Bio-social life-course factors associated with women’s early marriage in rural India: The prospective longitudinal Pune Maternal Nutrition Study

Supporting Information

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Figure S1. Study profile

| Retention | Exclusions |
|-----------|------------|
| 797 F₀ women enrolled June 1994 to April 1996 | 12 F₀ late abortions |
| 762 F₁ live births Nov 1994 to Sept 1996 | 14 F₀ late terminations |
| 700 F₁ infants enrolled into study 336 girls and 364 boys | 8 F₁ still births |
| 674 F₁ followed-up in early-childhood ~6y of age Dec 2000 to Feb 2003 | 1 F₀ maternal death |
| 690 F₁ followed-up in mid-childhood ~12y of age 2005 to 2007 | 1 F₁ death |
| 648 F₁ followed-up at ~18y of age 2013 to 2014; Marital status updated at ~21 years of age in 2017 | 27 F₁ refusals |
| 305 F₁ girls in this analysis Retention rate since birth (305/336) 90.8% | 4 F₁ unreachable |
| 343 F₁ boys excluded only 1 married at 21y | 3 F₁ hard to reach |

F₀ first generation; F₁ second generation

Flow diagram of study participants retained and excluded in the Pune Maternal Nutrition Study from recruitment at maternal pre-conception, and F₁ offspring at subsequent follow-ups.
Table S1. Baseline maternal pre-conception phenotype, household characteristics and girls’ birthweight stratified by girls lost to follow-up and girls followed-up at 18-years

| Maternal phenotype, at baseline | Lost to follow-up (n=31) | Followed-up at 18 years (n=305) | Difference¹ |
|---------------------------------|--------------------------|---------------------------------|-------------|
|                                 | Mean (SD)                | Mean (SD)                       | ∆ (SE), p-value |
| Age (years)* (n=331)            | 20.9 (1.15)              | 20.9 (1.17)                     | 0.99 (1.03), 0.893 |
| Marriage age (years) (n=323)    | 17.4 (3.02)              | 17.5 (2.70)                     | -0.07 (0.52), 0.886 |
| Parity (n=331)                  | 1.12 (0.95)              | 1.19 (1.14)                     | -0.07 (0.23), 0.757 |
| Height (cm) (n=331)             | 151.9 (4.69)             | 152.0 (4.78)                    | -0.08 (0.98), 0.937 |
| Gestation (weeks) (n=331)       | 39.0 (1.53)              | 39.0 (1.61)                     | -0.02 (0.33), 0.946 |
| Girls’ birthweight (kg) (n=311) | 2.54 (0.36)              | 2.56 (0.37)                     |              |
|                                 | n (%)                    | n (%)                           | p-value²     |
| Aggregate adiposity score (n=327) |                       | 0.037                           |             |
| Low                             | 5 (20.0)                 | 108 (35.8)                      |             |
| Mid                             | 6 (24.0)                 | 100 (33.1)                      |             |
| High                            | 14 (56.0)                | 94 (31.1)                       |             |
| Education (n=319)               |                         | 0.063                           |             |
| None to primary (0-5 years)     | 16 (61.5)                | 125 (42.7)                      |             |
| Upper primary + (≥6 years)      | 10 (38.5)                | 168 (57.3)                      |             |
| Household characteristics, at baseline |                       | 0.007                           |             |
| Caste (n=330)                   |                          | 0.549                           |             |
| Low (tribal, scheduled)         | 6 (23.1)                 | 19 (6.3)                        |             |
| Mid (artisan, agrarian)         | 4 (15.4)                 | 69 (22.7)                       |             |
| High (prestige, dominant)       | 16 (61.5)                | 216 (71.1)                      |             |
| Religion (n=331)                |                          | 0.240                           |             |
| Hindu                           | 25 (96.2)                | 299 (98.0)                      |             |
| Muslim                          | 1 (3.8)                  | 4 (1.3)                         |             |
| Buddha                          | 0 (0)                    | 2 (0.7)                         |             |
| Family type (n=330)             |                          | 0.738                           |             |
| Joint                           | 6 (23.1)                 | 44 (14.5)                       |             |
| Nuclear                         | 20 (76.9)                | 260 (85.5)                      |             |
| Family size (n=330)             |                          | 0.026                           |             |
| <6 adults                       | 16 (61.5)                | 197 (64.8)                      |             |
| ≥6 adults                       | 10 (38.5)                | 107 (35.2)                      |             |
| Socio-economic Status at baseline |                      | 0.206                           |             |
| Low (<25)                       | 11 (42.3)                | 80 (26.2)                       |             |
| Mid (25-29)                     | 8 (30.8)                 | 112 (36.7)                      |             |
| High (≥30)                      | 7 (26.9)                 | 113 (37.1)                      |             |
| Agrarian land size (n=312)      |                          | 0.200                           |             |
| Low (<3 acres)                  | 11 (50.0)                | 101 (34.8)                      |             |
| Mid (3 to 5 acres)              | 3 (13.6)                 | 87 (30.0)                       |             |
| High (≥6 acres)                 | 8 (36.4)                 | 102 (35.2)                      |             |
| Paternal education (n=319)      |                          | 0.134                           |             |
| None to primary (0-5 years)     | 11 (42.3)                | 83 (28.3)                       |             |
| Upper primary + (≥6 years)      | 15 (57.7)                | 210 (71.7)                      |             |

SD, standard deviation; ¹Independent samples t-test. ∆, difference (standard error, SE) between lost to follow-up and followed-up at 18-years. n, number. ²Chi-square test. ³Maternal age was positively skewed and natural log-transformed, but reported in original scale in Table. Boldface values indicate statistically significant differences at p≤0.05.
Table S2. Differences in markers of girls’ size and nutritional status (z-scores) and conditional growth from birth to late-adolescence stratified by early married and unmarried girls

|                          | Early married (n=71) | Unmarried (n=234) | Difference¹ |
|--------------------------|----------------------|-------------------|-------------|
| **Size and nutritional status** |                      |                   |             |
| Birth                    |                      |                   |             |
| Height z-score (n=301)   | -1.00 (0.79)         | -1.16 (0.98)      | 0.16 (0.13), 0.206 |
| Weight z-score (n=287)   | -1.52 (0.89)         | -1.66 (0.92)      | 0.13 (0.13), 0.294 |
| Early-childhood (~2y)    |                      |                   |             |
| Height z-score (n=286)   | -1.70 (0.79)         | -1.67 (1.09)      | -0.03 (0.12), 0.819 |
| Weight z-score (n=287)   | -1.91 (0.79)         | -1.83 (1.04)      | -0.08 (0.12), 0.504 |
| BMI z-score (n=286)      | -1.23 (0.94)         | -1.11 (1.04)      | -0.12 (0.14), 0.393 |
| Mid-childhood (~6y)      |                      |                   |             |
| Height z-score           | -1.50 (0.70)         | -1.39 (0.86)      | -0.11 (0.11), 0.340 |
| Weight z-score           | -2.39 (0.82)         | -2.16 (0.94)      | -0.23 (0.12), 0.061 |
| BMI z-score              | -2.01 (0.77)         | -1.78 (0.84)      | -0.23 (0.11), 0.041 |
| Early-adolescence (~12y) |                      |                   |             |
| Age at menarche (n=301)  | 13.69 (1.00)         | 13.41 (1.61)      | 0.28 (0.15), 0.066 |
| Height z-score           | -1.12 (0.80)         | -0.98 (0.90)      | -0.15 (0.12), 0.219 |
| Weight z-score           | -1.85 (1.09)         | -1.69 (1.16)      | -0.16 (0.15), 0.292 |
| BMI z-score              | -1.96 (1.24)         | -1.83 (1.32)      | -0.13 (0.18), 0.473 |
| Late-adolescence (~18y)  |                      |                   |             |
| Height z-score           | -1.06 (0.84)         | -1.07 (0.94)      | 0.01 (0.13), 0.924 |
| Weight z-score           | -1.66 (1.32)         | -1.78 (1.22)      | 0.11 (0.18), 0.534 |
| BMI z-score              | -1.11 (1.30)         | -1.24 (1.33)      | 0.12 (0.19), 0.517 |
| **Growth**               |                      |                   |             |
| Conditional height gain  |                      |                   |             |
| Birth to 2 years z-score (n=282) | -0.06 (0.88) | 0.08 (0.98)      | -0.14 (0.13), 0.312 |
| 2 to 6 years z-score (n=286) | -0.19 (0.75) | -0.01 (0.92)      | -0.18 (0.12), 0.135 |
| 6 to 12 years z-score    | 0.07 (1.12)          | 0.19 (1.08)       | -0.11 (0.15), 0.444 |
| 12 to 18 years z-score   | 0.14 (1.02)          | -0.09 (1.15)      | 0.23 (0.16), 0.152 |
| Conditional weight gain  |                      |                   |             |
| Birth to 2 years z-score (n=270) | -0.07 (0.80) | 0.05 (1.09)      | -0.12 (0.13), 0.346 |
| 2 to 6 years z-score (n=287) | -0.19 (0.95) | 0.12 (0.91)      | -0.31 (0.13), 0.017 |
| 6 to 12 years z-score    | 0.05 (1.10)          | -0.03 (1.07)      | 0.08 (0.15), 0.582 |
| 12 to 18 years z-score   | 0.15 (1.03)          | -0.20 (0.98)      | 0.35 (0.14), 0.015 |
| Conditional BMI gain     |                      |                   |             |
| Birth to 2 years z-score (n=269) | -0.09 (0.88) | 0.05 (1.06)      | -0.14 (0.15), 0.325 |
| 2 to 6 years z-score (n=286) | -0.13 (0.88) | 0.09 (0.94)      | -0.22 (0.13), 0.091 |
| 6 to 12 years z-score    | -0.09 (1.03)         | -0.20 (1.05)      | 0.11 (0.14), 0.446 |
| 12 to 18 years z-score   | 0.20 (0.90)          | -0.06 (0.90)      | 0.26 (0.13), 0.045 |

n, number of participants; SD, standard deviation; ¹Independent samples t-test. Δ, difference (standard error, SE) between early married girls and unmarried girls. Boldface values indicate statistically significant differences at p<0.05.
Table S3. Girls’ educational attainment and performance from pre-primary to late-adolescence stratified by early married and unmarried girls

|                         | Early married (n=71) | Unmarried (n=234) | p-value* |
|-------------------------|----------------------|-------------------|----------|
| **Participation in early childhood education** |                      |                   |          |
| Nursery school attendance |                      |                   | 0.873    |
| Yes                     | 63 (88.7)            | 206 (88.0)        |          |
| No                      | 8 (11.3)             | 28 (12.0)         |          |
| **Age-related progression in school** |                      |                   | 0.768    |
| Age at entry, 1st standard (n=301) |                      |                   |          |
| Below or at expected age (<7 years) | 7 (10.0)             | 26 (11.3)         |          |
| Higher than expected age (≥7 years) | 63 (90.0)            | 205 (88.7)        |          |
| **Standard/age, early-adolescence** |                      |                   | 0.957    |
| Below expected age       | 23 (32.4)            | 75 (32.1)         |          |
| At or higher than expected age | 48 (67.6)            | 159 (67.9)        |          |
| **School performance** |                      |                   | 0.359    |
| Failing school standard  |                     |                   |          |
| Did not fail a school standard | 62 (87.3%)           | 213 (91.0%)       |          |
| Failed in school between standards 1 to 9 | 9 (12.7%)            | 21 (9.0%)         |          |
| **School completion** |                      |                   | <0.001   |
| Lower-secondary school (10th standard) |                   |                   |          |
| Completed                | 51 (71.8)            | 220 (94.0)        |          |
| Not completed            | 20 (28.2)            | 14 (6.0)          |          |
| **Attending school in late-adolescence, 18 years of age** |                   |                   | <0.001   |
| Yes                      | 21 (29.6)            | 212 (90.6)        |          |
| No                       | 50 (70.4)            | 22 (9.4)          |          |

n, number of participants. *Chi-square test. Boldface values indicate statistically significant differences at p≤0.05.
Table S4. Univariable logistic regression testing associations of maternal phenotype, household and girls’ characteristics with girls’ early marriage

| Variable | OR (95%CI), p-value | NK | n |
|----------|---------------------|----|---|
| Maternal and household characteristics | | | |
| Maternal education (≥6 years=Ref) | 1.00 | 0.025 | n=293 |
| None to primary (0-5 years) | 1.86 (1.07, 3.21), **0.026** | | n=68 married girls |
| Constant | 0.23, <0.001 | | n=225 unmarried girls |
| Gestational age (Term, ≥40 weeks=Ref) | 1.00 | 0.037 | n=305 |
| Pre-term (<37 weeks) | 3.30 (1.29, 8.46), **0.013** | | n=71 married girls |
| Early term (37-39.99 weeks) | 2.07 (1.06, 4.07), **0.034** | | n=234 unmarried girls |
| Constant | 0.17, <0.001 | | |
| Maternal parity (0 births=Ref) | 1.00 | 0.017 | n=305 |
| 1 birth | 0.56 (0.28, 1.10), 0.091 | | n=71 married girls |
| ≥2 births | 0.94 (0.50, 1.77), 0.587 | | n=234 unmarried girls |
| Constant | 0.37, <0.001 | | |
| Family type (Joint=Ref) | 1.00 | 0.030 | n=304 |
| Nuclear | 2.40 (1.22, 4.73), **0.011** | | n=71 married girls |
| Constant | 0.26, <0.001 | | n=233 unmarried girls |
| Paternal education (≥6 years=Ref) | 1.00 | 0.052 | n=293 |
| None to primary (0-5 years) | 2.56 (1.45, 4.53), <0.001 | | n=68 married girls |
| Constant | 0.22, <0.001 | | n=225 unmarried girls |
| Agrarian land ownership (≥6 acres=Ref) | 1.00 | 0.055 | n=290 |
| <3 acres | 3.05 (1.51, 6.15), **0.002** | | n=70 married girls |
| 3 to 5.99 acres | 2.26 (1.08, 4.73), **0.031** | | n=220 unmarried girls |
| Constant | 0.16, <0.001 | | |
| Caste (Low: tribal, scheduled=Ref) | 1.00 | 0.007 | n=304 |
| Mid (artisan, agrarian) | 1.36 (0.35, 5.32), 0.661 | | n=71 married girls |
| High (prestige, dominant) | 1.78 (0.50, 6.34), 0.375 | | n=233 unmarried girls |
| Constant | 0.19, 0.008 | | |
| SES<sup>3</sup> at baseline (high=Ref) | 1.00 | 0.009 | n=305 |
| Low | 1.57 (0.80, 3.09), 0.192 | | n=71 married girls |
| Mid | 1.31 (0.70, 2.48), 0.400 | | n=234 unmarried girls |
| Constant | 242, <0.001 | | |
| SES<sup>3</sup> 6 years (high=Ref) | 1.00 | 0.037 | n=290 |
| Low | 2.20 (1.15, 4.22), **0.017** | | n=70 married girls |
| Mid | 2.19 (1.08, 4.44), **0.030** | | n=220 unmarried girls |
| Constant | 0.19, <0.001 | | |
| SES<sup>3</sup> 12 years (high=Ref) | 1.00 | 0.027 | n=283 |
| Low | 2.23 (1.06, 4.70), **0.034** | | n=63 married girls |
| Mid | 1.78 (0.91, 3.50), 0.094 | | n=220 unmarried girls |
| Constant | 0.18, <0.001 | | |
| Girls’ characteristics | | | |
| Conditional weight gain z-score, 2-6y (>1=Ref) | 1.00 | 0.039 | n=287 |
| <1 z-score | 4.20 (1.40, 12.64), **0.011** | | n=67 married girls |
| -1 to 1 z-score | 1.72 (0.68, 4.33), 0.250 | | n=220 unmarried girls |
| Constant | 0.17, <0.001 | | |
| Age at menarche (≥13 years=Ref) | 1.00 | 0.023 | n=301 |
| <13 years | 0.52 (0.28, 0.96), **0.036** | | n=71 married girls |
| Constant | 0.37, <0.001 | | n=230 unmarried girls |
| 10<sup>th</sup> school standard (Completed=Ref) | 1.00 | 0.109 | n=305 |
| Not completed | 6.16 (2.92, 13.02), <0.001 | | n=71 married girls |
| Constant | 0.23, <0.001 | | n=225 unmarried girls |

n, number of participants. OR, Odds Ratio. 95% CI, Confidence Interval. NK, Nagelkerke pseudo R<sup>2</sup>. <sup>3</sup>SES, Socio-economic status. Boldface values indicate statistically significant associations at p≤0.05.
Table S5. Multivariable logistic regression model showing confounders and independent associations of conventional risk factors, and of maternal phenotype, household and girls’ characteristics with girls’ early marriage

| Risk factors                                      | Model 1: Conventional risk factors NK=0.144, (n=266) | Model 2: Conventional risk factors & confounders NK=0.194, (n=266) | Model 3: Conventional risk factors, confounders & broader bio-social factors NK=0.350, (n=242) |
|--------------------------------------------------|-----------------------------------------------------|---------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Risk factors                                     | aOR (95%CI), p-value                                 | aOR (95%CI), p-value                                                 | aOR (95%CI), p-value                                                            |
| Conventional risk factors                        |                                                     |                                                                     |                                                                                  |
| SES baseline (high=Ref)                          | 1.00                                                | 1.00                                                                | 1.00                                                                             |
| Low                                              | 1.50 (0.64, 3.53), 0.351                             | 1.53 (0.55, 4.23), 0.412                                           | 1.56 (0.42, 5.73), 0.502                                                        |
| Mid                                              | 1.16 (0.54, 2.48), 0.705                             | 1.10 (0.49, 2.46), 0.820                                           | 1.10 (0.41, 2.97), 0.844                                                        |
| SES 6y (high=Ref)                                | 1.00                                                | 1.00                                                                | 1.00                                                                             |
| Low                                              | 1.79 (0.72, 4.45), 0.208                             | 1.56 (0.60, 4.02), 0.358                                           | 1.32 (0.41, 4.27), 0.648                                                        |
| Mid                                              | 2.10 (0.86, 5.13), 0.104                             | 2.01 (0.79, 5.13), 0.143                                           | 1.63 (0.52, 5.14), 0.401                                                        |
| SES 12y (high=Ref)                               | 1.00                                                | 1.00                                                                | 1.00                                                                             |
| Low                                              | 0.95 (0.34, 2.67), 0.927                             | 0.91 (0.31, 2.62), 0.855                                           | 0.64 (0.17, 2.40), 0.508                                                        |
| Mid                                              | 1.17 (0.53, 2.59), 0.702                             | 1.00 (0.44, 2.29), 0.998                                           | 0.70 (0.25, 1.96), 0.493                                                        |
| Girls’ 10th school standard (Completed=Ref)      | 1.00                                                | 1.00                                                                | 1.00                                                                             |
| Not completed                                    | 5.32 (2.27, 12.47), <0.001                           | 5.71 (2.32, 14.06), <0.001                                         | 9.20 (2.78, 30.44), <0.001                                                      |
| Girls’ age at menarche                           | 1.00                                                | 1.00                                                                | 1.00                                                                             |
| (≥13y =Ref)                                      |                                                     |                                                                     |                                                                                  |
| Early (<13y)                                      | 0.48 (0.24, 0.97), 0.042                             | 0.53 (0.25, 1.10), 0.090                                           | 0.62 (0.26, 1.47), 0.277                                                        |
| Potential confounders                            |                                                     |                                                                     |                                                                                  |
| Agrarian land                                    | 1.00                                                | 1.00                                                                | 1.00                                                                             |
| Mid (<3 acres)                                    | 2.48 (1.03, 6.00), 0.043                             | 1.43 (0.51, 3.97), 0.494                                           |                                                                                  |
| High (3 to 5 acres)                              | 1.53 (0.65, 3.60), 0.325                             | 1.25 (0.48, 3.28), 0.648                                           |                                                                                  |
| Caste (Low: tribal, scheduled=Ref)               | 1.00                                                | 1.00                                                                | 1.00                                                                             |
| Mid (artisan, agrarian)                          | 4.19 (0.67, 26.07), 0.125                            | 4.15 (0.55, 31.40), 0.168                                          |                                                                                  |
| High (prestige, dominant)                        | 5.60 (0.94, 33.39), 0.059                            | 6.31 (0.85, 46.78), 0.072                                          |                                                                                  |
| Maternal parity                                  | 1.00                                                | 1.00                                                                | 1.00                                                                             |
| (0 births=Ref)                                   |                                                     |                                                                     |                                                                                  |
| 1 birth                                           | 0.65 (0.30, 1.42), 0.283                             | 0.45 (0.17, 1.20), 0.110                                           |                                                                                  |
| ≥2 births                                        | 1.10 (0.51, 2.37), 0.802                             | 0.86 (0.35, 2.10), 0.746                                           |                                                                                  |
| Broader bio-social factors                       |                                                     |                                                                     |                                                                                  |
| Family type (Joint=Ref)                          | 1.00                                                |                                                                     |                                                                                  |
| Category                        | Odds Ratio (95% CI) | p-value |
|--------------------------------|---------------------|---------|
| Nuclear household              | 3.38 (1.14, 10.03)  | 0.028   |
| Paternal educ. (≥6y=Ref)       | 1.00                |         |
| None to primary (0-5y)         | 2.19 (0.95, 5.05)   | 0.065   |
| Maternal educ. (≥6y=Ref)       | 1.00                |         |
| None to primary (0-5y)         | 1.02 (0.44, 2.38)   | 0.955   |
| Gestational age (Term, ≥40 wks=Ref) | 1.00           |         |
| Pre-term (<37 wks)             | 7.17 (1.99, 25.80)  | 0.003   |
| Early-term (37-39.99 wks)      | 3.12 (1.22, 7.98)   | 0.017   |
| Girls’ infant weight gain z-score (≥1=Ref) | 1.00  |         |
| <1 z-score                     | 9.36 (2.05, 42.69)  | 0.004   |
| -1 to 1 z-score                | 2.06 (0.61, 6.90)   | 0.243   |
| Constant                       | 0.16, <0.001        | 0.01, <0.001 | 0.01, <0.001 |

$n$, number of participants. aOR, adjusted Odds Ratio. 95% CI, Confidence Interval. NK, Nagelkerke pseudo $R^2$.

$^1n=62$ early married girls vs. $n=204$ unmarried girls. $^2n=56$ early married girls vs. $n=186$ unmarried girls. $^4$SES, Socio-economic status. Boldface values indicate statistically significant associations at $p≤0.05$. 