UserGuide09

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Contents

9.1 Introduction and description of the example data

```
data(bang, package = "R2MLwiN")
summary(bang)
```

```
##      woman           district            use
##  Min.   :   1.0   Min.   : 1.00   Not_using:1728
##  1st Qu.: 717.5   1st Qu.:14.00   Using    :1139
##  Median :1434.0   Median :29.00
##  Mean   :1434.0   Mean   :29.25
##  3rd Qu.:2150.5   3rd Qu.:45.00
##  Max.   :2867.0   Max.   :61.00
##                        use4                 lc            age
##  Sterilization           : 302   None        : 774   Min.   :-14.0000
##  Modern_reversible_method: 555   One_child   : 517   1st Qu.: -8.0000
##  Traditional_method      : 282   Two_children: 461   Median : -2.0000
##  Not_using_contraception :1728   Three_plus  :1115   Mean   : -0.3279
##                                                      3rd Qu.:  6.0000
##                                                      Max.   : 19.0000
##    urban                         educ         hindu          d_lit
##  Rural:2063   None                 :1806   Muslim:2480   Min.   :0.0000
##  Urban: 804   Lower_primary        : 357   Hindu : 387   1st Qu.:0.0850
##               Upper_primary        : 265                 Median :0.1100
##               Secondary_and_above: 439                   Mean   :0.1115
##                                                          3rd Qu.:0.1400
##                                                          Max.   :0.3000
##      d_pray            cons
##  Min.   :0.1000   Min.   :1
##  1st Qu.:0.2900   1st Qu.:1
##  Median :0.4100   Median :1
##  Mean   :0.4253   Mean   :1
##  3rd Qu.:0.5500   3rd Qu.:1
##  Max.   :0.7800   Max.   :1
```

9.2 Single-level logistic regression

Link functions

Interpretation of coeficients

Fitting a single-level logit model in MLwiN

```
addmargins(with(bang, table(lc, use)))
```

```
##                use
## lc               Not_using Using  Sum
##   None                 584   190  774
##   One_child            283   234  517
##   Two_children         234   227  461
##   Three_plus           627   488 1115
##   Sum                 1728  1139 2867
```

```
(mymodel1 <- runMLwiN(logit(use) ~ 1 + lc, D = "Binomial", data = bang))
```

```
##
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
## MLwiN (version: 2.36)  multilevel model (Binomial)
## Estimation algorithm:  IGLS MQL1        Elapsed time : 3.32s
## Number of obs:  2867 (from total 2867)        The model converged after 4 iterations.
## Log likelihood:      NA
## Deviance statistic:  NA
## ---------------------------------------------------------------------------------------------------
## The model formula:
## logit(use) ~ 1 + lc
## Level 1: l1id
## ---------------------------------------------------------------------------------------------------
## The fixed part estimates:
##                     Coef.   Std. Err.        z    Pr(>|z|)         [95% Conf.   Interval]
## Intercept        -1.12288     0.08348   -13.45    3.05e-41   ***     -1.28650    -0.95926
## lcOne_child       0.93275     0.12156     7.67   1.675e-14   ***      0.69450     1.17100
## lcTwo_children    1.09251     0.12509     8.73   2.466e-18   ***      0.84733     1.33768
## lcThree_plus      0.87225     0.10302     8.47   2.523e-17   ***      0.67033     1.07416
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## ---------------------------------------------------------------------------------------------------
## The random part estimates at the l1id level:
##                 Coef.   Std. Err.
## var_bcons_1   1.00000     0.00000
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
```

```
linearHypothesis(mymodel1, "FP_lcOne_child = FP_lcTwo_children")
```

```
## Linear hypothesis test
##
## Hypothesis:
## FP_lcOne_child - FP_lcTwo_children = 0
##
## Model 1: restricted model
## Model 2: mymodel1
##
##   Res.Df Df  Chisq Pr(>Chisq)
```

```
## 1   2863
## 2   2862  1 1.5481     0.2134
```

A probit model

```
(mymodel2 <- runMLwiN(probit(use) ~ 1 + lc, D = "Binomial", data = bang))
```

```
##
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
## MLwiN (version: 2.36)  multilevel model (Binomial)
## Estimation algorithm:  IGLS MQL1        Elapsed time : 2.9s
## Number of obs:  2867 (from total 2867)        The model converged after 4 iterations.
## Log likelihood:      NA
## Deviance statistic:  NA
## ---------------------------------------------------------------------------------------------------
## The model formula:
## probit(use) ~ 1 + lc
## Level 1: l1id
## ---------------------------------------------------------------------------------------------------
## The fixed part estimates:
##                     Coef.   Std. Err.        z    Pr(>|z|)         [95% Conf.   Interval]
## Intercept        -0.68879     0.04915   -14.01   1.299e-44   ***     -0.78513    -0.59245
## lcOne_child       0.56972     0.07396     7.70   1.328e-14   ***      0.42476     0.71468
## lcTwo_children    0.66976     0.07631     8.78    1.69e-18   ***      0.52018     0.81933
## lcThree_plus      0.53190     0.06195     8.59   8.977e-18   ***      0.41049     0.65332
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## ---------------------------------------------------------------------------------------------------
## The random part estimates at the l1id level:
##                 Coef.   Std. Err.
## var_bcons_1   1.00000     0.00000
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
```

```
(mymodel3 <- runMLwiN(logit(use) ~ 1 + lc + age, D = "Binomial", data = bang))
```

```
##
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
## MLwiN (version: 2.36)  multilevel model (Binomial)
## Estimation algorithm:  IGLS MQL1        Elapsed time : 3.15s
## Number of obs:  2867 (from total 2867)        The model converged after 4 iterations.
## Log likelihood:      NA
## Deviance statistic:  NA
## ---------------------------------------------------------------------------------------------------
## The model formula:
## logit(use) ~ 1 + lc + age
## Level 1: l1id
## ---------------------------------------------------------------------------------------------------
## The fixed part estimates:
##                     Coef.   Std. Err.        z    Pr(>|z|)         [95% Conf.   Interval]
## Intercept        -1.25598     0.09776   -12.85   8.821e-38   ***     -1.44758    -1.06438
## lcOne_child       0.99131     0.12376     8.01    1.15e-15   ***      0.74874     1.23388
## lcTwo_children    1.22356     0.13480     9.08    1.12e-19   ***      0.95935     1.48777
## lcThree_plus      1.11655     0.13824     8.08   6.649e-16   ***      0.84560     1.38750
## age              -0.01629     0.00609    -2.67    0.007514   **      -0.02823    -0.00435
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## ---------------------------------------------------------------------------------------------------
```

```
## The random part estimates at the l1id level:
##                Coef.   Std. Err.
## var_bcons_1   1.00000     0.00000
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
```

9.3 A two-level random intercept model

Model specification

Estimation procedures

Fitting a two-level random intercept model in MLwiN

```
(mymodel4 <- runMLwiN(
  logit(use) ~ 1 + lc + age + (1 | district),
  D = "Binomial",
  data = bang))
```

```
##
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
## MLwiN (version: 2.36)  multilevel model (Binomial)
##           N min     mean max N_complete min_complete mean_complete
## district 60   3 47.78333 173         60            3      47.78333
##          max_complete
## district          173
## Estimation algorithm:  IGLS MQL1        Elapsed time : 2.98s
## Number of obs:  2867 (from total 2867)        The model converged after 5 iterations.
## Log likelihood:      NA
## Deviance statistic:  NA
## ---------------------------------------------------------------------------------------------------
## The model formula:
## logit(use) ~ 1 + lc + age + (1 | district)
## Level 2: district     Level 1: l1id
## ---------------------------------------------------------------------------------------------------
## The fixed part estimates:
##                     Coef.   Std. Err.        z    Pr(>|z|)         [95% Conf.   Interval]
## Intercept        -1.36711     0.12338   -11.08   1.557e-28   ***     -1.60893    -1.12529
## lcOne_child       0.98998     0.12643     7.83   4.869e-15   ***      0.74218     1.23777
## lcTwo_children    1.27523     0.13816     9.23   2.711e-20   ***      1.00443     1.54603
## lcThree_plus      1.21568     0.14245     8.53   1.413e-17   ***      0.93648     1.49487
## age              -0.01878     0.00625    -3.00    0.002659   **      -0.03102    -0.00653
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## ---------------------------------------------------------------------------------------------------
## The random part estimates at the district level:
##                   Coef.   Std. Err.
## var_Intercept   0.27409     0.07138
## ---------------------------------------------------------------------------------------------------
## The random part estimates at the l1id level:
##                Coef.   Std. Err.
## var_bcons_1   1.00000     0.00000
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
```

```
(mymodel5 <- runMLwiN(
  logit(use) ~ 1 + lc + age + (1 | district),
```

```r
  D = "Binomial",
  estoptions = list(
    nonlinear = c(N = 1,M = 2),
    startval = list(
      FP.b = mymodel4@FP,
      FP.v = mymodel4@FP.cov,
      RP.b = mymodel4@RP,
      RP.v = mymodel4@RP.cov)),
  data = bang))
```

```
##
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
## MLwiN (version: 2.36)  multilevel model (Binomial)
##           N min     mean max N_complete min_complete mean_complete
## district 60   3 47.78333 173         60            3      47.78333
##          max_complete
## district          173
## Estimation algorithm:  IGLS PQL2        Elapsed time : 3.39s
## Number of obs:  2867 (from total 2867)        The model converged after 5 iterations.
## Log likelihood:      NA
## Deviance statistic:  NA
## -------------------------------------------------------------------------------------------------
## The model formula:
## logit(use) ~ 1 + lc + age + (1 | district)
## Level 2: district     Level 1: l1id
## -------------------------------------------------------------------------------------------------
## The fixed part estimates:
##                     Coef.   Std. Err.        z    Pr(>|z|)         [95% Conf.   Interval]
## Intercept        -1.46602     0.12791   -11.46   2.058e-30   ***     -1.71671    -1.21532
## lcOne_child       1.06285     0.12882     8.25   1.575e-16   ***      0.81037     1.31533
## lcTwo_children    1.37010     0.14167     9.67   4.014e-22   ***      1.09242     1.64778
## lcThree_plus      1.30391     0.14595     8.93   4.104e-19   ***      1.01786     1.58997
## age              -0.02005     0.00640    -3.13    0.001747   **      -0.03260    -0.00749
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## -------------------------------------------------------------------------------------------------
## The random part estimates at the district level:
##                   Coef.   Std. Err.
## var_Intercept   0.30776     0.07899
## -------------------------------------------------------------------------------------------------
## The random part estimates at the l1id level:
##                 Coef.   Std. Err.
## var_bcons_1   1.00000     0.00000
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
```

```r
linearHypothesis(mymodel5, "RP2_var_Intercept = 0")
```

```
## Linear hypothesis test
##
## Hypothesis:
## RP2_var_Intercept = 0
##
## Model 1: restricted model
## Model 2: mymodel5
##
##   Res.Df Df  Chisq Pr(>Chisq)
```

```
## 1   2861
## 2   2860  1 15.181  9.769e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Variance partition coeficient

```
set.seed(1)

invlogit <- function(x) exp(x)/(1 + exp(x))

u <- sqrt(coef(mymodel5)["RP2_var_Intercept"]) * qnorm(runif(5000))

p1 <- invlogit(coef(mymodel5)["FP_Intercept"] + u)

p2 <- invlogit(coef(mymodel5)["FP_Intercept"] +
                 coef(mymodel5)["FP_lc3plus"] +
                 coef(mymodel5)["FP_age"] * -9.7 + u)

p3 <- invlogit(coef(mymodel5)["FP_Intercept"] +
                 coef(mymodel5)["FP_age"] * 15.3 + u)

v1 <- p1 * (1 - p1)
lev2var1 <- sd(p1)^2
lev1var1 <- mean(v1)

v2 <- p2 * (1 - p2)
lev2var2 <- sd(p2)^2
lev1var2 <- mean(v2)

v3 <- p3 * (1 - p3)
lev2var3 <- sd(p3)^2
lev1var3 <- mean(v3)

cat(
  paste0("VPC = ", lev2var1/(lev2var1 + lev1var1)))
```

```
## VPC = 0.0491754292049843
```

```
cat(
  paste0(
    "VPC for a young women with 3+ children (low probability use) = ",
    lev2var2/(lev2var2 + lev1var2)))
```

```
## VPC for a young women with 3+ children (low probability use) = NA
```

```
cat(
  paste0(
    "VPC for an old woman with no children (high probability use) = ",
    lev2var3/(lev2var3 + lev1var3)))
```

```
## VPC for an old woman with no children (high probability use) = 0.0419272272718661
```

Adding further explanatory variables

```
table(bang$educ)
```

```
##
##                  None        Lower_primary        Upper_primary
##                  1806                  357                  265
## Secondary_and_above
##                   439
```

```
(mymodel6 <-
    runMLwiN(
      logit(use) ~ 1 + lc + age + urban + educ + hindu + (1 | district),
      D = "Binomial", estoptions = list(
        nonlinear = c(N = 1, M = 2),
        startval = list(
          FP.b = mymodel5@FP,
          FP.v = mymodel5@FP.cov,
          RP.b = mymodel5@RP,
          RP.v = mymodel5@RP.cov)),
  data = bang))
```

```
##
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
## MLwiN (version: 2.36)  multilevel model (Binomial)
##           N min     mean max N_complete min_complete mean_complete
## district 60   3 47.78333 173         60            3      47.78333
##          max_complete
## district          173
## Estimation algorithm:  IGLS PQL2        Elapsed time : 3.1s
## Number of obs:  2867 (from total 2867)        The model converged after 5 iterations.
## Log likelihood:      NA
## Deviance statistic:  NA
## --------------------------------------------------------------------------------------------------
## The model formula:
## logit(use) ~ 1 + lc + age + urban + educ + hindu + (1 | district)
## Level 2: district     Level 1: l1id
## --------------------------------------------------------------------------------------------------
## The fixed part estimates:
##                              Coef.   Std. Err.        z    Pr(>|z|)          [95% Conf.   Interval]
## Intercept                 -2.05249     0.13819   -14.85   6.704e-50   ***     -2.32334    -1.78164
## lcOne_child                1.15141     0.13413     8.58    9.12e-18   ***      0.88853     1.41429
## lcTwo_children             1.51227     0.14734    10.26   1.026e-24   ***      1.22349     1.80105
## lcThree_plus               1.50191     0.15271     9.83   7.972e-23   ***      1.20260     1.80122
## age                       -0.01736     0.00665    -2.61    0.009033   **      -0.03039    -0.00433
## urbanUrban                 0.53306     0.10482     5.09   3.665e-07   ***      0.32762     0.73850
## educLower_primary          0.24654     0.12836     1.92     0.05478   .       -0.00505     0.49812
## educUpper_primary          0.72433     0.14380     5.04   4.731e-07   ***      0.44248     1.00618
## educSecondary_and_above    1.17020     0.12716     9.20   3.506e-20   ***      0.92096     1.41944
## hinduHindu                 0.43282     0.12765     3.39   0.0006973   ***      0.18263     0.68301
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## --------------------------------------------------------------------------------------------------
## The random part estimates at the district level:
##                    Coef.   Std. Err.
## var_Intercept    0.23364     0.06534
```

```
## ----------------------------------------------------------------------------------------------------
## The random part estimates at the l1id level:
##                 Coef.   Std. Err.
## var_bcons_1   1.00000     0.00000
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
```

9.4 A two-level random coeficient model

```
(mymodel7 <-
   runMLwiN(
     logit(use) ~ 1 + lc + age + urban + educ + hindu +
       (1 + urban | district),
     D = "Binomial",
     estoptions = list(
       nonlinear = c(N = 1, M = 2),
       startval = list(FP.b = mymodel6@FP,
                       FP.v = mymodel6@FP.cov,
                       RP.b = mymodel6@RP,
                       RP.v = mymodel6@RP.cov)),
     data = bang))
```

```
##
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
## MLwiN (version: 2.36)  multilevel model (Binomial)
##           N min     mean max N_complete min_complete mean_complete
## district 60   3 47.78333 173         60            3      47.78333
##          max_complete
## district          173
## Estimation algorithm:  IGLS PQL2        Elapsed time : 3.22s
## Number of obs:  2867 (from total 2867)        The model converged after 8 iterations.
## Log likelihood:      NA
## Deviance statistic:  NA
## ----------------------------------------------------------------------------------------------------
## The model formula:
## logit(use) ~ 1 + lc + age + urban + educ + hindu + (1 + urban |
##     district)
## Level 2: district     Level 1: l1id
## ----------------------------------------------------------------------------------------------------
## The fixed part estimates:
##                              Coef.   Std. Err.        z    Pr(>|z|)         [95% Conf.   Interval]
## Intercept                 -2.09365     0.14823   -14.12   2.704e-45   ***    -2.38418    -1.80312
## lcOne_child                1.16597     0.13489     8.64    5.44e-18   ***     0.90159     1.43036
## lcTwo_children             1.52627     0.14841    10.28    8.31e-25   ***     1.23539     1.81715
## lcThree_plus               1.52278     0.15408     9.88   4.924e-23   ***     1.22079     1.82477
## age                       -0.01818     0.00670    -2.71     0.00667   **     -0.03131    -0.00504
## urbanUrban                 0.57420     0.13647     4.21    2.58e-05   ***     0.30674     0.84167
## educLower_primary          0.24518     0.12951     1.89     0.05834   .      -0.00866     0.49901
## educUpper_primary          0.73327     0.14533     5.05   4.523e-07   ***     0.44843     1.01811
## educSecondary_and_above    1.17969     0.12839     9.19   4.003e-20   ***     0.92804     1.43134
## hinduHindu                 0.50956     0.13292     3.83   0.0001263   ***     0.24904     0.77007
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## ----------------------------------------------------------------------------------------------------
## The random part estimates at the district level:
##                               Coef.   Std. Err.
```

```
## var_Intercept               0.35974     0.09867
## cov_Intercept_urbanUrban   -0.25801     0.11151
## var_urbanUrban              0.34896     0.17340
## ------------------------------------------------------------------------------------------------------
## The random part estimates at the l1id level:
##                 Coef.   Std. Err.
## var_bcons_1   1.00000     0.00000
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
```

```
linearHypothesis(
  mymodel7,
  "RP2_cov_Intercept_urbanUrban = 0")
```

```
## Linear hypothesis test
##
## Hypothesis:
## RP2_cov_Intercept_urbanUrban = 0
##
## Model 1: restricted model
## Model 2: mymodel7
##
##   Res.Df Df  Chisq Pr(>Chisq)
## 1   2854
## 2   2853  1 5.3534    0.02068 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
linearHypothesis(
  mymodel7,
  "RP2_var_urbanUrban = 0")
```

```
## Linear hypothesis test
##
## Hypothesis:
## RP2_var_urbanUrban = 0
##
## Model 1: restricted model
## Model 2: mymodel7
##
##   Res.Df Df  Chisq Pr(>Chisq)
## 1   2854
## 2   2853  1 4.0499    0.04417 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
linearHypothesis(
  mymodel7,
  c("RP2_cov_Intercept_urbanUrban = 0", "RP2_var_urbanUrban = 0"))
```

```
## Linear hypothesis test
##
## Hypothesis:
## RP2_cov_Intercept_urbanUrban = 0
## RP2_var_urbanUrban = 0
##
## Model 1: restricted model
## Model 2: mymodel7
```

```
##
##   Res.Df Df  Chisq Pr(>Chisq)
## 1   2855
## 2   2853  2 5.4717    0.06484 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
(mymodel8 <-
   runMLwiN(
     logit(use) ~ 1 + lc + age + urban + educ + hindu + d_lit + d_pray +
       (1 + urban | district),
  D = "Binomial",
  estoptions = list(
    nonlinear = c(N = 1, M = 2),
    startval = list(
      FP.b = mymodel7@FP,
      FP.v = mymodel7@FP.cov,
      RP.b = mymodel7@RP,
      RP.v = mymodel7@RP.cov)),
  data = bang))
```

```
##
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
## MLwiN (version: 2.36)  multilevel model (Binomial)
##           N min     mean max N_complete min_complete mean_complete
## district 60   3 47.78333 173         60            3      47.78333
##          max_complete
## district          173
## Estimation algorithm:  IGLS PQL2        Elapsed time : 3.22s
## Number of obs:  2867 (from total 2867)        The model converged after 6 iterations.
## Log likelihood:      NA
## Deviance statistic:  NA
## ---------------------------------------------------------------------------------------------------
## The model formula:
## logit(use) ~ 1 + lc + age + urban + educ + hindu + d_lit + d_pray +
##     (1 + urban | district)
## Level 2: district     Level 1: l1id
## ---------------------------------------------------------------------------------------------------
## The fixed part estimates:
##                            Coef.   Std. Err.       z    Pr(>|z|)         [95% Conf.   Interval]
## Intercept               -1.72295     0.26327   -6.54   5.976e-11   ***     -2.23896    -1.20695
## lcOne_child              1.17020     0.13503    8.67   4.462e-18   ***      0.90555     1.43486
## lcTwo_children           1.53401     0.14861   10.32     5.6e-25   ***      1.24273     1.82529
## lcThree_plus             1.52828     0.15425    9.91   3.857e-23   ***      1.22595     1.83061
## age                     -0.01814     0.00670   -2.71    0.006761   **      -0.03127    -0.00501
## urbanUrban               0.52822     0.13814    3.82   0.0001314   ***      0.25747     0.79897
## educLower_primary        0.23770     0.12995    1.83     0.06738   .       -0.01700     0.49239
## educUpper_primary        0.74232     0.14559    5.10   3.421e-07   ***      0.45697     1.02768
## educSecondary_and_above  1.19596     0.12895    9.27   1.779e-20   ***      0.94323     1.44869
## hinduHindu               0.50955     0.13249    3.85   0.0001201   ***      0.24987     0.76922
## d_lit                    2.07495     1.70615    1.22      0.2239            -1.26905     5.41894
## d_pray                  -1.40837     0.53393   -2.64    0.008346   **      -2.45486    -0.36188
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## ---------------------------------------------------------------------------------------------------
## The random part estimates at the district level:
```

```
##                                  Coef.   Std. Err.
## var_Intercept                  0.30501     0.08818
## cov_Intercept_urbanUrban      -0.23343     0.10549
## var_urbanUrban                 0.35162     0.17408
## -----------------------------------------------------------------------------------------------
## The random part estimates at the l1id level:
##                   Coef.   Std. Err.
## var_bcons_1   1.00000     0.00000
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
```

9.5 Modelling binomial data

Modelling district-level variation with district-level proportions

Creating a district-level data set

```
bangshort <- summaryBy(
  use + cons ~ district + d_lit + d_pray,
  FUN = c(mean, sum), data = bang)

bangshort$use.sum <- NULL
colnames(bangshort) <- c("district", "d_lit", "d_pray", "use", "cons", "denom")
bangshort$use <- bangshort$use - 1
```

Fitting the model

```
(mymodel9 <-
   runMLwiN(
     logit(use, denom) ~ 1 + d_lit + d_pray + (1 | district),
     D = "Binomial", data = bangshort))
```

```
##
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
## MLwiN (version: 2.36)  multilevel model (Binomial)
##            N min mean max N_complete min_complete mean_complete
## district 60   1    1   1         60            1             1
##          max_complete
## district            1
## Estimation algorithm:  IGLS MQL1        Elapsed time : 9.02s
## Number of obs:  60 (from total 60)        The model converged after 4 iterations.
## Log likelihood:      NA
## Deviance statistic:  NA
## -----------------------------------------------------------------------------------------------
## The model formula:
## logit(use, denom) ~ 1 + d_lit + d_pray + (1 | district)
## Level 2: district     Level 1: l1id
## -----------------------------------------------------------------------------------------------
## The fixed part estimates:
##                 Coef.   Std. Err.       z   Pr(>|z|)         [95% Conf.   Interval]
## Intercept   -0.39797     0.23395   -1.70    0.08892   .       -0.85650     0.06056
## d_lit        3.75968     1.61790    2.32    0.02014   *        0.58865     6.93071
## d_pray      -1.19571     0.50106   -2.39    0.01702   *       -2.17777    -0.21366
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## --------------------------------------------------------------------------------------------
## The random part estimates at the district level:
##                  Coef.   Std. Err.
## var_Intercept   0.21061     0.05890
## --------------------------------------------------------------------------------------------
## The random part estimates at the l1id level:
##                Coef.   Std. Err.
## var_bcons_1   1.00000     0.00000
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
```

```
(mymodel10 <-
  runMLwiN(
    logit(use, denom) ~ 1 + d_lit + d_pray + (1 | district),
    D = "Binomial",
    estoptions = list(
      nonlinear = c(N = 1, M = 2),
      startval = list(
        FP.b = mymodel9@FP,
        FP.v = mymodel9@FP.cov,
        RP.b = mymodel9@RP,
        RP.v = mymodel9@RP.cov)),
    data = bangshort))
```

```
##
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
## MLwiN (version: 2.36)  multilevel model (Binomial)
##          N min mean max N_complete min_complete mean_complete
## district 60   1    1   1         60            1             1
##          max_complete
## district            1
## Estimation algorithm:  IGLS PQL2        Elapsed time : 4.72s
## Number of obs:  60 (from total 60)        The model converged after 5 iterations.
## Log likelihood:      NA
## Deviance statistic:  NA
## --------------------------------------------------------------------------------------------
## The model formula:
## logit(use, denom) ~ 1 + d_lit + d_pray + (1 | district)
## Level 2: district     Level 1: l1id
## --------------------------------------------------------------------------------------------
## The fixed part estimates:
##               Coef.   Std. Err.       z   Pr(>|z|)         [95% Conf.   Interval]
## Intercept   -0.42665     0.24072   -1.77    0.07633   .       -0.89845     0.04515
## d_lit        3.99760     1.68806    2.37    0.01788   *        0.68906     7.30614
## d_pray      -1.25083     0.52205   -2.40    0.01658   *       -2.27402    -0.22763
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## --------------------------------------------------------------------------------------------
## The random part estimates at the district level:
##                  Coef.   Std. Err.
## var_Intercept   0.22523     0.06234
## --------------------------------------------------------------------------------------------
## The random part estimates at the l1id level:
##                Coef.   Std. Err.
## var_bcons_1   1.00000     0.00000
## -*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
```

Literatur

Hox, Joop, and Leoniek Wijngaards-de Meij. 2014. "The Multilevel Regression Model." In *The Sage Handbook of Regression Analysis and Causal Inference*, edited by Henning Best and Christof Wolf, 133–52. SAGE Publications Ltd. doi:10.4135/9781446288146.n7.

Zhang, Zhengzheng, Richard M. A. Parker, Christopher M. J. Charlton, George Leckie, and William J. Browne. 2016. "R2MLwiN: A Package to Run Mlwin from Within R." *Journal of Statistical Software* 72 (10). doi:10.18637/jss.v072.i10.