
colnames(dat0_postmeno_bc)[7]="age.menarche"
dat0_postmeno_bc$n.children=as.numeric(as.character(dat0_postmeno_bc$n.children))
dat0_postmeno_bc$age.menopause=as.numeric(as.character(dat0_postmeno_bc$age.menopause))
dat0_postmeno_bc$n.children[which(dat0_postmeno_bc$n.children=="-3")]=NA
#winsorization
dat0_postmeno_bc$n.children.win=dat0_postmeno_bc$n.children
dat0_postmeno_bc$n.children.win[which(dat0_postmeno_bc$n.children.win>=5)]=5
dat0_postmeno_bc$alcohol=NA
dat0_postmeno_bc$alcohol[which(dat0_postmeno_bc$AlcoholFreq=="Never" | dat0_postmeno_bc$AlcoholFreq== "S
dat0_postmeno_bc$alcohol[which(dat0_postmeno_bc$AlcoholFreq=="Daily or almost daily" | dat0_postmeno_bc$
                                dat0_postmeno_bc$AlcoholFreq== "Once or twice a week" | dat0_postmeno_b
dat0_postmeno_bc$age.firstbirth=as.numeric(as.character(dat0_postmeno_bc$age.firstbirth))
dat0_postmeno_bc$age.firstbirth[which(dat0_postmeno_bc$age.firstbirth== -3 | dat0_postmeno_bc$age.firstb
dat0_postmeno_bc$age.firstbirth[which(dat0_postmeno_bc$n.children==0)]=999
dat0_postmeno_bc$age.firstbirth.group=NA
dat0_postmeno_bc$age.firstbirth.group<-cut(dat0_postmeno_bc$age.firstbirth, breaks=c( 0, 25,35,80,1000)
dat0_postmeno_bc$age.menarche[which(dat0_postmeno_bc$age.menarche<0)]=NA
dat0_postmeno_bc$birth.x[which(dat0_postmeno_bc$birth.x<0)]=NA
dat0_postmeno_bc$birth.y[which(dat0_postmeno_bc$birth.y<0)]=NA
```

```
#For post-menopause women, let's add the HRT use
hrt=hrt[-1,]
colnames(hrt)=c("IID","HRT.ever","age.start.hrt","age.last.hrt")
dat0_postmeno_bc=merge(dat0_postmeno_bc,hrt,by="IID")
dat0_postmeno_bc$HRT.ever[which(dat0_postmeno_bc$HRT.ever=="-3" | dat0_postmeno_bc$HRT.ever=="-1")]=NA
dat0_postmeno_bc$age.start.hrt[which(dat0_postmeno_bc$age.start.hrt=="-3" | dat0_postmeno_bc$age.start.h
dat0_postmeno_bc$age.last.hrt[which(dat0_postmeno_bc$age.last.hrt=="-3" | dat0_postmeno_bc$age.last.hrt=
dat0_postmeno_bc$age.last.hrt[which(dat0_postmeno_bc$age.last.hrt=="-11")]=dat0_postmeno_bc$age[which(da
dat0_postmeno_bc$length.hrt=as.numeric(as.character(dat0_postmeno_bc$age.last.hrt))-as.numeric(as.charac
dat0_postmeno_bc$length.hrt[which(dat0_postmeno_bc$HRT.ever==0)]=0
summary(dat0_postmeno_bc$length.hrt)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##   0.000   0.000   0.000   2.903   5.000  45.000    7667
```

```
table(dat0_postmeno_bc$HRT.ever) #let's just include HRT use: ever/never
```

```
##
##     0     1
## 62090 57280
```

2 Post-Menopause Cohort

2.1 Logistic Regression on Cohort Samples

We first look at post-menopause women:

```
dat_test=dat0_postmeno_bc[,c("IID","prs_bc","age","age.menarche","BMI","height","n.children.win","age.fi
                             "breast_cancer","breast_cancer_incident","length.oc","oral.contraceptive.ev
                             "assessment_center","age.menopause","agegroups", "HRT.ever",
                             "oc.cate" ,"alcohol","age.firstbirth.group","PC1","PC2","PC3","PC4","PC5",'

dat_test=dat_test[complete.cases(dat_test),]
table(dat_test$breast_cancer)
```

```
##
##     0     1
## 97383  2217
```

```
table(dat_test$breast_cancer_incident)
```

```
##
##     0     1
## 97383  2217
```

```
dim(dat_test)
```

```
## [1] 99600    29
```

```
dat_test$prs_scaled=scale(dat_test$prs_bc,center = T,scale = T)
dat_test$age.scale=scale(dat_test$age,center = T,scale=T)
dat_test$age.menarche.scale=scale(dat_test$age.menarche,center = T,scale=T)
dat_test$age.menopause.scale=scale(dat_test$age.menopause,center = T,scale=T)
dat_test$n.children.scale=scale(dat_test$n.children.win,center=T,scale = T)
dat_test$height.scale=scale(dat_test$height,center=T,scale = T)
dat_test$BMI.scale=scale(dat_test$BMI,center=T,scale = T)
dat_test$length.oc.scale=scale(dat_test$length.oc,center=T,scale = T)


dat_location=dat0_postmeno_bc[,c("IID","birth.x","birth.y")]
dat_test=merge(dat_test,dat_location,by="IID")
dat_test$birth.x=scale(dat_test$birth.x,center=T,scale=T)
dat_test$birth.y=scale(dat_test$birth.y,center=T,scale=T)

#add oc category
dat_test$oc.cate2=NA
dat_test$oc.cate2[which(dat_test$oral.contraceptive.ever==0)]=0
dat_test$oc.cate2[which(dat_test$oral.contraceptive.ever==1 & dat_test$length.oc<10)]=1
dat_test$oc.cate2[which( dat_test$length.oc>=10)]=2


#more specified interval
```

```r
dat_test$oc.cate3=NA
dat_test$oc.cate3[which(dat_test$oral.contraceptive.ever==0)]=0
dat_test$oc.cate3[which(dat_test$oral.contraceptive.ever==1 & dat_test$length.oc<5)]=1
dat_test$oc.cate3[which( dat_test$length.oc>=5 & dat_test$length.oc < 10)]=2
dat_test$oc.cate3[which( dat_test$length.oc>=10 & dat_test$length.oc < 15)]=3
dat_test$oc.cate3[which( dat_test$length.oc>=15 )]=4
```

```r
dat_test_complete=dat_test[complete.cases(dat_test),]
table(dat_test_complete$breast_cancer)
```

```
##
##     0     1
## 89241  2024
```

```r
fit.int.all <- glm(breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC9+PC10+HRT.ever+agegroups+
summary(fit.int.all)
```

```
##
## Call:
## glm(formula = breast_cancer ~ prs_scaled + PC1 + PC2 + PC3 +
##     PC4 + PC5 + PC6 + PC7 + PC8 + PC9 + PC10 + HRT.ever + agegroups +
##     n.children.scale + birth.x + birth.y + age.firstbirth.group +
##     height.scale + age.menarche.scale + age.menopause.scale +
##     length.oc.scale + BMI.scale + relevel(factor(dat_test_complete$assessment_center),
##     ref = "11001") + alcohol + prs_scaled:HRT.ever + prs_scaled:birth.x +
##     prs_scaled:birth.y + prs_scaled:length.oc.scale + prs_scaled:age.menopause.scale +
##     prs_scaled:age.menarche.scale + prs_scaled:BMI.scale + prs_scaled:agegroups +
##     prs_scaled:alcohol + prs_scaled:height.scale + prs_scaled:n.children.scale +
##     prs_scaled:age.firstbirth.group, family = binomial(), data = dat_test_complete,
##     model = FALSE, x = FALSE, y = FALSE)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.0288  -0.2357  -0.1951  -0.1590   3.6439
##
## Coefficients:
##                                                                    Estimate
## (Intercept)                                                      -4.378e+00
## prs_scaled                                                        5.483e-01
## PC1                                                              -2.484e-03
## PC2                                                              -1.197e-02
## PC3                                                              -2.847e-03
## PC4                                                               2.158e-03
## PC5                                                               2.129e-03
## PC6                                                              -1.818e-02
## PC7                                                              -4.929e-03
## PC8                                                               1.020e-02
## PC9                                                              -7.407e-03
## PC10                                                              7.823e-04
## HRT.ever1                                                         1.321e-01
## agegroups[50,60)                                                  4.504e-01
## agegroups[60,70)                                                  6.826e-01
```

```
## agegroups[70,80)                                                          8.795e-01
## n.children.scale                                                         -7.809e-02
## birth.x                                                                   3.131e-02
## birth.y                                                                   1.438e-02
## age.firstbirth.group[25,35)                                               1.358e-02
## age.firstbirth.group[35,80)                                               2.584e-01
## age.firstbirth.group[80,1e+03)                                           -3.042e-03
## height.scale                                                              1.345e-01
## age.menarche.scale                                                       -1.617e-02
## age.menopause.scale                                                       9.678e-02
## length.oc.scale                                                           2.577e-02
## BMI.scale                                                                 1.476e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003  4.230e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002 -1.246e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003 -3.593e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004 -2.197e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005 -2.079e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006 -1.473e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007 -1.294e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008 -2.089e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009 -3.011e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010 -4.446e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011 -3.394e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012 -2.830e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013 -4.061e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014 -6.837e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016 -2.225e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 -4.738e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 -7.266e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 -5.464e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 -5.708e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022 -2.962e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023 -1.220e+01
## alcohol                                                                   1.935e-01
## prs_scaled:HRT.ever1                                                     -9.527e-03
## prs_scaled:birth.x                                                       -6.816e-02
## prs_scaled:birth.y                                                       -1.195e-02
## prs_scaled:length.oc.scale                                               -5.475e-02
## prs_scaled:age.menopause.scale                                           -2.037e-03
## prs_scaled:age.menarche.scale                                            -9.776e-03
## prs_scaled:BMI.scale                                                     -9.503e-03
## prs_scaled:agegroups[50,60)                                              -5.049e-02
## prs_scaled:agegroups[60,70)                                              -5.481e-02
## prs_scaled:agegroups[70,80)                                              -5.449e-01
## prs_scaled:alcohol                                                       -9.063e-02
## prs_scaled:height.scale                                                  -2.033e-02
## prs_scaled:n.children.scale                                               5.335e-03
## prs_scaled:age.firstbirth.group[25,35)                                    1.075e-01
## prs_scaled:age.firstbirth.group[35,80)                                   -8.304e-02
## prs_scaled:age.firstbirth.group[80,1e+03)                                -1.906e-02
##                                                                         Std. Error
## (Intercept)                                                               2.559e-01
## prs_scaled                                                                1.942e-01
## PC1                                                                       8.037e-03
```

```
## PC2                                                                    7.287e-03
## PC3                                                                    9.693e-03
## PC4                                                                    5.534e-03
## PC5                                                                    3.872e-03
## PC6                                                                    1.247e-02
## PC7                                                                    7.379e-03
## PC8                                                                    8.854e-03
## PC9                                                                    5.797e-03
## PC10                                                                   1.081e-02
## HRT.ever1                                                              5.067e-02
## agegroups[50,60)                                                       2.018e-01
## agegroups[60,70)                                                       2.023e-01
## agegroups[70,80)                                                       3.551e-01
## n.children.scale                                                       3.976e-02
## birth.x                                                                3.350e-02
## birth.y                                                                3.947e-02
## age.firstbirth.group[25,35)                                            5.861e-02
## age.firstbirth.group[35,80)                                            1.170e-01
## age.firstbirth.group[80,1e+03)                                         1.119e-01
## height.scale                                                           2.557e-02
## age.menarche.scale                                                     2.511e-02
## age.menopause.scale                                                    2.648e-02
## length.oc.scale                                                        2.520e-02
## BMI.scale                                                              2.384e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003  7.319e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002  1.757e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003  1.809e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004  1.756e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005  1.729e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006  1.673e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007  1.529e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008  1.538e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009  1.534e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010  1.489e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011  1.504e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012  2.042e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013  1.541e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014  1.640e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016  1.498e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017  1.733e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018  1.794e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020  1.721e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021  1.713e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022  3.381e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023  1.281e+02
## alcohol                                                                6.354e-02
## prs_scaled:HRT.ever1                                                   4.650e-02
## prs_scaled:birth.x                                                     2.478e-02
## prs_scaled:birth.y                                                     2.496e-02
## prs_scaled:length.oc.scale                                             2.338e-02
## prs_scaled:age.menopause.scale                                         2.427e-02
## prs_scaled:age.menarche.scale                                          2.317e-02
## prs_scaled:BMI.scale                                                   2.182e-02
## prs_scaled:agegroups[50,60)                                            1.879e-01
```

```
## prs_scaled:agegroups[60,70)                                                    1.880e-01
## prs_scaled:agegroups[70,80)                                                    3.504e-01
## prs_scaled:alcohol                                                             5.702e-02
## prs_scaled:height.scale                                                        2.329e-02
## prs_scaled:n.children.scale                                                    3.628e-02
## prs_scaled:age.firstbirth.group[25,35)                                         5.358e-02
## prs_scaled:age.firstbirth.group[35,80)                                         1.108e-01
## prs_scaled:age.firstbirth.group[80,1e+03)                                      1.034e-01
##                                                                               z value
## (Intercept)                                                                  -17.108
## prs_scaled                                                                     2.823
## PC1                                                                           -0.309
## PC2                                                                           -1.642
## PC3                                                                           -0.294
## PC4                                                                            0.390
## PC5                                                                            0.550
## PC6                                                                           -1.458
## PC7                                                                           -0.668
## PC8                                                                            1.152
## PC9                                                                           -1.278
## PC10                                                                           0.072
## HRT.ever1                                                                      2.608
## agegroups[50,60)                                                               2.232
## agegroups[60,70)                                                               3.375
## agegroups[70,80)                                                               2.477
## n.children.scale                                                              -1.964
## birth.x                                                                        0.935
## birth.y                                                                        0.364
## age.firstbirth.group[25,35)                                                    0.232
## age.firstbirth.group[35,80)                                                    2.209
## age.firstbirth.group[80,1e+03)                                                -0.027
## height.scale                                                                   5.260
## age.menarche.scale                                                            -0.644
## age.menopause.scale                                                            3.655
## length.oc.scale                                                                1.023
## BMI.scale                                                                      6.191
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003       0.058
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002      -0.709
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003      -1.986
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004      -1.252
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005      -1.202
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006      -0.880
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007      -0.846
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008      -1.358
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009      -1.962
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010      -2.986
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011      -2.257
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012      -1.386
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013      -2.635
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014      -4.170
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016      -1.486
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017      -2.735
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018      -4.051
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020      -3.175
```

```
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021  -3.332
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022  -0.876
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023  -0.095
## alcohol                                                                    3.046
## prs_scaled:HRT.ever1                                                      -0.205
## prs_scaled:birth.x                                                        -2.751
## prs_scaled:birth.y                                                        -0.479
## prs_scaled:length.oc.scale                                                -2.342
## prs_scaled:age.menopause.scale                                            -0.084
## prs_scaled:age.menarche.scale                                             -0.422
## prs_scaled:BMI.scale                                                      -0.436
## prs_scaled:agegroups[50,60)                                               -0.269
## prs_scaled:agegroups[60,70)                                               -0.292
## prs_scaled:agegroups[70,80)                                               -1.555
## prs_scaled:alcohol                                                        -1.590
## prs_scaled:height.scale                                                   -0.873
## prs_scaled:n.children.scale                                                0.147
## prs_scaled:age.firstbirth.group[25,35)                                     2.007
## prs_scaled:age.firstbirth.group[35,80)                                    -0.749
## prs_scaled:age.firstbirth.group[80,1e+03)                                 -0.184
##                                                                          Pr(>|z|)
## (Intercept)                                                               < 2e-16
## prs_scaled                                                               0.004757
## PC1                                                                      0.757272
## PC2                                                                      0.100499
## PC3                                                                      0.768997
## PC4                                                                      0.696612
## PC5                                                                      0.582335
## PC6                                                                      0.144805
## PC7                                                                      0.504178
## PC8                                                                      0.249177
## PC9                                                                      0.201315
## PC10                                                                     0.942316
## HRT.ever1                                                                0.009119
## agegroups[50,60)                                                         0.025614
## agegroups[60,70)                                                         0.000738
## agegroups[70,80)                                                         0.013265
## n.children.scale                                                         0.049507
## birth.x                                                                  0.349976
## birth.y                                                                  0.715600
## age.firstbirth.group[25,35)                                              0.816759
## age.firstbirth.group[35,80)                                              0.027177
## age.firstbirth.group[80,1e+03)                                           0.978315
## height.scale                                                             1.44e-07
## age.menarche.scale                                                       0.519605
## age.menopause.scale                                                      0.000257
## length.oc.scale                                                          0.306482
## BMI.scale                                                                5.99e-10
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003 0.953905
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002 0.478222
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003 0.047039
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004 0.210722
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005 0.229349
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006 0.378607
```

```
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007 0.397484
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008 0.174354
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009 0.049713
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010 0.002825
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011 0.024034
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012 0.165714
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013 0.008414
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014 3.05e-05
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016 0.137305
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 0.006247
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 5.11e-05
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 0.001496
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 0.000863
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022 0.380954
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023 0.924079
## alcohol                                                                 0.002318
## prs_scaled:HRT.ever1                                                    0.837672
## prs_scaled:birth.x                                                      0.005944
## prs_scaled:birth.y                                                      0.631928
## prs_scaled:length.oc.scale                                              0.019202
## prs_scaled:age.menopause.scale                                          0.933098
## prs_scaled:age.menarche.scale                                           0.673135
## prs_scaled:BMI.scale                                                    0.663127
## prs_scaled:agegroups[50,60)                                             0.788086
## prs_scaled:agegroups[60,70)                                             0.770590
## prs_scaled:agegroups[70,80)                                             0.119929
## prs_scaled:alcohol                                                      0.111927
## prs_scaled:height.scale                                                 0.382744
## prs_scaled:n.children.scale                                             0.883102
## prs_scaled:age.firstbirth.group[25,35)                                  0.044761
## prs_scaled:age.firstbirth.group[35,80)                                  0.453575
## prs_scaled:age.firstbirth.group[80,1e+03)                               0.853733
##
## (Intercept)                                                             ***
## prs_scaled                                                              **
## PC1
## PC2
## PC3
## PC4
## PC5
## PC6
## PC7
## PC8
## PC9
## PC10
## HRT.ever1                                                               **
## agegroups[50,60)                                                        *
## agegroups[60,70)                                                        ***
## agegroups[70,80)                                                        *
## n.children.scale                                                        *
## birth.x
## birth.y
## age.firstbirth.group[25,35)
## age.firstbirth.group[35,80)                                             *
```

```
## age.firstbirth.group[80,1e+03)
## height.scale                                                          ***
## age.menarche.scale
## age.menopause.scale                                                   ***
## length.oc.scale
## BMI.scale                                                             ***
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003 *
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009 *
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010 **
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011 *
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013 **
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014 ***
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 **
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 ***
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 **
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 ***
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023
## alcohol                                                               **
## prs_scaled:HRT.ever1
## prs_scaled:birth.x                                                    **
## prs_scaled:birth.y
## prs_scaled:length.oc.scale                                            *
## prs_scaled:age.menopause.scale
## prs_scaled:age.menarche.scale
## prs_scaled:BMI.scale
## prs_scaled:agegroups[50,60)
## prs_scaled:agegroups[60,70)
## prs_scaled:agegroups[70,80)
## prs_scaled:alcohol
## prs_scaled:height.scale
## prs_scaled:n.children.scale
## prs_scaled:age.firstbirth.group[25,35)                                *
## prs_scaled:age.firstbirth.group[35,80)
## prs_scaled:age.firstbirth.group[80,1e+03)
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 19420  on 91264  degrees of freedom
## Residual deviance: 18772  on 91200  degrees of freedom
## AIC: 18902
##
## Number of Fisher Scoring iterations: 14
```

```r
fit.int.all2 <- glm(breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC9+PC10+HRT.ever+agegroups
summary(fit.int.all2)
```

```
##
## Call:
## glm(formula = breast_cancer ~ prs_scaled + PC1 + PC2 + PC3 +
##     PC4 + PC5 + PC6 + PC7 + PC8 + PC9 + PC10 + HRT.ever + agegroups +
##     n.children.scale + birth.x + birth.y + age.firstbirth.group +
##     height.scale + age.menarche.scale + age.menopause.scale +
##     factor(oc.cate2) + BMI.scale + relevel(factor(dat_test_complete$assessment_center),
##     ref = "11001") + alcohol + prs_scaled:HRT.ever + prs_scaled:birth.x +
##     prs_scaled:birth.y + prs_scaled:factor(oc.cate2) + prs_scaled:age.menopause.scale +
##     prs_scaled:age.menarche.scale + prs_scaled:BMI.scale + prs_scaled:agegroups +
##     prs_scaled:alcohol + prs_scaled:height.scale + prs_scaled:n.children.scale +
##     prs_scaled:age.firstbirth.group, family = binomial(), data = dat_test_complete,
##     model = FALSE, x = FALSE, y = FALSE)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.0419  -0.2358  -0.1950  -0.1590   3.6054
##
## Coefficients:
##                                                                                 Estimate
## (Intercept)                                                                   -4.399e+00
## prs_scaled                                                                     6.514e-01
## PC1                                                                           -2.376e-03
## PC2                                                                           -1.192e-02
## PC3                                                                           -2.837e-03
## PC4                                                                            2.191e-03
## PC5                                                                            2.048e-03
## PC6                                                                           -1.838e-02
## PC7                                                                           -5.053e-03
## PC8                                                                            1.019e-02
## PC9                                                                           -7.452e-03
## PC10                                                                           7.298e-04
## HRT.ever1                                                                      1.321e-01
## agegroups[50,60)                                                               4.525e-01
## agegroups[60,70)                                                               6.806e-01
## agegroups[70,80)                                                               8.736e-01
## n.children.scale                                                              -7.847e-02
## birth.x                                                                        3.130e-02
## birth.y                                                                        1.441e-02
## age.firstbirth.group[25,35)                                                    1.372e-02
## age.firstbirth.group[35,80)                                                    2.560e-01
## age.firstbirth.group[80,1e+03)                                                -4.469e-03
## height.scale                                                                   1.348e-01
## age.menarche.scale                                                            -1.628e-02
## age.menopause.scale                                                            9.765e-02
## factor(oc.cate2)1                                                             -1.431e-03
## factor(oc.cate2)2                                                              5.455e-02
## BMI.scale                                                                      1.475e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003       4.509e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002      -1.228e-01
```

```
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003 -3.541e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004 -2.156e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005 -2.043e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006 -1.459e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007 -1.241e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008 -2.083e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009 -2.965e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010 -4.415e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011 -3.366e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012 -2.790e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013 -4.028e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014 -6.795e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016 -2.179e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 -4.693e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 -7.217e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 -5.421e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 -5.684e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022 -2.881e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023 -1.220e+01
## alcohol                                                                  1.945e-01
## prs_scaled:HRT.ever1                                                    -2.706e-03
## prs_scaled:birth.x                                                      -6.820e-02
## prs_scaled:birth.y                                                      -1.191e-02
## prs_scaled:factor(oc.cate2)1                                            -8.747e-02
## prs_scaled:factor(oc.cate2)2                                            -1.803e-01
## prs_scaled:age.menopause.scale                                          -2.116e-03
## prs_scaled:age.menarche.scale                                           -1.011e-02
## prs_scaled:BMI.scale                                                    -9.218e-03
## prs_scaled:agegroups[50,60)                                             -5.346e-02
## prs_scaled:agegroups[60,70)                                             -6.641e-02
## prs_scaled:agegroups[70,80)                                             -5.695e-01
## prs_scaled:alcohol                                                      -8.739e-02
## prs_scaled:height.scale                                                 -1.939e-02
## prs_scaled:n.children.scale                                              4.587e-03
## prs_scaled:age.firstbirth.group[25,35)                                   1.085e-01
## prs_scaled:age.firstbirth.group[35,80)                                  -8.207e-02
## prs_scaled:age.firstbirth.group[80,1e+03)                               -3.010e-02
##                                                                         Std. Error
## (Intercept)                                                              2.606e-01
## prs_scaled                                                               1.996e-01
## PC1                                                                      8.018e-03
## PC2                                                                      7.278e-03
## PC3                                                                      9.695e-03
## PC4                                                                      5.534e-03
## PC5                                                                      3.871e-03
## PC6                                                                      1.247e-02
## PC7                                                                      7.377e-03
## PC8                                                                      8.855e-03
## PC9                                                                      5.796e-03
## PC10                                                                     1.081e-02
## HRT.ever1                                                                5.081e-02
## agegroups[50,60)                                                         2.018e-01
## agegroups[60,70)                                                         2.023e-01
## agegroups[70,80)                                                         3.556e-01
```

```
## n.children.scale                                                                 3.974e-02
## birth.x                                                                          3.350e-02
## birth.y                                                                          3.948e-02
## age.firstbirth.group[25,35)                                                      5.862e-02
## age.firstbirth.group[35,80)                                                      1.170e-01
## age.firstbirth.group[80,1e+03)                                                   1.122e-01
## height.scale                                                                     2.557e-02
## age.menarche.scale                                                               2.511e-02
## age.menopause.scale                                                              2.647e-02
## factor(oc.cate2)1                                                                6.653e-02
## factor(oc.cate2)2                                                                6.972e-02
## BMI.scale                                                                        2.384e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003         7.318e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002         1.758e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003         1.810e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004         1.756e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005         1.730e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006         1.674e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007         1.529e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008         1.538e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009         1.535e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010         1.489e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011         1.504e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012         2.042e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013         1.541e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014         1.640e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016         1.498e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017         1.733e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018         1.794e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020         1.721e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021         1.714e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022         3.382e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023         1.280e+02
## alcohol                                                                          6.364e-02
## prs_scaled:HRT.ever1                                                             4.670e-02
## prs_scaled:birth.x                                                               2.477e-02
## prs_scaled:birth.y                                                               2.495e-02
## prs_scaled:factor(oc.cate2)1                                                     6.018e-02
## prs_scaled:factor(oc.cate2)2                                                     6.370e-02
## prs_scaled:age.menopause.scale                                                   2.428e-02
## prs_scaled:age.menarche.scale                                                    2.318e-02
## prs_scaled:BMI.scale                                                             2.181e-02
## prs_scaled:agegroups[50,60)                                                      1.877e-01
## prs_scaled:agegroups[60,70)                                                      1.880e-01
## prs_scaled:agegroups[70,80)                                                      3.505e-01
## prs_scaled:alcohol                                                               5.706e-02
## prs_scaled:height.scale                                                          2.331e-02
## prs_scaled:n.children.scale                                                      3.622e-02
## prs_scaled:age.firstbirth.group[25,35)                                           5.359e-02
## prs_scaled:age.firstbirth.group[35,80)                                           1.108e-01
## prs_scaled:age.firstbirth.group[80,1e+03)                                        1.037e-01
##                                                                                 z value
## (Intercept)                                                                    -16.881
## prs_scaled                                                                       3.264
```

```
## PC1                                                                    -0.296
## PC2                                                                    -1.638
## PC3                                                                    -0.293
## PC4                                                                     0.396
## PC5                                                                     0.529
## PC6                                                                    -1.474
## PC7                                                                    -0.685
## PC8                                                                     1.151
## PC9                                                                    -1.286
## PC10                                                                    0.068
## HRT.ever1                                                               2.600
## agegroups[50,60)                                                        2.242
## agegroups[60,70)                                                        3.364
## agegroups[70,80)                                                        2.457
## n.children.scale                                                       -1.975
## birth.x                                                                 0.934
## birth.y                                                                 0.365
## age.firstbirth.group[25,35)                                             0.234
## age.firstbirth.group[35,80)                                             2.188
## age.firstbirth.group[80,1e+03)                                         -0.040
## height.scale                                                            5.271
## age.menarche.scale                                                     -0.648
## age.menopause.scale                                                     3.689
## factor(oc.cate2)1                                                      -0.022
## factor(oc.cate2)2                                                       0.782
## BMI.scale                                                               6.189
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003  0.062
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002 -0.699
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003 -1.957
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004 -1.228
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005 -1.181
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006 -0.872
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007 -0.812
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008 -1.354
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009 -1.932
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010 -2.965
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011 -2.238
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012 -1.366
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013 -2.613
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014 -4.143
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016 -1.455
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 -2.708
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 -4.023
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 -3.150
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 -3.317
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022 -0.852
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023 -0.095
## alcohol                                                                 3.057
## prs_scaled:HRT.ever1                                                   -0.058
## prs_scaled:birth.x                                                     -2.753
## prs_scaled:birth.y                                                     -0.477
## prs_scaled:factor(oc.cate2)1                                           -1.454
## prs_scaled:factor(oc.cate2)2                                           -2.831
## prs_scaled:age.menopause.scale                                         -0.087
```

```
## prs_scaled:age.menarche.scale                                          -0.436
## prs_scaled:BMI.scale                                                   -0.423
## prs_scaled:agegroups[50,60)                                            -0.285
## prs_scaled:agegroups[60,70)                                            -0.353
## prs_scaled:agegroups[70,80)                                            -1.625
## prs_scaled:alcohol                                                     -1.532
## prs_scaled:height.scale                                                -0.832
## prs_scaled:n.children.scale                                             0.127
## prs_scaled:age.firstbirth.group[25,35)                                  2.025
## prs_scaled:age.firstbirth.group[35,80)                                 -0.741
## prs_scaled:age.firstbirth.group[80,1e+03)                              -0.290
##                                                                       Pr(>|z|)
## (Intercept)                                                            < 2e-16
## prs_scaled                                                            0.001099
## PC1                                                                   0.766954
## PC2                                                                   0.101385
## PC3                                                                   0.769777
## PC4                                                                   0.692118
## PC5                                                                   0.596743
## PC6                                                                   0.140597
## PC7                                                                   0.493348
## PC8                                                                   0.249870
## PC9                                                                   0.198503
## PC10                                                                  0.946171
## HRT.ever1                                                             0.009322
## agegroups[50,60)                                                      0.024948
## agegroups[60,70)                                                      0.000769
## agegroups[70,80)                                                      0.014025
## n.children.scale                                                      0.048276
## birth.x                                                               0.350219
## birth.y                                                               0.715144
## age.firstbirth.group[25,35)                                           0.814899
## age.firstbirth.group[35,80)                                           0.028680
## age.firstbirth.group[80,1e+03)                                        0.968225
## height.scale                                                          1.36e-07
## age.menarche.scale                                                    0.516666
## age.menopause.scale                                                   0.000225
## factor(oc.cate2)1                                                     0.982843
## factor(oc.cate2)2                                                     0.433962
## BMI.scale                                                             6.05e-10
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003 0.950865
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002 0.484689
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003 0.050369
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004 0.219561
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005 0.237591
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006 0.383427
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007 0.416867
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008 0.175688
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009 0.053395
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010 0.003030
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011 0.025236
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012 0.171944
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013 0.008975
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014 3.43e-05
```

```
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016 0.145758
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 0.006777
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 5.74e-05
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 0.001634
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 0.000910
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022 0.394244
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023 0.924037
## alcohol                                                                 0.002237
## prs_scaled:HRT.ever1                                                    0.953796
## prs_scaled:birth.x                                                      0.005896
## prs_scaled:birth.y                                                      0.633206
## prs_scaled:factor(oc.cate2)1                                            0.146083
## prs_scaled:factor(oc.cate2)2                                            0.004646
## prs_scaled:age.menopause.scale                                          0.930534
## prs_scaled:age.menarche.scale                                           0.662824
## prs_scaled:BMI.scale                                                    0.672614
## prs_scaled:agegroups[50,60)                                             0.775813
## prs_scaled:agegroups[60,70)                                             0.723831
## prs_scaled:agegroups[70,80)                                             0.104243
## prs_scaled:alcohol                                                      0.125628
## prs_scaled:height.scale                                                 0.405475
## prs_scaled:n.children.scale                                             0.899223
## prs_scaled:age.firstbirth.group[25,35)                                  0.042848
## prs_scaled:age.firstbirth.group[35,80)                                  0.458799
## prs_scaled:age.firstbirth.group[80,1e+03)                               0.771536
##
## (Intercept)                                                             ***
## prs_scaled                                                              **
## PC1
## PC2
## PC3
## PC4
## PC5
## PC6
## PC7
## PC8
## PC9
## PC10
## HRT.ever1                                                               **
## agegroups[50,60)                                                        *
## agegroups[60,70)                                                        ***
## agegroups[70,80)                                                        *
## n.children.scale                                                        *
## birth.x
## birth.y
## age.firstbirth.group[25,35)
## age.firstbirth.group[35,80)                                             *
## age.firstbirth.group[80,1e+03)
## height.scale                                                            ***
## age.menarche.scale
## age.menopause.scale                                                     ***
## factor(oc.cate2)1
## factor(oc.cate2)2
## BMI.scale                                                               ***
```

```
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003 .
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009 .
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010 **
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011 *
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013 **
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014 ***
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 **
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 ***
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 **
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 ***
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023
## alcohol                                                              **
## prs_scaled:HRT.ever1
## prs_scaled:birth.x                                                   **
## prs_scaled:birth.y
## prs_scaled:factor(oc.cate2)1
## prs_scaled:factor(oc.cate2)2                                         **
## prs_scaled:age.menopause.scale
## prs_scaled:age.menarche.scale
## prs_scaled:BMI.scale
## prs_scaled:agegroups[50,60)
## prs_scaled:agegroups[60,70)
## prs_scaled:agegroups[70,80)
## prs_scaled:alcohol
## prs_scaled:height.scale
## prs_scaled:n.children.scale
## prs_scaled:age.firstbirth.group[25,35)                               *
## prs_scaled:age.firstbirth.group[35,80)
## prs_scaled:age.firstbirth.group[80,1e+03)
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 19420  on 91264  degrees of freedom
## Residual deviance: 18768  on 91198  degrees of freedom
## AIC: 18902
##
## Number of Fisher Scoring iterations: 14
```

```
fit.int.all3 <- glm(breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC9+PC10+HRT.ever+agegroups
summary(fit.int.all3)
```

```
##
```

```
## Call:
## glm(formula = breast_cancer ~ prs_scaled + PC1 + PC2 + PC3 +
##     PC4 + PC5 + PC6 + PC7 + PC8 + PC9 + PC10 + HRT.ever + agegroups +
##     n.children.scale + birth.x + birth.y + age.firstbirth.group +
##     height.scale + age.menarche.scale + age.menopause.scale +
##     factor(oc.cate3) + BMI.scale + relevel(factor(dat_test_complete$assessment_center),
##     ref = "11001") + alcohol + prs_scaled:birth.x + prs_scaled:HRT.ever +
##     prs_scaled:birth.y + prs_scaled:factor(oc.cate3) + prs_scaled:age.menopause.scale +
##     prs_scaled:age.menarche.scale + prs_scaled:BMI.scale + prs_scaled:agegroups +
##     prs_scaled:alcohol + prs_scaled:height.scale + prs_scaled:n.children.scale +
##     prs_scaled:age.firstbirth.group, family = binomial(), data = dat_test_complete,
##     model = FALSE, x = FALSE, y = FALSE)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.0372  -0.2359  -0.1950  -0.1591   3.6194
##
## Coefficients:
##                                                                                 Estimate
## (Intercept)                                                                   -4.400e+00
## prs_scaled                                                                     6.544e-01
## PC1                                                                           -2.371e-03
## PC2                                                                           -1.187e-02
## PC3                                                                           -2.861e-03
## PC4                                                                            2.166e-03
## PC5                                                                            2.130e-03
## PC6                                                                           -1.831e-02
## PC7                                                                           -5.034e-03
## PC8                                                                            1.017e-02
## PC9                                                                           -7.414e-03
## PC10                                                                           6.726e-04
## HRT.ever1                                                                      1.312e-01
## agegroups[50,60)                                                               4.520e-01
## agegroups[60,70)                                                               6.835e-01
## agegroups[70,80)                                                               8.768e-01
## n.children.scale                                                              -7.760e-02
## birth.x                                                                        3.127e-02
## birth.y                                                                        1.452e-02
## age.firstbirth.group[25,35)                                                    1.204e-02
## age.firstbirth.group[35,80)                                                    2.558e-01
## age.firstbirth.group[80,1e+03)                                                -2.487e-03
## height.scale                                                                   1.348e-01
## age.menarche.scale                                                            -1.641e-02
## age.menopause.scale                                                            9.776e-02
## factor(oc.cate3)1                                                             -3.481e-02
## factor(oc.cate3)2                                                              3.667e-02
## factor(oc.cate3)3                                                              6.553e-02
## factor(oc.cate3)4                                                              4.715e-02
## BMI.scale                                                                      1.475e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003  4.638e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002 -1.224e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003 -3.538e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004 -2.185e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005 -2.063e-01
```

```
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006 -1.459e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007 -1.250e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008 -2.078e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009 -2.969e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010 -4.422e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011 -3.361e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012 -2.798e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013 -4.040e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014 -6.791e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016 -2.180e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 -4.703e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 -7.230e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 -5.434e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 -5.683e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022 -2.885e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023 -1.220e+01
## alcohol                                                                  1.929e-01
## prs_scaled:birth.x                                                      -6.843e-02
## prs_scaled:HRT.ever1                                                    -3.209e-03
## prs_scaled:birth.y                                                      -1.242e-02
## prs_scaled:factor(oc.cate3)1                                            -9.670e-02
## prs_scaled:factor(oc.cate3)2                                            -7.737e-02
## prs_scaled:factor(oc.cate3)3                                            -1.564e-01
## prs_scaled:factor(oc.cate3)4                                            -2.015e-01
## prs_scaled:age.menopause.scale                                          -1.909e-03
## prs_scaled:age.menarche.scale                                           -1.013e-02
## prs_scaled:BMI.scale                                                    -9.135e-03
## prs_scaled:agegroups[50,60)                                             -5.656e-02
## prs_scaled:agegroups[60,70)                                             -6.858e-02
## prs_scaled:agegroups[70,80)                                             -5.727e-01
## prs_scaled:alcohol                                                      -8.760e-02
## prs_scaled:height.scale                                                 -1.911e-02
## prs_scaled:n.children.scale                                              4.376e-03
## prs_scaled:age.firstbirth.group[25,35)                                   1.071e-01
## prs_scaled:age.firstbirth.group[35,80)                                  -8.183e-02
## prs_scaled:age.firstbirth.group[80,1e+03)                               -2.902e-02
##                                                                        Std. Error
## (Intercept)                                                             2.607e-01
## prs_scaled                                                              1.999e-01
## PC1                                                                     8.019e-03
## PC2                                                                     7.276e-03
## PC3                                                                     9.681e-03
## PC4                                                                     5.528e-03
## PC5                                                                     3.871e-03
## PC6                                                                     1.248e-02
## PC7                                                                     7.379e-03
## PC8                                                                     8.858e-03
## PC9                                                                     5.795e-03
## PC10                                                                    1.081e-02
## HRT.ever1                                                               5.082e-02
## agegroups[50,60)                                                        2.019e-01
## agegroups[60,70)                                                        2.025e-01
## agegroups[70,80)                                                        3.557e-01
## n.children.scale                                                        3.976e-02
```

```
## birth.x                                                                    3.350e-02
## birth.y                                                                    3.947e-02
## age.firstbirth.group[25,35)                                                5.867e-02
## age.firstbirth.group[35,80)                                                1.170e-01
## age.firstbirth.group[80,1e+03)                                             1.122e-01
## height.scale                                                               2.558e-02
## age.menarche.scale                                                         2.511e-02
## age.menopause.scale                                                        2.647e-02
## factor(oc.cate3)1                                                          7.581e-02
## factor(oc.cate3)2                                                          7.781e-02
## factor(oc.cate3)3                                                          8.164e-02
## factor(oc.cate3)4                                                          8.012e-02
## BMI.scale                                                                  2.384e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003  7.319e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002  1.758e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003  1.810e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004  1.756e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005  1.730e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006  1.674e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007  1.529e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008  1.538e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009  1.535e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010  1.489e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011  1.504e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012  2.042e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013  1.542e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014  1.640e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016  1.498e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017  1.733e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018  1.794e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020  1.721e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021  1.714e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022  3.382e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023  1.280e+02
## alcohol                                                                    6.367e-02
## prs_scaled:birth.x                                                         2.477e-02
## prs_scaled:HRT.ever1                                                       4.670e-02
## prs_scaled:birth.y                                                         2.496e-02
## prs_scaled:factor(oc.cate3)1                                               6.883e-02
## prs_scaled:factor(oc.cate3)2                                               7.040e-02
## prs_scaled:factor(oc.cate3)3                                               7.513e-02
## prs_scaled:factor(oc.cate3)4                                               7.382e-02
## prs_scaled:age.menopause.scale                                             2.427e-02
## prs_scaled:age.menarche.scale                                              2.318e-02
## prs_scaled:BMI.scale                                                       2.183e-02
## prs_scaled:agegroups[50,60)                                                1.880e-01
## prs_scaled:agegroups[60,70)                                                1.883e-01
## prs_scaled:agegroups[70,80)                                                3.506e-01
## prs_scaled:alcohol                                                         5.710e-02
## prs_scaled:height.scale                                                    2.331e-02
## prs_scaled:n.children.scale                                                3.624e-02
## prs_scaled:age.firstbirth.group[25,35)                                     5.364e-02
## prs_scaled:age.firstbirth.group[35,80)                                     1.108e-01
## prs_scaled:age.firstbirth.group[80,1e+03)                                  1.037e-01
```

```
##                                                                      z value
## (Intercept)                                                        -16.879
## prs_scaled                                                           3.275
## PC1                                                                 -0.296
## PC2                                                                 -1.631
## PC3                                                                 -0.296
## PC4                                                                  0.392
## PC5                                                                  0.550
## PC6                                                                 -1.468
## PC7                                                                 -0.682
## PC8                                                                  1.148
## PC9                                                                 -1.279
## PC10                                                                 0.062
## HRT.ever1                                                            2.582
## agegroups[50,60)                                                     2.239
## agegroups[60,70)                                                     3.376
## agegroups[70,80)                                                     2.465
## n.children.scale                                                    -1.952
## birth.x                                                              0.933
## birth.y                                                              0.368
## age.firstbirth.group[25,35)                                          0.205
## age.firstbirth.group[35,80)                                          2.186
## age.firstbirth.group[80,1e+03)                                      -0.022
## height.scale                                                         5.272
## age.menarche.scale                                                  -0.653
## age.menopause.scale                                                  3.693
## factor(oc.cate3)1                                                   -0.459
## factor(oc.cate3)2                                                    0.471
## factor(oc.cate3)3                                                    0.803
## factor(oc.cate3)4                                                    0.588
## BMI.scale                                                            6.188
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003   0.063
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002  -0.696
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003  -1.955
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004  -1.244
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005  -1.192
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006  -0.872
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007  -0.817
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008  -1.351
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009  -1.935
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010  -2.969
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011  -2.234
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012  -1.370
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013  -2.621
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014  -4.141
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016  -1.455
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017  -2.713
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018  -4.030
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020  -3.157
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021  -3.316
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022  -0.853
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023  -0.095
## alcohol                                                              3.029
## prs_scaled:birth.x                                                  -2.762
```

```
## prs_scaled:HRT.ever1                                                    -0.069
## prs_scaled:birth.y                                                      -0.498
## prs_scaled:factor(oc.cate3)1                                            -1.405
## prs_scaled:factor(oc.cate3)2                                            -1.099
## prs_scaled:factor(oc.cate3)3                                            -2.082
## prs_scaled:factor(oc.cate3)4                                            -2.729
## prs_scaled:age.menopause.scale                                          -0.079
## prs_scaled:age.menarche.scale                                           -0.437
## prs_scaled:BMI.scale                                                    -0.419
## prs_scaled:agegroups[50,60)                                             -0.301
## prs_scaled:agegroups[60,70)                                             -0.364
## prs_scaled:agegroups[70,80)                                             -1.634
## prs_scaled:alcohol                                                      -1.534
## prs_scaled:height.scale                                                 -0.820
## prs_scaled:n.children.scale                                              0.121
## prs_scaled:age.firstbirth.group[25,35)                                   1.996
## prs_scaled:age.firstbirth.group[35,80)                                  -0.739
## prs_scaled:age.firstbirth.group[80,1e+03)                               -0.280
##                                                                        Pr(>|z|)
## (Intercept)                                                             < 2e-16
## prs_scaled                                                             0.001058
## PC1                                                                    0.767491
## PC2                                                                    0.102821
## PC3                                                                    0.767559
## PC4                                                                    0.695238
## PC5                                                                    0.582192
## PC6                                                                    0.142232
## PC7                                                                    0.495073
## PC8                                                                    0.250934
## PC9                                                                    0.200812
## PC10                                                                   0.950390
## HRT.ever1                                                              0.009835
## agegroups[50,60)                                                       0.025146
## agegroups[60,70)                                                       0.000735
## agegroups[70,80)                                                       0.013696
## n.children.scale                                                       0.050984
## birth.x                                                                0.350580
## birth.y                                                                0.713003
## age.firstbirth.group[25,35)                                            0.837352
## age.firstbirth.group[35,80)                                            0.028780
## age.firstbirth.group[80,1e+03)                                         0.982314
## height.scale                                                           1.35e-07
## age.menarche.scale                                                     0.513447
## age.menopause.scale                                                    0.000222
## factor(oc.cate3)1                                                      0.646105
## factor(oc.cate3)2                                                      0.637441
## factor(oc.cate3)3                                                      0.422178
## factor(oc.cate3)4                                                      0.556217
## BMI.scale                                                              6.10e-10
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003 0.949472
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002 0.486174
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003 0.050577
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004 0.213434
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005 0.233180
```

```
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006 0.383309
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007 0.413727
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008 0.176852
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009 0.053029
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010 0.002988
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011 0.025479
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012 0.170675
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013 0.008768
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014 3.46e-05
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016 0.145629
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 0.006662
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 5.59e-05
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 0.001592
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 0.000912
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022 0.393606
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023 0.924067
## alcohol                                                                 0.002450
## prs_scaled:birth.x                                                      0.005742
## prs_scaled:HRT.ever1                                                    0.945215
## prs_scaled:birth.y                                                      0.618723
## prs_scaled:factor(oc.cate3)1                                            0.160073
## prs_scaled:factor(oc.cate3)2                                            0.271796
## prs_scaled:factor(oc.cate3)3                                            0.037319
## prs_scaled:factor(oc.cate3)4                                            0.006349
## prs_scaled:age.menopause.scale                                          0.937288
## prs_scaled:age.menarche.scale                                           0.662055
## prs_scaled:BMI.scale                                                    0.675564
## prs_scaled:agegroups[50,60)                                             0.763566
## prs_scaled:agegroups[60,70)                                             0.715648
## prs_scaled:agegroups[70,80)                                             0.102329
## prs_scaled:alcohol                                                      0.124958
## prs_scaled:height.scale                                                 0.412161
## prs_scaled:n.children.scale                                             0.903877
## prs_scaled:age.firstbirth.group[25,35)                                  0.045942
## prs_scaled:age.firstbirth.group[35,80)                                  0.460062
## prs_scaled:age.firstbirth.group[80,1e+03)                               0.779512
##
## (Intercept)                                                             ***
## prs_scaled                                                              **
## PC1
## PC2
## PC3
## PC4
## PC5
## PC6
## PC7
## PC8
## PC9
## PC10
## HRT.ever1                                                               **
## agegroups[50,60)                                                        *
## agegroups[60,70)                                                        ***
## agegroups[70,80)                                                        *
## n.children.scale                                                        .
```

```
## birth.x
## birth.y
## age.firstbirth.group[25,35)
## age.firstbirth.group[35,80)                                                    *
## age.firstbirth.group[80,1e+03)
## height.scale                                                                   ***
## age.menarche.scale
## age.menopause.scale                                                            ***
## factor(oc.cate3)1
## factor(oc.cate3)2
## factor(oc.cate3)3
## factor(oc.cate3)4
## BMI.scale                                                                      ***
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003 .
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009 .
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010 **
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011 *
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013 **
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014 ***
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 **
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 ***
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 **
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 ***
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023
## alcohol                                                                        **
## prs_scaled:birth.x                                                             **
## prs_scaled:HRT.ever1
## prs_scaled:birth.y
## prs_scaled:factor(oc.cate3)1
## prs_scaled:factor(oc.cate3)2
## prs_scaled:factor(oc.cate3)3                                                   *
## prs_scaled:factor(oc.cate3)4                                                   **
## prs_scaled:age.menopause.scale
## prs_scaled:age.menarche.scale
## prs_scaled:BMI.scale
## prs_scaled:agegroups[50,60)
## prs_scaled:agegroups[60,70)
## prs_scaled:agegroups[70,80)
## prs_scaled:alcohol
## prs_scaled:height.scale
## prs_scaled:n.children.scale
## prs_scaled:age.firstbirth.group[25,35)                                         *
## prs_scaled:age.firstbirth.group[35,80)
## prs_scaled:age.firstbirth.group[80,1e+03)
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 19420  on 91264  degrees of freedom
## Residual deviance: 18767  on 91194  degrees of freedom
## AIC: 18909
##
## Number of Fisher Scoring iterations: 14
```

2.2 Retrospective Model on Case-Control Samples

```
#Now let's select the control samples for the case/control study
table(dat_test_complete$breast_cancer)
```

```
##
##     0     1
## 89241  2024
```

```
#select 2024 controls who did not have breast cancer
control=dat_test_complete[which(dat_test_complete$breast_cancer==0),]
set.seed(10252022)
control=control[sample(1:dim(control)[1],size=2024,replace = F),]
dat_test_casecontrol=rbind(control,dat_test_complete[which(dat_test_complete$breast_cancer==1),])
dat_test_casecontrol$prs_scaled=scale(dat_test_casecontrol$prs_bc,center = T,scale = T)
dat_test_casecontrol$age.menarche.scale=scale(dat_test_casecontrol$age.menarche,center = T,scale=T)
dat_test_casecontrol$age.menopause.scale=scale(dat_test_casecontrol$age.menopause,center = T,scale=T)
dat_test_casecontrol$n.children.scale=scale(dat_test_casecontrol$n.children.win,center=T,scale = T)
dat_test_casecontrol$height.scale=scale(dat_test_casecontrol$height,center=T,scale = T)
dat_test_casecontrol$BMI.scale=scale(dat_test_casecontrol$BMI,center=T,scale = T)
dat_test_casecontrol$length.oc.scale=scale(dat_test_casecontrol$length.oc,center=T,scale = T)
dat_test_casecontrol$birth.x=scale(dat_test_casecontrol$birth.x,center=T,scale=T)
dat_test_casecontrol$birth.y=scale(dat_test_casecontrol$birth.y,center=T,scale=T)

dat_test_casecontrol.coordinate=dat_test_casecontrol[complete.cases(dat_test_casecontrol),]
table(dat_test_casecontrol.coordinate$breast_cancer)
```

```
##
##    0    1
## 2024 2024
```

```
dat_test_casecontrol.coordinate$assessment_center=factor(dat_test_casecontrol.coordinate$assessment_cen
dat_test_casecontrol.coordinate$assessment_center=relevel(dat_test_casecontrol.coordinate$assessment_ce
fit_normal.coordinate1<-prs_e_function_gr(data=dat_test_casecontrol.coordinate,
                                          formula = breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC7
                                          formula_prs = prs_scaled ~ PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC9
                                          numDeriv = F,
                                          facVar="assessment_center")
```

```
## After removing missing values, the number of observations is 4048
## initial  value 8390.902284
## iter  50 value 8369.798706
## iter 100 value 8368.161818
## iter 100 value 8368.161773
## iter 100 value 8368.161770
## final  value 8368.161770
## converged
```

```
fit_normal.coordinate2<-prs_e_function_gr(data=dat_test_casecontrol.coordinate,
                                          formula = breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC
                                          formula_prs = prs_scaled ~ PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC
                                          numDeriv = F,
                                          facVar="assessment_center")
```

```
## After removing missing values, the number of observations is 4048
## initial  value 8388.862534
## iter  50 value 8367.676436
## final  value 8366.343437
## converged
```

```
fit_normal.coordinate3<-prs_e_function_gr(data=dat_test_casecontrol.coordinate,
                                          formula = breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC
                                          formula_prs = prs_scaled ~ PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC
                                          numDeriv = F,
                                          facVar="assessment_center")
```

```
## After removing missing values, the number of observations is 4048
## initial  value 8391.674153
## iter  50 value 8366.035996
## iter 100 value 8364.536027
## final  value 8364.535193
## converged
```

```
#Print the results, our method
fit_normal.coordinate1$res_normal
```

```
##                                        Estimate    Std.Error
## (Intercept)                        3.948664e-02 3.422669e-01
## prs_scaled                         5.567272e-01 1.962090e-01
## PC1                               -2.260605e-03 9.282367e-03
## PC2                               -9.034258e-03 1.116144e-02
## PC3                               -2.504868e-03 1.683675e-02
## PC4                                2.426211e-03 8.993225e-03
## PC5                               -2.248847e-03 5.621667e-03
## PC6                               -4.131319e-02 1.602939e-02
## PC7                               -5.026927e-03 1.065833e-02
## PC8                                2.027277e-02 1.237372e-02
## PC9                               -3.664627e-03 8.243453e-03
## PC10                              -1.795839e-02 1.577233e-02
## HRT.ever1                          1.097781e-01 6.745237e-02
## agegroups[50,60)                   3.813120e-01 2.378596e-01
```

```
## agegroups[60,70)                              5.273348e-01 2.384501e-01
## agegroups[70,80)                              4.843595e-01 4.800389e-01
## n.children.scale                             -7.691003e-02 5.179446e-02
## birth.x                                       2.096387e-02 4.607019e-02
## birth.y                                       1.141679e-02 5.450359e-02
## age.firstbirth.group[25,35)                   1.559022e-02 7.746185e-02
## age.firstbirth.group[35,80)                   2.778220e-01 1.687056e-01
## age.firstbirth.group[80,1e+03)               -1.614229e-01 1.483240e-01
## height.scale                                  8.730861e-02 3.381184e-02
## age.menarche.scale                            1.831520e-02 3.310839e-02
## age.menopause.scale                           9.486220e-02 3.373300e-02
## length.oc.scale                              -7.725375e-03 3.370364e-02
## BMI.scale                                     1.375522e-01 3.365540e-02
## assessment_center10003                       -9.858323e-01 9.552895e-01
## assessment_center11002                       -7.939277e-01 2.712663e-01
## assessment_center11003                       -5.697407e-01 2.837481e-01
## assessment_center11004                       -6.346776e-01 2.754790e-01
## assessment_center11005                       -5.498312e-01 2.767912e-01
## assessment_center11006                       -6.721534e-01 2.633832e-01
## assessment_center11007                       -4.991430e-01 2.487615e-01
## assessment_center11008                       -6.516487e-01 2.469267e-01
## assessment_center11009                       -5.839815e-01 2.487204e-01
## assessment_center11010                       -8.304449e-01 2.397990e-01
## assessment_center11011                       -6.872853e-01 2.421198e-01
## assessment_center11012                       -8.493216e-01 3.063264e-01
## assessment_center11013                       -7.760932e-01 2.468453e-01
## assessment_center11014                       -1.031056e+00 2.537289e-01
## assessment_center11016                       -7.207543e-01 2.414505e-01
## assessment_center11017                       -8.759684e-01 2.695332e-01
## assessment_center11018                       -1.140084e+00 2.714138e-01
## assessment_center11020                       -1.039008e+00 2.639268e-01
## assessment_center11021                       -9.233514e-01 2.634024e-01
## assessment_center11022                       -7.682391e-01 5.010388e-01
## assessment_center11023                       -1.387961e+01 4.300565e+02
## alcohol                                       2.351016e-01 8.038411e-02
## prs_scaled:HRT.ever1                         -2.325342e-02 4.737374e-02
## prs_scaled:birth.x                           -7.854187e-02 3.721116e-02
## prs_scaled:birth.y                           -1.915056e-02 3.777037e-02
## prs_scaled:length.oc.scale                   -5.014684e-02 2.401896e-02
## prs_scaled:age.menopause.scale                2.002935e-05 2.399891e-02
## prs_scaled:age.menarche.scale                -1.359233e-02 2.340060e-02
## prs_scaled:BMI.scale                         -1.177562e-02 2.303585e-02
## prs_scaled:agegroups[50,60)                  -2.190439e-02 1.877971e-01
## prs_scaled:agegroups[60,70)                  -3.747816e-02 1.878514e-01
## prs_scaled:agegroups[70,80)                  -5.474055e-01 3.473865e-01
## prs_scaled:alcohol                           -9.894633e-02 5.766611e-02
## prs_scaled:height.scale                      -1.265516e-02 2.366219e-02
## prs_scaled:n.children.scale                   1.130654e-02 3.668144e-02
## prs_scaled:age.firstbirth.group[25,35)        8.385054e-02 5.439041e-02
## prs_scaled:age.firstbirth.group[35,80)       -1.400071e-01 1.138158e-01
## prs_scaled:age.firstbirth.group[80,1e+03) -3.353563e-02 1.050644e-01
## eta_(Intercept)                              -2.823509e-01 5.256166e-02
## eta_PC1                                      -6.243737e-03 4.185849e-03
## eta_PC2                                      -1.402430e-03 5.060852e-03
```

```
## eta_PC3                                  -2.661478e-03 7.773258e-03
## eta_PC4                                  -9.829818e-03 4.156795e-03
## eta_PC5                                  -9.089082e-04 2.515611e-03
## eta_PC6                                   2.558639e-03 6.559343e-03
## eta_PC7                                   1.940953e-03 5.040109e-03
## eta_PC8                                   1.641648e-03 5.496468e-03
## eta_PC9                                   4.412288e-03 3.631581e-03
## eta_PC10                                  4.939431e-03 7.068537e-03
## eta_birth.x                              -1.895135e-03 2.582357e-02
## eta_birth.y                              -1.434456e-03 2.706437e-02
## sigma_stratadata[, facVar]11001           9.089072e-01 5.722480e-02
## sigma_stratadata[, facVar]10003           3.818508e-01 1.290926e-01
## sigma_stratadata[, facVar]11002           8.986934e-01 4.861801e-02
## sigma_stratadata[, facVar]11003           9.661814e-01 5.099034e-02
## sigma_stratadata[, facVar]11004           9.392241e-01 4.437291e-02
## sigma_stratadata[, facVar]11005           9.602117e-01 4.831127e-02
## sigma_stratadata[, facVar]11006           9.519442e-01 4.738247e-02
## sigma_stratadata[, facVar]11007           9.692230e-01 3.789705e-02
## sigma_stratadata[, facVar]11008           9.995270e-01 4.021558e-02
## sigma_stratadata[, facVar]11009           9.858991e-01 3.703801e-02
## sigma_stratadata[, facVar]11010           9.385364e-01 3.360697e-02
## sigma_stratadata[, facVar]11011           9.444339e-01 3.306721e-02
## sigma_stratadata[, facVar]11012           9.276127e-01 6.564758e-02
## sigma_stratadata[, facVar]11013           1.027898e+00 4.075617e-02
## sigma_stratadata[, facVar]11014           9.866691e-01 4.367755e-02
## sigma_stratadata[, facVar]11016           9.947623e-01 3.580687e-02
## sigma_stratadata[, facVar]11017           9.841431e-01 5.021236e-02
## sigma_stratadata[, facVar]11018           9.981146e-01 5.219447e-02
## sigma_stratadata[, facVar]11020           9.687747e-01 4.689130e-02
## sigma_stratadata[, facVar]11021           1.009229e+00 5.011865e-02
## sigma_stratadata[, facVar]11022           1.160742e+00 1.501061e-01
## sigma_stratadata[, facVar]11023           5.669919e-01 2.023234e-01
##                                               Z.value        Pvalue
## (Intercept)                               0.115367976  9.081535e-01
## prs_scaled                                2.837419428  4.547982e-03
## PC1                                      -0.243537579  8.075890e-01
## PC2                                      -0.809416604  4.182756e-01
## PC3                                      -0.148773860  8.817321e-01
## PC4                                       0.269782043  7.873279e-01
## PC5                                      -0.400032004  6.891329e-01
## PC6                                      -2.577340549  9.956381e-03
## PC7                                      -0.471643009  6.371816e-01
## PC8                                       1.638373164  1.013439e-01
## PC9                                      -0.444549980  6.566450e-01
## PC10                                     -1.138600747  2.548697e-01
## HRT.ever1                                 1.627491044  1.036328e-01
## agegroups[50,60)                          1.603097169  1.089132e-01
## agegroups[60,70)                          2.211509898  2.700055e-02
## agegroups[70,80)                          1.009000521  3.129744e-01
## n.children.scale                         -1.484908464  1.375681e-01
## birth.x                                   0.455041991  6.490790e-01
## birth.y                                   0.209468660  8.340824e-01
## age.firstbirth.group[25,35)               0.201263197  8.404928e-01
## age.firstbirth.group[35,80)               1.646786553  9.960193e-02
```

```
## age.firstbirth.group[80,1e+03)            -1.088312788  2.764570e-01
## height.scale                               2.582190084  9.817549e-03
## age.menarche.scale                         0.553189102  5.801339e-01
## age.menopause.scale                        2.812148392  4.921179e-03
## length.oc.scale                           -0.229214842  8.187019e-01
## BMI.scale                                  4.087075928  4.368442e-05
## assessment_center10003                    -1.031972249  3.020851e-01
## assessment_center11002                    -2.926746058  3.425284e-03
## assessment_center11003                    -2.007910290  4.465283e-02
## assessment_center11004                    -2.303905515  2.122795e-02
## assessment_center11005                    -1.986447363  4.698367e-02
## assessment_center11006                    -2.551998013  1.071071e-02
## assessment_center11007                    -2.006512179  4.480163e-02
## assessment_center11008                    -2.639037445  8.314180e-03
## assessment_center11009                    -2.347943713  1.887737e-02
## assessment_center11010                    -3.463087438  5.340148e-04
## assessment_center11011                    -2.838617280  4.530947e-03
## assessment_center11012                    -2.772603681  5.560980e-03
## assessment_center11013                    -3.144047016  1.666287e-03
## assessment_center11014                    -4.063611538  4.831922e-05
## assessment_center11016                    -2.985101854  2.834839e-03
## assessment_center11017                    -3.249946503  1.154267e-03
## assessment_center11018                    -4.200536660  2.662830e-05
## assessment_center11020                    -3.936726725  8.260058e-05
## assessment_center11021                    -3.505478837  4.557867e-04
## assessment_center11022                    -1.533292567  1.252038e-01
## assessment_center11023                    -0.032273918  9.742536e-01
## alcohol                                    2.924727934  3.447575e-03
## prs_scaled:HRT.ever1                      -0.490850468  6.235322e-01
## prs_scaled:birth.x                        -2.110707141  3.479749e-02
## prs_scaled:birth.y                        -0.507025991  6.121366e-01
## prs_scaled:length.oc.scale                -2.087802149  3.681569e-02
## prs_scaled:age.menopause.scale             0.000834594  9.993341e-01
## prs_scaled:age.menarche.scale             -0.580853788  5.613390e-01
## prs_scaled:BMI.scale                      -0.511186638  6.092204e-01
## prs_scaled:agegroups[50,60)               -0.116638603  9.071464e-01
## prs_scaled:agegroups[60,70)               -0.199509591  8.418641e-01
## prs_scaled:agegroups[70,80)               -1.575782381  1.150760e-01
## prs_scaled:alcohol                        -1.715848802  8.618972e-02
## prs_scaled:height.scale                   -0.534826380  5.927699e-01
## prs_scaled:n.children.scale                0.308236024  7.579027e-01
## prs_scaled:age.firstbirth.group[25,35)     1.541641862  1.231606e-01
## prs_scaled:age.firstbirth.group[35,80)    -1.230119774  2.186523e-01
## prs_scaled:age.firstbirth.group[80,1e+03) -0.319191207  7.495815e-01
## eta_(Intercept)                           -5.371802382  7.795351e-08
## eta_PC1                                   -1.491629764  1.357962e-01
## eta_PC2                                   -0.277113501  7.816930e-01
## eta_PC3                                   -0.342388961  7.320582e-01
## eta_PC4                                   -2.364759039  1.804181e-02
## eta_PC5                                   -0.361307129  7.178699e-01
## eta_PC6                                    0.390075591  6.964807e-01
## eta_PC7                                    0.385101335  7.001623e-01
## eta_PC8                                    0.298673301  7.651893e-01
## eta_PC9                                    1.214977204  2.243748e-01
```

```
## eta_PC10                                  0.698791168  4.846825e-01
## eta_birth.x                              -0.073387805  9.414975e-01
## eta_birth.y                              -0.053001646  9.577306e-01
## sigma_stratadata[, facVar]11001          15.883098482  8.297625e-57
## sigma_stratadata[, facVar]10003           2.957960652  3.096817e-03
## sigma_stratadata[, facVar]11002          18.484784332  2.737914e-76
## sigma_stratadata[, facVar]11003          18.948321814  4.558916e-80
## sigma_stratadata[, facVar]11004          21.166609570  1.940233e-99
## sigma_stratadata[, facVar]11005          19.875519308  6.629693e-88
## sigma_stratadata[, facVar]11006          20.090639984  8.910614e-90
## sigma_stratadata[, facVar]11007          25.575155321 2.883581e-144
## sigma_stratadata[, facVar]11008          24.854223902 2.327788e-136
## sigma_stratadata[, facVar]11009          26.618578290 4.137585e-156
## sigma_stratadata[, facVar]11010          27.926839933 1.260110e-171
## sigma_stratadata[, facVar]11011          28.561037858 2.048756e-179
## sigma_stratadata[, facVar]11012          14.130188579  2.474807e-45
## sigma_stratadata[, facVar]11013          25.220666562 2.377099e-140
## sigma_stratadata[, facVar]11014          22.589845189 5.453844e-113
## sigma_stratadata[, facVar]11016          27.781325603 7.293567e-170
## sigma_stratadata[, facVar]11017          19.599619447  1.557845e-85
## sigma_stratadata[, facVar]11018          19.122996512  1.624980e-81
## sigma_stratadata[, facVar]11020          20.660009250  7.934912e-95
## sigma_stratadata[, facVar]11021          20.136791113  3.513769e-90
## sigma_stratadata[, facVar]11022           7.732806973  1.052007e-14
## sigma_stratadata[, facVar]11023           2.802404178  5.072328e-03
```

```
fit_normal.coordinate2$res_normal
```

```
##                                             Estimate    Std.Error
## (Intercept)                              1.143833e-01 3.496256e-01
## prs_scaled                               6.319211e-01 2.020940e-01
## PC1                                     -2.070278e-03 9.272338e-03
## PC2                                     -9.256453e-03 1.116082e-02
## PC3                                     -2.482732e-03 1.684083e-02
## PC4                                      2.789588e-03 8.995437e-03
## PC5                                     -2.545690e-03 5.625386e-03
## PC6                                     -4.190635e-02 1.605306e-02
## PC7                                     -5.524403e-03 1.066883e-02
## PC8                                      1.964101e-02 1.239240e-02
## PC9                                     -4.084408e-03 8.249830e-03
## PC10                                    -1.856019e-02 1.578256e-02
## HRT.ever1                                1.138537e-01 6.766522e-02
## agegroups[50,60)                         3.847854e-01 2.379479e-01
## agegroups[60,70)                         5.187767e-01 2.384781e-01
## agegroups[70,80)                         4.655907e-01 4.805113e-01
## n.children.scale                        -7.449453e-02 5.177401e-02
## birth.x                                  2.020331e-02 4.606847e-02
## birth.y                                  1.241593e-02 5.451456e-02
## age.firstbirth.group[25,35)              1.723651e-02 7.749110e-02
## age.firstbirth.group[35,80)              2.795794e-01 1.687465e-01
## age.firstbirth.group[80,1e+03)          -1.722964e-01 1.486196e-01
## height.scale                             8.787780e-02 3.383175e-02
## age.menarche.scale                       1.794572e-02 3.311777e-02
## age.menopause.scale                      9.542472e-02 3.375995e-02
```

```
## factor(oc.cate2)1                            -1.181491e-01 8.746166e-02
## factor(oc.cate2)2                            -5.718852e-02 9.221518e-02
## BMI.scale                                     1.380113e-01 3.367526e-02
## assessment_center10003                       -9.940654e-01 9.550528e-01
## assessment_center11002                       -7.966172e-01 2.712466e-01
## assessment_center11003                       -5.727424e-01 2.837607e-01
## assessment_center11004                       -6.428171e-01 2.755457e-01
## assessment_center11005                       -5.517754e-01 2.767953e-01
## assessment_center11006                       -6.791771e-01 2.634324e-01
## assessment_center11007                       -4.997692e-01 2.487943e-01
## assessment_center11008                       -6.571765e-01 2.469160e-01
## assessment_center11009                       -5.780287e-01 2.487112e-01
## assessment_center11010                       -8.354209e-01 2.397895e-01
## assessment_center11011                       -6.907660e-01 2.420599e-01
## assessment_center11012                       -8.486605e-01 3.063364e-01
## assessment_center11013                       -7.777573e-01 2.467860e-01
## assessment_center11014                       -1.029529e+00 2.536799e-01
## assessment_center11016                       -7.260955e-01 2.414270e-01
## assessment_center11017                       -8.837694e-01 2.695998e-01
## assessment_center11018                       -1.144572e+00 2.712972e-01
## assessment_center11020                       -1.042954e+00 2.638730e-01
## assessment_center11021                       -9.296488e-01 2.633687e-01
## assessment_center11022                       -7.927843e-01 5.014704e-01
## assessment_center11023                       -1.390991e+01 4.342067e+02
## alcohol                                       2.399167e-01 8.049237e-02
## prs_scaled:HRT.ever1                         -1.938411e-02 4.750312e-02
## prs_scaled:birth.x                           -7.862657e-02 3.721077e-02
## prs_scaled:birth.y                           -1.837563e-02 3.775392e-02
## prs_scaled:factor(oc.cate2)1                 -5.725996e-02 6.057236e-02
## prs_scaled:factor(oc.cate2)2                 -1.486511e-01 6.418316e-02
## prs_scaled:age.menopause.scale               -2.021497e-03 2.402176e-02
## prs_scaled:age.menarche.scale                -1.353702e-02 2.340212e-02
## prs_scaled:BMI.scale                         -1.200163e-02 2.302626e-02
## prs_scaled:agegroups[50,60)                  -2.102673e-02 1.879070e-01
## prs_scaled:agegroups[60,70)                  -4.023784e-02 1.879376e-01
## prs_scaled:agegroups[70,80)                  -5.510212e-01 3.472439e-01
## prs_scaled:alcohol                           -9.743896e-02 5.773019e-02
## prs_scaled:height.scale                      -1.127736e-02 2.368171e-02
## prs_scaled:n.children.scale                   1.277305e-02 3.665719e-02
## prs_scaled:age.firstbirth.group[25,35)        8.250360e-02 5.439157e-02
## prs_scaled:age.firstbirth.group[35,80)       -1.345102e-01 1.138379e-01
## prs_scaled:age.firstbirth.group[80,1e+03) -3.648980e-02 1.052210e-01
## eta_(Intercept)                              -2.828490e-01 5.256334e-02
## eta_PC1                                      -6.310626e-03 4.186107e-03
## eta_PC2                                      -1.457553e-03 5.060929e-03
## eta_PC3                                      -2.590204e-03 7.772518e-03
## eta_PC4                                      -9.794635e-03 4.157308e-03
## eta_PC5                                      -9.134795e-04 2.515632e-03
## eta_PC6                                       2.458747e-03 6.562283e-03
## eta_PC7                                       1.933820e-03 5.040290e-03
## eta_PC8                                       1.584608e-03 5.498501e-03
## eta_PC9                                       4.370385e-03 3.632141e-03
## eta_PC10                                      4.829798e-03 7.069596e-03
## eta_birth.x                                  -1.824304e-03 2.580971e-02
```

```
## eta_birth.y                                -1.416815e-03 2.704950e-02
## sigma_stratadata[, facVar]11001             9.082338e-01 5.711694e-02
## sigma_stratadata[, facVar]10003             3.828844e-01 1.303017e-01
## sigma_stratadata[, facVar]11002             8.985844e-01 4.859521e-02
## sigma_stratadata[, facVar]11003             9.667816e-01 5.106369e-02
## sigma_stratadata[, facVar]11004             9.385829e-01 4.429839e-02
## sigma_stratadata[, facVar]11005             9.600718e-01 4.828930e-02
## sigma_stratadata[, facVar]11006             9.514111e-01 4.730712e-02
## sigma_stratadata[, facVar]11007             9.699872e-01 3.797949e-02
## sigma_stratadata[, facVar]11008             9.985094e-01 4.011958e-02
## sigma_stratadata[, facVar]11009             9.861407e-01 3.706165e-02
## sigma_stratadata[, facVar]11010             9.383851e-01 3.359246e-02
## sigma_stratadata[, facVar]11011             9.446947e-01 3.308987e-02
## sigma_stratadata[, facVar]11012             9.278460e-01 6.569226e-02
## sigma_stratadata[, facVar]11013             1.027825e+00 4.075064e-02
## sigma_stratadata[, facVar]11014             9.861788e-01 4.361588e-02
## sigma_stratadata[, facVar]11016             9.947505e-01 3.580433e-02
## sigma_stratadata[, facVar]11017             9.843239e-01 5.024189e-02
## sigma_stratadata[, facVar]11018             9.975388e-01 5.211610e-02
## sigma_stratadata[, facVar]11020             9.686957e-01 4.687530e-02
## sigma_stratadata[, facVar]11021             1.008143e+00 4.997772e-02
## sigma_stratadata[, facVar]11022             1.157042e+00 1.489144e-01
## sigma_stratadata[, facVar]11023             5.661837e-01 2.016666e-01
##                                                Z.value        Pvalue
## (Intercept)                                 0.32715928  7.435474e-01
## prs_scaled                                  3.12686717  1.766797e-03
## PC1                                        -0.22327465  8.233218e-01
## PC2                                        -0.82937035  4.068949e-01
## PC3                                        -0.14742336  8.827979e-01
## PC4                                         0.31011142  7.564762e-01
## PC5                                        -0.45253603  6.508829e-01
## PC6                                        -2.61049013  9.041258e-03
## PC7                                        -0.51780753  6.045926e-01
## PC8                                         1.58492391  1.129836e-01
## PC9                                        -0.49508994  6.205366e-01
## PC10                                       -1.17599384  2.395973e-01
## HRT.ever1                                   1.68260318  9.245194e-02
## agegroups[50,60)                            1.61709900  1.058569e-01
## agegroups[60,70)                            2.17536372  2.960287e-02
## agegroups[70,80)                            0.96894837  3.325709e-01
## n.children.scale                           -1.43884029  1.501958e-01
## birth.x                                     0.43854972  6.609878e-01
## birth.y                                     0.22775444  8.198371e-01
## age.firstbirth.group[25,35)                 0.22243217  8.239775e-01
## age.firstbirth.group[35,80)                 1.65680081  9.755975e-02
## age.firstbirth.group[80,1e+03)             -1.15931105  2.463294e-01
## height.scale                                2.59749543  9.390637e-03
## age.menarche.scale                          0.54187600  5.879039e-01
## age.menopause.scale                         2.82656548  4.705012e-03
## factor(oc.cate2)1                          -1.35086719  1.767380e-01
## factor(oc.cate2)2                          -0.62016379  5.351500e-01
## BMI.scale                                   4.09830020  4.161953e-05
## assessment_center10003                     -1.04084865  2.979458e-01
## assessment_center11002                     -2.93687411  3.315387e-03
```

```
## assessment_center11003                    -2.01839936  4.354969e-02
## assessment_center11004                    -2.33288764  1.965404e-02
## assessment_center11005                    -1.99344185  4.621309e-02
## assessment_center11006                    -2.57818394  9.932111e-03
## assessment_center11007                    -2.00876443  4.456212e-02
## assessment_center11008                    -2.66153903  7.778432e-03
## assessment_center11009                    -2.32409598  2.012035e-02
## assessment_center11010                    -3.48397547  4.940248e-04
## assessment_center11011                    -2.85369847  4.321353e-03
## assessment_center11012                    -2.77035453  5.599531e-03
## assessment_center11013                    -3.15154536  1.624089e-03
## assessment_center11014                    -4.05837667  4.941502e-05
## assessment_center11016                    -3.00751526  2.633929e-03
## assessment_center11017                    -3.27807867  1.045163e-03
## assessment_center11018                    -4.21888491  2.455136e-05
## assessment_center11020                    -3.95248395  7.734412e-05
## assessment_center11021                    -3.52983737  4.158152e-04
## assessment_center11022                    -1.58091951  1.138964e-01
## assessment_center11023                    -0.03203522  9.744440e-01
## alcohol                                    2.98061443  2.876707e-03
## prs_scaled:HRT.ever1                      -0.40805968  6.832299e-01
## prs_scaled:birth.x                        -2.11300566  3.460028e-02
## prs_scaled:birth.y                        -0.48672113  6.264560e-01
## prs_scaled:factor(oc.cate2)1              -0.94531505  3.444981e-01
## prs_scaled:factor(oc.cate2)2              -2.31604539  2.055579e-02
## prs_scaled:age.menopause.scale            -0.08415275  9.329350e-01
## prs_scaled:age.menarche.scale             -0.57845257  5.629586e-01
## prs_scaled:BMI.scale                      -0.52121500  6.022170e-01
## prs_scaled:agegroups[50,60)               -0.11189967  9.109030e-01
## prs_scaled:agegroups[60,70)               -0.21410215  8.304674e-01
## prs_scaled:agegroups[70,80)               -1.58684204  1.125484e-01
## prs_scaled:alcohol                        -1.68783375  9.144315e-02
## prs_scaled:height.scale                   -0.47620539  6.339281e-01
## prs_scaled:n.children.scale                0.34844594  7.275053e-01
## prs_scaled:age.firstbirth.group[25,35)     1.51684545  1.293057e-01
## prs_scaled:age.firstbirth.group[35,80)    -1.18159398  2.373668e-01
## prs_scaled:age.firstbirth.group[80,1e+03) -0.34679204  7.287476e-01
## eta_(Intercept)                           -5.38110828  7.402865e-08
## eta_PC1                                   -1.50751663  1.316783e-01
## eta_PC2                                   -0.28800097  7.733460e-01
## eta_PC3                                   -0.33325157  7.389444e-01
## eta_PC4                                   -2.35600437  1.847270e-02
## eta_PC5                                   -0.36312134  7.165142e-01
## eta_PC6                                    0.37467864  7.078995e-01
## eta_PC7                                    0.38367247  7.012212e-01
## eta_PC8                                    0.28818903  7.732020e-01
## eta_PC9                                    1.20325305  2.288784e-01
## eta_PC10                                   0.68317880  4.944939e-01
## eta_birth.x                               -0.07068284  9.436502e-01
## eta_birth.y                               -0.05237860  9.582270e-01
## sigma_stratadata[, facVar]11001           15.90130234  6.206104e-57
## sigma_stratadata[, facVar]10003            2.93844569  3.298624e-03
## sigma_stratadata[, facVar]11002           18.49121492  2.430171e-76
## sigma_stratadata[, facVar]11003           18.93285910  6.115152e-80
```

```
## sigma_stratadata[, facVar]11004          21.18774161  1.238991e-99
## sigma_stratadata[, facVar]11005          19.88166950  5.864948e-88
## sigma_stratadata[, facVar]11006          20.11137366  5.867619e-90
## sigma_stratadata[, facVar]11007          25.53976632 7.133959e-144
## sigma_stratadata[, facVar]11008          24.88833351 9.952133e-137
## sigma_stratadata[, facVar]11009          26.60811301 5.468589e-156
## sigma_stratadata[, facVar]11010          27.93439302 1.020167e-171
## sigma_stratadata[, facVar]11011          28.54936271 2.860587e-179
## sigma_stratadata[, facVar]11012          14.12412954  2.697119e-45
## sigma_stratadata[, facVar]11013          25.22230940 2.280469e-140
## sigma_stratadata[, facVar]11014          22.61054456 3.413023e-113
## sigma_stratadata[, facVar]11016          27.78296202 6.968994e-170
## sigma_stratadata[, facVar]11017          19.59169601  1.820245e-85
## sigma_stratadata[, facVar]11018          19.14070083  1.157033e-81
## sigma_stratadata[, facVar]11020          20.66537687  7.100066e-95
## sigma_stratadata[, facVar]11021          20.17185553  1.730237e-90
## sigma_stratadata[, facVar]11022           7.76984462  7.858246e-15
## sigma_stratadata[, facVar]11023           2.80752323  4.992408e-03
```

```
fit_normal.coordinate3$res_normal
```

```
##                                            Estimate    Std.Error
## (Intercept)                            1.322011e-01 3.499958e-01
## prs_scaled                             6.367533e-01 2.021180e-01
## PC1                                   -1.850946e-03 9.271079e-03
## PC2                                   -9.398864e-03 1.117055e-02
## PC3                                   -1.970011e-03 1.685374e-02
## PC4                                    2.770548e-03 8.999440e-03
## PC5                                   -2.637584e-03 5.628723e-03
## PC6                                   -4.185826e-02 1.610184e-02
## PC7                                   -5.094107e-03 1.067844e-02
## PC8                                    1.945790e-02 1.241537e-02
## PC9                                   -4.175635e-03 8.256584e-03
## PC10                                  -1.887346e-02 1.579004e-02
## HRT.ever1                              1.147030e-01 6.770202e-02
## agegroups[50,60)                       3.722819e-01 2.382826e-01
## agegroups[60,70)                       5.008160e-01 2.389267e-01
## agegroups[70,80)                       4.439550e-01 4.808832e-01
## n.children.scale                      -7.565547e-02 5.183995e-02
## birth.x                                2.183244e-02 4.611032e-02
## birth.y                                1.063284e-02 5.453532e-02
## age.firstbirth.group[25,35)            1.572182e-02 7.753043e-02
## age.firstbirth.group[35,80)            2.742498e-01 1.688651e-01
## age.firstbirth.group[80,1e+03)        -1.707966e-01 1.487208e-01
## height.scale                           8.827477e-02 3.385064e-02
## age.menarche.scale                     1.874234e-02 3.314140e-02
## age.menopause.scale                    9.759685e-02 3.380240e-02
## factor(oc.cate3)1                     -1.146778e-01 9.962546e-02
## factor(oc.cate3)2                     -1.241402e-01 1.019382e-01
## factor(oc.cate3)3                      4.261436e-02 1.097103e-01
## factor(oc.cate3)4                     -1.441037e-01 1.055874e-01
## BMI.scale                              1.382541e-01 3.369213e-02
## assessment_center10003                -1.021523e+00 9.564248e-01
## assessment_center11002                -7.964777e-01 2.714002e-01
```

```
## assessment_center11003                    -5.757292e-01 2.841500e-01
## assessment_center11004                    -6.428831e-01 2.756726e-01
## assessment_center11005                    -5.515785e-01 2.769601e-01
## assessment_center11006                    -6.803446e-01 2.635296e-01
## assessment_center11007                    -5.086664e-01 2.489972e-01
## assessment_center11008                    -6.536859e-01 2.470162e-01
## assessment_center11009                    -5.780593e-01 2.488821e-01
## assessment_center11010                    -8.393380e-01 2.399584e-01
## assessment_center11011                    -6.884303e-01 2.422241e-01
## assessment_center11012                    -8.585367e-01 3.065301e-01
## assessment_center11013                    -7.758307e-01 2.469358e-01
## assessment_center11014                    -1.025822e+00 2.537957e-01
## assessment_center11016                    -7.264878e-01 2.415214e-01
## assessment_center11017                    -8.934081e-01 2.697337e-01
## assessment_center11018                    -1.135855e+00 2.714778e-01
## assessment_center11020                    -1.047318e+00 2.639590e-01
## assessment_center11021                    -9.237389e-01 2.634548e-01
## assessment_center11022                    -7.849327e-01 5.017214e-01
## assessment_center11023                    -1.393009e+01 4.396332e+02
## alcohol                                    2.444591e-01 8.058532e-02
## prs_scaled:HRT.ever1                      -1.933169e-02 4.752234e-02
## prs_scaled:birth.x                        -7.808567e-02 3.722136e-02
## prs_scaled:birth.y                        -1.884832e-02 3.777626e-02
## prs_scaled:factor(oc.cate3)1              -6.663107e-02 6.943037e-02
## prs_scaled:factor(oc.cate3)2              -4.755356e-02 7.098707e-02
## prs_scaled:factor(oc.cate3)3              -1.221756e-01 7.569109e-02
## prs_scaled:factor(oc.cate3)4              -1.736876e-01 7.480506e-02
## prs_scaled:age.menopause.scale            -1.445074e-03 2.403370e-02
## prs_scaled:age.menarche.scale             -1.304529e-02 2.341047e-02
## prs_scaled:BMI.scale                      -1.179838e-02 2.303611e-02
## prs_scaled:agegroups[50,60)               -2.609236e-02 1.879265e-01
## prs_scaled:agegroups[60,70)               -4.510058e-02 1.880180e-01
## prs_scaled:agegroups[70,80)               -5.585333e-01 3.473501e-01
## prs_scaled:alcohol                        -9.729574e-02 5.777404e-02
## prs_scaled:height.scale                   -1.111525e-02 2.368190e-02
## prs_scaled:n.children.scale                1.304029e-02 3.671553e-02
## prs_scaled:age.firstbirth.group[25,35)     8.214459e-02 5.440779e-02
## prs_scaled:age.firstbirth.group[35,80)    -1.349295e-01 1.138737e-01
## prs_scaled:age.firstbirth.group[80,1e+03) -3.484424e-02 1.052932e-01
## eta_(Intercept)                           -2.824238e-01 5.256379e-02
## eta_PC1                                   -6.289158e-03 4.185568e-03
## eta_PC2                                   -1.470220e-03 5.060148e-03
## eta_PC3                                   -2.482129e-03 7.773657e-03
## eta_PC4                                   -9.771823e-03 4.157577e-03
## eta_PC5                                   -9.243851e-04 2.515628e-03
## eta_PC6                                    2.473590e-03 6.561012e-03
## eta_PC7                                    1.982095e-03 5.040737e-03
## eta_PC8                                    1.565566e-03 5.498229e-03
## eta_PC9                                    4.372106e-03 3.631928e-03
## eta_PC10                                   4.831467e-03 7.069976e-03
## eta_birth.x                               -1.833114e-03 2.580439e-02
## eta_birth.y                               -1.380910e-03 2.704577e-02
## sigma_stratadata[, facVar]11001            9.081064e-01 5.710089e-02
## sigma_stratadata[, facVar]10003            3.843039e-01 1.312299e-01
```

```
## sigma_stratadata[, facVar]11002           8.983847e-01 4.856955e-02
## sigma_stratadata[, facVar]11003           9.671056e-01 5.111672e-02
## sigma_stratadata[, facVar]11004           9.384501e-01 4.428256e-02
## sigma_stratadata[, facVar]11005           9.597507e-01 4.824817e-02
## sigma_stratadata[, facVar]11006           9.512984e-01 4.729225e-02
## sigma_stratadata[, facVar]11007           9.694363e-01 3.793234e-02
## sigma_stratadata[, facVar]11008           9.985661e-01 4.012606e-02
## sigma_stratadata[, facVar]11009           9.861901e-01 3.707037e-02
## sigma_stratadata[, facVar]11010           9.382374e-01 3.357968e-02
## sigma_stratadata[, facVar]11011           9.446911e-01 3.308797e-02
## sigma_stratadata[, facVar]11012           9.276220e-01 6.564295e-02
## sigma_stratadata[, facVar]11013           1.027713e+00 4.073696e-02
## sigma_stratadata[, facVar]11014           9.862002e-01 4.362215e-02
## sigma_stratadata[, facVar]11016           9.946471e-01 3.579466e-02
## sigma_stratadata[, facVar]11017           9.838511e-01 5.018133e-02
## sigma_stratadata[, facVar]11018           9.977893e-01 5.215113e-02
## sigma_stratadata[, facVar]11020           9.683496e-01 4.683644e-02
## sigma_stratadata[, facVar]11021           1.008301e+00 5.000200e-02
## sigma_stratadata[, facVar]11022           1.156663e+00 1.487671e-01
## sigma_stratadata[, facVar]11023           5.656962e-01 2.012569e-01
##                                              Z.value        Pvalue
## (Intercept)                                0.37772202  7.056371e-01
## prs_scaled                                 3.15040378  1.630450e-03
## PC1                                       -0.19964733  8.417564e-01
## PC2                                       -0.84139652  4.001258e-01
## PC3                                       -0.11688866  9.069483e-01
## PC4                                        0.30785783  7.581905e-01
## PC5                                       -0.46859363  6.393601e-01
## PC6                                       -2.59959524  9.333378e-03
## PC7                                       -0.47704596  6.333294e-01
## PC8                                        1.56724228  1.170581e-01
## PC9                                       -0.50573394  6.130434e-01
## PC10                                      -1.19527605  2.319792e-01
## HRT.ever1                                  1.69423320  9.022098e-02
## agegroups[50,60)                           1.56235465  1.182045e-01
## agegroups[60,70)                           2.09610693  3.607271e-02
## agegroups[70,80)                           0.92320769  3.558990e-01
## n.children.scale                          -1.45940474  1.444537e-01
## birth.x                                    0.47348280  6.358688e-01
## birth.y                                    0.19497166  8.454151e-01
## age.firstbirth.group[25,35)                0.20278260  8.393050e-01
## age.firstbirth.group[35,80)                1.62407641  1.043595e-01
## age.firstbirth.group[80,1e+03)            -1.14843804  2.507878e-01
## height.scale                               2.60777269  9.113345e-03
## age.menarche.scale                         0.56552662  5.717156e-01
## age.menopause.scale                        2.88727597  3.885932e-03
## factor(oc.cate3)1                         -1.15108964  2.496954e-01
## factor(oc.cate3)2                         -1.21779772  2.233009e-01
## factor(oc.cate3)3                          0.38842616  6.977007e-01
## factor(oc.cate3)4                         -1.36478093  1.723219e-01
## BMI.scale                                  4.10345427  4.070269e-05
## assessment_center10003                    -1.06806408  2.854916e-01
## assessment_center11002                    -2.93469779  3.338727e-03
## assessment_center11003                    -2.02614524  4.274990e-02
```

```
## assessment_center11004                    -2.33205280  1.969791e-02
## assessment_center11005                    -1.99154504  4.642100e-02
## assessment_center11006                    -2.58166322  9.832548e-03
## assessment_center11007                    -2.04285996  4.106630e-02
## assessment_center11008                    -2.64632798  8.137088e-03
## assessment_center11009                    -2.32262349  2.019939e-02
## assessment_center11010                    -3.49784846  4.690276e-04
## assessment_center11011                    -2.84212086  4.481450e-03
## assessment_center11012                    -2.80082373  5.097235e-03
## assessment_center11013                    -3.14183138  1.678947e-03
## assessment_center11014                    -4.04192209  5.301485e-05
## assessment_center11016                    -3.00796429  2.630040e-03
## assessment_center11017                    -3.31218531  9.257021e-04
## assessment_center11018                    -4.18397250  2.864588e-05
## assessment_center11020                    -3.96773106  7.256015e-05
## assessment_center11021                    -3.50625194  4.544648e-04
## assessment_center11022                    -1.56447916  1.177051e-01
## assessment_center11023                    -0.03168571  9.747227e-01
## alcohol                                    3.03354446  2.416991e-03
## prs_scaled:HRT.ever1                      -0.40679173  6.841610e-01
## prs_scaled:birth.x                        -2.09787235  3.591642e-02
## prs_scaled:birth.y                        -0.49894625  6.178173e-01
## prs_scaled:factor(oc.cate3)1              -0.95968192  3.372153e-01
## prs_scaled:factor(oc.cate3)2              -0.66989049  5.029276e-01
## prs_scaled:factor(oc.cate3)3              -1.61413417  1.064983e-01
## prs_scaled:factor(oc.cate3)4              -2.32186938  2.023997e-02
## prs_scaled:age.menopause.scale            -0.06012699  9.520545e-01
## prs_scaled:age.menarche.scale             -0.55724195  5.773621e-01
## prs_scaled:BMI.scale                      -0.51216906  6.085327e-01
## prs_scaled:agegroups[50,60)               -0.13884346  8.895739e-01
## prs_scaled:agegroups[60,70)               -0.23987368  8.104282e-01
## prs_scaled:agegroups[70,80)               -1.60798374  1.078387e-01
## prs_scaled:alcohol                        -1.68407354  9.216746e-02
## prs_scaled:height.scale                   -0.46935649  6.388148e-01
## prs_scaled:n.children.scale                0.35517104  7.224615e-01
## prs_scaled:age.firstbirth.group[25,35)     1.50979449  1.310959e-01
## prs_scaled:age.firstbirth.group[35,80)    -1.18490449  2.360552e-01
## prs_scaled:age.firstbirth.group[80,1e+03) -0.33092580  7.407005e-01
## eta_(Intercept)                           -5.37297174  7.744947e-08
## eta_PC1                                   -1.50258189  1.329469e-01
## eta_PC2                                   -0.29054886  7.713964e-01
## eta_PC3                                   -0.31930005  7.494990e-01
## eta_PC4                                   -2.35036495  1.875501e-02
## eta_PC5                                   -0.36745696  7.132782e-01
## eta_PC6                                    0.37701349  7.061636e-01
## eta_PC7                                    0.39321532  6.941605e-01
## eta_PC8                                    0.28474004  7.758433e-01
## eta_PC9                                    1.20379743  2.286679e-01
## eta_PC10                                   0.68337815  4.943679e-01
## eta_birth.x                               -0.07103884  9.433668e-01
## eta_birth.y                               -0.05105824  9.592791e-01
## sigma_stratadata[, facVar]11001           15.90354243  5.988079e-57
## sigma_stratadata[, facVar]10003            2.92847724  3.406268e-03
## sigma_stratadata[, facVar]11002           18.49687224  2.188094e-76
```

```
## sigma_stratadata[, facVar]11003          18.91955527  7.871588e-80
## sigma_stratadata[, facVar]11004          21.19231950  1.124206e-99
## sigma_stratadata[, facVar]11005          19.89196139  4.776967e-88
## sigma_stratadata[, facVar]11006          20.11531205  5.419697e-90
## sigma_stratadata[, facVar]11007          25.55698404 4.591972e-144
## sigma_stratadata[, facVar]11008          24.88572640 1.062038e-136
## sigma_stratadata[, facVar]11009          26.60318670 6.235588e-156
## sigma_stratadata[, facVar]11010          27.94063309 8.567682e-172
## sigma_stratadata[, facVar]11011          28.55089605 2.737914e-179
## sigma_stratadata[, facVar]11012          14.13132889  2.435054e-45
## sigma_stratadata[, facVar]11013          25.22802103 1.974033e-140
## sigma_stratadata[, facVar]11014          22.60778464 3.633221e-113
## sigma_stratadata[, facVar]11016          27.78758029 6.128715e-170
## sigma_stratadata[, facVar]11017          19.60592028  1.376398e-85
## sigma_stratadata[, facVar]11018          19.13265194  1.350272e-81
## sigma_stratadata[, facVar]11020          20.67513376  5.800574e-95
## sigma_stratadata[, facVar]11021          20.16522328  1.978518e-90
## sigma_stratadata[, facVar]11022           7.77499406  7.545095e-15
## sigma_stratadata[, facVar]11023           2.81081650  4.941596e-03
```

```
#Logistic regression on the case-control samples
fit_normal.coordinate1$res_glm
```

```
##                                          Estimate   Std. Error
## (Intercept)                           0.008260155 3.470132e-01
## prs_scaled                            0.462734925 2.489029e-01
## PC1                                  -0.002552555 9.511719e-03
## PC2                                  -0.009801941 1.121935e-02
## PC3                                  -0.003871033 1.689315e-02
## PC4                                   0.002685681 9.041623e-03
## PC5                                  -0.001999965 5.654077e-03
## PC6                                  -0.040135343 1.601504e-02
## PC7                                  -0.006380204 1.072084e-02
## PC8                                   0.018868195 1.240621e-02
## PC9                                  -0.003638269 8.300298e-03
## PC10                                 -0.020522066 1.587645e-02
## HRT.ever1                             0.106212346 6.863169e-02
## agegroups[50,60)                      0.404696644 2.398028e-01
## agegroups[60,70)                      0.548401751 2.404813e-01
## agegroups[70,80)                      0.498258381 4.824690e-01
## n.children.scale                     -0.084219246 5.251027e-02
## birth.x                               0.025849019 4.651104e-02
## birth.y                               0.003866377 5.506817e-02
## age.firstbirth.group[25,35)           0.016437898 7.876510e-02
## age.firstbirth.group[35,80)           0.260007977 1.696139e-01
## age.firstbirth.group[80,1e+03)       -0.165231548 1.505095e-01
## height.scale                          0.083879912 3.442054e-02
## age.menarche.scale                    0.027495427 3.362473e-02
## age.menopause.scale                   0.091853321 3.430845e-02
## length.oc.scale                      -0.002853642 3.425966e-02
## BMI.scale                             0.140799613 3.441024e-02
## assessment_center10003               -0.907901843 9.730490e-01
## assessment_center11002               -0.794653476 2.766786e-01
## assessment_center11003               -0.572683907 2.913205e-01
```

```
## assessment_center11004                      -0.627713208 2.821625e-01
## assessment_center11005                      -0.566219723 2.835295e-01
## assessment_center11006                      -0.659979986 2.693549e-01
## assessment_center11007                      -0.509679603 2.535954e-01
## assessment_center11008                      -0.603107201 2.525945e-01
## assessment_center11009                      -0.556675326 2.537102e-01
## assessment_center11010                      -0.784519512 2.443396e-01
## assessment_center11011                      -0.649556236 2.470902e-01
## assessment_center11012                      -0.859819191 3.116595e-01
## assessment_center11013                      -0.805985131 2.519570e-01
## assessment_center11014                      -1.015569554 2.594015e-01
## assessment_center11016                      -0.688411115 2.470628e-01
## assessment_center11017                      -0.872962357 2.749402e-01
## assessment_center11018                      -1.131530426 2.767520e-01
## assessment_center11020                      -1.026225978 2.687791e-01
## assessment_center11021                      -0.977117327 2.690906e-01
## assessment_center11022                      -0.863385349 5.254582e-01
## assessment_center11023                     -13.879574550 2.518714e+02
## alcohol                                      0.235770877 8.172890e-02
## prs_scaled:HRT.ever1                        -0.047536994 7.151213e-02
## prs_scaled:birth.x                          -0.090084658 3.993376e-02
## prs_scaled:birth.y                          -0.014453339 4.136727e-02
## prs_scaled:length.oc.scale                  -0.032203472 3.618277e-02
## prs_scaled:age.menopause.scale              -0.014892211 3.592411e-02
## prs_scaled:age.menarche.scale                0.018043250 3.563105e-02
## prs_scaled:BMI.scale                         0.023374515 3.669647e-02
## prs_scaled:agegroups[50,60)                  0.136294825 2.432236e-01
## prs_scaled:agegroups[60,70)                  0.119744835 2.431940e-01
## prs_scaled:agegroups[70,80)                 -0.791308929 5.118362e-01
## prs_scaled:alcohol                          -0.121363525 8.640887e-02
## prs_scaled:height.scale                     -0.030653526 3.613488e-02
## prs_scaled:n.children.scale                 -0.035647760 5.574318e-02
## prs_scaled:age.firstbirth.group[25,35)       0.083487651 8.209140e-02
## prs_scaled:age.firstbirth.group[35,80)      -0.372146454 1.699289e-01
## prs_scaled:age.firstbirth.group[80,1e+03)   -0.121637151 1.592475e-01
##                                                z value     Pr(>|z|)
## (Intercept)                                 0.02380358 9.810093e-01
## prs_scaled                                  1.85909838 6.301319e-02
## PC1                                        -0.26835897 7.884230e-01
## PC2                                        -0.87366376 3.823014e-01
## PC3                                        -0.22914813 8.187538e-01
## PC4                                         0.29703529 7.664396e-01
## PC5                                        -0.35372087 7.235481e-01
## PC6                                        -2.50610393 1.220697e-02
## PC7                                        -0.59512149 5.517623e-01
## PC8                                         1.52086640 1.282934e-01
## PC9                                        -0.43832985 6.611472e-01
## PC10                                       -1.29261034 1.961459e-01
## HRT.ever1                                   1.54756996 1.217259e-01
## agegroups[50,60)                            1.68762240 9.148374e-02
## agegroups[60,70)                            2.28043404 2.258196e-02
## agegroups[70,80)                            1.03272617 3.017321e-01
## n.children.scale                           -1.60386237 1.087444e-01
## birth.x                                     0.55576095 5.783743e-01
```

```
## birth.y                                        0.07021074 9.440259e-01
## age.firstbirth.group[25,35)                    0.20869519 8.346862e-01
## age.firstbirth.group[35,80)                    1.53293999 1.252906e-01
## age.firstbirth.group[80,1e+03)                -1.09781444 2.722855e-01
## height.scale                                   2.43691415 1.481320e-02
## age.menarche.scale                             0.81771455 4.135202e-01
## age.menopause.scale                            2.67727970 7.422264e-03
## length.oc.scale                               -0.08329452 9.336174e-01
## BMI.scale                                      4.09179344 4.280499e-05
## assessment_center10003                        -0.93304841 3.507950e-01
## assessment_center11002                        -2.87211747 4.077314e-03
## assessment_center11003                        -1.96582088 4.931930e-02
## assessment_center11004                        -2.22465127 2.610466e-02
## assessment_center11005                        -1.99704017 4.582082e-02
## assessment_center11006                        -2.45022422 1.427673e-02
## assessment_center11007                        -2.00981394 4.445089e-02
## assessment_center11008                        -2.38764945 1.695651e-02
## assessment_center11009                        -2.19413851 2.822545e-02
## assessment_center11010                        -3.21077515 1.323775e-03
## assessment_center11011                        -2.62882236 8.568111e-03
## assessment_center11012                        -2.75884173 5.800662e-03
## assessment_center11013                        -3.19889906 1.379535e-03
## assessment_center11014                        -3.91504839 9.038608e-05
## assessment_center11016                        -2.78638160 5.330009e-03
## assessment_center11017                        -3.17509922 1.497853e-03
## assessment_center11018                        -4.08860801 4.339695e-05
## assessment_center11020                        -3.81810187 1.344824e-04
## assessment_center11021                        -3.63118399 2.821240e-04
## assessment_center11022                        -1.64310946 1.003603e-01
## assessment_center11023                        -0.05510580 9.560542e-01
## alcohol                                        2.88479200 3.916723e-03
## prs_scaled:HRT.ever1                          -0.66474031 5.062166e-01
## prs_scaled:birth.x                            -2.25585219 2.407989e-02
## prs_scaled:birth.y                            -0.34939069 7.267960e-01
## prs_scaled:length.oc.scale                    -0.89002234 3.734539e-01
## prs_scaled:age.menopause.scale                -0.41454643 6.784740e-01
## prs_scaled:age.menarche.scale                  0.50639125 6.125820e-01
## prs_scaled:BMI.scale                           0.63696904 5.241450e-01
## prs_scaled:agegroups[50,60)                    0.56036836 5.752282e-01
## prs_scaled:agegroups[60,70)                    0.49238406 6.224479e-01
## prs_scaled:agegroups[70,80)                   -1.54601996 1.220997e-01
## prs_scaled:alcohol                            -1.40452632 1.601622e-01
## prs_scaled:height.scale                       -0.84830849 3.962662e-01
## prs_scaled:n.children.scale                   -0.63949993 5.224978e-01
## prs_scaled:age.firstbirth.group[25,35)         1.01700846 3.091494e-01
## prs_scaled:age.firstbirth.group[35,80)        -2.19001302 2.852329e-02
## prs_scaled:age.firstbirth.group[80,1e+03) -0.76382434 4.449719e-01
```

```
fit_normal.coordinate2$res_glm
```

```
##                                                Estimate   Std. Error
## (Intercept)                                 0.084099113 3.543370e-01
## prs_scaled                                  0.539253770 2.606993e-01
## PC1                                        -0.002163022 9.475977e-03
```

```
## PC2                                    -0.010132590 1.120552e-02
## PC3                                    -0.003428894 1.689114e-02
## PC4                                     0.003311438 9.043707e-03
## PC5                                    -0.002417363 5.659955e-03
## PC6                                    -0.041077883 1.603872e-02
## PC7                                    -0.007117651 1.073552e-02
## PC8                                     0.018207167 1.243182e-02
## PC9                                    -0.004065519 8.307971e-03
## PC10                                   -0.021170482 1.589182e-02
## HRT.ever1                               0.109869979 6.885802e-02
## agegroups[50,60)                        0.410361275 2.399195e-01
## agegroups[60,70)                        0.539542033 2.405337e-01
## agegroups[70,80)                        0.483933724 4.829253e-01
## n.children.scale                       -0.080850512 5.250915e-02
## birth.x                                 0.024253020 4.654079e-02
## birth.y                                 0.004156738 5.510173e-02
## age.firstbirth.group[25,35)             0.019211589 7.882071e-02
## age.firstbirth.group[35,80)             0.263991308 1.697172e-01
## age.firstbirth.group[80,1e+03)         -0.173358103 1.508467e-01
## height.scale                            0.084798118 3.444708e-02
## age.menarche.scale                      0.026891753 3.364506e-02
## age.menopause.scale                     0.092469164 3.434733e-02
## factor(oc.cate2)1                      -0.122010945 8.895405e-02
## factor(oc.cate2)2                      -0.049753651 9.381845e-02
## BMI.scale                               0.141672313 3.443464e-02
## assessment_center10003                 -0.920777501 9.721551e-01
## assessment_center11002                 -0.798984660 2.766144e-01
## assessment_center11003                 -0.577172610 2.913421e-01
## assessment_center11004                 -0.641975926 2.823466e-01
## assessment_center11005                 -0.570069494 2.835443e-01
## assessment_center11006                 -0.671918074 2.693501e-01
## assessment_center11007                 -0.508594474 2.536176e-01
## assessment_center11008                 -0.607497112 2.527437e-01
## assessment_center11009                 -0.554783204 2.537570e-01
## assessment_center11010                 -0.790002809 2.442424e-01
## assessment_center11011                 -0.656251556 2.470950e-01
## assessment_center11012                 -0.863436322 3.117450e-01
## assessment_center11013                 -0.808730749 2.518993e-01
## assessment_center11014                 -1.014651609 2.593691e-01
## assessment_center11016                 -0.692904889 2.470503e-01
## assessment_center11017                 -0.878687956 2.750220e-01
## assessment_center11018                 -1.138356662 2.766618e-01
## assessment_center11020                 -1.030238263 2.688831e-01
## assessment_center11021                 -0.983779561 2.691310e-01
## assessment_center11022                 -0.874401715 5.265075e-01
## assessment_center11023                -13.909880108 2.529276e+02
## alcohol                                 0.241331336 8.183928e-02
## prs_scaled:HRT.ever1                   -0.042648114 7.164019e-02
## prs_scaled:birth.x                     -0.092821154 3.994858e-02
## prs_scaled:birth.y                     -0.017282810 4.139910e-02
## prs_scaled:factor(oc.cate2)1           -0.053874050 9.280338e-02
## prs_scaled:factor(oc.cate2)2           -0.130461755 9.808540e-02
## prs_scaled:age.menopause.scale         -0.016202964 3.596159e-02
## prs_scaled:age.menarche.scale           0.017115264 3.569845e-02
```

```
## prs_scaled:BMI.scale                          0.023930049 3.670429e-02
## prs_scaled:agegroups[50,60)                   0.127397630 2.429625e-01
## prs_scaled:agegroups[60,70)                   0.100806963 2.432399e-01
## prs_scaled:agegroups[70,80)                  -0.814848646 5.131527e-01
## prs_scaled:alcohol                           -0.117001891 8.654854e-02
## prs_scaled:height.scale                      -0.028138773 3.619028e-02
## prs_scaled:n.children.scale                  -0.033707284 5.578834e-02
## prs_scaled:age.firstbirth.group[25,35)        0.083914662 8.216649e-02
## prs_scaled:age.firstbirth.group[35,80)       -0.369853170 1.702754e-01
## prs_scaled:age.firstbirth.group[80,1e+03)    -0.120434312 1.605752e-01
##                                                 z value     Pr(>|z|)
## (Intercept)                                  0.23734220 8.123913e-01
## prs_scaled                                   2.06848956 3.859401e-02
## PC1                                         -0.22826378 8.194412e-01
## PC2                                         -0.90424992 3.658629e-01
## PC3                                         -0.20299960 8.391353e-01
## PC4                                          0.36615934 7.142462e-01
## PC5                                         -0.42709925 6.693070e-01
## PC6                                         -2.56116934 1.043205e-02
## PC7                                         -0.66300031 5.073304e-01
## PC8                                          1.46456165 1.430406e-01
## PC9                                         -0.48935163 6.245928e-01
## PC10                                        -1.33216263 1.828068e-01
## HRT.ever1                                    1.59560181 1.105777e-01
## agegroups[50,60)                             1.71041233 8.718965e-02
## agegroups[60,70)                             2.24310352 2.489014e-02
## agegroups[70,80)                             1.00208816 3.163010e-01
## n.children.scale                            -1.53974150 1.236234e-01
## birth.x                                      0.52111323 6.022879e-01
## birth.y                                      0.07543753 9.398666e-01
## age.firstbirth.group[25,35)                  0.24373783 8.074339e-01
## age.firstbirth.group[35,80)                  1.55547783 1.198323e-01
## age.firstbirth.group[80,1e+03)              -1.14923352 2.504597e-01
## height.scale                                 2.46169252 1.382832e-02
## age.menarche.scale                           0.79927784 4.241293e-01
## age.menopause.scale                          2.69217905 7.098682e-03
## factor(oc.cate2)1                           -1.37161773 1.701825e-01
## factor(oc.cate2)2                           -0.53031842 5.958912e-01
## BMI.scale                                    4.11423865 3.884594e-05
## assessment_center10003                      -0.94715087 3.435619e-01
## assessment_center11002                      -2.88844209 3.871553e-03
## assessment_center11003                      -1.98108221 4.758205e-02
## assessment_center11004                      -2.27371603 2.298307e-02
## assessment_center11005                      -2.01051296 4.437693e-02
## assessment_center11006                      -2.49459026 1.261027e-02
## assessment_center11007                      -2.00535974 4.492460e-02
## assessment_center11008                      -2.40360895 1.623413e-02
## assessment_center11009                      -2.18627730 2.879532e-02
## assessment_center11010                      -3.23450295 1.218547e-03
## assessment_center11011                      -2.65586693 7.910482e-03
## assessment_center11012                      -2.76968791 5.611003e-03
## assessment_center11013                      -3.21053180 1.324896e-03
## assessment_center11014                      -3.91199899 9.153530e-05
## assessment_center11016                      -2.80471213 5.036154e-03
```

```
## assessment_center11017                    -3.19497385 1.398435e-03
## assessment_center11018                    -4.11461527 3.878257e-05
## assessment_center11020                    -3.83154696 1.273401e-04
## assessment_center11021                    -3.65539303 2.567883e-04
## assessment_center11022                    -1.66075827 9.676201e-02
## assessment_center11023                    -0.05499551 9.561420e-01
## alcohol                                    2.94884465 3.189643e-03
## prs_scaled:HRT.ever1                      -0.59530989 5.516363e-01
## prs_scaled:birth.x                        -2.32351558 2.015147e-02
## prs_scaled:birth.y                        -0.41746824 6.763359e-01
## prs_scaled:factor(oc.cate2)1              -0.58051821 5.615652e-01
## prs_scaled:factor(oc.cate2)2              -1.33008330 1.834908e-01
## prs_scaled:age.menopause.scale            -0.45056304 6.523045e-01
## prs_scaled:age.menarche.scale              0.47943999 6.316256e-01
## prs_scaled:BMI.scale                       0.65196874 5.144213e-01
## prs_scaled:agegroups[50,60)                0.52435110 6.000344e-01
## prs_scaled:agegroups[60,70)                0.41443436 6.785560e-01
## prs_scaled:agegroups[70,80)               -1.58792631 1.123030e-01
## prs_scaled:alcohol                        -1.35186444 1.764187e-01
## prs_scaled:height.scale                   -0.77752305 4.368502e-01
## prs_scaled:n.children.scale               -0.60419939 5.457111e-01
## prs_scaled:age.firstbirth.group[25,35)     1.02127593 3.071237e-01
## prs_scaled:age.firstbirth.group[35,80)    -2.17208791 2.984903e-02
## prs_scaled:age.firstbirth.group[80,1e+03) -0.75001818 4.532438e-01
```

```
fit_normal.coordinate3$res_glm
```

```
##                                             Estimate   Std. Error
## (Intercept)                                9.592044e-02 3.546142e-01
## prs_scaled                                 5.434897e-01 2.585761e-01
## PC1                                       -1.849708e-03 9.464514e-03
## PC2                                       -1.048159e-02 1.122079e-02
## PC3                                       -2.669243e-03 1.692696e-02
## PC4                                        3.509450e-03 9.055153e-03
## PC5                                       -2.874827e-03 5.669129e-03
## PC6                                       -4.150908e-02 1.609610e-02
## PC7                                       -7.014964e-03 1.075969e-02
## PC8                                        1.805324e-02 1.246472e-02
## PC9                                       -4.205615e-03 8.316995e-03
## PC10                                      -2.128389e-02 1.591193e-02
## HRT.ever1                                  1.119814e-01 6.891983e-02
## agegroups[50,60)                           4.011869e-01 2.401393e-01
## agegroups[60,70)                           5.237160e-01 2.408743e-01
## agegroups[70,80)                           4.522265e-01 4.833021e-01
## n.children.scale                          -8.193791e-02 5.259468e-02
## birth.x                                    2.400648e-02 4.658974e-02
## birth.y                                    6.255068e-04 5.514362e-02
## age.firstbirth.group[25,35)                1.698120e-02 7.888473e-02
## age.firstbirth.group[35,80)                2.666510e-01 1.699352e-01
## age.firstbirth.group[80,1e+03)            -1.734104e-01 1.509869e-01
## height.scale                               8.385630e-02 3.448699e-02
## age.menarche.scale                         2.778278e-02 3.368448e-02
## age.menopause.scale                        9.467130e-02 3.439286e-02
## factor(oc.cate3)1                         -1.148840e-01 1.013758e-01
```

```
## factor(oc.cate3)2                           -1.334059e-01 1.035384e-01
## factor(oc.cate3)3                            3.558564e-02 1.111321e-01
## factor(oc.cate3)4                           -1.194039e-01 1.078383e-01
## BMI.scale                                    1.413105e-01 3.445894e-02
## assessment_center10003                      -9.549665e-01 9.747334e-01
## assessment_center11002                      -7.945980e-01 2.768132e-01
## assessment_center11003                      -5.749387e-01 2.918730e-01
## assessment_center11004                      -6.320929e-01 2.826409e-01
## assessment_center11005                      -5.620557e-01 2.838579e-01
## assessment_center11006                      -6.728585e-01 2.694865e-01
## assessment_center11007                      -5.063815e-01 2.538320e-01
## assessment_center11008                      -5.951811e-01 2.530042e-01
## assessment_center11009                      -5.472708e-01 2.540400e-01
## assessment_center11010                      -7.874633e-01 2.445656e-01
## assessment_center11011                      -6.530683e-01 2.473650e-01
## assessment_center11012                      -8.684709e-01 3.118907e-01
## assessment_center11013                      -8.027725e-01 2.521281e-01
## assessment_center11014                      -1.006256e+00 2.595541e-01
## assessment_center11016                      -6.882193e-01 2.472351e-01
## assessment_center11017                      -8.790774e-01 2.752101e-01
## assessment_center11018                      -1.129544e+00 2.769844e-01
## assessment_center11020                      -1.031703e+00 2.689788e-01
## assessment_center11021                      -9.788918e-01 2.692612e-01
## assessment_center11022                      -8.662371e-01 5.265371e-01
## assessment_center11023                      -1.393005e+01 2.546562e+02
## alcohol                                      2.462156e-01 8.197299e-02
## prs_scaled:HRT.ever1                        -4.514183e-02 7.173930e-02
## prs_scaled:birth.x                          -9.582476e-02 4.007790e-02
## prs_scaled:birth.y                          -1.556683e-02 4.145647e-02
## prs_scaled:factor(oc.cate3)1                -2.942689e-02 1.062434e-01
## prs_scaled:factor(oc.cate3)2                -7.858976e-02 1.078889e-01
## prs_scaled:factor(oc.cate3)3                -2.203162e-01 1.161664e-01
## prs_scaled:factor(oc.cate3)4                -5.922072e-02 1.133993e-01
## prs_scaled:age.menopause.scale              -1.874488e-02 3.602656e-02
## prs_scaled:age.menarche.scale                1.582781e-02 3.575517e-02
## prs_scaled:BMI.scale                         2.418313e-02 3.671342e-02
## prs_scaled:agegroups[50,60)                  1.261065e-01 2.408419e-01
## prs_scaled:agegroups[60,70)                  9.988798e-02 2.408434e-01
## prs_scaled:agegroups[70,80)                 -8.107028e-01 5.123439e-01
## prs_scaled:alcohol                          -1.218825e-01 8.660897e-02
## prs_scaled:height.scale                     -2.634636e-02 3.622962e-02
## prs_scaled:n.children.scale                 -3.387916e-02 5.598839e-02
## prs_scaled:age.firstbirth.group[25,35)       9.074475e-02 8.229384e-02
## prs_scaled:age.firstbirth.group[35,80)      -3.776702e-01 1.707841e-01
## prs_scaled:age.firstbirth.group[80,1e+03) -1.232166e-01 1.609637e-01
##                                                 z value     Pr(>|z|)
## (Intercept)                                  0.27049241 7.867815e-01
## prs_scaled                                   2.10185629 3.556587e-02
## PC1                                         -0.19543615 8.450515e-01
## PC2                                         -0.93412263 3.502406e-01
## PC3                                         -0.15769182 8.746996e-01
## PC4                                          0.38756388 6.983388e-01
## PC5                                         -0.50710209 6.120832e-01
## PC6                                         -2.57882821 9.913608e-03
```

```
## PC7                                  -0.65196688 5.144225e-01
## PC8                                   1.44834711 1.475200e-01
## PC9                                  -0.50566517 6.130917e-01
## PC10                                 -1.33760598 1.810249e-01
## HRT.ever1                             1.62480693 1.042037e-01
## agegroups[50,60)                      1.67064251 9.479231e-02
## agegroups[60,70)                      2.17422968 2.968789e-02
## agegroups[70,80)                      0.93570164 3.494268e-01
## n.children.scale                     -1.55791258 1.192540e-01
## birth.x                               0.51527395 6.063616e-01
## birth.y                               0.01134323 9.909496e-01
## age.firstbirth.group[25,35)           0.21526601 8.295599e-01
## age.firstbirth.group[35,80)           1.56913315 1.166169e-01
## age.firstbirth.group[80,1e+03)       -1.14851264 2.507570e-01
## height.scale                          2.43153471 1.503501e-02
## age.menarche.scale                    0.82479469 4.094882e-01
## age.menopause.scale                   2.75264366 5.911620e-03
## factor(oc.cate3)1                    -1.13324861 2.571099e-01
## factor(oc.cate3)2                    -1.28846839 1.975830e-01
## factor(oc.cate3)3                     0.32021034 7.488089e-01
## factor(oc.cate3)4                    -1.10724986 2.681859e-01
## BMI.scale                             4.10083614 4.116600e-05
## assessment_center10003               -0.97972076 3.272240e-01
## assessment_center11002               -2.87052097 4.097960e-03
## assessment_center11003               -1.96982471 4.885846e-02
## assessment_center11004               -2.23638130 2.532681e-02
## assessment_center11005               -1.98006001 4.769679e-02
## assessment_center11006               -2.49681737 1.253135e-02
## assessment_center11007               -1.99494731 4.604863e-02
## assessment_center11008               -2.35245535 1.864993e-02
## assessment_center11009               -2.15427049 3.121897e-02
## assessment_center11010               -3.21984534 1.282598e-03
## assessment_center11011               -2.64010016 8.288153e-03
## assessment_center11012               -2.78453604 5.360436e-03
## assessment_center11013               -3.18398637 1.452619e-03
## assessment_center11014               -3.87686477 1.058111e-04
## assessment_center11016               -2.78366303 5.374884e-03
## assessment_center11017               -3.19420477 1.402166e-03
## assessment_center11018               -4.07800783 4.542324e-05
## assessment_center11020               -3.83562987 1.252429e-04
## assessment_center11021               -3.63547242 2.774717e-04
## assessment_center11022               -1.64515876 9.993708e-02
## assessment_center11023               -0.05470142 9.563763e-01
## alcohol                               3.00361825 2.667899e-03
## prs_scaled:HRT.ever1                 -0.62924829 5.291865e-01
## prs_scaled:birth.x                   -2.39096255 1.680427e-02
## prs_scaled:birth.y                   -0.37549832 7.072899e-01
## prs_scaled:factor(oc.cate3)1         -0.27697625 7.817983e-01
## prs_scaled:factor(oc.cate3)2         -0.72843239 4.663489e-01
## prs_scaled:factor(oc.cate3)3         -1.89655745 5.788637e-02
## prs_scaled:factor(oc.cate3)4         -0.52223187 6.015089e-01
## prs_scaled:age.menopause.scale       -0.52030721 6.028495e-01
## prs_scaled:age.menarche.scale         0.44267185 6.580031e-01
## prs_scaled:BMI.scale                  0.65869995 5.100885e-01
```

```
## prs_scaled:agegroups[50,60)                 0.52360678 6.005521e-01
## prs_scaled:agegroups[60,70)                 0.41474246 6.783304e-01
## prs_scaled:agegroups[70,80)                -1.58234112 1.135717e-01
## prs_scaled:alcohol                         -1.40727352 1.593463e-01
## prs_scaled:height.scale                    -0.72720499 4.671004e-01
## prs_scaled:n.children.scale                -0.60511050 5.451056e-01
## prs_scaled:age.firstbirth.group[25,35)      1.10269201 2.701609e-01
## prs_scaled:age.firstbirth.group[35,80)     -2.21139022 2.700883e-02
## prs_scaled:age.firstbirth.group[80,1e+03) -0.76549335 4.439778e-01
```

2.3 Case-only method for Post-Menopause

```
summary.caseonly=function (parms, sd, sided = 2)
{
  if (sided != 1)
    sided <- 2
  cols <- c("Estimate", "Std.Error", "Z.value", "Pvalue")
  n <- length(parms)
  ret <- matrix(data = NA, nrow = n, ncol = 4)
  pnames <- c("prs",paste0("prs:",names(parms)[-1]))
  rownames(ret) <- pnames
  colnames(ret) <- cols
  ret[, 1] <- parms
  if (is.null(pnames))
    pnames <- 1:n
  cov <- sd
  ret[, 2] <- cov
  ret[, 3] <- parms/cov
  ret[, 4] <- sided * pnorm(abs(ret[, 3]), lower.tail = FALSE)
  ret
}
dat_caseonly=dat_test_casecontrol.coordinate[which(dat_test_casecontrol.coordinate$breast_cancer==1),]
fit_caseonly <- lm(prs_scaled~PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC9+PC10+HRT.ever+agegroups+n.children.sca
beta_int=fit_caseonly$coefficients[-1]/(sd(fit_caseonly$residuals))^2
sd_int=summary(fit_caseonly)$coef[-1,2]/(sd(fit_caseonly$residuals))^2
mean_prs=mean(dat_test_complete$prs_scaled)
beta_prs=(fit_caseonly$coefficients[1]-mean_prs)/(sd(fit_caseonly$residuals))^2
sd_prs= sqrt(( (summary(fit_caseonly)$coef[1,2])^2 +(sd(fit_caseonly$residuals))^2/dim(dat_test_complete
res_caseonly_post=summary.caseonly(parms = c(beta_prs,beta_int),sd=c(sd_prs,sd_int))
print(res_caseonly_post)
```

```
##                                      Estimate   Std.Error     Z.value
## prs                             0.3728294232 0.252853609  1.47448725
## prs:PC1                        -0.0013406026 0.009799870 -0.13679799
## prs:PC2                         0.0040196087 0.008794805  0.45704352
## prs:PC3                        -0.0124403709 0.012104001 -1.02778996
## prs:PC4                        -0.0159482490 0.006812588 -2.34099713
## prs:PC5                        -0.0053440327 0.004052694 -1.31863718
## prs:PC6                        -0.0037472430 0.013533251 -0.27689156
## prs:PC7                         0.0046584632 0.007807159  0.59669119
## prs:PC8                         0.0083720993 0.009819084  0.85263550
## prs:PC9                         0.0064857885 0.005917769  1.09598541
```

```
## prs:PC10                              0.0092619437 0.011417671  0.81119378
## prs:HRT.ever1                        -0.0278167796 0.048365028 -0.57514242
## prs:agegroups[50,60)                 -0.0712761694 0.191323443 -0.37254279
## prs:agegroups[60,70)                 -0.0802104321 0.191098749 -0.41973290
## prs:agegroups[70,80)                 -0.6629463398 0.358763078 -1.84786668
## prs:n.children.scale                  0.0106798315 0.037500287  0.28479333
## prs:birth.x                          -0.0911838656 0.032915548 -2.77023689
## prs:birth.y                          -0.0077704336 0.038827275 -0.20012823
## prs:age.firstbirth.group[25,35)       0.0824116394 0.055935308  1.47333844
## prs:age.firstbirth.group[35,80)      -0.1489171292 0.116058444 -1.28312189
## prs:age.firstbirth.group[80,1e+03) -0.0373014572 0.108486179 -0.34383603
## prs:height.scale                     -0.0163562863 0.024059436 -0.67982834
## prs:age.menarche.scale               -0.0114750268 0.023099427 -0.49676672
## prs:age.menopause.scale              -0.0008313827 0.024108716 -0.03448474
## prs:length.oc.scale                  -0.0501674937 0.024349621 -2.06029877
## prs:BMI.scale                        -0.0140314662 0.024984648 -0.56160351
## prs:assessment_center10003           -0.3698482992 0.751905360 -0.49188145
## prs:assessment_center11002           -0.0132612901 0.178675116 -0.07422013
## prs:assessment_center11003            0.0144130623 0.185067630  0.07787997
## prs:assessment_center11004           -0.0700282341 0.178696029 -0.39188467
## prs:assessment_center11005            0.0055300825 0.178774441  0.03093329
## prs:assessment_center11006            0.0450617140 0.171118409  0.26333645
## prs:assessment_center11007           -0.0104247430 0.157206880 -0.06631226
## prs:assessment_center11008           -0.0998227445 0.157450547 -0.63399427
## prs:assessment_center11009           -0.0337616535 0.157028028 -0.21500400
## prs:assessment_center11010           -0.2010175695 0.152666291 -1.31671221
## prs:assessment_center11011           -0.0956082806 0.154248338 -0.61983346
## prs:assessment_center11012            0.1495237490 0.209584471  0.71342952
## prs:assessment_center11013            0.1015525225 0.158175239  0.64202541
## prs:assessment_center11014           -0.0851876884 0.167958370 -0.50719526
## prs:assessment_center11016           -0.0893563686 0.154111000 -0.57981824
## prs:assessment_center11017           -0.0613602476 0.178677402 -0.34341359
## prs:assessment_center11018            0.0140224545 0.184764848  0.07589352
## prs:assessment_center11020           -0.0923511493 0.176740308 -0.52252455
## prs:assessment_center11021            0.0569829084 0.174871261  0.32585634
## prs:assessment_center11022            0.3766075671 0.346484121  1.08694034
## prs:alcohol                          -0.0908146015 0.059297025 -1.53152038
##                                           Pvalue
## prs                                  0.140350447
## prs:PC1                              0.891190473
## prs:PC2                              0.647639769
## prs:PC3                              0.304048638
## prs:PC4                              0.019232315
## prs:PC5                              0.187290439
## prs:PC6                              0.781863372
## prs:PC7                              0.550713579
## prs:PC8                              0.393861469
## prs:PC9                              0.273085160
## prs:PC10                             0.417254399
## prs:HRT.ever1                        0.565194980
## prs:agegroups[50,60)                 0.709488758
## prs:agegroups[60,70)                 0.674680587
## prs:agegroups[70,80)                 0.064621631
## prs:n.children.scale                 0.775802481
```

```
## prs:birth.x                          0.005601554
## prs:birth.y                          0.841380297
## prs:age.firstbirth.group[25,35)      0.140659801
## prs:age.firstbirth.group[35,80)      0.199449377
## prs:age.firstbirth.group[80,1e+03)   0.730969602
## prs:height.scale                     0.496613163
## prs:age.menarche.scale               0.619353565
## prs:age.menopause.scale              0.972490613
## prs:length.oc.scale                  0.039369987
## prs:BMI.scale                        0.574386188
## prs:assessment_center10003           0.622803152
## prs:assessment_center11002           0.940835230
## prs:assessment_center11003           0.937923529
## prs:assessment_center11004           0.695143431
## prs:assessment_center11005           0.975322737
## prs:assessment_center11006           0.792291269
## prs:assessment_center11007           0.947129225
## prs:assessment_center11008           0.526084562
## prs:assessment_center11009           0.829764203
## prs:assessment_center11010           0.187935108
## prs:assessment_center11011           0.535367440
## prs:assessment_center11012           0.475580009
## prs:assessment_center11013           0.520856686
## prs:assessment_center11014           0.612017823
## prs:assessment_center11016           0.562037197
## prs:assessment_center11017           0.731287339
## prs:assessment_center11018           0.939503813
## prs:assessment_center11020           0.601305160
## prs:assessment_center11021           0.744533052
## prs:assessment_center11022           0.277063179
## prs:alcohol                          0.125640835
```

```
fit_caseonly <- lm(prs_scaled~HRT.ever+agegroups+n.children.scale+birth.x+birth.y+age.firstbirth.group+
beta_int=fit_caseonly$coefficients[-1]/(sd(fit_caseonly$residuals))^2
sd_int=summary(fit_caseonly)$coef[-1,2]/(sd(fit_caseonly$residuals))^2

beta_prs=(fit_caseonly$coefficients[1]-mean_prs)/(sd(fit_caseonly$residuals))^2
sd_prs= sqrt(( (summary(fit_caseonly)$coef[1,2])^2 +(sd(fit_caseonly$residuals))^2/dim(dat_test_complete
res_caseonly=summary.caseonly(parms = c(beta_prs,beta_int),sd=c(sd_prs,sd_int))
print(res_caseonly)
```

```
##                                       Estimate  Std.Error    Z.value
## prs                                0.338447886 0.19289246  1.7545937
## prs:HRT.ever1                     -0.018313578 0.04702643 -0.3894316
## prs:agegroups[50,60)              -0.035260410 0.18731082 -0.1882454
## prs:agegroups[60,70)              -0.041579990 0.18703791 -0.2223078
## prs:agegroups[70,80)              -0.587543027 0.34991132 -1.6791198
## prs:n.children.scale               0.009730859 0.03661136  0.2657880
## prs:birth.x                       -0.060790336 0.02587224 -2.3496355
## prs:birth.y                       -0.024643090 0.02574363 -0.9572498
## prs:age.firstbirth.group[25,35)    0.085125919 0.05421099  1.5702704
## prs:age.firstbirth.group[35,80)   -0.150253018 0.11301486 -1.3294979
## prs:age.firstbirth.group[80,1e+03) -0.041552281 0.10526615 -0.3947355
## prs:height.scale                  -0.011844765 0.02337593 -0.5067078
```

```
## prs:age.menarche.scale             -0.010913432 0.02259508 -0.4830003
## prs:age.menopause.scale             0.003841007 0.02353369  0.1632131
## prs:length.oc.scale                -0.049364503 0.02368247 -2.0844324
## prs:BMI.scale                      -0.015010495 0.02439820 -0.6152296
## prs:alcohol                        -0.109211341 0.05767745 -1.8934843
##                                        Pvalue
## prs                                0.07932883
## prs:HRT.ever1                      0.69695689
## prs:agegroups[50,60)               0.85068425
## prs:agegroups[60,70)               0.82407426
## prs:agegroups[70,80)               0.09312869
## prs:n.children.scale               0.79040251
## prs:birth.x                        0.01879180
## prs:birth.y                        0.33844117
## prs:age.firstbirth.group[25,35)    0.11635221
## prs:age.firstbirth.group[35,80)    0.18368375
## prs:age.firstbirth.group[80,1e+03) 0.69303813
## prs:height.scale                   0.61235983
## prs:age.menarche.scale             0.62909550
## prs:age.menopause.scale            0.87035063
## prs:length.oc.scale                0.03712085
## prs:BMI.scale                      0.53840307
## prs:alcohol                        0.05829349
```

3 Pre-Menopause Cohort

For pre-menopause cohort, we also found PRS by length.oc use interaction term significant in association with breast cancer.

```
dat0_premeno_bc=dat0[which(dat0$menopause=="No" ),]
dat0_premeno_bc$prs_scaled=scale(dat0_premeno_bc$prs_bc,center = T,scale = T)
fit <- glm(breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC9+PC10, data=dat0_premeno_bc,famil
summary(fit)
```

```
##
## Call:
## glm(formula = breast_cancer ~ prs_scaled + PC1 + PC2 + PC3 +
##     PC4 + PC5 + PC6 + PC7 + PC8 + PC9 + PC10, family = binomial(),
##     data = dat0_premeno_bc, model = FALSE, x = FALSE, y = FALSE)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.5244  -0.2109  -0.1803  -0.1504   3.3244
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -4.2259386  0.1154316 -36.610   <2e-16 ***
## prs_scaled   0.4890811  0.0346920  14.098   <2e-16 ***
## PC1         -0.0107784  0.0106381  -1.013   0.3110
## PC2          0.0046543  0.0124950   0.372   0.7095
## PC3          0.0112037  0.0164868   0.680   0.4968
## PC4         -0.0008491  0.0075349  -0.113   0.9103
```

```
## PC5          0.0006075  0.0047876   0.127   0.8990
## PC6          0.0070373  0.0111434   0.632   0.5277
## PC7          0.0071911  0.0076283   0.943   0.3458
## PC8         -0.0174168  0.0090184  -1.931   0.0535 .
## PC9         -0.0019333  0.0078675  -0.246   0.8059
## PC10        -0.0002838  0.0137931  -0.021   0.9836
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 8515.3  on 46815  degrees of freedom
## Residual deviance: 8309.0  on 46804  degrees of freedom
## AIC: 8333
##
## Number of Fisher Scoring iterations: 7
```

```
exp(0.4890811)
```

```
## [1] 1.630817
```

```
colnames(dat0_premeno_bc)[7]="age.menarche"
dat0_premeno_bc$n.children=as.numeric(as.character(dat0_premeno_bc$n.children))
dat0_premeno_bc$age.menopause=as.numeric(as.character(dat0_premeno_bc$age.menopause))
dat0_premeno_bc$n.children[which(dat0_premeno_bc$n.children=="-3")]=NA
#winsorization
dat0_premeno_bc$n.children.win=dat0_premeno_bc$n.children
dat0_premeno_bc$n.children.win[which(dat0_premeno_bc$n.children.win>=5)]=5
dat0_premeno_bc$alcohol=NA
dat0_premeno_bc$alcohol[which(dat0_premeno_bc$AlcoholFreq=="Never" | dat0_premeno_bc$AlcoholFreq== "Spe
dat0_premeno_bc$alcohol[which(dat0_premeno_bc$AlcoholFreq=="Daily or almost daily" | dat0_premeno_bc$Al
                               dat0_premeno_bc$AlcoholFreq== "Once or twice a week" | dat0_premeno_bc
dat0_premeno_bc$age.firstbirth=as.numeric(as.character(dat0_premeno_bc$age.firstbirth))
dat0_premeno_bc$age.firstbirth[which(dat0_premeno_bc$age.firstbirth== -3 | dat0_premeno_bc$age.firstbir
dat0_premeno_bc$age.firstbirth[which(dat0_premeno_bc$n.children==0)]=999
dat0_premeno_bc$age.firstbirth.group=NA
dat0_premeno_bc$age.firstbirth.group<-cut(dat0_premeno_bc$age.firstbirth, breaks=c( 0, 25,35,80,1000),
dat0_premeno_bc$age.menarche[which(dat0_premeno_bc$age.menarche<0)]=NA
dat0_premeno_bc$agegroups<-cut(dat0_premeno_bc$age, breaks=c( 40, 45,50,80), right = FALSE)

dat0_premeno_bc$birth.x[which(dat0_premeno_bc$birth.x<0)]=NA
dat0_premeno_bc$birth.y[which(dat0_premeno_bc$birth.y<0)]=NA

dat0_premeno_bc$oc.cate2=NA
dat0_premeno_bc$oc.cate2[which(dat0_premeno_bc$oral.contraceptive.ever==0)]=0
dat0_premeno_bc$oc.cate2[which(dat0_premeno_bc$oral.contraceptive.ever==1 & dat0_premeno_bc$length.oc<1
dat0_premeno_bc$oc.cate2[which( dat0_premeno_bc$length.oc>=10)]=2


#more specified interval
dat0_premeno_bc$oc.cate3=NA
dat0_premeno_bc$oc.cate3[which(dat0_premeno_bc$oral.contraceptive.ever==0)]=0
dat0_premeno_bc$oc.cate3[which(dat0_premeno_bc$oral.contraceptive.ever==1 & dat0_premeno_bc$length.oc<5
```

```
dat0_premeno_bc$oc.cate3[which( dat0_premeno_bc$length.oc>=5 & dat0_premeno_bc$length.oc < 10)]=2
dat0_premeno_bc$oc.cate3[which( dat0_premeno_bc$length.oc>=10 & dat0_premeno_bc$length.oc < 15)]=3
dat0_premeno_bc$oc.cate3[which( dat0_premeno_bc$length.oc>=15 )]=4
```

```
dat_test=dat0_premeno_bc[,c("IID","prs_bc","age","age.menarche","BMI","height","n.children.win","age.fi
                            "breast_cancer","breast_cancer_incident","length.oc","oral.contraceptive.e
                            "assessment_center","agegroups",
                            "oc.cate","oc.cate2","oc.cate3" ,"alcohol","age.firstbirth.group","PC1","P

dat_test=dat_test[complete.cases(dat_test),]
table(dat_test$breast_cancer)
```

```
##
##     0     1
## 42046   777
```

```
table(dat_test$breast_cancer_incident)
```

```
##
##     0     1
## 42046   777
```

```
dim(dat_test)
```

```
## [1] 42823    29
```

```
dat_test$prs_scaled=scale(dat_test$prs_bc,center = T,scale = T)
dat_test$age.scale=scale(dat_test$age,center = T,scale=T)
dat_test$age.menarche.scale=scale(dat_test$age.menarche,center = T,scale=T)
dat_test$n.children.scale=scale(dat_test$n.children.win,center=T,scale = T)
dat_test$height.scale=scale(dat_test$height,center=T,scale = T)
dat_test$BMI.scale=scale(dat_test$BMI,center=T,scale = T)
dat_test$length.oc.scale=scale(dat_test$length.oc,center=T,scale = T)
dat_location=dat0_premeno_bc[,c("IID","birth.x","birth.y")]
dat_test=merge(dat_test,dat_location,by="IID")
dat_test$birth.x=scale(dat_test$birth.x,center=T,scale=T)
dat_test$birth.y=scale(dat_test$birth.y,center=T,scale=T)
dat_test_complete=dat_test[complete.cases(dat_test),]
table(dat_test_complete$breast_cancer)
```

```
##
##     0     1
## 37785   704
```

```
fit.int.all.premeno <- glm(breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC9+PC10+agegroups+
summary(fit.int.all.premeno)
```

```
##
## Call:
## glm(formula = breast_cancer ~ prs_scaled + PC1 + PC2 + PC3 +
```

```
##     PC4 + PC5 + PC6 + PC7 + PC8 + PC9 + PC10 + agegroups + n.children.scale +
##     birth.x + birth.y + age.firstbirth.group + height.scale +
##     age.menarche.scale + length.oc.scale + BMI.scale + relevel(factor(dat_test_complete$assessment_c
##     ref = "11001") + alcohol + prs_scaled:birth.x + prs_scaled:birth.y +
##     prs_scaled:length.oc.scale + prs_scaled:age.menarche.scale +
##     prs_scaled:BMI.scale + prs_scaled:agegroups + prs_scaled:alcohol +
##     prs_scaled:height.scale + prs_scaled:n.children.scale + prs_scaled:age.firstbirth.group,
##     family = binomial(), data = dat_test_complete, model = FALSE,
##     x = FALSE, y = FALSE)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.7079  -0.2142  -0.1762  -0.1394   3.4253
##
## Coefficients:
##                                                                                  Estimate
## (Intercept)                                                                    -4.976e+00
## prs_scaled                                                                      4.337e-01
## PC1                                                                            -2.398e-02
## PC2                                                                            -1.990e-02
## PC3                                                                             1.211e-02
## PC4                                                                            -8.805e-03
## PC5                                                                            -8.895e-04
## PC6                                                                             4.826e-02
## PC7                                                                             1.915e-02
## PC8                                                                            -2.501e-02
## PC9                                                                             9.461e-04
## PC10                                                                            8.655e-03
## agegroups[45,50)                                                                1.934e-01
## agegroups[50,80)                                                                1.561e-01
## n.children.scale                                                                1.311e-01
## birth.x                                                                         6.402e-03
## birth.y                                                                         8.102e-02
## age.firstbirth.group[25,35)                                                     3.022e-01
## age.firstbirth.group[35,80)                                                     5.181e-01
## age.firstbirth.group[80,1e+03)                                                  6.951e-01
## height.scale                                                                    1.051e-01
## age.menarche.scale                                                             -7.205e-03
## length.oc.scale                                                                 1.426e-01
## BMI.scale                                                                       1.894e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003        4.412e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002        1.683e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003        3.371e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004        1.273e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005        6.826e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006        4.104e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007        2.454e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008        3.878e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009        1.326e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010        1.189e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011       -8.398e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012       -5.414e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013       -7.733e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014       -2.828e-01
```

```
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016 -2.445e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 -1.908e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 -7.623e-04
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 -3.425e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 -4.059e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022 -1.237e+01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023 -1.229e+01
## alcohol                                                                   1.758e-01
## prs_scaled:birth.x                                                       -1.455e-02
## prs_scaled:birth.y                                                       -2.874e-03
## prs_scaled:length.oc.scale                                               -8.066e-02
## prs_scaled:age.menarche.scale                                            -3.156e-02
## prs_scaled:BMI.scale                                                     -2.976e-02
## prs_scaled:agegroups[45,50)                                               2.942e-02
## prs_scaled:agegroups[50,80)                                               1.462e-01
## prs_scaled:alcohol                                                        5.734e-02
## prs_scaled:height.scale                                                   9.110e-04
## prs_scaled:n.children.scale                                              -3.516e-03
## prs_scaled:age.firstbirth.group[25,35)                                   -4.107e-02
## prs_scaled:age.firstbirth.group[35,80)                                    2.475e-02
## prs_scaled:age.firstbirth.group[80,1e+03)                                -5.703e-02
##                                                                          Std. Error
## (Intercept)                                                               3.216e-01
## prs_scaled                                                                1.575e-01
## PC1                                                                       1.668e-02
## PC2                                                                       1.442e-02
## PC3                                                                       1.667e-02
## PC4                                                                       8.744e-03
## PC5                                                                       6.358e-03
## PC6                                                                       2.128e-02
## PC7                                                                       1.036e-02
## PC8                                                                       1.435e-02
## PC9                                                                       1.020e-02
## PC10                                                                      1.743e-02
## agegroups[45,50)                                                          9.558e-02
## agegroups[50,80)                                                          1.192e-01
## n.children.scale                                                          7.618e-02
## birth.x                                                                   5.725e-02
## birth.y                                                                   6.550e-02
## age.firstbirth.group[25,35)                                               1.289e-01
## age.firstbirth.group[35,80)                                               1.840e-01
## age.firstbirth.group[80,1e+03)                                            2.124e-01
## height.scale                                                              4.363e-02
## age.menarche.scale                                                        4.320e-02
## length.oc.scale                                                           4.117e-02
## BMI.scale                                                                 4.373e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003  1.041e+00
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002  3.018e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003  2.944e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004  2.988e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005  2.933e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006  2.806e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007  2.666e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008  2.661e-01
```

```
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009  2.662e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010  2.527e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011  2.625e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012  3.931e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013  2.712e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014  2.882e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016  2.857e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017  3.087e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018  2.858e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020  3.121e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021  3.176e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022  1.935e+02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023  3.399e+02
## alcohol                                                                   1.237e-01
## prs_scaled:birth.x                                                        4.387e-02
## prs_scaled:birth.y                                                        4.236e-02
## prs_scaled:length.oc.scale                                                3.744e-02
## prs_scaled:age.menarche.scale                                             3.984e-02
## prs_scaled:BMI.scale                                                      4.065e-02
## prs_scaled:agegroups[45,50)                                               8.748e-02
## prs_scaled:agegroups[50,80)                                               1.063e-01
## prs_scaled:alcohol                                                        1.141e-01
## prs_scaled:height.scale                                                   3.884e-02
## prs_scaled:n.children.scale                                               6.797e-02
## prs_scaled:age.firstbirth.group[25,35)                                    1.154e-01
## prs_scaled:age.firstbirth.group[35,80)                                    1.658e-01
## prs_scaled:age.firstbirth.group[80,1e+03)                                 1.905e-01
##                                                                          z value
## (Intercept)                                                             -15.471
## prs_scaled                                                                2.753
## PC1                                                                      -1.437
## PC2                                                                      -1.380
## PC3                                                                       0.727
## PC4                                                                      -1.007
## PC5                                                                      -0.140
## PC6                                                                       2.267
## PC7                                                                       1.848
## PC8                                                                      -1.742
## PC9                                                                       0.093
## PC10                                                                      0.497
## agegroups[45,50)                                                          2.023
## agegroups[50,80)                                                          1.309
## n.children.scale                                                          1.721
## birth.x                                                                   0.112
## birth.y                                                                   1.237
## age.firstbirth.group[25,35)                                               2.343
## age.firstbirth.group[35,80)                                               2.816
## age.firstbirth.group[80,1e+03)                                            3.272
## height.scale                                                              2.409
## age.menarche.scale                                                       -0.167
## length.oc.scale                                                           3.464
## BMI.scale                                                                 0.433
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003   0.424
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002   0.558
```

```
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003   1.145
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004   0.426
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005   0.233
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006   1.462
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007   0.920
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008   1.458
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009   0.498
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010   0.470
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011  -0.320
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012  -1.377
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013  -0.285
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014  -0.981
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016  -0.856
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017  -0.618
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018  -0.003
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020  -1.097
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021  -1.278
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022  -0.064
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023  -0.036
## alcohol                                                                   1.422
## prs_scaled:birth.x                                                       -0.332
## prs_scaled:birth.y                                                       -0.068
## prs_scaled:length.oc.scale                                               -2.155
## prs_scaled:age.menarche.scale                                            -0.792
## prs_scaled:BMI.scale                                                     -0.732
## prs_scaled:agegroups[45,50)                                               0.336
## prs_scaled:agegroups[50,80)                                               1.375
## prs_scaled:alcohol                                                        0.503
## prs_scaled:height.scale                                                   0.023
## prs_scaled:n.children.scale                                              -0.052
## prs_scaled:age.firstbirth.group[25,35)                                   -0.356
## prs_scaled:age.firstbirth.group[35,80)                                    0.149
## prs_scaled:age.firstbirth.group[80,1e+03)                                -0.299
##                                                                        Pr(>|z|)
## (Intercept)                                                             < 2e-16
## prs_scaled                                                             0.005896
## PC1                                                                    0.150609
## PC2                                                                    0.167658
## PC3                                                                    0.467495
## PC4                                                                    0.313942
## PC5                                                                    0.888725
## PC6                                                                    0.023364
## PC7                                                                    0.064639
## PC8                                                                    0.081480
## PC9                                                                    0.926121
## PC10                                                                   0.619481
## agegroups[45,50)                                                       0.043040
## agegroups[50,80)                                                       0.190378
## n.children.scale                                                       0.085234
## birth.x                                                                0.910963
## birth.y                                                                0.216094
## age.firstbirth.group[25,35)                                            0.019111
## age.firstbirth.group[35,80)                                            0.004862
## age.firstbirth.group[80,1e+03)                                         0.001066
```

```
## height.scale                                                                  0.016008
## age.menarche.scale                                                            0.867540
## length.oc.scale                                                               0.000532
## BMI.scale                                                                     0.664873
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003 0.671803
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002 0.577020
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003 0.252143
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004 0.670062
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005 0.815991
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006 0.143630
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007 0.357313
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008 0.144933
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009 0.618432
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010 0.638043
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011 0.749045
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012 0.168464
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013 0.775530
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014 0.326531
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016 0.392058
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 0.536645
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 0.997872
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 0.272517
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 0.201267
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022 0.949029
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023 0.971162
## alcohol                                                                       0.155069
## prs_scaled:birth.x                                                            0.740045
## prs_scaled:birth.y                                                            0.945909
## prs_scaled:length.oc.scale                                                    0.031191
## prs_scaled:age.menarche.scale                                                 0.428331
## prs_scaled:BMI.scale                                                          0.464097
## prs_scaled:agegroups[45,50)                                                   0.736621
## prs_scaled:agegroups[50,80)                                                   0.169269
## prs_scaled:alcohol                                                            0.615303
## prs_scaled:height.scale                                                       0.981289
## prs_scaled:n.children.scale                                                   0.958749
## prs_scaled:age.firstbirth.group[25,35)                                        0.721988
## prs_scaled:age.firstbirth.group[35,80)                                        0.881325
## prs_scaled:age.firstbirth.group[80,1e+03)                                     0.764702
##
## (Intercept)                                                                   ***
## prs_scaled                                                                    **
## PC1
## PC2
## PC3
## PC4
## PC5
## PC6                                                                           *
## PC7                                                                           .
## PC8                                                                           .
## PC9
## PC10
## agegroups[45,50)                                                              *
## agegroups[50,80)
```

```
## n.children.scale                                                    .
## birth.x
## birth.y
## age.firstbirth.group[25,35)                                         *
## age.firstbirth.group[35,80)                                         **
## age.firstbirth.group[80,1e+03)                                      **
## height.scale                                                        *
## age.menarche.scale
## length.oc.scale                                                     ***
## BMI.scale
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023
## alcohol
## prs_scaled:birth.x
## prs_scaled:birth.y
## prs_scaled:length.oc.scale                                          *
## prs_scaled:age.menarche.scale
## prs_scaled:BMI.scale
## prs_scaled:agegroups[45,50)
## prs_scaled:agegroups[50,80)
## prs_scaled:alcohol
## prs_scaled:height.scale
## prs_scaled:n.children.scale
## prs_scaled:age.firstbirth.group[25,35)
## prs_scaled:age.firstbirth.group[35,80)
## prs_scaled:age.firstbirth.group[80,1e+03)
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 7028.9  on 38488  degrees of freedom
## Residual deviance: 6757.4  on 38430  degrees of freedom
## AIC: 6875.4
##
```

```
## Number of Fisher Scoring iterations: 15
```

```
fit.int.all2.premeno <- glm(breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC9+PC10+agegroups+
summary(fit.int.all2.premeno)
```

```
##
## Call:
## glm(formula = breast_cancer ~ prs_scaled + PC1 + PC2 + PC3 +
##     PC4 + PC5 + PC6 + PC7 + PC8 + PC9 + PC10 + agegroups + n.children.scale +
##     birth.x + birth.y + age.firstbirth.group + height.scale +
##     age.menarche.scale + factor(oc.cate2) + BMI.scale + relevel(factor(dat_test_complete$assessment_
##     ref = "11001") + alcohol + prs_scaled:birth.x + prs_scaled:birth.y +
##     prs_scaled:factor(oc.cate2) + prs_scaled:age.menarche.scale +
##     prs_scaled:BMI.scale + prs_scaled:agegroups + prs_scaled:alcohol +
##     prs_scaled:height.scale + prs_scaled:n.children.scale + prs_scaled:age.firstbirth.group,
##     family = binomial(), data = dat_test_complete, model = FALSE,
##     x = FALSE, y = FALSE)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.7631  -0.2145  -0.1761  -0.1391   3.5061
##
## Coefficients:
##                                                                          Estimate
## (Intercept)                                                            -4.900e+00
## prs_scaled                                                              4.392e-01
## PC1                                                                    -2.387e-02
## PC2                                                                    -1.943e-02
## PC3                                                                     1.215e-02
## PC4                                                                    -8.990e-03
## PC5                                                                    -1.329e-03
## PC6                                                                     4.843e-02
## PC7                                                                     1.900e-02
## PC8                                                                    -2.513e-02
## PC9                                                                     9.175e-04
## PC10                                                                    8.565e-03
## agegroups[45,50)                                                        2.036e-01
## agegroups[50,80)                                                        1.643e-01
## n.children.scale                                                        1.242e-01
## birth.x                                                                 7.647e-03
## birth.y                                                                 8.093e-02
## age.firstbirth.group[25,35)                                             2.927e-01
## age.firstbirth.group[35,80)                                             4.875e-01
## age.firstbirth.group[80,1e+03)                                          6.554e-01
## height.scale                                                            1.040e-01
## age.menarche.scale                                                     -6.514e-03
## factor(oc.cate2)1                                                      -2.960e-01
## factor(oc.cate2)2                                                       5.227e-02
## BMI.scale                                                               1.762e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003  4.706e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002  1.743e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003  3.353e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004  1.242e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005  8.003e-02
```

```
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006  4.135e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007  2.523e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008  3.876e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009  1.311e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010  1.172e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011 -7.703e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012 -5.301e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013 -7.699e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014 -2.789e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016 -2.470e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 -1.912e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 -3.562e-03
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 -3.389e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 -4.086e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022 -1.238e+01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023 -1.226e+01
## alcohol                                                                   1.921e-01
## prs_scaled:birth.x                                                       -1.619e-02
## prs_scaled:birth.y                                                       -2.530e-03
## prs_scaled:factor(oc.cate2)1                                              8.368e-02
## prs_scaled:factor(oc.cate2)2                                             -6.423e-02
## prs_scaled:age.menarche.scale                                            -3.139e-02
## prs_scaled:BMI.scale                                                     -2.902e-02
## prs_scaled:agegroups[45,50)                                               2.540e-02
## prs_scaled:agegroups[50,80)                                               1.432e-01
## prs_scaled:alcohol                                                        5.007e-02
## prs_scaled:height.scale                                                   2.371e-03
## prs_scaled:n.children.scale                                               2.278e-04
## prs_scaled:age.firstbirth.group[25,35)                                   -3.771e-02
## prs_scaled:age.firstbirth.group[35,80)                                    3.598e-02
## prs_scaled:age.firstbirth.group[80,1e+03)                                -4.626e-02
##                                                                          Std. Error
## (Intercept)                                                               3.456e-01
## prs_scaled                                                                1.941e-01
## PC1                                                                       1.665e-02
## PC2                                                                       1.442e-02
## PC3                                                                       1.672e-02
## PC4                                                                       8.747e-03
## PC5                                                                       6.354e-03
## PC6                                                                       2.132e-02
## PC7                                                                       1.036e-02
## PC8                                                                       1.436e-02
## PC9                                                                       1.020e-02
## PC10                                                                      1.745e-02
## agegroups[45,50)                                                          9.564e-02
## agegroups[50,80)                                                          1.195e-01
## n.children.scale                                                          7.609e-02
## birth.x                                                                   5.728e-02
## birth.y                                                                   6.552e-02
## age.firstbirth.group[25,35)                                               1.290e-01
## age.firstbirth.group[35,80)                                               1.843e-01
## age.firstbirth.group[80,1e+03)                                            2.132e-01
## height.scale                                                              4.360e-02
## age.menarche.scale                                                        4.314e-02
```

```
## factor(oc.cate2)1                                                          1.595e-01
## factor(oc.cate2)2                                                          1.480e-01
## BMI.scale                                                                  4.366e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003   1.041e+00
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002   3.018e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003   2.944e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004   2.988e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005   2.933e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006   2.807e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007   2.666e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008   2.661e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009   2.662e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010   2.527e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011   2.626e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012   3.932e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013   2.712e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014   2.883e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016   2.857e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017   3.087e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018   2.858e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020   3.121e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021   3.176e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022   1.934e+02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023   3.400e+02
## alcohol                                                                    1.240e-01
## prs_scaled:birth.x                                                         4.387e-02
## prs_scaled:birth.y                                                         4.237e-02
## prs_scaled:factor(oc.cate2)1                                               1.431e-01
## prs_scaled:factor(oc.cate2)2                                               1.347e-01
## prs_scaled:age.menarche.scale                                              3.986e-02
## prs_scaled:BMI.scale                                                       4.064e-02
## prs_scaled:agegroups[45,50)                                                8.764e-02
## prs_scaled:agegroups[50,80)                                                1.068e-01
## prs_scaled:alcohol                                                         1.146e-01
## prs_scaled:height.scale                                                    3.890e-02
## prs_scaled:n.children.scale                                                6.790e-02
## prs_scaled:age.firstbirth.group[25,35)                                     1.156e-01
## prs_scaled:age.firstbirth.group[35,80)                                     1.662e-01
## prs_scaled:age.firstbirth.group[80,1e+03)                                  1.912e-01
##                                                                           z value
## (Intercept)                                                               -14.178
## prs_scaled                                                                  2.263
## PC1                                                                        -1.434
## PC2                                                                        -1.348
## PC3                                                                         0.727
## PC4                                                                        -1.028
## PC5                                                                        -0.209
## PC6                                                                         2.272
## PC7                                                                         1.833
## PC8                                                                        -1.750
## PC9                                                                         0.090
## PC10                                                                        0.491
## agegroups[45,50)                                                            2.129
## agegroups[50,80)                                                            1.375
```

```
## n.children.scale                                                          1.632
## birth.x                                                                   0.134
## birth.y                                                                   1.235
## age.firstbirth.group[25,35)                                               2.268
## age.firstbirth.group[35,80)                                               2.645
## age.firstbirth.group[80,1e+03)                                            3.074
## height.scale                                                              2.386
## age.menarche.scale                                                       -0.151
## factor(oc.cate2)1                                                        -1.856
## factor(oc.cate2)2                                                         0.353
## BMI.scale                                                                 0.403
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003  0.452
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002  0.577
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003  1.139
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004  0.416
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005  0.273
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006  1.473
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007  0.946
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008  1.456
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009  0.493
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010  0.464
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011 -0.293
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012 -1.348
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013 -0.284
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014 -0.967
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016 -0.864
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 -0.619
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 -0.012
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 -1.086
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 -1.286
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022 -0.064
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023 -0.036
## alcohol                                                                   1.549
## prs_scaled:birth.x                                                       -0.369
## prs_scaled:birth.y                                                       -0.060
## prs_scaled:factor(oc.cate2)1                                              0.585
## prs_scaled:factor(oc.cate2)2                                             -0.477
## prs_scaled:age.menarche.scale                                            -0.788
## prs_scaled:BMI.scale                                                     -0.714
## prs_scaled:agegroups[45,50)                                               0.290
## prs_scaled:agegroups[50,80)                                               1.341
## prs_scaled:alcohol                                                        0.437
## prs_scaled:height.scale                                                   0.061
## prs_scaled:n.children.scale                                               0.003
## prs_scaled:age.firstbirth.group[25,35)                                   -0.326
## prs_scaled:age.firstbirth.group[35,80)                                    0.216
## prs_scaled:age.firstbirth.group[80,1e+03)                                -0.242
##                                                                         Pr(>|z|)
## (Intercept)                                                              < 2e-16
## prs_scaled                                                               0.02361
## PC1                                                                      0.15151
## PC2                                                                      0.17780
## PC3                                                                      0.46728
## PC4                                                                      0.30406
```

```
## PC5                                                                    0.83428
## PC6                                                                    0.02308
## PC7                                                                    0.06676
## PC8                                                                    0.08006
## PC9                                                                    0.92833
## PC10                                                                   0.62351
## agegroups[45,50)                                                       0.03329
## agegroups[50,80)                                                       0.16918
## n.children.scale                                                       0.10275
## birth.x                                                                0.89379
## birth.y                                                                0.21679
## age.firstbirth.group[25,35)                                            0.02334
## age.firstbirth.group[35,80)                                            0.00816
## age.firstbirth.group[80,1e+03)                                         0.00211
## height.scale                                                           0.01705
## age.menarche.scale                                                     0.87998
## factor(oc.cate2)1                                                      0.06347
## factor(oc.cate2)2                                                      0.72403
## BMI.scale                                                              0.68660
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003  0.65129
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002  0.56366
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003  0.25472
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004  0.67761
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005  0.78495
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006  0.14075
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007  0.34399
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008  0.14528
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009  0.62224
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010  0.64274
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011  0.76924
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012  0.17755
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013  0.77650
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014  0.33330
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016  0.38736
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017  0.53570
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018  0.99005
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020  0.27760
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021  0.19828
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022  0.94896
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023  0.97124
## alcohol                                                                0.12133
## prs_scaled:birth.x                                                     0.71208
## prs_scaled:birth.y                                                     0.95239
## prs_scaled:factor(oc.cate2)1                                           0.55878
## prs_scaled:factor(oc.cate2)2                                           0.63344
## prs_scaled:age.menarche.scale                                          0.43097
## prs_scaled:BMI.scale                                                   0.47520
## prs_scaled:agegroups[45,50)                                            0.77194
## prs_scaled:agegroups[50,80)                                            0.18002
## prs_scaled:alcohol                                                     0.66222
## prs_scaled:height.scale                                                0.95141
## prs_scaled:n.children.scale                                            0.99732
## prs_scaled:age.firstbirth.group[25,35)                                 0.74428
## prs_scaled:age.firstbirth.group[35,80)                                 0.82861
```

```
## prs_scaled:age.firstbirth.group[80,1e+03)                                    0.80886
##
## (Intercept)                                                                 ***
## prs_scaled                                                                  *
## PC1
## PC2
## PC3
## PC4
## PC5
## PC6                                                                         *
## PC7                                                                         .
## PC8                                                                         .
## PC9
## PC10
## agegroups[45,50)                                                            *
## agegroups[50,80)
## n.children.scale
## birth.x
## birth.y
## age.firstbirth.group[25,35)                                                 *
## age.firstbirth.group[35,80)                                                 **
## age.firstbirth.group[80,1e+03)                                              **
## height.scale                                                                *
## age.menarche.scale
## factor(oc.cate2)1                                                           .
## factor(oc.cate2)2
## BMI.scale
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023
## alcohol
## prs_scaled:birth.x
## prs_scaled:birth.y
## prs_scaled:factor(oc.cate2)1
## prs_scaled:factor(oc.cate2)2
## prs_scaled:age.menarche.scale
```

```
## prs_scaled:BMI.scale
## prs_scaled:agegroups[45,50)
## prs_scaled:agegroups[50,80)
## prs_scaled:alcohol
## prs_scaled:height.scale
## prs_scaled:n.children.scale
## prs_scaled:age.firstbirth.group[25,35)
## prs_scaled:age.firstbirth.group[35,80)
## prs_scaled:age.firstbirth.group[80,1e+03)
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 7028.9  on 38488  degrees of freedom
## Residual deviance: 6755.9  on 38428  degrees of freedom
## AIC: 6877.9
##
## Number of Fisher Scoring iterations: 15
```

```
fit.int.all3.premeno <- glm(breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC9+PC10+agegroups+
summary(fit.int.all3.premeno)
```

```
##
## Call:
## glm(formula = breast_cancer ~ prs_scaled + PC1 + PC2 + PC3 +
##     PC4 + PC5 + PC6 + PC7 + PC8 + PC9 + PC10 + agegroups + n.children.scale +
##     birth.x + birth.y + age.firstbirth.group + height.scale +
##     age.menarche.scale + factor(oc.cate3) + BMI.scale + relevel(factor(dat_test_complete$assessment_
##     ref = "11001") + alcohol + prs_scaled:birth.x + prs_scaled:birth.y +
##     prs_scaled:factor(oc.cate3) + prs_scaled:age.menarche.scale +
##     prs_scaled:BMI.scale + prs_scaled:agegroups + prs_scaled:alcohol +
##     prs_scaled:height.scale + prs_scaled:n.children.scale + prs_scaled:age.firstbirth.group,
##     family = binomial(), data = dat_test_complete, model = FALSE,
##     x = FALSE, y = FALSE)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.7927  -0.2146  -0.1758  -0.1389   3.4537
##
## Coefficients:
##                                                                    Estimate
## (Intercept)                                                      -4.901e+00
## prs_scaled                                                        4.356e-01
## PC1                                                              -2.401e-02
## PC2                                                              -1.936e-02
## PC3                                                               1.233e-02
## PC4                                                              -8.849e-03
## PC5                                                              -1.193e-03
## PC6                                                               4.850e-02
## PC7                                                               1.888e-02
## PC8                                                              -2.522e-02
## PC9                                                               9.153e-04
## PC10                                                              8.395e-03
```

```
## agegroups[45,50)                                                                2.043e-01
## agegroups[50,80)                                                                1.691e-01
## n.children.scale                                                                1.278e-01
## birth.x                                                                         7.774e-03
## birth.y                                                                         8.091e-02
## age.firstbirth.group[25,35)                                                     2.962e-01
## age.firstbirth.group[35,80)                                                     4.888e-01
## age.firstbirth.group[80,1e+03)                                                  6.526e-01
## height.scale                                                                    1.052e-01
## age.menarche.scale                                                             -7.545e-03
## factor(oc.cate3)1                                                              -3.521e-01
## factor(oc.cate3)2                                                              -2.592e-01
## factor(oc.cate3)3                                                              -5.787e-02
## factor(oc.cate3)4                                                               1.117e-01
## BMI.scale                                                                       1.831e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003  4.746e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002  1.750e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003  3.354e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004  1.257e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005  8.096e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006  4.124e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007  2.527e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008  3.894e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009  1.383e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010  1.200e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011 -7.624e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012 -5.221e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013 -7.514e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014 -2.779e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016 -2.437e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017 -1.911e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018 -2.659e-03
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020 -3.363e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021 -4.039e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022 -1.236e+01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023 -1.226e+01
## alcohol                                                                         1.894e-01
## prs_scaled:birth.x                                                             -1.554e-02
## prs_scaled:birth.y                                                             -2.253e-03
## prs_scaled:factor(oc.cate3)1                                                    1.455e-01
## prs_scaled:factor(oc.cate3)2                                                    3.554e-02
## prs_scaled:factor(oc.cate3)3                                                   -6.933e-02
## prs_scaled:factor(oc.cate3)4                                                   -6.159e-02
## prs_scaled:age.menarche.scale                                                  -3.071e-02
## prs_scaled:BMI.scale                                                           -2.831e-02
## prs_scaled:agegroups[45,50)                                                     2.475e-02
## prs_scaled:agegroups[50,80)                                                     1.410e-01
## prs_scaled:alcohol                                                              5.203e-02
## prs_scaled:height.scale                                                         1.157e-03
## prs_scaled:n.children.scale                                                     2.669e-04
## prs_scaled:age.firstbirth.group[25,35)                                         -3.195e-02
## prs_scaled:age.firstbirth.group[35,80)                                          3.460e-02
## prs_scaled:age.firstbirth.group[80,1e+03)                                      -4.382e-02
##                                                                                Std. Error
```

```
## (Intercept)                                                                  3.457e-01
## prs_scaled                                                                   1.940e-01
## PC1                                                                          1.667e-02
## PC2                                                                          1.444e-02
## PC3                                                                          1.670e-02
## PC4                                                                          8.738e-03
## PC5                                                                          6.356e-03
## PC6                                                                          2.132e-02
## PC7                                                                          1.037e-02
## PC8                                                                          1.437e-02
## PC9                                                                          1.021e-02
## PC10                                                                         1.745e-02
## agegroups[45,50)                                                             9.566e-02
## agegroups[50,80)                                                             1.196e-01
## n.children.scale                                                             7.603e-02
## birth.x                                                                      5.729e-02
## birth.y                                                                      6.552e-02
## age.firstbirth.group[25,35)                                                  1.291e-01
## age.firstbirth.group[35,80)                                                  1.842e-01
## age.firstbirth.group[80,1e+03)                                               2.130e-01
## height.scale                                                                 4.361e-02
## age.menarche.scale                                                           4.317e-02
## factor(oc.cate3)1                                                            1.849e-01
## factor(oc.cate3)2                                                            1.738e-01
## factor(oc.cate3)3                                                            1.663e-01
## factor(oc.cate3)4                                                            1.526e-01
## BMI.scale                                                                    4.370e-02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003  1.041e+00
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002  3.018e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003  2.944e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004  2.988e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005  2.933e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006  2.808e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007  2.666e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008  2.661e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009  2.662e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010  2.527e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011  2.626e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012  3.932e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013  2.712e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014  2.883e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016  2.857e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017  3.087e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018  2.858e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020  3.122e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021  3.177e-01
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022  1.935e+02
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023  3.404e+02
## alcohol                                                                      1.240e-01
## prs_scaled:birth.x                                                           4.388e-02
## prs_scaled:birth.y                                                           4.237e-02
## prs_scaled:factor(oc.cate3)1                                                 1.632e-01
## prs_scaled:factor(oc.cate3)2                                                 1.560e-01
## prs_scaled:factor(oc.cate3)3                                                 1.515e-01
```

```
## prs_scaled:factor(oc.cate3)4                                                  1.392e-01
## prs_scaled:age.menarche.scale                                                 3.989e-02
## prs_scaled:BMI.scale                                                          4.067e-02
## prs_scaled:agegroups[45,50)                                                   8.769e-02
## prs_scaled:agegroups[50,80)                                                   1.068e-01
## prs_scaled:alcohol                                                            1.147e-01
## prs_scaled:height.scale                                                       3.896e-02
## prs_scaled:n.children.scale                                                   6.784e-02
## prs_scaled:age.firstbirth.group[25,35)                                        1.157e-01
## prs_scaled:age.firstbirth.group[35,80)                                        1.659e-01
## prs_scaled:age.firstbirth.group[80,1e+03)                                     1.911e-01
##                                                                              z value
## (Intercept)                                                                 -14.179
## prs_scaled                                                                    2.245
## PC1                                                                          -1.440
## PC2                                                                          -1.341
## PC3                                                                           0.738
## PC4                                                                          -1.013
## PC5                                                                          -0.188
## PC6                                                                           2.275
## PC7                                                                           1.820
## PC8                                                                          -1.755
## PC9                                                                           0.090
## PC10                                                                          0.481
## agegroups[45,50)                                                              2.136
## agegroups[50,80)                                                              1.414
## n.children.scale                                                              1.681
## birth.x                                                                       0.136
## birth.y                                                                       1.235
## age.firstbirth.group[25,35)                                                   2.294
## age.firstbirth.group[35,80)                                                   2.654
## age.firstbirth.group[80,1e+03)                                                3.063
## height.scale                                                                  2.412
## age.menarche.scale                                                           -0.175
## factor(oc.cate3)1                                                            -1.904
## factor(oc.cate3)2                                                            -1.492
## factor(oc.cate3)3                                                            -0.348
## factor(oc.cate3)4                                                             0.732
## BMI.scale                                                                     0.419
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003      0.456
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002      0.580
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003      1.139
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004      0.421
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005      0.276
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006      1.469
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007      0.948
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008      1.463
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009      0.519
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010      0.475
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011     -0.290
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012     -1.328
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013     -0.277
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014     -0.964
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016     -0.853
```

```
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017  -0.619
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018  -0.009
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020  -1.077
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021  -1.271
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022  -0.064
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023  -0.036
## alcohol                                                                   1.527
## prs_scaled:birth.x                                                       -0.354
## prs_scaled:birth.y                                                       -0.053
## prs_scaled:factor(oc.cate3)1                                              0.891
## prs_scaled:factor(oc.cate3)2                                              0.228
## prs_scaled:factor(oc.cate3)3                                             -0.458
## prs_scaled:factor(oc.cate3)4                                             -0.443
## prs_scaled:age.menarche.scale                                            -0.770
## prs_scaled:BMI.scale                                                     -0.696
## prs_scaled:agegroups[45,50)                                               0.282
## prs_scaled:agegroups[50,80)                                               1.320
## prs_scaled:alcohol                                                        0.454
## prs_scaled:height.scale                                                   0.030
## prs_scaled:n.children.scale                                               0.004
## prs_scaled:age.firstbirth.group[25,35)                                   -0.276
## prs_scaled:age.firstbirth.group[35,80)                                    0.209
## prs_scaled:age.firstbirth.group[80,1e+03)                                -0.229
##                                                                         Pr(>|z|)
## (Intercept)                                                              < 2e-16
## prs_scaled                                                               0.02474
## PC1                                                                      0.14977
## PC2                                                                      0.17997
## PC3                                                                      0.46036
## PC4                                                                      0.31118
## PC5                                                                      0.85112
## PC6                                                                      0.02288
## PC7                                                                      0.06883
## PC8                                                                      0.07919
## PC9                                                                      0.92855
## PC10                                                                     0.63055
## agegroups[45,50)                                                         0.03270
## agegroups[50,80)                                                         0.15733
## n.children.scale                                                         0.09271
## birth.x                                                                  0.89206
## birth.y                                                                  0.21683
## age.firstbirth.group[25,35)                                              0.02181
## age.firstbirth.group[35,80)                                              0.00796
## age.firstbirth.group[80,1e+03)                                           0.00219
## height.scale                                                             0.01587
## age.menarche.scale                                                       0.86124
## factor(oc.cate3)1                                                        0.05689
## factor(oc.cate3)2                                                        0.13574
## factor(oc.cate3)3                                                        0.72793
## factor(oc.cate3)4                                                        0.46435
## BMI.scale                                                                0.67513
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003  0.64851
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002  0.56198
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003  0.25459
```

```
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004  0.67407
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005  0.78250
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006  0.14191
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007  0.34330
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008  0.14343
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009  0.60347
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010  0.63492
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011  0.77157
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012  0.18418
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013  0.78177
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014  0.33509
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016  0.39367
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017  0.53603
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018  0.99258
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020  0.28141
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021  0.20357
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022  0.94906
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023  0.97127
## alcohol                                                                   0.12678
## prs_scaled:birth.x                                                        0.72315
## prs_scaled:birth.y                                                        0.95759
## prs_scaled:factor(oc.cate3)1                                              0.37274
## prs_scaled:factor(oc.cate3)2                                              0.81972
## prs_scaled:factor(oc.cate3)3                                              0.64724
## prs_scaled:factor(oc.cate3)4                                              0.65812
## prs_scaled:age.menarche.scale                                             0.44135
## prs_scaled:BMI.scale                                                      0.48640
## prs_scaled:agegroups[45,50)                                               0.77778
## prs_scaled:agegroups[50,80)                                               0.18695
## prs_scaled:alcohol                                                        0.65002
## prs_scaled:height.scale                                                   0.97631
## prs_scaled:n.children.scale                                               0.99686
## prs_scaled:age.firstbirth.group[25,35)                                    0.78251
## prs_scaled:age.firstbirth.group[35,80)                                    0.83482
## prs_scaled:age.firstbirth.group[80,1e+03)                                 0.81862
##
## (Intercept)                                                              ***
## prs_scaled                                                               *
## PC1
## PC2
## PC3
## PC4
## PC5
## PC6                                                                      *
## PC7                                                                      .
## PC8                                                                      .
## PC9
## PC10
## agegroups[45,50)                                                         *
## agegroups[50,80)
## n.children.scale                                                         .
## birth.x
## birth.y
## age.firstbirth.group[25,35)                                              *
```

```
## age.firstbirth.group[35,80)                                                  **
## age.firstbirth.group[80,1e+03)                                               **
## height.scale                                                                 *
## age.menarche.scale
## factor(oc.cate3)1                                                            .
## factor(oc.cate3)2
## factor(oc.cate3)3
## factor(oc.cate3)4
## BMI.scale
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")10003
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11002
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11003
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11004
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11005
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11006
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11007
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11008
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11009
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11010
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11011
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11012
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11013
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11014
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11016
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11017
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11018
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11020
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11021
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11022
## relevel(factor(dat_test_complete$assessment_center), ref = "11001")11023
## alcohol
## prs_scaled:birth.x
## prs_scaled:birth.y
## prs_scaled:factor(oc.cate3)1
## prs_scaled:factor(oc.cate3)2
## prs_scaled:factor(oc.cate3)3
## prs_scaled:factor(oc.cate3)4
## prs_scaled:age.menarche.scale
## prs_scaled:BMI.scale
## prs_scaled:agegroups[45,50)
## prs_scaled:agegroups[50,80)
## prs_scaled:alcohol
## prs_scaled:height.scale
## prs_scaled:n.children.scale
## prs_scaled:age.firstbirth.group[25,35)
## prs_scaled:age.firstbirth.group[35,80)
## prs_scaled:age.firstbirth.group[80,1e+03)
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 7028.9  on 38488  degrees of freedom
## Residual deviance: 6752.5  on 38424  degrees of freedom
```

```
## AIC: 6882.5
##
## Number of Fisher Scoring iterations: 15
```

```
#Now let's select the control samples for the case/control study
table(dat_test_complete$breast_cancer)
```

```
##
##     0     1
## 37785   704
```

```
#select 704 controls who did not have breast cancer
control=dat_test_complete[which(dat_test_complete$breast_cancer==0),]
set.seed(10252022)
control=control[sample(1:dim(control)[1],size=704,replace = F),]
dat_test_casecontrol=rbind(control,dat_test_complete[which(dat_test_complete$breast_cancer==1),])
dat_test_casecontrol$prs_scaled=scale(dat_test_casecontrol$prs_bc,center = T,scale = T)
dat_test_casecontrol$age.menarche.scale=scale(dat_test_casecontrol$age.menarche,center = T,scale=T)
dat_test_casecontrol$n.children.scale=scale(dat_test_casecontrol$n.children.win,center=T,scale = T)
dat_test_casecontrol$height.scale=scale(dat_test_casecontrol$height,center=T,scale = T)
dat_test_casecontrol$BMI.scale=scale(dat_test_casecontrol$BMI,center=T,scale = T)
dat_test_casecontrol$length.oc.scale=scale(dat_test_casecontrol$length.oc,center=T,scale = T)
dat_test_casecontrol$birth.x=scale(dat_test_casecontrol$birth.x,center=T,scale=T)
dat_test_casecontrol$birth.y=scale(dat_test_casecontrol$birth.y,center=T,scale=T)
dat_test_casecontrol.coordinate=dat_test_casecontrol[complete.cases(dat_test_casecontrol),]
table(dat_test_casecontrol.coordinate$breast_cancer)
```

```
##
##   0   1
## 704 704
```

```
dat_test_casecontrol.coordinate$assessment_center=factor(dat_test_casecontrol.coordinate$assessment_cen
dat_test_casecontrol.coordinate$assessment_center=relevel(dat_test_casecontrol.coordinate$assessment_ce
fit_normal.coordinate1.premeno<-prs_e_function_gr(data=dat_test_casecontrol.coordinate,
                                          formula = breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC7
                                          formula_prs = prs_scaled ~ PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC9
                                          numDeriv = F,
                                          facVar="assessment_center")
```

```
## After removing missing values, the number of observations is 1408
## initial  value 2899.717713
## iter  50 value 2878.712959
## final  value 2878.045107
## converged
```

```
fit_normal.coordinate2.premeno<-prs_e_function_gr(data=dat_test_casecontrol.coordinate,
                                           formula = breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC
                                           formula_prs = prs_scaled ~ PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC
                                           numDeriv = F,
                                           facVar="assessment_center")
```

```
## After removing missing values, the number of observations is 1408
## initial  value 2894.601813
## iter  50 value 2874.418008
## final  value 2873.837624
## converged
```

```
fit_normal.coordinate3.premeno<-prs_e_function_gr(data=dat_test_casecontrol.coordinate,
                                                  formula = breast_cancer~prs_scaled+PC1+PC2+PC3+PC4+PC5+PC6+PC
                                                  formula_prs = prs_scaled ~ PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC
                                                  numDeriv = F,
                                                  facVar="assessment_center")
```

```
## After removing missing values, the number of observations is 1408
## initial  value 2894.543856
## iter  50 value 2873.815226
## final  value 2873.572471
## converged
```

```
#Print the results, our method
fit_normal.coordinate1.premeno$res_normal
```

```
##                                              Estimate    Std.Error
## (Intercept)                                -8.269280e-01 4.548883e-01
## prs_scaled                                  4.542047e-01 1.643696e-01
## PC1                                        -2.558438e-02 2.337236e-02
## PC2                                        -3.497893e-02 2.472434e-02
## PC3                                         3.868873e-02 3.117105e-02
## PC4                                         3.593217e-03 1.488781e-02
## PC5                                        -6.884867e-03 9.344226e-03
## PC6                                         7.026714e-02 3.320704e-02
## PC7                                         2.372458e-02 1.486668e-02
## PC8                                        -6.034577e-02 2.168831e-02
## PC9                                        -5.854040e-04 1.490000e-02
## PC10                                       -1.916557e-02 2.733881e-02
## agegroups[45,50)                            3.650722e-01 1.279668e-01
## agegroups[50,80)                            2.512753e-01 1.563238e-01
## n.children.scale                            1.659684e-01 9.927062e-02
## birth.x                                     4.640277e-02 7.894811e-02
## birth.y                                     7.096295e-02 9.151537e-02
## age.firstbirth.group[25,35)                 2.139111e-01 1.661355e-01
## age.firstbirth.group[35,80)                 5.417790e-01 2.440843e-01
## age.firstbirth.group[80,1e+03)              7.564740e-01 2.753546e-01
## height.scale                                7.987473e-02 5.798382e-02
## age.menarche.scale                         -2.861460e-02 5.713823e-02
## length.oc.scale                             8.492363e-02 5.688934e-02
## BMI.scale                                   3.903553e-02 5.799412e-02
## assessment_center10003                      1.441584e+01 1.352772e+03
## assessment_center11002                      2.762022e-01 4.439040e-01
## assessment_center11003                      6.663534e-01 4.425624e-01
## assessment_center11004                      1.931194e-01 4.329954e-01
## assessment_center11005                      2.284277e-01 4.265564e-01
## assessment_center11006                      3.620310e-01 4.064697e-01
## assessment_center11007                      7.423235e-02 3.766943e-01
```

```
## assessment_center11008                     4.369356e-01 3.874189e-01
## assessment_center11009                     2.817981e-01 3.832897e-01
## assessment_center11010                     2.873712e-01 3.597294e-01
## assessment_center11011                    -1.102428e-01 3.684821e-01
## assessment_center11012                    -2.096053e-01 5.393307e-01
## assessment_center11013                     2.920107e-01 3.939899e-01
## assessment_center11014                    -4.601950e-02 4.034813e-01
## assessment_center11016                    -1.471340e-01 3.947241e-01
## assessment_center11017                    -5.930094e-01 4.151474e-01
## assessment_center11018                    -3.005023e-01 3.936160e-01
## assessment_center11020                    -4.564929e-01 4.277204e-01
## assessment_center11021                    -1.673695e-01 4.432721e-01
## assessment_center11022                    -1.422272e+01 9.086527e+02
## alcohol                                    6.824005e-02 1.626758e-01
## prs_scaled:birth.x                        -2.105416e-02 6.339035e-02
## prs_scaled:birth.y                         2.619643e-03 6.339225e-02
## prs_scaled:length.oc.scale                -8.362498e-02 3.937142e-02
## prs_scaled:age.menarche.scale             -2.531219e-02 3.989727e-02
## prs_scaled:BMI.scale                      -3.248636e-02 4.006528e-02
## prs_scaled:agegroups[45,50)                1.312336e-02 9.055365e-02
## prs_scaled:agegroups[50,80)                1.255340e-01 1.102676e-01
## prs_scaled:alcohol                         6.945791e-02 1.175117e-01
## prs_scaled:height.scale                   -3.642083e-03 4.049962e-02
## prs_scaled:n.children.scale                1.477038e-02 6.959438e-02
## prs_scaled:age.firstbirth.group[25,35)    -1.384160e-02 1.192467e-01
## prs_scaled:age.firstbirth.group[35,80)     3.971260e-02 1.675649e-01
## prs_scaled:age.firstbirth.group[80,1e+03) -4.538395e-04 1.945985e-01
## eta_(Intercept)                           -3.004578e-01 8.305741e-02
## eta_PC1                                   -5.776163e-03 6.700804e-03
## eta_PC2                                   -2.485202e-04 9.122994e-03
## eta_PC3                                    1.252684e-02 1.398803e-02
## eta_PC4                                    4.413829e-03 6.446549e-03
## eta_PC5                                   -2.709303e-03 4.093081e-03
## eta_PC6                                    1.867398e-04 1.513566e-02
## eta_PC7                                    8.294567e-03 6.598633e-03
## eta_PC8                                   -1.849780e-03 9.833610e-03
## eta_PC9                                   -2.806268e-04 6.529570e-03
## eta_PC10                                  -2.395467e-03 1.244716e-02
## eta_birth.x                                9.475703e-03 4.175363e-02
## eta_birth.y                                5.874407e-03 4.462461e-02
## sigma_stratadata[, facVar]11001            9.141192e-01 8.819766e-02
## sigma_stratadata[, facVar]10003            2.637547e-01 2.220114e-01
## sigma_stratadata[, facVar]11002            9.441194e-01 8.808938e-02
## sigma_stratadata[, facVar]11003            9.664791e-01 8.125759e-02
## sigma_stratadata[, facVar]11004            9.690319e-01 7.436885e-02
## sigma_stratadata[, facVar]11005            9.443220e-01 7.650728e-02
## sigma_stratadata[, facVar]11006            9.716573e-01 7.581669e-02
## sigma_stratadata[, facVar]11007            9.212861e-01 5.786060e-02
## sigma_stratadata[, facVar]11008            9.369924e-01 6.475685e-02
## sigma_stratadata[, facVar]11009            9.963599e-01 6.160843e-02
## sigma_stratadata[, facVar]11010            1.019698e+00 5.506250e-02
## sigma_stratadata[, facVar]11011            9.427020e-01 5.211507e-02
## sigma_stratadata[, facVar]11012            8.908023e-01 1.199856e-01
## sigma_stratadata[, facVar]11013            9.037637e-01 6.493505e-02
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## sigma_stratadata[, facVar]11014           9.119175e-01 7.337680e-02
## sigma_stratadata[, facVar]11016           9.336310e-01 6.868496e-02
## sigma_stratadata[, facVar]11017           1.067494e+00 8.366302e-02
## sigma_stratadata[, facVar]11018           9.228904e-01 6.712057e-02
## sigma_stratadata[, facVar]11020           1.102430e+00 9.268883e-02
## sigma_stratadata[, facVar]11021           9.289243e-01 8.983780e-02
## sigma_stratadata[, facVar]11022           7.065314e-01 2.934857e-01
##                                               Z.value       Pvalue
## (Intercept)                               -1.817870486 6.908393e-02
## prs_scaled                                 2.763313844 5.721772e-03
## PC1                                       -1.094642608 2.736732e-01
## PC2                                       -1.414756875 1.571398e-01
## PC3                                        1.241174944 2.145411e-01
## PC4                                        0.241352985 8.092815e-01
## PC5                                       -0.736804474 4.612413e-01
## PC6                                        2.116031655 3.434212e-02
## PC7                                        1.595822378 1.105285e-01
## PC8                                       -2.782409863 5.395685e-03
## PC9                                       -0.039288867 9.686601e-01
## PC10                                      -0.701039002 4.832787e-01
## agegroups[45,50)                           2.852866135 4.332687e-03
## agegroups[50,80)                           1.607402828 1.079660e-01
## n.children.scale                           1.671878698 9.454824e-02
## birth.x                                    0.587762851 5.566915e-01
## birth.y                                    0.775421188 4.380908e-01
## age.firstbirth.group[25,35)                1.287570362 1.978956e-01
## age.firstbirth.group[35,80)                2.219638954 2.644329e-02
## age.firstbirth.group[80,1e+03)             2.747272220 6.009323e-03
## height.scale                               1.377534880 1.683469e-01
## age.menarche.scale                        -0.500796036 6.165147e-01
## length.oc.scale                            1.492786188 1.354932e-01
## BMI.scale                                  0.673094531 5.008872e-01
## assessment_center10003                     0.010656519 9.914975e-01
## assessment_center11002                     0.622211686 5.338027e-01
## assessment_center11003                     1.505671131 1.321516e-01
## assessment_center11004                     0.446008089 6.555914e-01
## assessment_center11005                     0.535515792 5.922932e-01
## assessment_center11006                     0.890671464 3.731054e-01
## assessment_center11007                     0.197062611 8.437785e-01
## assessment_center11008                     1.127811799 2.593994e-01
## assessment_center11009                     0.735209040 4.622122e-01
## assessment_center11010                     0.798853622 4.243753e-01
## assessment_center11011                    -0.299180789 7.648021e-01
## assessment_center11012                    -0.388639665 6.975427e-01
## assessment_center11013                     0.741162997 4.585946e-01
## assessment_center11014                    -0.114056078 9.091933e-01
## assessment_center11016                    -0.372751393 7.093335e-01
## assessment_center11017                    -1.428430913 1.531679e-01
## assessment_center11018                    -0.763440347 4.452008e-01
## assessment_center11020                    -1.067269215 2.858503e-01
## assessment_center11021                    -0.377577432 7.057445e-01
## assessment_center11022                    -0.015652542 9.875116e-01
## alcohol                                    0.419485079 6.748617e-01
## prs_scaled:birth.x                        -0.332135164 7.397872e-01
```

```
## prs_scaled:birth.y                           0.041324345 9.670373e-01
## prs_scaled:length.oc.scale                  -2.124002227 3.366996e-02
## prs_scaled:age.menarche.scale               -0.634434023 5.257976e-01
## prs_scaled:BMI.scale                        -0.810835659 4.174601e-01
## prs_scaled:agegroups[45,50)                  0.144923592 8.847712e-01
## prs_scaled:agegroups[50,80)                  1.138448788 2.549331e-01
## prs_scaled:alcohol                           0.591072523 5.544718e-01
## prs_scaled:height.scale                     -0.089928815 9.283438e-01
## prs_scaled:n.children.scale                  0.212235311 8.319235e-01
## prs_scaled:age.firstbirth.group[25,35)      -0.116075354 9.075928e-01
## prs_scaled:age.firstbirth.group[35,80)       0.236998288 8.126581e-01
## prs_scaled:age.firstbirth.group[80,1e+03) -0.002332185 9.981392e-01
## eta_(Intercept)                             -3.617471400 2.974952e-04
## eta_PC1                                     -0.862010475 3.886818e-01
## eta_PC2                                     -0.027241079 9.782675e-01
## eta_PC3                                      0.895539673 3.704987e-01
## eta_PC4                                      0.684680928 4.935453e-01
## eta_PC5                                     -0.661922666 5.080208e-01
## eta_PC6                                      0.012337738 9.901562e-01
## eta_PC7                                      1.257012795 2.087490e-01
## eta_PC8                                     -0.188107959 8.507920e-01
## eta_PC9                                     -0.042977832 9.657192e-01
## eta_PC10                                    -0.192450887 8.473890e-01
## eta_birth.x                                  0.226943181 8.204679e-01
## eta_birth.y                                  0.131640528 8.952686e-01
## sigma_stratadata[, facVar]11001             10.364439263 3.598629e-25
## sigma_stratadata[, facVar]10003              1.188023491 2.348242e-01
## sigma_stratadata[, facVar]11002             10.717743000 8.402879e-27
## sigma_stratadata[, facVar]11003             11.894016844 1.271414e-32
## sigma_stratadata[, facVar]11004             13.030077787 8.252348e-39
## sigma_stratadata[, facVar]11005             12.342904383 5.320151e-35
## sigma_stratadata[, facVar]11006             12.815875585 1.336214e-37
## sigma_stratadata[, facVar]11007             15.922511357 4.422631e-57
## sigma_stratadata[, facVar]11008             14.469394649 1.891293e-47
## sigma_stratadata[, facVar]11009             16.172459645 7.888503e-59
## sigma_stratadata[, facVar]11010             18.518927572 1.453026e-76
## sigma_stratadata[, facVar]11011             18.088857310 3.900917e-73
## sigma_stratadata[, facVar]11012              7.424240538 1.134289e-13
## sigma_stratadata[, facVar]11013             13.917965628 4.927300e-44
## sigma_stratadata[, facVar]11014             12.427873099 1.844775e-35
## sigma_stratadata[, facVar]11016             13.592946163 4.409662e-42
## sigma_stratadata[, facVar]11017             12.759449732 2.761449e-37
## sigma_stratadata[, facVar]11018             13.749741846 5.111158e-43
## sigma_stratadata[, facVar]11020             11.893881613 1.273475e-32
## sigma_stratadata[, facVar]11021             10.340016746 4.644564e-25
## sigma_stratadata[, facVar]11022              2.407379188 1.606748e-02
```

```
fit_normal.coordinate2.premeno$res_normal
```

```
##                                          Estimate    Std.Error
## (Intercept)                          -6.036384e-01 4.914734e-01
## prs_scaled                            4.856305e-01 1.998392e-01
## PC1                                  -2.407773e-02 2.353074e-02
## PC2                                  -3.241733e-02 2.492873e-02
```

```
## PC3                                          3.938896e-02 3.128143e-02
## PC4                                          3.331982e-03 1.490957e-02
## PC5                                         -7.741436e-03 9.369597e-03
## PC6                                          7.547927e-02 3.330043e-02
## PC7                                          2.436134e-02 1.491927e-02
## PC8                                         -6.102503e-02 2.175224e-02
## PC9                                         -3.905199e-04 1.494606e-02
## PC10                                        -1.863641e-02 2.740757e-02
## agegroups[45,50)                             3.777763e-01 1.284823e-01
## agegroups[50,80)                             2.688612e-01 1.570744e-01
## n.children.scale                             1.730633e-01 9.964890e-02
## birth.x                                      5.125000e-02 7.936395e-02
## birth.y                                      6.901322e-02 9.190932e-02
## age.firstbirth.group[25,35)                  2.270733e-01 1.668931e-01
## age.firstbirth.group[35,80)                  5.221605e-01 2.448607e-01
## age.firstbirth.group[80,1e+03)               7.400388e-01 2.768563e-01
## height.scale                                 8.036553e-02 5.819322e-02
## age.menarche.scale                          -2.862161e-02 5.736327e-02
## factor(oc.cate2)1                           -5.119388e-01 2.173620e-01
## factor(oc.cate2)2                           -1.073318e-01 2.083972e-01
## BMI.scale                                    3.870995e-02 5.825690e-02
## assessment_center10003                       1.431803e+01 1.357102e+03
## assessment_center11002                       2.790522e-01 4.449475e-01
## assessment_center11003                       6.568132e-01 4.443218e-01
## assessment_center11004                       1.897913e-01 4.342305e-01
## assessment_center11005                       2.568709e-01 4.275473e-01
## assessment_center11006                       3.929606e-01 4.075374e-01
## assessment_center11007                       6.610801e-02 3.774580e-01
## assessment_center11008                       4.502624e-01 3.883943e-01
## assessment_center11009                       2.901477e-01 3.844263e-01
## assessment_center11010                       2.695464e-01 3.605206e-01
## assessment_center11011                      -1.168405e-01 3.693260e-01
## assessment_center11012                      -1.437975e-01 5.407695e-01
## assessment_center11013                       3.211362e-01 3.946652e-01
## assessment_center11014                      -5.541862e-02 4.045419e-01
## assessment_center11016                      -1.583712e-01 3.959833e-01
## assessment_center11017                      -6.047008e-01 4.161103e-01
## assessment_center11018                      -3.104998e-01 3.948133e-01
## assessment_center11020                      -4.372980e-01 4.284127e-01
## assessment_center11021                      -1.723390e-01 4.438873e-01
## assessment_center11022                      -1.423605e+01 9.052690e+02
## alcohol                                      8.157501e-02 1.637920e-01
## prs_scaled:birth.x                          -2.389570e-02 6.339617e-02
## prs_scaled:birth.y                           2.118811e-03 6.342680e-02
## prs_scaled:factor(oc.cate2)1                 8.230418e-02 1.461940e-01
## prs_scaled:factor(oc.cate2)2                -8.838775e-02 1.375803e-01
## prs_scaled:age.menarche.scale               -2.597528e-02 3.996804e-02
## prs_scaled:BMI.scale                        -3.216953e-02 3.995744e-02
## prs_scaled:agegroups[45,50)                  7.384435e-03 9.059493e-02
## prs_scaled:agegroups[50,80)                  1.244129e-01 1.103879e-01
## prs_scaled:alcohol                           6.263881e-02 1.177404e-01
## prs_scaled:height.scale                     -4.243693e-03 4.059175e-02
## prs_scaled:n.children.scale                  1.738340e-02 6.947587e-02
## prs_scaled:age.firstbirth.group[25,35)      -1.383778e-02 1.191315e-01
```

```
## prs_scaled:age.firstbirth.group[35,80)     4.447126e-02 1.673987e-01
## prs_scaled:age.firstbirth.group[80,1e+03)  7.086129e-03 1.944932e-01
## eta_(Intercept)                           -3.007873e-01 8.303537e-02
## eta_PC1                                   -5.842309e-03 6.695367e-03
## eta_PC2                                   -4.624998e-04 9.122451e-03
## eta_PC3                                    1.238988e-02 1.399815e-02
## eta_PC4                                    4.485884e-03 6.449913e-03
## eta_PC5                                   -2.434971e-03 4.095762e-03
## eta_PC6                                   -6.673611e-04 1.514684e-02
## eta_PC7                                    8.078356e-03 6.600803e-03
## eta_PC8                                   -1.587794e-03 9.836592e-03
## eta_PC9                                   -4.143236e-04 6.531120e-03
## eta_PC10                                  -1.905985e-03 1.246241e-02
## eta_birth.x                                1.041036e-02 4.174553e-02
## eta_birth.y                                5.927429e-03 4.469251e-02
## sigma_stratadata[, facVar]11001            9.149430e-01 8.837144e-02
## sigma_stratadata[, facVar]10003            2.620924e-01 2.214623e-01
## sigma_stratadata[, facVar]11002            9.440187e-01 8.807499e-02
## sigma_stratadata[, facVar]11003            9.679840e-01 8.163155e-02
## sigma_stratadata[, facVar]11004            9.698911e-01 7.458851e-02
## sigma_stratadata[, facVar]11005            9.424026e-01 7.620024e-02
## sigma_stratadata[, facVar]11006            9.716158e-01 7.576074e-02
## sigma_stratadata[, facVar]11007            9.213945e-01 5.789866e-02
## sigma_stratadata[, facVar]11008            9.372689e-01 6.471986e-02
## sigma_stratadata[, facVar]11009            9.974989e-01 6.174909e-02
## sigma_stratadata[, facVar]11010            1.020470e+00 5.520308e-02
## sigma_stratadata[, facVar]11011            9.429172e-01 5.213514e-02
## sigma_stratadata[, facVar]11012            8.891882e-01 1.191879e-01
## sigma_stratadata[, facVar]11013            9.015366e-01 6.453782e-02
## sigma_stratadata[, facVar]11014            9.127298e-01 7.350067e-02
## sigma_stratadata[, facVar]11016            9.363416e-01 6.920795e-02
## sigma_stratadata[, facVar]11017            1.067561e+00 8.364555e-02
## sigma_stratadata[, facVar]11018            9.233604e-01 6.725673e-02
## sigma_stratadata[, facVar]11020            1.102178e+00 9.265633e-02
## sigma_stratadata[, facVar]11021            9.274174e-01 8.950612e-02
## sigma_stratadata[, facVar]11022            7.088441e-01 2.946511e-01
##                                               Z.value       Pvalue
## (Intercept)                               -1.22822177 2.193637e-01
## prs_scaled                                 2.43010630 1.509440e-02
## PC1                                       -1.02324566 3.061917e-01
## PC2                                       -1.30040025 1.934638e-01
## PC3                                        1.25918044 2.079652e-01
## PC4                                        0.22347934 8.231625e-01
## PC5                                       -0.82622931 4.086740e-01
## PC6                                        2.26661554 2.341372e-02
## PC7                                        1.63287752 1.024948e-01
## PC8                                       -2.80545906 5.024496e-03
## PC9                                       -0.02612863 9.791547e-01
## PC10                                      -0.67997313 4.965215e-01
## agegroups[45,50)                           2.94029784 3.278969e-03
## agegroups[50,80)                           1.71168024 8.695561e-02
## n.children.scale                           1.73673083 8.243469e-02
## birth.x                                    0.64575924 5.184353e-01
## birth.y                                    0.75088377 4.527226e-01
```

```
## age.firstbirth.group[25,35)                1.36059139 1.736429e-01
## age.firstbirth.group[35,80)                2.13247967 3.296743e-02
## age.firstbirth.group[80,1e+03)             2.67300734 7.517461e-03
## height.scale                               1.38101190 1.672753e-01
## age.menarche.scale                        -0.49895368 6.178120e-01
## factor(oc.cate2)1                         -2.35523555 1.851097e-02
## factor(oc.cate2)2                         -0.51503466 6.065288e-01
## BMI.scale                                  0.66446988 5.063896e-01
## assessment_center10003                     0.01055045 9.915821e-01
## assessment_center11002                     0.62715755 5.305560e-01
## assessment_center11003                     1.47823769 1.393442e-01
## assessment_center11004                     0.43707505 6.620569e-01
## assessment_center11005                     0.60080109 5.479725e-01
## assessment_center11006                     0.96423210 3.349296e-01
## assessment_center11007                     0.17514005 8.609696e-01
## assessment_center11008                     1.15929179 2.463373e-01
## assessment_center11009                     0.75475509 4.503959e-01
## assessment_center11010                     0.74765884 4.546660e-01
## assessment_center11011                    -0.31636141 7.517282e-01
## assessment_center11012                    -0.26591279 7.903064e-01
## assessment_center11013                     0.81369287 4.158209e-01
## assessment_center11014                    -0.13699105 8.910379e-01
## assessment_center11016                    -0.39994430 6.891975e-01
## assessment_center11017                    -1.45322260 1.461620e-01
## assessment_center11018                    -0.78644719 4.316055e-01
## assessment_center11020                    -1.02074003 3.073776e-01
## assessment_center11021                    -0.38824937 6.978315e-01
## assessment_center11022                    -0.01572577 9.874532e-01
## alcohol                                    0.49804039 6.184556e-01
## prs_scaled:birth.x                        -0.37692654 7.062282e-01
## prs_scaled:birth.y                         0.03340561 9.733511e-01
## prs_scaled:factor(oc.cate2)1               0.56297918 5.734491e-01
## prs_scaled:factor(oc.cate2)2              -0.64244459 5.205846e-01
## prs_scaled:age.menarche.scale             -0.64990122 5.157560e-01
## prs_scaled:BMI.scale                      -0.80509478 4.207650e-01
## prs_scaled:agegroups[45,50)                0.08151047 9.350360e-01
## prs_scaled:agegroups[50,80)                1.12705180 2.597206e-01
## prs_scaled:alcohol                         0.53200793 5.947205e-01
## prs_scaled:height.scale                   -0.10454570 9.167363e-01
## prs_scaled:n.children.scale                0.25020778 8.024267e-01
## prs_scaled:age.firstbirth.group[25,35)    -0.11615555 9.075293e-01
## prs_scaled:age.firstbirth.group[35,80)     0.26566075 7.905005e-01
## prs_scaled:age.firstbirth.group[80,1e+03)  0.03643382 9.709364e-01
## eta_(Intercept)                           -3.62239978 2.918826e-04
## eta_PC1                                   -0.87258972 3.828867e-01
## eta_PC2                                   -0.05069907 9.595653e-01
## eta_PC3                                    0.88510869 3.760980e-01
## eta_PC4                                    0.69549527 4.867450e-01
## eta_PC5                                   -0.59450982 5.521712e-01
## eta_PC6                                   -0.04405943 9.648570e-01
## eta_PC7                                    1.22384444 2.210109e-01
## eta_PC8                                   -0.16141705 8.717649e-01
## eta_PC9                                   -0.06343836 9.494174e-01
## eta_PC10                                  -0.15293876 8.784466e-01
```

```
## eta_birth.x                                0.24937664 8.030695e-01
## eta_birth.y                                0.13262689 8.944885e-01
## sigma_stratadata[, facVar]11001           10.35337928 4.039702e-25
## sigma_stratadata[, facVar]10003            1.18346318 2.366256e-01
## sigma_stratadata[, facVar]11002           10.71835169 8.347771e-27
## sigma_stratadata[, facVar]11003           11.85796386 1.956758e-32
## sigma_stratadata[, facVar]11004           13.00322402 1.172922e-38
## sigma_stratadata[, facVar]11005           12.36744921 3.920757e-35
## sigma_stratadata[, facVar]11006           12.82479196 1.191058e-37
## sigma_stratadata[, facVar]11007           15.91391544 5.073862e-57
## sigma_stratadata[, facVar]11008           14.48193718 1.575923e-47
## sigma_stratadata[, facVar]11009           16.15406669 1.063155e-58
## sigma_stratadata[, facVar]11010           18.48575037 2.689316e-76
## sigma_stratadata[, facVar]11011           18.08601837 4.107099e-73
## sigma_stratadata[, facVar]11012            7.46038757 8.626834e-14
## sigma_stratadata[, facVar]11013           13.96911978 2.405816e-44
## sigma_stratadata[, facVar]11014           12.41797990 2.087665e-35
## sigma_stratadata[, facVar]11016           13.52939274 1.048865e-41
## sigma_stratadata[, facVar]11017           12.76291186 2.641393e-37
## sigma_stratadata[, facVar]11018           13.72889215 6.816788e-43
## sigma_stratadata[, facVar]11020           11.89533044 1.251567e-32
## sigma_stratadata[, facVar]11021           10.36149664 3.711092e-25
## sigma_stratadata[, facVar]11022            2.40570704 1.614120e-02
```

```
fit_normal.coordinate3.premeno$res_normal
```

```
##                                              Estimate    Std.Error
## (Intercept)                               -6.030681e-01 4.916567e-01
## prs_scaled                                 4.834290e-01 1.999589e-01
## PC1                                       -2.437040e-02 2.355753e-02
## PC2                                       -3.267051e-02 2.496128e-02
## PC3                                        3.962000e-02 3.133163e-02
## PC4                                        3.406917e-03 1.493361e-02
## PC5                                       -7.474407e-03 9.384280e-03
## PC6                                        7.488371e-02 3.332560e-02
## PC7                                        2.409037e-02 1.493817e-02
## PC8                                       -6.084248e-02 2.176378e-02
## PC9                                       -2.354267e-04 1.494811e-02
## PC10                                      -1.769046e-02 2.750409e-02
## agegroups[45,50)                           3.792724e-01 1.285723e-01
## agegroups[50,80)                           2.718982e-01 1.572277e-01
## n.children.scale                           1.748595e-01 9.971471e-02
## birth.x                                    5.197520e-02 7.939960e-02
## birth.y                                    6.900374e-02 9.191738e-02
## age.firstbirth.group[25,35)                2.315620e-01 1.670917e-01
## age.firstbirth.group[35,80)                5.212595e-01 2.448755e-01
## age.firstbirth.group[80,1e+03)             7.394951e-01 2.770383e-01
## height.scale                               7.982300e-02 5.820120e-02
## age.menarche.scale                        -2.941666e-02 5.740054e-02
## factor(oc.cate3)1                         -5.201128e-01 2.448579e-01
## factor(oc.cate3)2                         -5.066867e-01 2.345209e-01
## factor(oc.cate3)3                         -1.586910e-01 2.327571e-01
## factor(oc.cate3)4                         -7.995669e-02 2.151473e-01
## BMI.scale                                  4.004497e-02 5.848709e-02
```

```
## assessment_center10003                      1.434424e+01 1.342782e+03
## assessment_center11002                      2.702606e-01 4.450792e-01
## assessment_center11003                      6.494632e-01 4.444431e-01
## assessment_center11004                      1.837279e-01 4.344730e-01
## assessment_center11005                      2.445649e-01 4.280193e-01
## assessment_center11006                      3.886089e-01 4.081083e-01
## assessment_center11007                      5.943782e-02 3.777004e-01
## assessment_center11008                      4.421748e-01 3.888315e-01
## assessment_center11009                      2.829191e-01 3.853465e-01
## assessment_center11010                      2.620463e-01 3.611014e-01
## assessment_center11011                     -1.232852e-01 3.697448e-01
## assessment_center11012                     -1.497323e-01 5.410006e-01
## assessment_center11013                      3.136287e-01 3.949667e-01
## assessment_center11014                     -5.844650e-02 4.045028e-01
## assessment_center11016                     -1.599245e-01 3.961270e-01
## assessment_center11017                     -6.157565e-01 4.166125e-01
## assessment_center11018                     -3.165940e-01 3.953370e-01
## assessment_center11020                     -4.469887e-01 4.290099e-01
## assessment_center11021                     -1.816574e-01 4.440861e-01
## assessment_center11022                     -1.425224e+01 9.138673e+02
## alcohol                                     8.217321e-02 1.639616e-01
## prs_scaled:birth.x                         -2.407554e-02 6.340013e-02
## prs_scaled:birth.y                          2.758555e-03 6.345298e-02
## prs_scaled:factor(oc.cate3)1                1.240336e-01 1.665844e-01
## prs_scaled:factor(oc.cate3)2                4.736964e-02 1.601489e-01
## prs_scaled:factor(oc.cate3)3               -8.375771e-02 1.557043e-01
## prs_scaled:factor(oc.cate3)4               -9.236681e-02 1.422857e-01
## prs_scaled:age.menarche.scale              -2.551287e-02 3.999325e-02
## prs_scaled:BMI.scale                       -3.058051e-02 4.016082e-02
## prs_scaled:agegroups[45,50)                 8.086746e-03 9.065731e-02
## prs_scaled:agegroups[50,80)                 1.234713e-01 1.105198e-01
## prs_scaled:alcohol                          6.570420e-02 1.178867e-01
## prs_scaled:height.scale                    -3.861275e-03 4.061332e-02
## prs_scaled:n.children.scale                 1.638361e-02 6.954255e-02
## prs_scaled:age.firstbirth.group[25,35)     -1.183316e-02 1.193089e-01
## prs_scaled:age.firstbirth.group[35,80)      4.516450e-02 1.674385e-01
## prs_scaled:age.firstbirth.group[80,1e+03)   5.011693e-03 1.946767e-01
## eta_(Intercept)                            -3.012850e-01 8.307733e-02
## eta_PC1                                    -5.835038e-03 6.700790e-03
## eta_PC2                                    -3.508714e-04 9.127782e-03
## eta_PC3                                     1.206375e-02 1.400716e-02
## eta_PC4                                     4.349079e-03 6.453067e-03
## eta_PC5                                    -2.451736e-03 4.098460e-03
## eta_PC6                                    -5.950954e-04 1.514636e-02
## eta_PC7                                     8.120735e-03 6.599742e-03
## eta_PC8                                    -1.550074e-03 9.835756e-03
## eta_PC9                                    -3.789679e-04 6.533442e-03
## eta_PC10                                   -1.907775e-03 1.248031e-02
## eta_birth.x                                 1.032018e-02 4.173253e-02
## eta_birth.y                                 5.973132e-03 4.466633e-02
## sigma_stratadata[, facVar]11001             9.156277e-01 8.857062e-02
## sigma_stratadata[, facVar]10003             2.638237e-01 2.233296e-01
## sigma_stratadata[, facVar]11002             9.443325e-01 8.814163e-02
## sigma_stratadata[, facVar]11003             9.685271e-01 8.174889e-02
```

```
## sigma_stratadata[, facVar]11004           9.699736e-01 7.459925e-02
## sigma_stratadata[, facVar]11005           9.428483e-01 7.627387e-02
## sigma_stratadata[, facVar]11006           9.705090e-01 7.559002e-02
## sigma_stratadata[, facVar]11007           9.222382e-01 5.803860e-02
## sigma_stratadata[, facVar]11008           9.370973e-01 6.470263e-02
## sigma_stratadata[, facVar]11009           9.960743e-01 6.159429e-02
## sigma_stratadata[, facVar]11010           1.020156e+00 5.516453e-02
## sigma_stratadata[, facVar]11011           9.426153e-01 5.209988e-02
## sigma_stratadata[, facVar]11012           8.892506e-01 1.192046e-01
## sigma_stratadata[, facVar]11013           9.018776e-01 6.462057e-02
## sigma_stratadata[, facVar]11014           9.128749e-01 7.355572e-02
## sigma_stratadata[, facVar]11016           9.358242e-01 6.912200e-02
## sigma_stratadata[, facVar]11017           1.067621e+00 8.368633e-02
## sigma_stratadata[, facVar]11018           9.229090e-01 6.717033e-02
## sigma_stratadata[, facVar]11020           1.101659e+00 9.250257e-02
## sigma_stratadata[, facVar]11021           9.284805e-01 8.979264e-02
## sigma_stratadata[, facVar]11022           7.081647e-01 2.943990e-01
##                                              Z.value       Pvalue
## (Intercept)                               -1.22660405 2.199714e-01
## prs_scaled                                 2.41764162 1.562145e-02
## PC1                                       -1.03450564 3.008998e-01
## PC2                                       -1.30884737 1.905861e-01
## PC3                                        1.26453700 2.060373e-01
## PC4                                        0.22813752 8.195393e-01
## PC5                                       -0.79648168 4.257521e-01
## PC6                                        2.24703271 2.463794e-02
## PC7                                        1.61267161 1.068159e-01
## PC8                                       -2.79558417 5.180601e-03
## PC9                                       -0.01574960 9.874342e-01
## PC10                                      -0.64319377 5.200984e-01
## agegroups[45,50)                           2.94987534 3.179022e-03
## agegroups[50,80)                           1.72932719 8.375055e-02
## n.children.scale                           1.75359754 7.949949e-02
## birth.x                                    0.65460281 5.127235e-01
## birth.y                                    0.75071478 4.528243e-01
## age.firstbirth.group[25,35)                1.38583773 1.657965e-01
## age.firstbirth.group[35,80)                2.12867160 3.328144e-02
## age.firstbirth.group[80,1e+03)             2.66928788 7.601227e-03
## height.scale                               1.37150098 1.702188e-01
## age.menarche.scale                        -0.51248061 6.083147e-01
## factor(oc.cate3)1                         -2.12414157 3.365831e-02
## factor(oc.cate3)2                         -2.16051863 3.073254e-02
## factor(oc.cate3)3                         -0.68178825 4.953729e-01
## factor(oc.cate3)4                         -0.37163691 7.101632e-01
## BMI.scale                                  0.68468042 4.935456e-01
## assessment_center10003                     0.01068248 9.914768e-01
## assessment_center11002                     0.60721902 5.437056e-01
## assessment_center11003                     1.46129665 1.439340e-01
## assessment_center11004                     0.42287538 6.723862e-01
## assessment_center11005                     0.57138763 5.677369e-01
## assessment_center11006                     0.95222001 3.409854e-01
## assessment_center11007                     0.15736765 8.749551e-01
## assessment_center11008                     1.13718873 2.554594e-01
## assessment_center11009                     0.73419393 4.628306e-01
```

```
## assessment_center11010                     0.72568633 4.680311e-01
## assessment_center11011                    -0.33343310 7.388074e-01
## assessment_center11012                    -0.27676916 7.819574e-01
## assessment_center11013                     0.79406377 4.271583e-01
## assessment_center11014                    -0.14448974 8.851138e-01
## assessment_center11016                    -0.40372032 6.864184e-01
## assessment_center11017                    -1.47800763 1.394057e-01
## assessment_center11018                    -0.80082045 4.232356e-01
## assessment_center11020                    -1.04190783 2.974544e-01
## assessment_center11021                    -0.40905902 6.824964e-01
## assessment_center11022                    -0.01559553 9.875571e-01
## alcohol                                    0.50117342 6.162491e-01
## prs_scaled:birth.x                        -0.37973959 7.041387e-01
## prs_scaled:birth.y                         0.04347401 9.653237e-01
## prs_scaled:factor(oc.cate3)1               0.74456901 4.565323e-01
## prs_scaled:factor(oc.cate3)2               0.29578496 7.673943e-01
## prs_scaled:factor(oc.cate3)3              -0.53792815 5.906267e-01
## prs_scaled:factor(oc.cate3)4              -0.64916433 5.162322e-01
## prs_scaled:age.menarche.scale             -0.63792957 5.235195e-01
## prs_scaled:BMI.scale                      -0.76145134 4.463875e-01
## prs_scaled:agegroups[45,50)                0.08920125 9.289220e-01
## prs_scaled:agegroups[50,80)                1.11718696 2.639144e-01
## prs_scaled:alcohol                         0.55735060 5.772879e-01
## prs_scaled:height.scale                   -0.09507411 9.242560e-01
## prs_scaled:n.children.scale                0.23559122 8.137499e-01
## prs_scaled:age.firstbirth.group[25,35)    -0.09918087 9.209947e-01
## prs_scaled:age.firstbirth.group[35,80)     0.26973776 7.873620e-01
## prs_scaled:age.firstbirth.group[80,1e+03)  0.02574367 9.794618e-01
## eta_(Intercept)                           -3.62656115 2.872208e-04
## eta_PC1                                   -0.87079856 3.838641e-01
## eta_PC2                                   -0.03843994 9.693369e-01
## eta_PC3                                    0.86125636 3.890969e-01
## eta_PC4                                    0.67395541 5.003397e-01
## eta_PC5                                   -0.59820899 5.497005e-01
## eta_PC6                                   -0.03928966 9.686594e-01
## eta_PC7                                    1.23046249 2.185240e-01
## eta_PC8                                   -0.15759585 8.747753e-01
## eta_PC9                                   -0.05800432 9.537452e-01
## eta_PC10                                  -0.15286281 8.785065e-01
## eta_birth.x                                0.24729333 8.046812e-01
## eta_birth.y                                0.13372784 8.936178e-01
## sigma_stratadata[, facVar]11001           10.33782690 4.751907e-25
## sigma_stratadata[, facVar]10003            1.18132016 2.374756e-01
## sigma_stratadata[, facVar]11002           10.71380842 8.767901e-27
## sigma_stratadata[, facVar]11003           11.84758678 2.214772e-32
## sigma_stratadata[, facVar]11004           13.00245838 1.184726e-38
## sigma_stratadata[, facVar]11005           12.36135410 4.229711e-35
## sigma_stratadata[, facVar]11006           12.83911593 9.899852e-38
## sigma_stratadata[, facVar]11007           15.89008495 7.422692e-57
## sigma_stratadata[, facVar]11008           14.48314007 1.548579e-47
## sigma_stratadata[, facVar]11009           16.17153728 8.007507e-59
## sigma_stratadata[, facVar]11010           18.49297316 2.352206e-76
## sigma_stratadata[, facVar]11011           18.09246492 3.653733e-73
## sigma_stratadata[, facVar]11012            7.45986872 8.660873e-14
```

```
## sigma_stratadata[, facVar]11013          13.95651003 2.871547e-44
## sigma_stratadata[, facVar]11014          12.41065947 2.287608e-35
## sigma_stratadata[, facVar]11016          13.53873205 9.236953e-42
## sigma_stratadata[, facVar]11017          12.75741506 2.834519e-37
## sigma_stratadata[, facVar]11018          13.73983149 5.861205e-43
## sigma_stratadata[, facVar]11020          11.90949882 1.056101e-32
## sigma_stratadata[, facVar]11021          10.34027380 4.632122e-25
## sigma_stratadata[, facVar]11022           2.40545922 1.615215e-02
```

```
#Logistic regression on the case-control samples
fit_normal.coordinate1.premeno$res_glm
```

```
##                                          Estimate   Std. Error
## (Intercept)                          -8.243300e-01 4.742918e-01
## prs_scaled                            6.022829e-01 2.428489e-01
## PC1                                  -2.882915e-02 2.459981e-02
## PC2                                  -3.786671e-02 2.544744e-02
## PC3                                   4.096103e-02 3.184662e-02
## PC4                                   3.578548e-03 1.534377e-02
## PC5                                  -7.816834e-03 9.467848e-03
## PC6                                   6.479887e-02 3.358688e-02
## PC7                                   2.282345e-02 1.474043e-02
## PC8                                  -5.607639e-02 2.197096e-02
## PC9                                  -5.395428e-04 1.499070e-02
## PC10                                 -2.205444e-02 2.793398e-02
## agegroups[45,50)                      3.333805e-01 1.313576e-01
## agegroups[50,80)                      2.778238e-01 1.617468e-01
## n.children.scale                      1.302927e-01 1.009571e-01
## birth.x                               5.469061e-02 8.085656e-02
## birth.y                               7.141507e-02 9.409417e-02
## age.firstbirth.group[25,35)           2.398731e-01 1.691833e-01
## age.firstbirth.group[35,80)           5.616887e-01 2.508323e-01
## age.firstbirth.group[80,1e+03)        6.871900e-01 2.808257e-01
## height.scale                          7.843799e-02 5.929138e-02
## age.menarche.scale                   -1.531947e-02 5.836095e-02
## length.oc.scale                       9.464637e-02 5.862197e-02
## BMI.scale                             4.221617e-02 5.946850e-02
## assessment_center10003                1.441583e+01 8.827435e+02
## assessment_center11002                3.010470e-01 4.611352e-01
## assessment_center11003                6.126563e-01 4.573325e-01
## assessment_center11004                2.219473e-01 4.505146e-01
## assessment_center11005                2.168008e-01 4.424195e-01
## assessment_center11006                2.638907e-01 4.212699e-01
## assessment_center11007                1.448371e-01 3.924672e-01
## assessment_center11008                6.200225e-01 4.042327e-01
## assessment_center11009                2.306281e-01 3.992872e-01
## assessment_center11010                2.858121e-01 3.745669e-01
## assessment_center11011               -6.465953e-02 3.843211e-01
## assessment_center11012               -2.025977e-01 5.578473e-01
## assessment_center11013                1.488063e-01 4.093823e-01
## assessment_center11014               -3.556650e-02 4.182090e-01
## assessment_center11016               -7.483747e-02 4.088478e-01
## assessment_center11017               -6.547522e-01 4.332296e-01
## assessment_center11018               -3.959249e-01 4.094623e-01
```

```
## assessment_center11020                    -4.903342e-01 4.444563e-01
## assessment_center11021                    -2.653443e-01 4.574402e-01
## assessment_center11022                    -1.422271e+01 4.900044e+02
## alcohol                                    6.694736e-02 1.674530e-01
## prs_scaled:birth.x                        -2.748162e-02 7.095202e-02
## prs_scaled:birth.y                        -5.962796e-03 6.966354e-02
## prs_scaled:length.oc.scale                -1.382725e-02 6.203834e-02
## prs_scaled:age.menarche.scale              1.631170e-02 6.441085e-02
## prs_scaled:BMI.scale                      -1.194260e-02 6.412914e-02
## prs_scaled:agegroups[45,50)               -9.626903e-02 1.406591e-01
## prs_scaled:agegroups[50,80)                2.121685e-01 1.739780e-01
## prs_scaled:alcohol                        -5.782103e-02 1.874503e-01
## prs_scaled:height.scale                    5.034938e-02 6.272358e-02
## prs_scaled:n.children.scale               -1.020612e-01 1.103808e-01
## prs_scaled:age.firstbirth.group[25,35)     1.029491e-01 1.771755e-01
## prs_scaled:age.firstbirth.group[35,80)     1.181946e-01 2.550182e-01
## prs_scaled:age.firstbirth.group[80,1e+03) -2.153718e-01 2.949661e-01
##                                               z value   Pr(>|z|)
## (Intercept)                               -1.73802299 0.08220676
## prs_scaled                                 2.48007277 0.01313556
## PC1                                       -1.17192599 0.24122677
## PC2                                       -1.48803590 0.13674143
## PC3                                        1.28619679 0.19837439
## PC4                                        0.23322476 0.81558688
## PC5                                       -0.82561888 0.40902032
## PC6                                        1.92929138 0.05369470
## PC7                                        1.54835736 0.12153628
## PC8                                       -2.55229574 0.01070156
## PC9                                       -0.03599184 0.97128886
## PC10                                      -0.78952005 0.42980812
## agegroups[45,50)                           2.53796151 0.01115002
## agegroups[50,80)                           1.71764679 0.08586106
## n.children.scale                           1.29057503 0.19685108
## birth.x                                    0.67639052 0.49879274
## birth.y                                    0.75897442 0.44786786
## age.firstbirth.group[25,35)                1.41782975 0.15624048
## age.firstbirth.group[35,80)                2.23930013 0.02513639
## age.firstbirth.group[80,1e+03)             2.44703417 0.01440372
## height.scale                               1.32292403 0.18586064
## age.menarche.scale                        -0.26249519 0.79293969
## length.oc.scale                            1.61452050 0.10641457
## BMI.scale                                  0.70989123 0.47777159
## assessment_center10003                     0.01633072 0.98697055
## assessment_center11002                     0.65283883 0.51386019
## assessment_center11003                     1.33962981 0.18036573
## assessment_center11004                     0.49265284 0.62225791
## assessment_center11005                     0.49003439 0.62410956
## assessment_center11006                     0.62641714 0.53104137
## assessment_center11007                     0.36904258 0.71209599
## assessment_center11008                     1.53382562 0.12507256
## assessment_center11009                     0.57759949 0.56353455
## assessment_center11010                     0.76304696 0.44543539
## assessment_center11011                    -0.16824349 0.86639173
## assessment_center11012                    -0.36317764 0.71647219
```

```
## assessment_center11013                      0.36348989 0.71623896
## assessment_center11014                     -0.08504480 0.93222577
## assessment_center11016                     -0.18304479 0.85476287
## assessment_center11017                     -1.51132859 0.13070475
## assessment_center11018                     -0.96693872 0.33357467
## assessment_center11020                     -1.10322248 0.26993056
## assessment_center11021                     -0.58006337 0.56187188
## assessment_center11022                     -0.02902568 0.97684411
## alcohol                                     0.39979789 0.68930538
## prs_scaled:birth.x                         -0.38732679 0.69851429
## prs_scaled:birth.y                         -0.08559421 0.93178900
## prs_scaled:length.oc.scale                 -0.22288231 0.82362711
## prs_scaled:age.menarche.scale               0.25324466 0.80007916
## prs_scaled:BMI.scale                       -0.18622728 0.85226653
## prs_scaled:agegroups[45,50)                -0.68441378 0.49371392
## prs_scaled:agegroups[50,80)                 1.21951343 0.22264938
## prs_scaled:alcohol                         -0.30846053 0.75773193
## prs_scaled:height.scale                     0.80271849 0.42213746
## prs_scaled:n.children.scale                -0.92462795 0.35515947
## prs_scaled:age.firstbirth.group[25,35)      0.58105736 0.56120179
## prs_scaled:age.firstbirth.group[35,80)      0.46347521 0.64302378
## prs_scaled:age.firstbirth.group[80,1e+03) -0.73015763 0.46529384
```

```
fit_normal.coordinate2.premeno$res_glm
```

```
##                                          Estimate   Std. Error
## (Intercept)                           -5.899455e-01 5.135351e-01
## prs_scaled                             5.058746e-01 3.063313e-01
## PC1                                   -2.681831e-02 2.477276e-02
## PC2                                   -3.554226e-02 2.584053e-02
## PC3                                    4.149386e-02 3.201562e-02
## PC4                                    3.524074e-03 1.536907e-02
## PC5                                   -8.745633e-03 9.499192e-03
## PC6                                    7.084685e-02 3.372489e-02
## PC7                                    2.338551e-02 1.478529e-02
## PC8                                   -5.697421e-02 2.207109e-02
## PC9                                   -6.525635e-04 1.506272e-02
## PC10                                  -2.074899e-02 2.799405e-02
## agegroups[45,50)                       3.515697e-01 1.317263e-01
## agegroups[50,80)                       3.036412e-01 1.625602e-01
## n.children.scale                       1.340794e-01 1.014205e-01
## birth.x                                6.298543e-02 8.128115e-02
## birth.y                                7.452464e-02 9.448404e-02
## age.firstbirth.group[25,35)            2.500018e-01 1.700084e-01
## age.firstbirth.group[35,80)            5.341185e-01 2.517843e-01
## age.firstbirth.group[80,1e+03)         6.579923e-01 2.827994e-01
## height.scale                           8.169514e-02 5.960098e-02
## age.menarche.scale                    -1.607536e-02 5.864723e-02
## factor(oc.cate2)1                     -5.110098e-01 2.220163e-01
## factor(oc.cate2)2                     -8.894853e-02 2.134113e-01
## BMI.scale                              4.572423e-02 5.988413e-02
## assessment_center10003                 1.431802e+01 8.827435e+02
## assessment_center11002                 2.945649e-01 4.631877e-01
## assessment_center11003                 5.907679e-01 4.601427e-01
```

```
## assessment_center11004                      2.010841e-01 4.521563e-01
## assessment_center11005                      2.283557e-01 4.435372e-01
## assessment_center11006                      2.851812e-01 4.233220e-01
## assessment_center11007                      1.286208e-01 3.940284e-01
## assessment_center11008                      6.189153e-01 4.063733e-01
## assessment_center11009                      2.205079e-01 4.016102e-01
## assessment_center11010                      2.537691e-01 3.762147e-01
## assessment_center11011                     -8.569009e-02 3.862009e-01
## assessment_center11012                     -1.267790e-01 5.637605e-01
## assessment_center11013                      1.594563e-01 4.106897e-01
## assessment_center11014                     -5.641216e-02 4.197684e-01
## assessment_center11016                     -9.716454e-02 4.108805e-01
## assessment_center11017                     -6.813809e-01 4.350066e-01
## assessment_center11018                     -4.192676e-01 4.113160e-01
## assessment_center11020                     -4.767572e-01 4.462915e-01
## assessment_center11021                     -2.834204e-01 4.588754e-01
## assessment_center11022                     -1.423604e+01 4.791850e+02
## alcohol                                     7.843716e-02 1.686531e-01
## prs_scaled:birth.x                         -3.493772e-02 7.124272e-02
## prs_scaled:birth.y                         -6.316855e-03 7.000364e-02
## prs_scaled:factor(oc.cate2)1                1.262087e-01 2.204809e-01
## prs_scaled:factor(oc.cate2)2                8.795263e-02 2.112897e-01
## prs_scaled:age.menarche.scale               8.210232e-03 6.473349e-02
## prs_scaled:BMI.scale                       -2.369488e-02 6.407806e-02
## prs_scaled:agegroups[45,50)                -1.006656e-01 1.410064e-01
## prs_scaled:agegroups[50,80)                 2.062175e-01 1.740766e-01
## prs_scaled:alcohol                         -5.657852e-02 1.879799e-01
## prs_scaled:height.scale                     4.425442e-02 6.304676e-02
## prs_scaled:n.children.scale                -8.949471e-02 1.114801e-01
## prs_scaled:age.firstbirth.group[25,35)      1.041917e-01 1.776863e-01
## prs_scaled:age.firstbirth.group[35,80)      1.138125e-01 2.556207e-01
## prs_scaled:age.firstbirth.group[80,1e+03) -1.739911e-01 2.978507e-01
##                                              z value    Pr(>|z|)
## (Intercept)                                -1.14879282 0.250641421
## prs_scaled                                  1.65139708 0.098657521
## PC1                                        -1.08257266 0.278998147
## PC2                                        -1.37544667 0.168993008
## PC3                                         1.29605015 0.194958207
## PC4                                         0.22929643 0.818638526
## PC5                                        -0.92067122 0.357222108
## PC6                                         2.10072872 0.035664787
## PC7                                         1.58167348 0.113724129
## PC8                                        -2.58139513 0.009840188
## PC9                                        -0.04332308 0.965443997
## PC10                                       -0.74119296 0.458576452
## agegroups[45,50)                            2.66894114 0.007609078
## agegroups[50,80)                            1.86786918 0.061780308
## n.children.scale                            1.32201462 0.186163282
## birth.x                                     0.77490814 0.438393941
## birth.y                                     0.78875373 0.430255960
## age.firstbirth.group[25,35)                 1.47052624 0.141419285
## age.firstbirth.group[35,80)                 2.12133303 0.033893786
## age.firstbirth.group[80,1e+03)              2.32671058 0.019980674
## height.scale                                1.37070143 0.170468048
```

```
## age.menarche.scale                           -0.27410266 0.784005733
## factor(oc.cate2)1                            -2.30167634 0.021353431
## factor(oc.cate2)2                            -0.41679390 0.676829162
## BMI.scale                                     0.76354507 0.445138393
## assessment_center10003                        0.01621991 0.987058948
## assessment_center11002                        0.63595141 0.524808092
## assessment_center11003                        1.28387967 0.199184062
## assessment_center11004                        0.44472256 0.656520262
## assessment_center11005                        0.51485117 0.606657026
## assessment_center11006                        0.67367445 0.500518310
## assessment_center11007                        0.32642510 0.744102751
## assessment_center11008                        1.52302158 0.127753306
## assessment_center11009                        0.54905935 0.582964719
## assessment_center11010                        0.67453260 0.499972764
## assessment_center11011                       -0.22187955 0.824407650
## assessment_center11012                       -0.22488095 0.822071892
## assessment_center11013                        0.38826456 0.697820263
## assessment_center11014                       -0.13438877 0.893095161
## assessment_center11016                       -0.23647885 0.813061114
## assessment_center11017                       -1.56636927 0.117262193
## assessment_center11018                       -1.01933208 0.308045341
## assessment_center11020                       -1.06826401 0.285401438
## assessment_center11021                       -0.61764131 0.536811808
## assessment_center11022                       -0.02970886 0.976299249
## alcohol                                       0.46507996 0.641874195
## prs_scaled:birth.x                           -0.49040407 0.623847999
## prs_scaled:birth.y                           -0.09023608 0.928099612
## prs_scaled:factor(oc.cate2)1                  0.57242440 0.567034491
## prs_scaled:factor(oc.cate2)2                  0.41626565 0.677215622
## prs_scaled:age.menarche.scale                 0.12683128 0.899073935
## prs_scaled:BMI.scale                         -0.36978147 0.711545325
## prs_scaled:agegroups[45,50)                  -0.71390804 0.475284044
## prs_scaled:agegroups[50,80)                   1.18463634 0.236161261
## prs_scaled:alcohol                           -0.30098174 0.763428422
## prs_scaled:height.scale                       0.70193021 0.482722687
## prs_scaled:n.children.scale                  -0.80278662 0.422098079
## prs_scaled:age.firstbirth.group[25,35)        0.58638032 0.557619965
## prs_scaled:age.firstbirth.group[35,80)        0.44523979 0.656146472
## prs_scaled:age.firstbirth.group[80,1e+03) -0.58415532 0.559115821
```

```
fit_normal.coordinate3.premeno$res_glm
```

```
##                                          Estimate   Std. Error
## (Intercept)                          -5.852458e-01 5.136339e-01
## prs_scaled                            4.981781e-01 3.070549e-01
## PC1                                  -2.685566e-02 2.474547e-02
## PC2                                  -3.551844e-02 2.585408e-02
## PC3                                   4.210044e-02 3.206285e-02
## PC4                                   3.675404e-03 1.538254e-02
## PC5                                  -8.763056e-03 9.521437e-03
## PC6                                   7.020305e-02 3.376372e-02
## PC7                                   2.292026e-02 1.481660e-02
## PC8                                  -5.685700e-02 2.207473e-02
## PC9                                  -6.441159e-04 1.508002e-02
```

```
## PC10                                          -2.027194e-02 2.809406e-02
## agegroups[45,50)                               3.500074e-01 1.319578e-01
## agegroups[50,80)                               3.043384e-01 1.627712e-01
## n.children.scale                               1.344238e-01 1.015162e-01
## birth.x                                        6.344343e-02 8.133537e-02
## birth.y                                        7.431559e-02 9.465812e-02
## age.firstbirth.group[25,35)                    2.497953e-01 1.704622e-01
## age.firstbirth.group[35,80)                    5.310076e-01 2.518733e-01
## age.firstbirth.group[80,1e+03)                 6.520145e-01 2.832351e-01
## height.scale                                   8.184770e-02 5.963968e-02
## age.menarche.scale                            -1.649879e-02 5.873583e-02
## factor(oc.cate3)1                             -5.295831e-01 2.502849e-01
## factor(oc.cate3)2                             -5.021454e-01 2.392394e-01
## factor(oc.cate3)3                             -1.144676e-01 2.389966e-01
## factor(oc.cate3)4                             -7.603932e-02 2.203070e-01
## BMI.scale                                      4.632786e-02 6.023004e-02
## assessment_center10003                         1.434424e+01 8.827435e+02
## assessment_center11002                         2.935678e-01 4.637559e-01
## assessment_center11003                         5.838198e-01 4.606139e-01
## assessment_center11004                         1.987220e-01 4.527261e-01
## assessment_center11005                         2.291045e-01 4.445396e-01
## assessment_center11006                         2.844610e-01 4.241983e-01
## assessment_center11007                         1.289784e-01 3.946885e-01
## assessment_center11008                         6.179574e-01 4.071907e-01
## assessment_center11009                         2.158629e-01 4.031041e-01
## assessment_center11010                         2.529012e-01 3.770603e-01
## assessment_center11011                        -8.419909e-02 3.869854e-01
## assessment_center11012                        -1.277287e-01 5.642854e-01
## assessment_center11013                         1.567140e-01 4.110588e-01
## assessment_center11014                        -5.349773e-02 4.203180e-01
## assessment_center11016                        -9.256728e-02 4.114040e-01
## assessment_center11017                        -6.922614e-01 4.358152e-01
## assessment_center11018                        -4.180248e-01 4.120689e-01
## assessment_center11020                        -4.806726e-01 4.469895e-01
## assessment_center11021                        -2.853067e-01 4.593924e-01
## assessment_center11022                        -1.425223e+01 4.802748e+02
## alcohol                                        7.848826e-02 1.689775e-01
## prs_scaled:birth.x                            -3.492013e-02 7.125984e-02
## prs_scaled:birth.y                            -5.714095e-03 7.014386e-02
## prs_scaled:factor(oc.cate3)1                   1.612311e-01 2.567951e-01
## prs_scaled:factor(oc.cate3)2                   1.062818e-01 2.375471e-01
## prs_scaled:factor(oc.cate3)3                   1.301479e-01 2.401129e-01
## prs_scaled:factor(oc.cate3)4                   6.434936e-02 2.198784e-01
## prs_scaled:age.menarche.scale                  9.283290e-03 6.495195e-02
## prs_scaled:BMI.scale                          -2.276658e-02 6.442835e-02
## prs_scaled:agegroups[45,50)                   -1.006707e-01 1.413755e-01
## prs_scaled:agegroups[50,80)                    2.026325e-01 1.746399e-01
## prs_scaled:alcohol                            -5.149641e-02 1.889183e-01
## prs_scaled:height.scale                        4.507351e-02 6.317919e-02
## prs_scaled:n.children.scale                   -9.011938e-02 1.120537e-01
## prs_scaled:age.firstbirth.group[25,35)         1.068376e-01 1.780441e-01
## prs_scaled:age.firstbirth.group[35,80)         1.188177e-01 2.565879e-01
## prs_scaled:age.firstbirth.group[80,1e+03) -1.667526e-01 3.002657e-01
##                                                  z value    Pr(>|z|)
```

```
## (Intercept)                          -1.13942200 0.254527182
## prs_scaled                            1.62243960 0.104709255
## PC1                                  -1.08527573 0.277799554
## PC2                                  -1.37380418 0.169502484
## PC3                                   1.31305993 0.189162753
## PC4                                   0.23893343 0.811157201
## PC5                                  -0.92035021 0.357389778
## PC6                                   2.07924499 0.037594838
## PC7                                   1.54693058 0.121879985
## PC8                                  -2.57566017 0.010004892
## PC9                                  -0.04271319 0.965930164
## PC10                                 -0.72157377 0.470556569
## agegroups[45,50)                      2.65241868 0.007991738
## agegroups[50,80)                      1.86973128 0.061521144
## n.children.scale                      1.32416176 0.185449329
## birth.x                               0.78002264 0.435377547
## birth.y                               0.78509470 0.432398048
## age.firstbirth.group[25,35)           1.46540013 0.142811783
## age.firstbirth.group[35,80)           2.10823289 0.035010849
## age.firstbirth.group[80,1e+03)        2.30202580 0.021333718
## height.scale                          1.37236993 0.169948307
## age.menarche.scale                   -0.28089820 0.778788480
## factor(oc.cate3)1                    -2.11592107 0.034351521
## factor(oc.cate3)2                    -2.09892459 0.035823549
## factor(oc.cate3)3                    -0.47895054 0.631973815
## factor(oc.cate3)4                    -0.34515171 0.729980317
## BMI.scale                             0.76918189 0.441785339
## assessment_center10003                0.01624961 0.987035260
## assessment_center11002                0.63302216 0.526719171
## assessment_center11003                1.26748180 0.204983067
## assessment_center11004                0.43894531 0.660701165
## assessment_center11005                0.51537466 0.606291236
## assessment_center11006                0.67058491 0.502484997
## assessment_center11007                0.32678516 0.743830384
## assessment_center11008                1.51761197 0.129112247
## assessment_center11009                0.53550177 0.592302935
## assessment_center11010                0.67071804 0.502400166
## assessment_center11011               -0.21757691 0.827758776
## assessment_center11012               -0.22635482 0.820925461
## assessment_center11013                0.38124471 0.703021674
## assessment_center11014               -0.12727917 0.898719450
## assessment_center11016               -0.22500335 0.821976672
## assessment_center11017               -1.58842859 0.112189456
## assessment_center11018               -1.01445345 0.310366429
## assessment_center11020               -1.07535547 0.282215608
## assessment_center11021               -0.62105220 0.534565279
## assessment_center11022               -0.02967516 0.976326121
## alcohol                               0.46448934 0.642297192
## prs_scaled:birth.x                   -0.49003947 0.624105966
## prs_scaled:birth.y                   -0.08146251 0.935074140
## prs_scaled:factor(oc.cate3)1          0.62785911 0.530096240
## prs_scaled:factor(oc.cate3)2          0.44741343 0.654576578
## prs_scaled:factor(oc.cate3)3          0.54202801 0.587799210
## prs_scaled:factor(oc.cate3)4          0.29265890 0.769782891
```

```
## prs_scaled:age.menarche.scale              0.14292550 0.886349023
## prs_scaled:BMI.scale                      -0.35336285 0.723816432
## prs_scaled:agegroups[45,50)               -0.71207975 0.476415394
## prs_scaled:agegroups[50,80)                1.16028767 0.245931704
## prs_scaled:alcohol                        -0.27258558 0.785171798
## prs_scaled:height.scale                    0.71342338 0.475583809
## prs_scaled:n.children.scale               -0.80425160 0.421251681
## prs_scaled:age.firstbirth.group[25,35)     0.60006240 0.548464649
## prs_scaled:age.firstbirth.group[35,80)     0.46306806 0.643315585
## prs_scaled:age.firstbirth.group[80,1e+03) -0.55535010 0.578655220
```

3.1 Case-only method for Pre-Menopause

```
summary.caseonly=function (parms, sd, sided = 2)
{
  if (sided != 1)
    sided <- 2
  cols <- c("Estimate", "Std.Error", "Z.value", "Pvalue")
  n <- length(parms)
  ret <- matrix(data = NA, nrow = n, ncol = 4)
  pnames <- c("prs",paste0("prs:",names(parms)[-1]))
  rownames(ret) <- pnames
  colnames(ret) <- cols
  ret[, 1] <- parms
  if (is.null(pnames))
    pnames <- 1:n
  cov <- sd
  ret[, 2] <- cov
  ret[, 3] <- parms/cov
  ret[, 4] <- sided * pnorm(abs(ret[, 3]), lower.tail = FALSE)
  ret
}
dat_caseonly=dat_test_casecontrol.coordinate[which(dat_test_casecontrol.coordinate$breast_cancer==1),]
fit_caseonly <- lm(prs_scaled~PC1+PC2+PC3+PC4+PC5+PC6+PC7+PC8+PC9+PC10+agegroups+n.children.scale+birth
beta_int=fit_caseonly$coefficients[-1]/(sd(fit_caseonly$residuals))^2
sd_int=summary(fit_caseonly)$coef[-1,2]/(sd(fit_caseonly$residuals))^2
mean_prs=mean(dat_test_complete$prs_scaled)
beta_prs=(fit_caseonly$coefficients[1]-mean_prs)/(sd(fit_caseonly$residuals))^2
sd_prs= sqrt(( (summary(fit_caseonly)$coef[1,2])^2 +(sd(fit_caseonly$residuals))^2/dim(dat_test_complet
res_caseonly_pre=summary.caseonly(parms = c(beta_prs,beta_int),sd=c(sd_prs,sd_int))
print(res_caseonly_pre)
```

```
##                                      Estimate   Std.Error     Z.value
## prs                                0.288358114 0.370143026  0.77904511
## prs:PC1                            0.020993351 0.019732921  1.06387445
## prs:PC2                            0.009377135 0.017038174  0.55036031
## prs:PC3                            0.021167924 0.021642056  0.97809207
## prs:PC4                            0.020634087 0.011492329  1.79546610
## prs:PC5                           -0.011494856 0.007050321 -1.63040186
## prs:PC6                            0.020195763 0.026156378  0.77211619
## prs:PC7                            0.001354234 0.011707255  0.11567481
## prs:PC8                           -0.001234178 0.017125764 -0.07206559
```

```
## prs:PC9                                0.011964244 0.010879514  1.09970386
## prs:PC10                               0.022415221 0.020179276  1.11080407
## prs:agegroups[45,50)                  -0.014085161 0.099330705 -0.14180068
## prs:agegroups[50,80)                   0.098439939 0.122081159  0.80634833
## prs:n.children.scale                   0.026730115 0.077300598  0.34579441
## prs:birth.x                           -0.068762916 0.059257018 -1.16041809
## prs:birth.y                            0.001594965 0.067425920  0.02365507
## prs:age.firstbirth.group[25,35)       -0.042621703 0.131747036 -0.32351167
## prs:age.firstbirth.group[35,80)        0.057033374 0.183629818  0.31058885
## prs:age.firstbirth.group[80,1e+03) -0.003308597 0.217378444 -0.01522045
## prs:height.scale                      -0.012664575 0.043830390 -0.28894506
## prs:age.menarche.scale                -0.037101842 0.044630475 -0.83131184
## prs:length.oc.scale                   -0.097716992 0.043760733 -2.23298342
## prs:BMI.scale                         -0.042504338 0.043124649 -0.98561586
## prs:assessment_center10003             0.016176505 1.164487188  0.01389153
## prs:assessment_center11002             0.247358460 0.336514382  0.73506059
## prs:assessment_center11003             0.382857900 0.325890497  1.17480535
## prs:assessment_center11004            -0.121073196 0.339052122 -0.35709317
## prs:assessment_center11005             0.242223822 0.329171672  0.73585865
## prs:assessment_center11006             0.318100720 0.310702156  1.02381240
## prs:assessment_center11007             0.145305686 0.295915861  0.49103717
## prs:assessment_center11008            -0.207194534 0.294792850 -0.70284790
## prs:assessment_center11009             0.543733538 0.294352247  1.84722061
## prs:assessment_center11010             0.096825783 0.278643737  0.34748954
## prs:assessment_center11011             0.268334421 0.292303301  0.91799997
## prs:assessment_center11012            -0.325215195 0.434446531 -0.74857358
## prs:assessment_center11013             0.303140588 0.303097829  1.00014107
## prs:assessment_center11014            -0.194568580 0.319711402 -0.60857567
## prs:assessment_center11016            -0.132037806 0.319464911 -0.41330926
## prs:assessment_center11017             0.377750810 0.339585768  1.11238705
## prs:assessment_center11018             0.607162760 0.319620715  1.89963520
## prs:assessment_center11020             0.562240469 0.345512998  1.62726286
## prs:assessment_center11021             0.285523854 0.353849294  0.80690808
## prs:alcohol                            0.054216366 0.131337435  0.41280208
##                                           Pvalue
## prs                                    0.43595314
## prs:PC1                                0.28738558
## prs:PC2                                0.58207227
## prs:PC3                                0.32802879
## prs:PC4                                0.07257947
## prs:PC5                                0.10301659
## prs:PC6                                0.44004561
## prs:PC7                                0.90791027
## prs:PC8                                0.94254971
## prs:PC9                                0.27146117
## prs:PC10                               0.26665269
## prs:agegroups[45,50)                   0.88723745
## prs:agegroups[50,80)                   0.42004203
## prs:n.children.scale                   0.72949722
## prs:birth.x                            0.24587863
## prs:birth.y                            0.98112775
## prs:age.firstbirth.group[25,35)        0.74630777
## prs:age.firstbirth.group[35,80)        0.75611320
## prs:age.firstbirth.group[80,1e+03)     0.98785631
```

```
## prs:height.scale                   0.77262342
## prs:age.menarche.scale             0.40579749
## prs:length.oc.scale                0.02555004
## prs:BMI.scale                      0.32432165
## prs:assessment_center10003         0.98891652
## prs:assessment_center11002         0.46230259
## prs:assessment_center11003         0.24007260
## prs:assessment_center11004         0.72102206
## prs:assessment_center11005         0.46181672
## prs:assessment_center11006         0.30592389
## prs:assessment_center11007         0.62340016
## prs:assessment_center11008         0.48215055
## prs:assessment_center11009         0.06471517
## prs:assessment_center11010         0.72822358
## prs:assessment_center11011         0.35861888
## prs:assessment_center11012         0.45411426
## prs:assessment_center11013         0.31724224
## prs:assessment_center11014         0.54280574
## prs:assessment_center11016         0.67938005
## prs:assessment_center11017         0.26597177
## prs:assessment_center11018         0.05748101
## prs:assessment_center11020         0.10368128
## prs:assessment_center11021         0.41971944
## prs:alcohol                        0.67975163
```

```
fit_caseonly <- lm(prs_scaled~agegroups+n.children.scale+birth.x+birth.y+age.firstbirth.group+height.sca
beta_int=fit_caseonly$coefficients[-1]/(sd(fit_caseonly$residuals))^2
sd_int=summary(fit_caseonly)$coef[-1,2]/(sd(fit_caseonly$residuals))^2

beta_prs=(fit_caseonly$coefficients[1]-mean_prs)/(sd(fit_caseonly$residuals))^2
sd_prs= sqrt(( (summary(fit_caseonly)$coef[1,2])^2 +(sd(fit_caseonly$residuals))^2/dim(dat_test_complete
res_caseonly=summary.caseonly(parms = c(beta_prs,beta_int),sd=c(sd_prs,sd_int))
print(res_caseonly)
```

```
##                                      Estimate  Std.Error     Z.value
## prs                                0.199809343 0.15769506  1.26706155
## prs:agegroups[45,50)               0.004834961 0.09228672  0.05239065
## prs:agegroups[50,80)               0.110419777 0.11291983  0.97785992
## prs:n.children.scale               0.003469724 0.07152696  0.04850932
## prs:birth.x                        0.003299014 0.04479902  0.07364030
## prs:birth.y                        0.012117665 0.04413193  0.27457815
## prs:age.firstbirth.group[25,35)   -0.022184984 0.12207186 -0.18173709
## prs:age.firstbirth.group[35,80)    0.040040408 0.16920934  0.23663238
## prs:age.firstbirth.group[80,1e+03) -0.032134943 0.20073836 -0.16008372
## prs:height.scale                   -0.003559479 0.04044851 -0.08800024
## prs:age.menarche.scale             -0.029090545 0.04183389 -0.69538231
## prs:length.oc.scale                -0.083151529 0.04066973 -2.04455573
## prs:BMI.scale                      -0.028189123 0.03987906 -0.70686522
## prs:alcohol                        0.081075510 0.12046285  0.67303328
##                                         Pvalue
## prs                                0.20513328
## prs:agegroups[45,50)               0.95821743
## prs:agegroups[50,80)               0.32814361
## prs:n.children.scale               0.96131034
```

```
## prs:birth.x                          0.94129660
## prs:birth.y                          0.78364036
## prs:age.firstbirth.group[25,35)      0.85578906
## prs:age.firstbirth.group[35,80)      0.81294200
## prs:age.firstbirth.group[80,1e+03)   0.87281513
## prs:height.scale                     0.92987648
## prs:age.menarche.scale               0.48681575
## prs:length.oc.scale                  0.04089868
## prs:BMI.scale                        0.47965024
## prs:alcohol                          0.50092612
```

4 Results Summary

Let's summarize the results:

```
data1=array(0,c(4,4))
data1[1,]=fit_normal.coordinate1$res_normal[53,]
data1[2,]=summary(fit.int.all)$coef[53,]
data1[3,]=fit_normal.coordinate1$res_glm[53,]
data1[4,]=res_caseonly_post[25,]
rownames(data1)=c("retro_normal","logistic_regression_cohort","logistic_regression_casecontrol","case-o
colnames(data1)=colnames(fit_normal.coordinate1$res_normal)

data2=array(0,c(4,4))
data2[1,]=fit_normal.coordinate1$res_normal[51,]
data2[2,]=summary(fit.int.all)$coef[51,]
data2[3,]=fit_normal.coordinate1$res_glm[51,]
data2[4,]=res_caseonly_post[17,]
rownames(data2)=c("retro_normal","logistic_regression_cohort","logistic_regression_casecontrol","case-o
colnames(data2)=colnames(fit_normal.coordinate1$res_normal)


data3=array(0,c(4,4))
data3[1,]=fit_normal.coordinate1.premeno$res_normal[48,]
data3[2,]=summary(fit.int.all.premeno)$coef[49,]
data3[3,]=fit_normal.coordinate1.premeno$res_glm[48,]
data3[4,]=res_caseonly_pre[22,]
rownames(data3)=c("retro_normal","logistic_regression_cohort","logistic_regression_casecontrol","case-o
colnames(data3)=colnames(fit_normal.coordinate1.premeno$res_normal)
```

We found interesting interactions between PRS and use of oral contraceptive use (Table 1) for both pre-menopause and post-menupause women, PRS and birth location in association with breast cancer (Table 2) for post-menopause women. In addition, in the cohort logistic regression, we found significant interaction between PRS and age at first birth.

```
library(knitr)
kable(data1,caption="PRS X Years of Oral Contraceptive Pill Use - Post-Menopause Women",digits=4)
```

Table 1: PRS X Years of Oral Contraceptive Pill Use - Post-Menopause Women

	Estimate	Std.Error	Z.value	Pvalue
retro_normal	-0.0501	0.0240	-2.0878	0.0368
logistic_regression_cohort	-0.0547	0.0234	-2.3416	0.0192
logistic_regression_casecontrol	-0.0322	0.0362	-0.8900	0.3735
case-only	-0.0502	0.0243	-2.0603	0.0394

```
kable(data2,caption="PRS X Birth Location (east coordinate) - Post-Menopause Women",digits=4)
```

Table 2: PRS X Birth Location (east coordinate) - Post-Menopause Women

	Estimate	Std.Error	Z.value	Pvalue
retro_normal	-0.0785	0.0372	-2.1107	0.0348
logistic_regression_cohort	-0.0682	0.0248	-2.7508	0.0059
logistic_regression_casecontrol	-0.0901	0.0399	-2.2559	0.0241
case-only	-0.0912	0.0329	-2.7702	0.0056

```
kable(data3,caption="PRS X Years of Oral Contraceptive Pill Use - Pre-Menopause Women",digits=4)
```

Table 3: PRS X Years of Oral Contraceptive Pill Use - Pre-Menopause Women

	Estimate	Std.Error	Z.value	Pvalue
retro_normal	-0.0836	0.0394	-2.1240	0.0337
logistic_regression_cohort	-0.0807	0.0374	-2.1546	0.0312
logistic_regression_casecontrol	-0.0138	0.0620	-0.2229	0.8236
case-only	-0.0977	0.0438	-2.2330	0.0256

4.1 Sensitivity Analysis Results for Years of OC use

We additionally did sensitivity analysis for the years of OC use by categorizing them. We make two different categorical variables for the years of OC use by different intervals. The first test is to categorize the years of OC use to three categories: never, 0-10 years, and >10 years. The second test we categorized the length to 5 categories: never, 0-5 years, 5-10 years, 10-15 years, and >15 years. We found interesting dose-response relationship between the length of years of OC use by PRS for post-menopause women for both sensitivity analysis. We did not observe significant interaction terms for pre-menopause women, the main reason could be not enough power in the analysis as the sample size is small.

```
data1=array(0,c(6,4))
data1[1,]=fit_normal.coordinate2$res_normal[54,]
data1[2,]=fit_normal.coordinate2$res_normal[55,]
data1[3,]=summary(fit.int.all2)$coef[54,]
data1[4,]=summary(fit.int.all2)$coef[55,]
data1[5,]=fit_normal.coordinate2$res_glm[54,]
data1[6,]=fit_normal.coordinate2$res_glm[55,]
rownames(data1)=c("retro_normal_prs_scaled:factor(oc.cate2)1","prs_scaled:factor(oc.cate2)2","logistic_
colnames(data1)=colnames(fit_normal.coordinate2$res_normal)

data2=array(0,c(12,4))
data2[1:4,]=fit_normal.coordinate3$res_normal[56:59,]
data2[5:8,]=summary(fit.int.all3)$coef[56:59,]
data2[9:12,]=fit_normal.coordinate3$res_glm[56:59,]
rownames(data2)=c(paste0("retro_normal_prs_scaled:factor(oc.cate3)",1:4),paste0("logistic_regression_co
colnames(data2)=colnames(fit_normal.coordinate3$res_normal)
```

```
kable(data1,caption="Sensitivity Analysis 1: PRS X Years of Oral Contraceptive 3 Categories - Post-Meno
```

Table 4: Sensitivity Analysis 1: PRS X Years of Oral Contraceptive 3 Categories - Post-Menopause Women

	Estimate	Std.Error	Z.value	Pvalue
retro_normal_prs_scaled:factor(oc.cate2)1	-0.0573	0.0606	-0.9453	0.3445
prs_scaled:factor(oc.cate2)2	-0.1487	0.0642	-2.3160	0.0206
logistic_regression_cohort_prs_scaled:factor(oc.cate2)1	-0.0875	0.0602	-1.4535	0.1461
prs_scaled:factor(oc.cate2)2	-0.1803	0.0637	-2.8306	0.0046
logistic_regression_casecontrol_prs_scaled:factor(oc.cate2)1	-0.0539	0.0928	-0.5805	0.5616
prs_scaled:factor(oc.cate2)2	-0.1305	0.0981	-1.3301	0.1835

```
kable(data2,caption="Sensitivity Analysis 2: PRS X Years of Oral Contraceptive 5 Categories - Post-Meno
```

Table 5: Sensitivity Analysis 2: PRS X Years of Oral Contraceptive 5 Categories - Post-Menopause Women

	Estimate	Std.Error	Z.value	Pvalue
retro_normal_prs_scaled:factor(oc.cate3)1	-0.0666	0.0694	-0.9597	0.3372
retro_normal_prs_scaled:factor(oc.cate3)2	-0.0476	0.0710	-0.6699	0.5029
retro_normal_prs_scaled:factor(oc.cate3)3	-0.1222	0.0757	-1.6141	0.1065
retro_normal_prs_scaled:factor(oc.cate3)4	-0.1737	0.0748	-2.3219	0.0202
logistic_regression_cohort_prs_scaled:factor(oc.cate3)1	-0.0967	0.0688	-1.4048	0.1601
logistic_regression_cohort_prs_scaled:factor(oc.cate3)2	-0.0774	0.0704	-1.0989	0.2718
logistic_regression_cohort_prs_scaled:factor(oc.cate3)3	-0.1564	0.0751	-2.0823	0.0373
logistic_regression_cohort_prs_scaled:factor(oc.cate3)4	-0.2015	0.0738	-2.7292	0.0063
logistic_regression_casecontrol_prs_scaled:factor(oc.cate3)1	-0.0294	0.1062	-0.2770	0.7818
logistic_regression_casecontrol_prs_scaled:factor(oc.cate3)2	-0.0786	0.1079	-0.7284	0.4663
logistic_regression_casecontrol_prs_scaled:factor(oc.cate3)3	-0.2203	0.1162	-1.8966	0.0579
logistic_regression_casecontrol_prs_scaled:factor(oc.cate3)4	-0.0592	0.1134	-0.5222	0.6015