**Supplementary results**

**Table S1: Univariate survey logistic regression analysis of the factors associated with menarche attainment**

|  |  |  |
| --- | --- | --- |
| **Variable**  | **OR (95 % C.I)** | **P-value** |
| **Nutritional status related**  |  |  |
| Age  | 1.96 (1.76, 2.19) | <0.0001 |
| Height-for-age z-score (HAZ) | 1.54 (1.36, 1.75) | <0.0001 |
| Stunted (Yes vs No) | 0.24 (0.13, 0.43) | <0.0001 |
| Body mass index-for-age z-score (BAZ) | 2.43 (1.97, 3.01) | <0.0001 |
| Body mass index-for-age z-score category, |  | 0.001 |
|  Normal  | Ref |  |
|  Thin | 0.33 (0.14, 0.77) |  |
|  Overweight/obese  | 3.09(1.38, 6.92) |  |
| Fat mass (Kg) | 1.59 (1.46, 1.73) | <0.0001 |
| Fat-free mass (Kg) | 1.32 (1.26, 1.38) | <0.0001 |
| Haemoglobin, g/L | 1.00 (0.88, 1.14) | 0.96 |
| Anaemia (Yes vs. No) | 1.13 (0.83, 1.54) | 0.44 |
| Typical number of days for vigorous physical activity | 1.05 (0.97, 1.13) | 0.21 |
| **Socio-demographic**  |  |  |
| Religion of girl |  | 0.001 |
|  Islam  | Ref |  |
|  Christianity  | 1.75 (1.29, 2.39) |  |
|  Other  | 2.02 (0.62, 6.58) |  |
| Ethnicity of girl |  | 0.001 |
|  Dagomba  | Ref |  |
|  Konkomba | 1.72 (1.27, 2.34) |  |
|  Other  | 0.31 (0.04, 2.35) |  |
| **Dietary characteristics**  |  |  |
| Dietary diversity score  | 0.94 (0.82, 1.07) | 0.34 |
| Minimum dietary diversity (Yes vs. No) | 0.65 (0.40, 1.05) | 0.08 |
| Mean frequency of consuming fruits and vegetables in the last month | 1.01 (0.98, 1.03) | 0.66 |
| Mean frequency of consuming animal-sourced foods in the last month  | 1.02 (0.98, 1.06) | 0.32 |
| **Household-level factors**  |  |  |
| Mother is literate (Yes vs. No) | 1.05 (0.59, 1.85) | 0.87 |
| Household size  | 0.97 (0.94, 1.04) | 0.11 |
| Dependency ratio | 0.84 (0.68, 1.05) | 0.12 |
| Literacy ratio | 0.98 (0.83, 1.15) | 0.82 |
| Female/male ratio | 1.10 (0.98, 1.22) | 0.09 |
| Household Food Security  |  | 0.44 |
|  Food secured  | Ref |  |
|  Mild food insecurity  | 1.13 (0.83, 2.08) |  |
|  Moderate food insecurity  | 1.18 (0.76, 1.84) |  |
|  Severe food insecurity  | 0.93 (0.56, 1.55) |  |
| Household wealth index  |  | 0.07 |
|  Quintile 1 | Ref |  |
|  Quintile 2 | 1.43 (0.88, 2.34) |  |
|  Quintile 3 | 1.14 (0.70, 1.87) |  |
|  Quintile 4 | 0.70 (0.41, 1.20) |  |
|  Quintile 5 | 1.24 (0.75, 2.05) |  |

**Table S2: Univariate survey linear regression analysis of the factors associated with pubertal development score**

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable**  | **Regression Co-efficient (β)** | **S. E** | **P-value** |
| **Nutritional status related**  |  |  |  |
| Age  | 0.20 | 0.01 | <0.0001 |
| Height-for-age z-score (HAZ) | 0.13 | 0.01 | <0.0001 |
| Stunted (Yes vs. No) | -0.33 | 0.04 | <0.0001 |
| Body mass index-for-age z-score (BAZ) | 0.20 | 0.02 | <0.0001 |
| Body mass index-for-age z-score category, |  |  | <0.0001 |
|  Normal  | Ref |  |  |
|  Thin | -0.30 | 0.05 | <0.0001 |
|  Overweight/obese  | 0.34 | 0.14 | 0.01 |
| Fat mass (Kg) | 0.10 | 0.01 | <0.0001 |
| Fat-free mass (Kg) | 0.06 | 0.002 | <0.0001 |
| Haemoglobin, g/L | 0.04 | 0.02 | 0.004 |
| Anaemia (Yes vs. No) | 0.01 | 0.04 | 0.73 |
| Typical number of days for vigorous physical activity | 0.015 | 0.01 | 0.09 |
| **Socio-demographic**  |  |  |  |
| Religion of girl |  |  | <0.0001 |
|  Islam  | Ref |  |  |
|  Christianity  | 0.20 | 0.04 | <0.0001 |
|  Other  | 0.17 | 0.19 | 0.37 |
| Ethnicity of girl |  |  | <0.0001 |
|  Dagomba  | Ref |  |  |
|  Konkomba | 0.19 | 0.04 | <0.0001 |
|  Other  | -0.22 | 0.10 | 0.03 |
| **Dietary characteristics**  |  |  |  |
| Dietary diversity score  | -0.001 | 0.02 | 0.92 |
| Minimum dietary diversity (Yes vs. No) | -0.07 | 0.06 | 0.29 |
| Mean frequency of consuming fruits and vegetables in the last month | -0.001 | 0.003 | 0.77 |
| Mean frequency of consuming animal-sourced foods in the last month  | 0.01 | 0.004 | 0.25 |
| **Household-level factors**  |  |  |  |
| Mother is literate (Yes vs. No) | -0.05 | 0.07 | 0.47 |
| Household size  | -0.01 | 0.003 | 0.08 |
| Dependency ratio | -0.05 | 0.02 | 0.03 |
| Literacy ratio | -0.04 | 0.02 | 0.01 |
| Female/male ratio | 0.01 | 0.02 | 0.51 |
| Household Food Security  |  |  | 0.08 |
|  Food secured  | Ref |  |  |
|  Mild food insecurity  | 0.07 | 0.06 | 0.24 |
|  Moderate food insecurity  | 0.07 | 0.05 | 0.19 |
|  Severe food insecurity  | -0.04 | 0.05 | 0.41 |
| Household wealth index  |  |  | 0.02 |
|  Quintile 1 | Ref |  |  |
|  Quintile 2 | 0.18 | 0.06 | 0.002 |
|  Quintile 3 | 0.13 | 0.06 | 0.03 |
|  Quintile 4 | 0.07 | 0.06 | 0.19 |
|  Quintile 5 | 0.04 | 0.06 | 0.49 |

**Table S3: Univariate survey linear regression analysis of the factors associated with age-at-menarche**

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable**  | **Regression Co-efficient (β)** | **S. E** | **P-value** |
| **Nutritional status related**  |  |  |  |
| Age  | 0.38 | 0.06 | <0.0001 |
| Height-for-age z-score (HAZ) | -0.26 | 0.09 | 0.004 |
| Stunted (Yes vs. No) | -0.70 | 0.35 | 0.046 |
| Body mass index-for-age z-score (BAZ) | -0.29 | 0.12 | 0.022 |
| Body mass index-for-age z-score category, |  |  | 0.18 |
|  Normal  | Ref |  |  |
|  Thin | 1.34 | 0.82 | 0.105 |
|  Overweight/obese  | -0.19 | 0.24 | 0.444 |
| Fat mass (Kg) | -0.0004 | 0.03 | 0.98 |
| Fat-free mass (Kg) | 0.05 | 0.02 | 0.004 |
| Haemoglobin, g/L | 0.04 | 0.08 | 0.60 |
| Anaemia (Yes vs. No) | 0.02 | 0.21 | 0.93 |
| Typical number of days for vigorous physical activity | -0.04 | 0.05 | 0.36 |
| **Socio-demographic**  |  |  |  |
| Religion of girl |  |  | 0.28 |
|  Islam  | Ref |  |  |
|  Christianity  | 0.15 | 0.21 | 0.47 |
|  Other  | 1.39 | 0.94 | 0.14 |
| Ethnicity of girl |  |  | <0.0001 |
|  Dagomba  | Ref |  |  |
|  Konkomba | 0.20 | 0.22 | 0.35 |
|  Other  | -1.33 | 0.12 | <0.0001 |
| **Dietary characteristics**  |  |  |  |
| Dietary diversity score  | 0.04 | 0.09 | 0.63 |
| Minimum dietary diversity (Yes vs. No) | -0.06 | 0.35 | 0.87 |
| Mean frequency of consuming fruits and vegetables in the last month | 0.03 | 0.02 | 0.08 |
| Mean frequency of consuming animal-sourced foods in the last month  | 0.01 | 0.03 | 0.78 |
| **Household-level factors**  |  |  |  |
| Mother is literate (Yes vs. No) | -0.66 | 0.43 | 0.13 |
| Household size  | -0.002 | 0.02 | 0.90 |
| Dependency ratio | -0.21 | 0.12 | 0.09 |
| Literacy ratio | 0.057 | 0.12 | 0.57 |
| Female/male ratio | 0.04 | 0.06 | 0.47 |
| Household Food Security  |  |  | 0.75 |
|  Food secured  | Ref |  |  |
|  Mild food insecurity  | -0.22 | 0.30 | 0.47 |
|  Moderate food insecurity  | 0.07 | 0.27 | 0.80 |
|  Severe food insecurity  | -0.05 | 0.38 | 0.88 |
| Household wealth index  |  |  |  |
|  Quintile 1 | Ref |  |  |
|  Quintile 2 | -0.24 | 0.33 | 0.46 |
|  Quintile 3 | -0.23 | 0.35 | 0.51 |
|  Quintile 4 | 0.22 | 0.35 | 0.53 |
|  Quintile 5 | -0.21 | 0.34 | 0.53 |

**Table S4: Factors associated with the attainment of menarche with(out) fat-mass and fat-free mass**

|  |  |  |
| --- | --- | --- |
|  | **Model with Nutritional status indices** | **Model with fat mass and fat-free mass** |
| **Variable**  | **OR (95 % C.I)** | **P-value** | **OR (95 % C.I)** | **P-value** |
| Age  | 2.06 (1.83, 2.31) | <0.0001 | 1.40 (1.24, 1.58) | <0.0001 |
| Stunted  |  |  |  |  |
|  No  | Ref. |  |  |  |
|  Yes | 0.20 (0.10, 0.40) | <0.0001 |  |  |
| Body mass index-for-age z-score category |  | <0.0001 |  |  |
|  Normal  | Ref. |  |  |  |
|  Thin | 0.30 (0.11, 0.80) | 0.02 |  |  |
|  Overweight/obese  | 7.29 (2.60, 20.43) | 0.0002 |  |  |
| Fat-free mass(kg) |  |  | 1.19 (1.14, 1.25) | <0.0001 |
| Fat mass (kg) |  |  | 1.26 (1.17, 1.36) | <0.0001 |
| **Model fit**  |  |  |  |  |
| Likelihood Ratio | 140.48 | <0.0001 | 71.87 | <0.0001 |
|  −2logL | 1043.06 |  | 1043.06 |  |
|  **AIC** | 1045.06 |  | 1045.06 |  |

**Table S5 : Factors associated with age-at-menarche with(out) fat-mass and fat-free mass**

|  |  |  |
| --- | --- | --- |
| **Variable**  | **Model with Nutritional status indices** | **Model with fat mass and fat-free mass** |
| **β (95% C.I)** | **S. E** | **P-value** | **β (95% C.I)** | **S. E** | **P-value** |
| Age  | 0.39 (0.28, 0.50) | 0.06 | <0.0001 | 0.40 (0.29, 0.51) | 0.06 | <0.0001 |
| Stunted  |  |  |  |  |  |  |
|  No  | Ref. |  |  |  |  |  |
|  Yes  | -0.92 (-1.63, -0.20) | 0.36 | 0.01 |  |  |  |
| Body mass index-for-age z-score category |  |  |  |  |  |  |
|  Normal  | Ref. |  |  |  |  |  |
|  Thin | 1.25 (0.32, 2.17) | 0.47 | 0.01 |  |  |  |
|  Overweight/obese  | 0.41(-0.19, 1.01) | 0.30 | 0.18 |  |  |  |
| Fat-mass (Kg) |  |  |  | -0.05 (-0.10, -0.05) | 0.02 | 0.03 |
| Fat-free mass (Kg) |  |  |  |  |  |  |
| Mother is literate  |  |  |  |  |  |  |
|  No | Ref. |  |  |  |  |  |
|  Yes | -0.70 (-1.34, -0.06) | 0.32 | 0.03 | -0.77 (-1.43, -0.11) | 0.33 | 0.02 |
| **Model fit statistics**  |  |  |  |  |  |  |
|  R-square  |  | 0.26 |  |  | 0.23 |  |
|  Root MSE |  | 1.38 |  |  | 1.39 |  |