Supplement to Longitudinal analysis of early childhood stunting in low-resource settings

Jade Benjamin-Chung et al.

2019-12-18

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Chapter 1

Overview

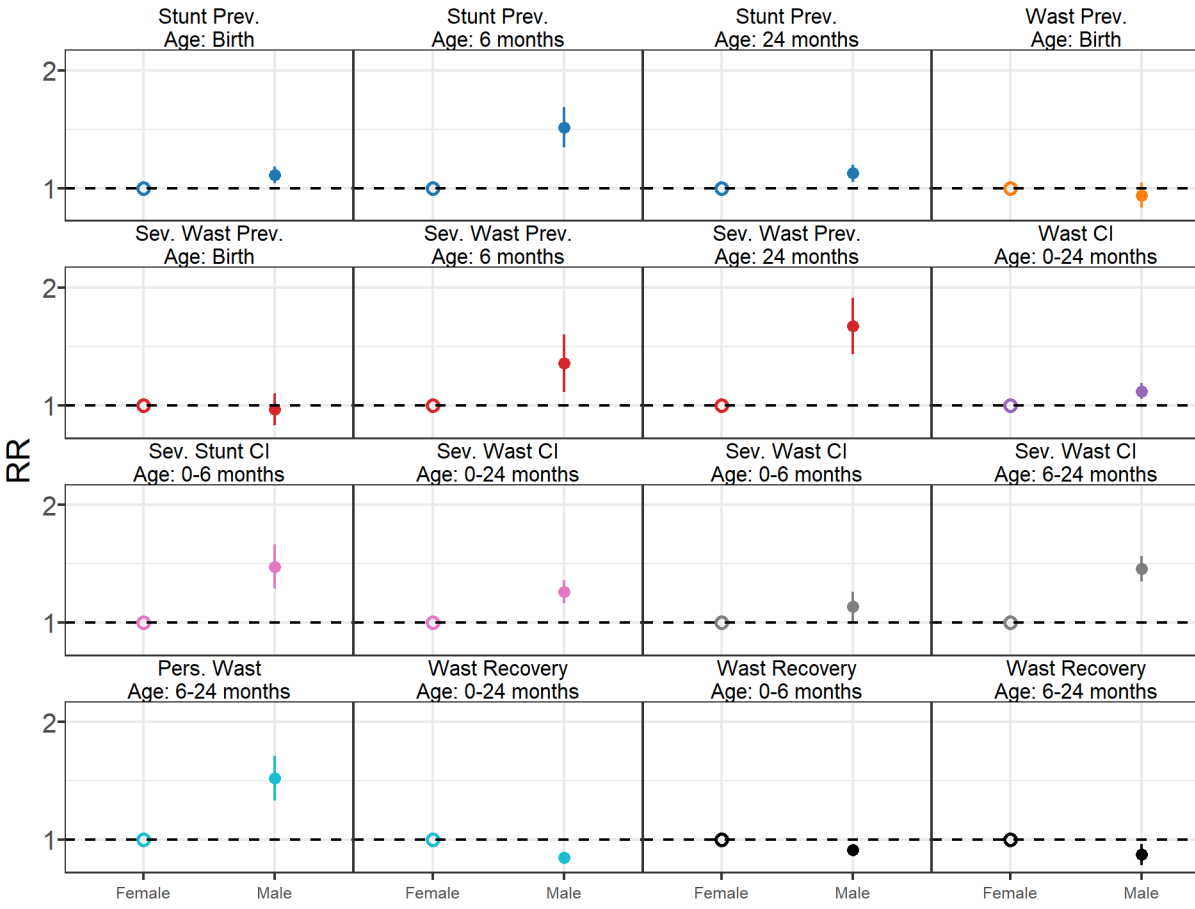
Recommended citation: Benjamin-Chung J, et al. 2020. Longitudinal analyses of early childhood stunting in low-resource settings. *Journal Name*. doi.

This site contains supplementary information to the *Longitudinal analyses of early childhood stunting in low-resource settings*.

Chapter 2

Relative risk plots

2.0.1 Relative risks between levels of all exposures for prevalence and cumulative incidence of wasting and stunting outcomes



Chapter 3

Growth velocity

** [TEMP] Will fill in with PAR plots of growth velocity **

Chapter 4

Sensitivity analysis using fixed effects

The primary analyses presented in this manuscript pooled across individual studies using random effects. Inferences about estimates from fixed effects models are restricted to only the included studies.[^1] The random effects approach was more conservative in the presence of study heterogeneity, as evidenced by larger confidence intervals around each point estimates. Overall, the inference from results produced by each method was similar.

4.1 Primary manuscript figures recreated with estimates pooled using fixed effects

More estimates are significant when pooling using fixed effects due to the generally smaller confidence intervals.

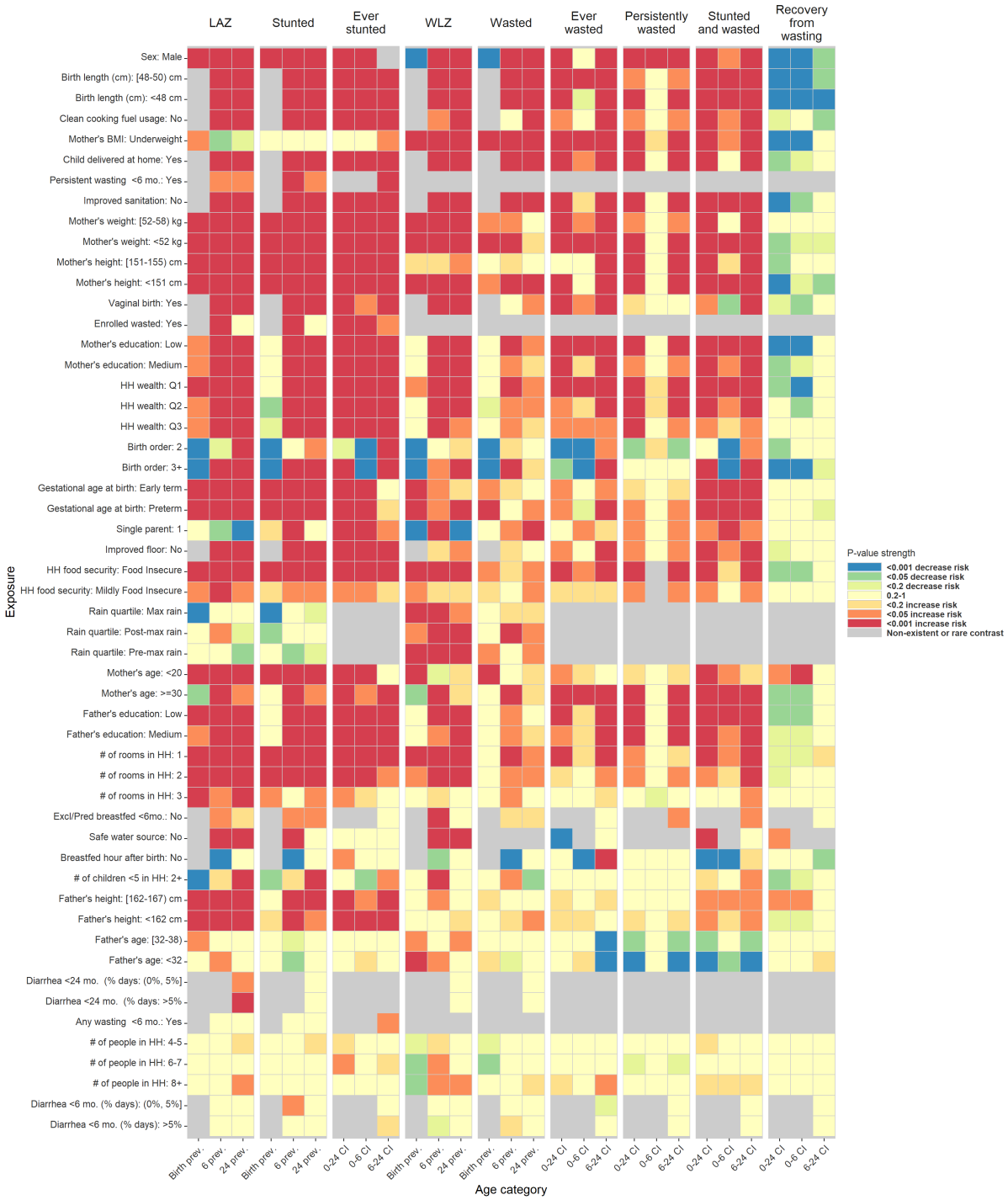
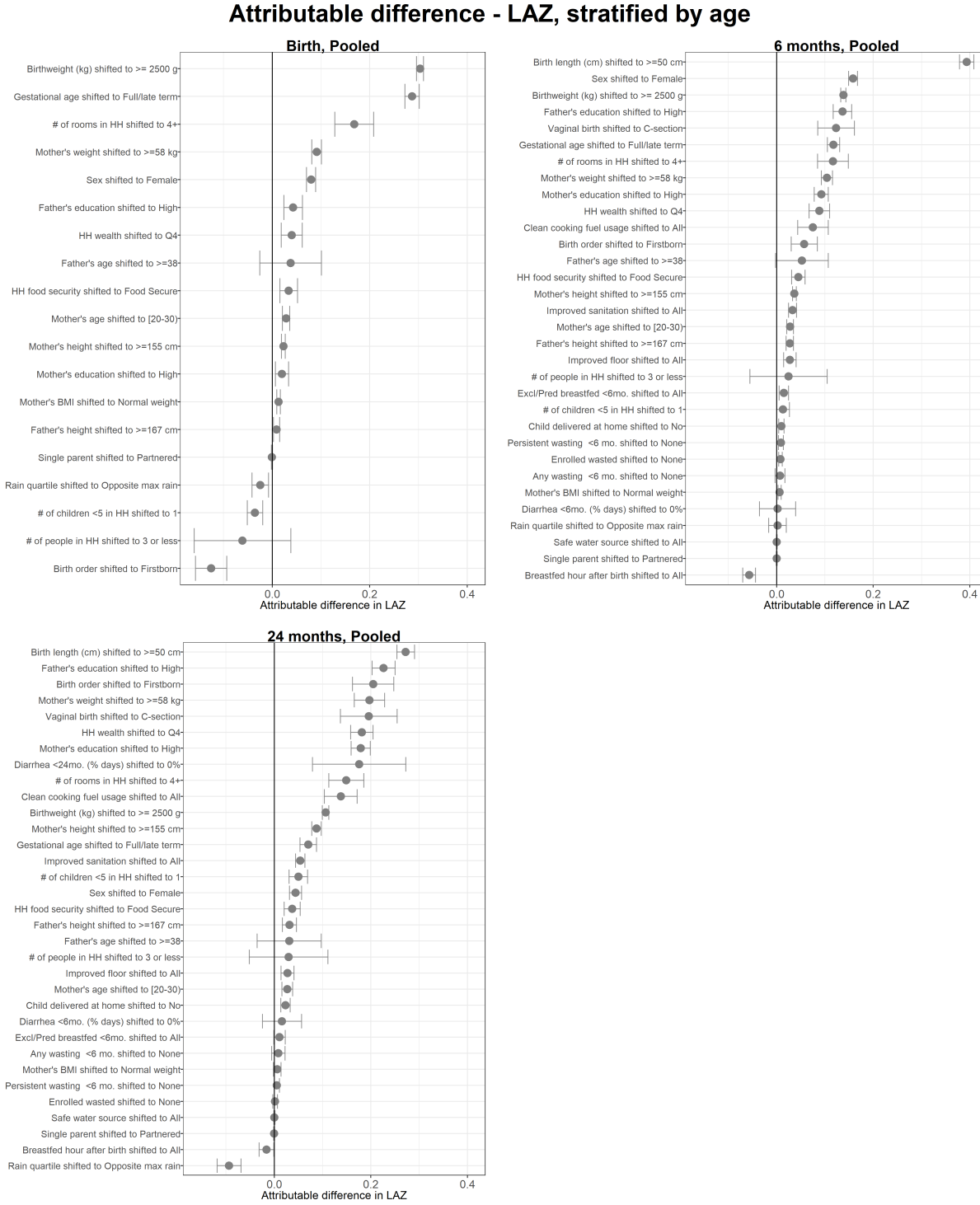
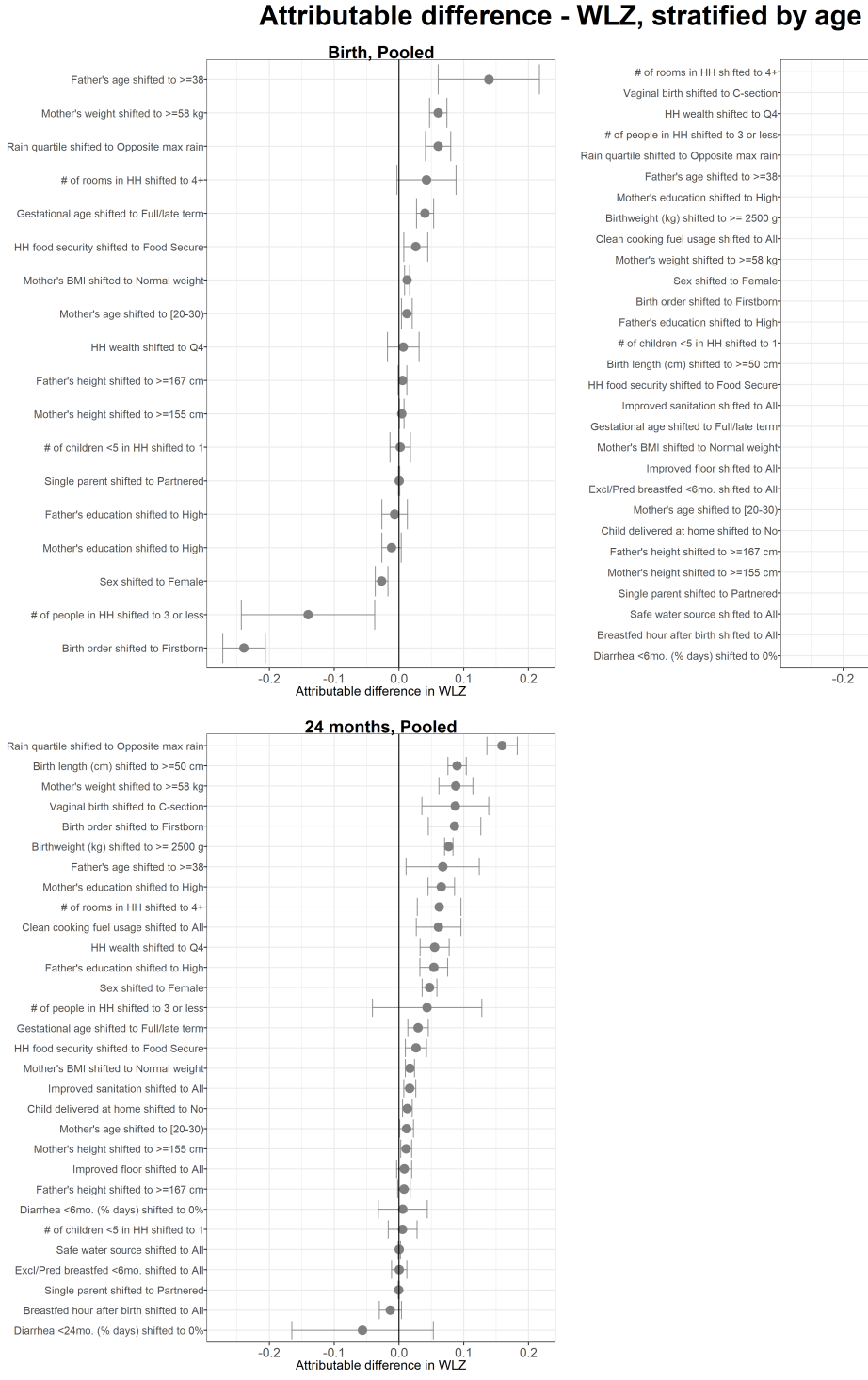

LAZ
Stunted
Ever stunted
WLZ
Wasted
Ever wasted
Persistently wasted
Stunted and wasted
Recovery from wasting
Exposure
Sex: Male
Birth length (cm): [48-50) cm
Birth length (cm): <48 cm
Clean cooking fuel usage: No
Mother's BMI: Underweight
Child delivered at home: Yes
Persistent wasting <6 mo.: Yes
Improved sanitation: No
Mother's weight: [52-58) kg
Mother's weight: <52 kg
Mother's height: [151-155) cm
Mother's height: <151 cm
Vaginal birth: Yes
Enrolled wasted: Yes
Mother's education: Low
Mother's education: Medium
HH wealth: Q1
HH wealth: Q2
HH wealth: Q3
Birth order: 2
Birth order: 3+
Gestational age at birth: Early term
Gestational age at birth: Preterm
Single parent: 1
Improved floor: No
HH food security: Food Insecure
HH food security: Mildly Food Insecure
Rain quartile: Max rain
Rain quartile: Post-max rain
Rain quartile: Pre-max rain
Mother's age: <20
Mother's age: >=30
Father's education: Low
Father's education: Medium
# of rooms in HH: 1
# of rooms in HH: 2
# of rooms in HH: 3
Excl/Pred breastfed <6mo.: No
Safe water source: No
Breastfed hour after birth: No
# of children <5 in HH: 2+
Father's height: [162-167) cm
Father's height: <162 cm
Father's age: [32-38)
Father's age: <32
Diarrhea <24 mo. (% days: (0%, 5%]
Diarrhea <24 mo. (% days: >5%
Any wasting <6 mo.: Yes
# of people in HH: 4-5
# of people in HH: 6-7
# of people in HH: 8+
Diarrhea <6 mo. (% days): (0%, 5%]
Diarrhea <6 mo. (% days): >5%
Birth prev.
6 prev.
24 prev.
0-24 CI
0-6 CI
6-24 CI
Age category
P-value strength
<0.001 decrease risk
<0.05 decrease risk
<0.2 decrease risk
0.2-1
<0.2 increase risk
<0.05 increase risk
<0.001 increase risk
Non-existent or rare contrast

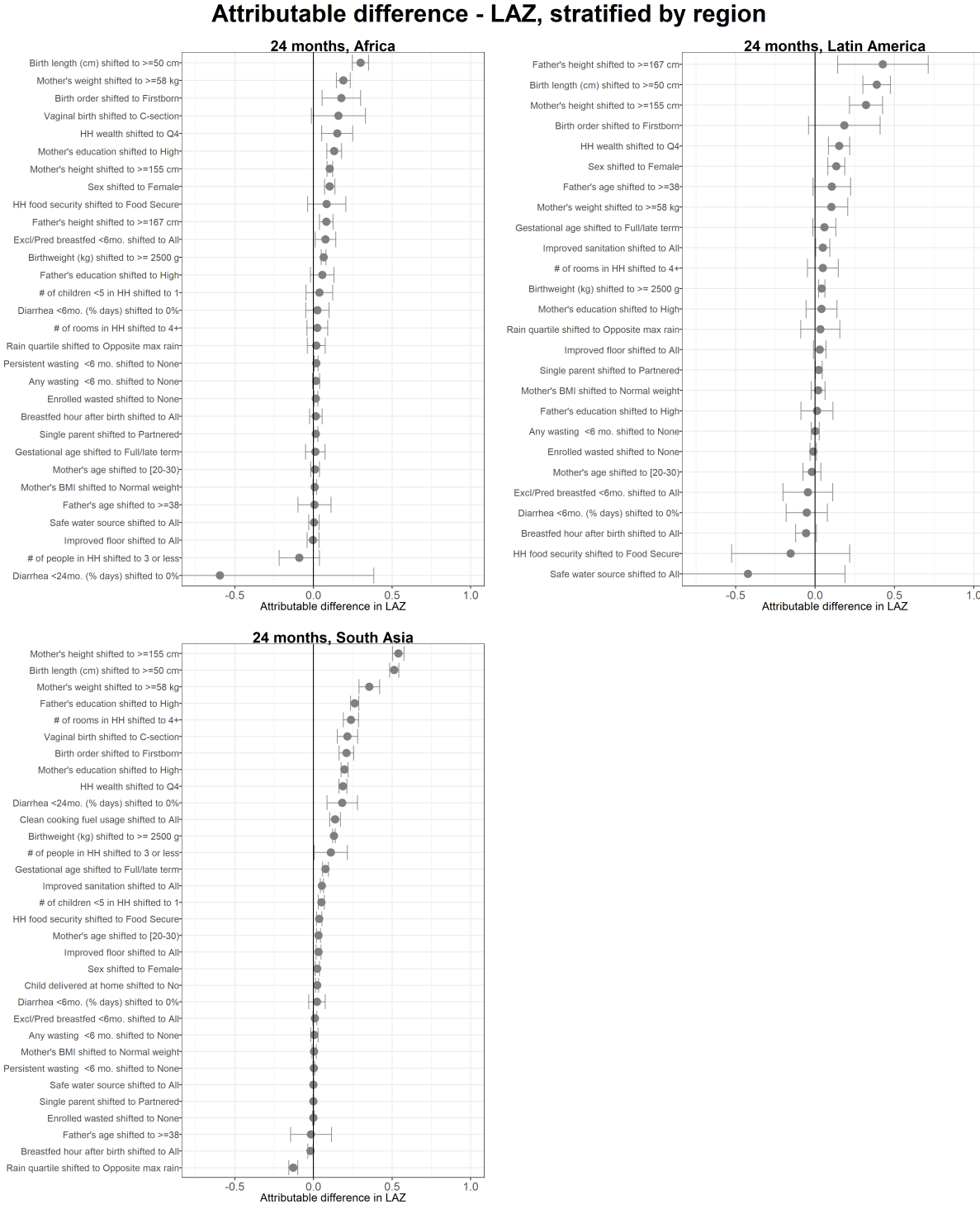
Figure 1a. Heatmap of significance and direction across exposure-outcome combinations of associations estimated using fixed effects.


Attributable difference - LAZ, stratified by age
Birth, Pooled
Birthweight (kg) shifted to >= 2500 g
Gestational age shifted to Full/late term
# of rooms in HH shifted to 4+
Mother's weight shifted to >=58 kg
Sex shifted to Female
Father's education shifted to High
HH wealth shifted to Q4
Father's age shifted to >=38
HH food security shifted to Food Secure
Mother's age shifted to [20-30)
Mother's height shifted to >=155 cm
Mother's education shifted to High
Mother's BMI shifted to Normal weight
Father's height shifted to >=167 cm
Single parent shifted to Partnered
Rain quartile shifted to Opposite max rain
# of children <5 in HH shifted to 1
# of people in HH shifted to 3 or less
Birth order shifted to Firstborn
0.0
0.2
0.4
Attributable difference in LAZ
6 months, Pooled
Birth length (cm) shifted to >=50 cm
Sex shifted to Female
Birthweight (kg) shifted to >= 2500 g
Father's education shifted to High
Vaginal birth shifted to C-section
Gestational age shifted to Full/late term
# of rooms in HH shifted to 4+
Mother's weight shifted to >=58 kg
Mother's education shifted to High
HH wealth shifted to Q4
Clean cooking fuel usage shifted to All
Birth order shifted to Firstborn
Father's age shifted to >=38
HH food security shifted to Food Secure
Mother's height shifted to >=155 cm
Improved sanitation shifted to All
Mother's age shifted to [20-30)
Father's height shifted to >=167 cm
Improved floor shifted to All
# of people in HH shifted to 3 or less
Excl/Pred breastfed <6mo. shifted to All
# of children <5 in HH shifted to 1
Child delivered at home shifted to No
Persistent wasting <6 mo. shifted to None
Enrolled wasted shifted to None
Any wasting <6 mo. shifted to None
Mother's BMI shifted to Normal weight
Diarrhea <6mo. (% days) shifted to 0%
Rain quartile shifted to Opposite max rain
Safe water source shifted to All
Single parent shifted to Partnered
Breastfed hour after birth shifted to All
0.0
0.2
0.4
Attributable difference in LAZ
24 months, Pooled
Birth length (cm) shifted to >=50 cm
Father's education shifted to High
Birth order shifted to Firstborn
Mother's weight shifted to >=58 kg
Vaginal birth shifted to C-section
HH wealth shifted to Q4
Mother's education shifted to High
Diarrhea <24mo. (% days) shifted to 0%
# of rooms in HH shifted to 4+
Clean cooking fuel usage shifted to All
Birthweight (kg) shifted to >= 2500 g
Mother's height shifted to >=155 cm
Gestational age shifted to Full/late term
Improved sanitation shifted to All
# of children <5 in HH shifted to 1
Sex shifted to Female
HH food security shifted to Food Secure
Father's height shifted to >=167 cm
Father's age shifted to >=38
# of people in HH shifted to 3 or less
Improved floor shifted to All
Mother's age shifted to [20-30)
Child delivered at home shifted to No
Diarrhea <6mo. (% days) shifted to 0%
Excl/Pred breastfed <6mo. shifted to All
Any wasting <6 mo. shifted to None
Mother's BMI shifted to Normal weight
Persistent wasting <6 mo. shifted to None
Enrolled wasted shifted to None
Safe water source shifted to All
Single parent shifted to Partnered
Breastfed hour after birth shifted to All
Rain quartile shifted to Opposite max rain
0.0
0.2
0.4
Attributable difference in LAZ

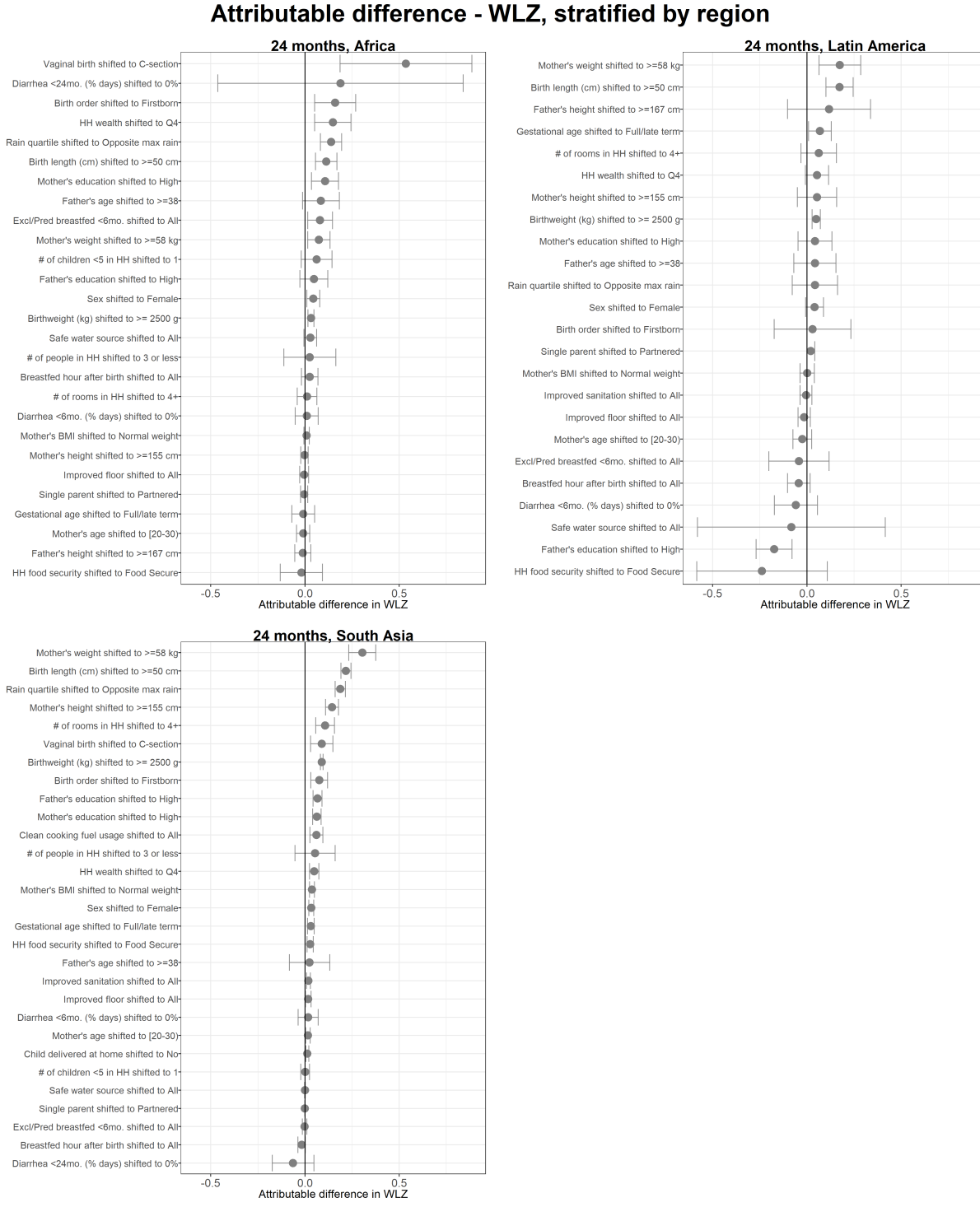
Extended Data Figure 3 | Age-stratified population attributable differences in length-for-age Z-scores estimated using fixed effects.


Attributable difference - WLZ, stratified by age
Birth, Pooled
Father's age shifted to >=38
Mother's weight shifted to >=58 kg
Rain quartile shifted to Opposite max rain
# of rooms in HH shifted to 4+
Gestational age shifted to Full/late term
HH food security shifted to Food Secure
Mother's BMI shifted to Normal weight
Mother's age shifted to [20-30)
HH wealth shifted to Q4
Father's height shifted to >=167 cm
Mother's height shifted to >=155 cm
# of children <5 in HH shifted to 1
Single parent shifted to Partnered
Father's education shifted to High
Mother's education shifted to High
Sex shifted to Female
# of people in HH shifted to 3 or less
Birth order shifted to Firstborn
-0.2 -0.1 0.0 0.1 0.2
Attributable difference in WLZ
6 months, Pooled
# of rooms in HH shifted to 4+
Vaginal birth shifted to C-section
HH wealth shifted to Q4
# of people in HH shifted to 3 or less
Rain quartile shifted to Opposite max rain
Father's age shifted to >=38
Mother's education shifted to High
Birthweight (kg) shifted to >= 2500 g
Clean cooking fuel usage shifted to All
Mother's weight shifted to >=58 kg
Sex shifted to Female
Birth order shifted to Firstborn
Father's education shifted to High
# of children <5 in HH shifted to 1
Birth length (cm) shifted to >=50 cm
HH food security shifted to Food Secure
Improved sanitation shifted to All
Gestational age shifted to Full/late term
Mother's BMI shifted to Normal weight
Improved floor shifted to All
Excl/Pred breastfed <6mo. shifted to All
Mother's age shifted to [20-30)
Child delivered at home shifted to No
Father's height shifted to >=167 cm
Mother's height shifted to >=155 cm
Single parent shifted to Partnered
Safe water source shifted to All
Breastfed hour after birth shifted to All
Diarrhea <6mo. (% days) shifted to 0%
-0.2 -0.1 0.0 0.1 0.2
Attributable difference in WLZ
24 months, Pooled
Rain quartile shifted to Opposite max rain
Birth length (cm) shifted to >=50 cm
Mother's weight shifted to >=58 kg
Vaginal birth shifted to C-section
Birth order shifted to Firstborn
Birthweight (kg) shifted to >= 2500 g
Father's age shifted to >=38
Mother's education shifted to High
# of rooms in HH shifted to 4+
Clean cooking fuel usage shifted to All
HH wealth shifted to Q4
Father's education shifted to High
Sex shifted to Female
# of people in HH shifted to 3 or less
Gestational age shifted to Full/late term
HH food security shifted to Food Secure
Mother's BMI shifted to Normal weight
Improved sanitation shifted to All
Child delivered at home shifted to No
Mother's age shifted to [20-30)
Mother's height shifted to >=155 cm
Improved floor shifted to All
Father's height shifted to >=167 cm
Diarrhea <6mo. (% days) shifted to 0%
# of children <5 in HH shifted to 1
Safe water source shifted to All
Excl/Pred breastfed <6mo. shifted to All
Single parent shifted to Partnered
Breastfed hour after birth shifted to All
Diarrhea <24mo. (% days) shifted to 0%
-0.2 -0.1 0.0 0.1 0.2
Attributable difference in WLZ

Extended Data Figure 4 | Age-stratified population attributable differences in weight-for-length Z-scores estimated using fixed effects.


Attributable difference - LAZ, stratified by region
24 months, Africa
Birth length (cm) shifted to >=50 cm
Mother's weight shifted to >=58 kg
Birth order shifted to Firstborn
Vaginal birth shifted to C-section
HH wealth shifted to Q4
Mother's education shifted to High
Mother's height shifted to >=155 cm
Sex shifted to Female
HH food security shifted to Food Secure
Father's height shifted to >=167 cm
Excl/Pred breastfed <6mo. shifted to All
Birthweight (kg) shifted to >= 2500 g
Father's education shifted to High
# of children <5 in HH shifted to 1
Diarrhea <6mo. (% days) shifted to 0%
# of rooms in HH shifted to 4+
Rain quartile shifted to Opposite max rain
Persistent wasting <6 mo. shifted to None
Any wasting <6 mo. shifted to None
Enrolled wasted shifted to None
Breastfed hour after birth shifted to All
Single parent shifted to Partnered
Gestational age shifted to Full/late term
Mother's age shifted to [20-30)
Mother's BMI shifted to Normal weight
Father's age shifted to >=38
Safe water source shifted to All
Improved floor shifted to All
# of people in HH shifted to 3 or less
Diarrhea <24mo. (% days) shifted to 0%
-0.5
0.0
0.5
1.0
Attributable difference in LAZ
24 months, Latin America
Father's height shifted to >=167 cm
Birth length (cm) shifted to >=50 cm
Mother's height shifted to >=155 cm
Birth order shifted to Firstborn
HH wealth shifted to Q4
Sex shifted to Female
Father's age shifted to >=38
Mother's weight shifted to >=58 kg
Gestational age shifted to Full/late term
Improved sanitation shifted to All
# of rooms in HH shifted to 4+
Birthweight (kg) shifted to >= 2500 g
Mother's education shifted to High
Rain quartile shifted to Opposite max rain
Improved floor shifted to All
Single parent shifted to Partnered
Mother's BMI shifted to Normal weight
Father's education shifted to High
Any wasting <6 mo. shifted to None
Enrolled wasted shifted to None
Mother's age shifted to [20-30)
Excl/Pred breastfed <6mo. shifted to All
Diarrhea <6mo. (% days) shifted to 0%
Breastfed hour after birth shifted to All
HH food security shifted to Food Secure
Safe water source shifted to All
-0.5
0.0
0.5
1.0
Attributable difference in LAZ
24 months, South Asia
Mother's height shifted to >=155 cm
Birth length (cm) shifted to >=50 cm
Mother's weight shifted to >=58 kg
Father's education shifted to High
# of rooms in HH shifted to 4+
Vaginal birth shifted to C-section
Birth order shifted to Firstborn
Mother's education shifted to High
HH wealth shifted to Q4
Diarrhea <24mo. (% days) shifted to 0%
Clean cooking fuel usage shifted to All
Birthweight (kg) shifted to >= 2500 g
# of people in HH shifted to 3 or less
Gestational age shifted to Full/late term
Improved sanitation shifted to All
# of children <5 in HH shifted to 1
HH food security shifted to Food Secure
Mother's age shifted to [20-30)
Improved floor shifted to All
Sex shifted to Female
Child delivered at home shifted to No
Diarrhea <6mo. (% days) shifted to 0%
Excl/Pred breastfed <6mo. shifted to All
Any wasting <6 mo. shifted to None
Mother's BMI shifted to Normal weight
Persistent wasting <6 mo. shifted to None
Safe water source shifted to All
Single parent shifted to Partnered
Enrolled wasted shifted to None
Father's age shifted to >=38
Breastfed hour after birth shifted to All
Rain quartile shifted to Opposite max rain
-0.5
0.0
0.5
1.0
Attributable difference in LAZ

Extended Data Figure 7 | Region-stratified population attributable differences in length-for-age Z-scores estimated using fixed effects.


Attributable difference - WLZ, stratified by region
24 months, Africa
Vaginal birth shifted to C-section
Diarrhea <24mo. (% days) shifted to 0%
Birth order shifted to Firstborn
HH wealth shifted to Q4
Rain quartile shifted to Opposite max rain
Birth length (cm) shifted to >=50 cm
Mother's education shifted to High
Father's age shifted to >=38
Excl/Pred breastfed <6mo. shifted to All
Mother's weight shifted to >=58 kg
# of children <5 in HH shifted to 1
Father's education shifted to High
Sex shifted to Female
Birthweight (kg) shifted to >= 2500 g
Safe water source shifted to All
# of people in HH shifted to 3 or less
Breastfed hour after birth shifted to All
# of rooms in HH shifted to 4+
Diarrhea <6mo. (% days) shifted to 0%
Mother's BMI shifted to Normal weight
Mother's height shifted to >=155 cm
Improved floor shifted to All
Single parent shifted to Partnered
Gestational age shifted to Full/late term
Mother's age shifted to [20-30)
Father's height shifted to >=167 cm
HH food security shifted to Food Secure
-0.5
0.0
0.5
Attributable difference in WLZ
24 months, Latin America
Mother's weight shifted to >=58 kg
Birth length (cm) shifted to >=50 cm
Father's height shifted to >=167 cm
Gestational age shifted to Full/late term
# of rooms in HH shifted to 4+
HH wealth shifted to Q4
Mother's height shifted to >=155 cm
Birthweight (kg) shifted to >= 2500 g
Mother's education shifted to High
Father's age shifted to >=38
Rain quartile shifted to Opposite max rain
Sex shifted to Female
Birth order shifted to Firstborn
Single parent shifted to Partnered
Mother's BMI shifted to Normal weight
Improved sanitation shifted to All
Improved floor shifted to All
Mother's age shifted to [20-30)
Excl/Pred breastfed <6mo. shifted to All
Breastfed hour after birth shifted to All
Diarrhea <6mo. (% days) shifted to 0%
Safe water source shifted to All
Father's education shifted to High
HH food security shifted to Food Secure
-0.5
0.0
0.5
Attributable difference in WLZ
24 months, South Asia
Mother's weight shifted to >=58 kg
Birth length (cm) shifted to >=50 cm
Rain quartile shifted to Opposite max rain
Mother's height shifted to >=155 cm
# of rooms in HH shifted to 4+
Vaginal birth shifted to C-section
Birthweight (kg) shifted to >= 2500 g
Birth order shifted to Firstborn
Father's education shifted to High
Mother's education shifted to High
Clean cooking fuel usage shifted to All
# of people in HH shifted to 3 or less
HH wealth shifted to Q4
Mother's BMI shifted to Normal weight
Sex shifted to Female
Gestational age shifted to Full/late term
HH food security shifted to Food Secure
Father's age shifted to >=38
Improved sanitation shifted to All
Improved floor shifted to All
Diarrhea <6mo. (% days) shifted to 0%
Mother's age shifted to [20-30)
Child delivered at home shifted to No
# of children <5 in HH shifted to 1
Safe water source shifted to All
Single parent shifted to Partnered
Excl/Pred breastfed <6mo. shifted to All
Breastfed hour after birth shifted to All
Diarrhea <24mo. (% days) shifted to 0%
-0.5
0.0
0.5
Attributable difference in WLZ

Extended Data Figure 8 | Region-stratified population attributable differences in weight-for-length Z-scores estimated using fixed effects.

Chapter 5

Unadjusted RF plots

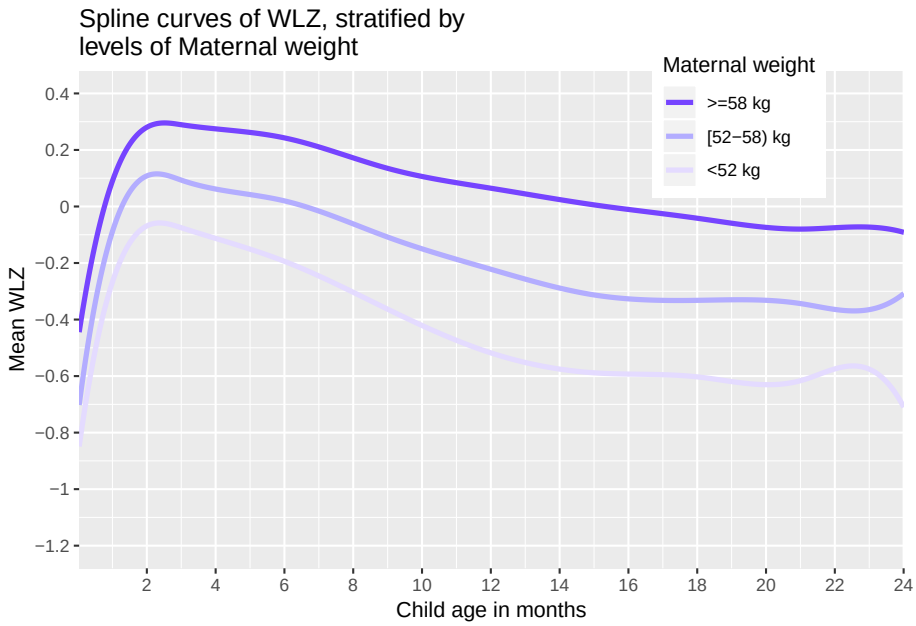
** [TEMP] Will fill in with all primary plots, unadjusted **

Chapter 6

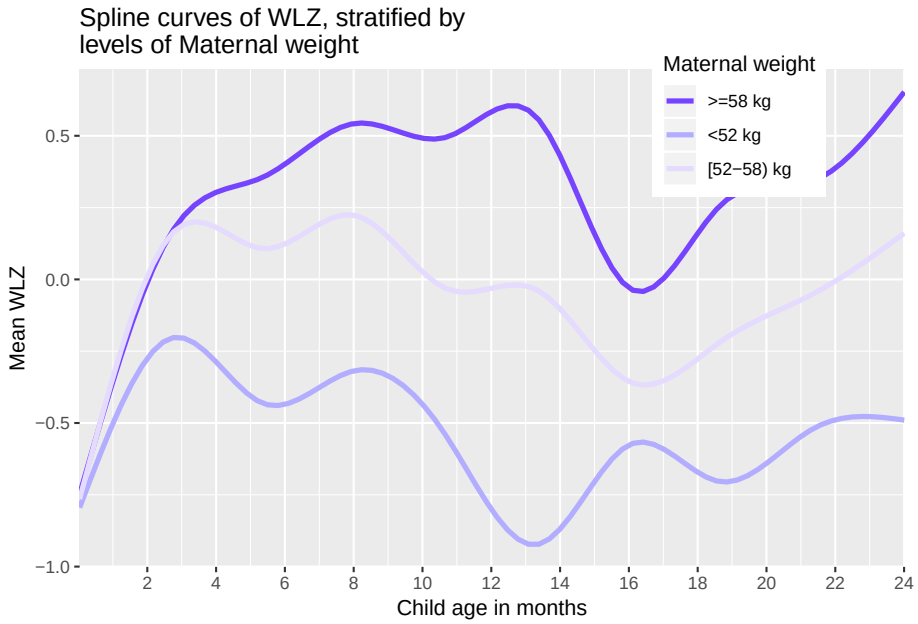
Sensitivity analysis of spline-fitting method

6.1 WLZ, stratified by maternal weight

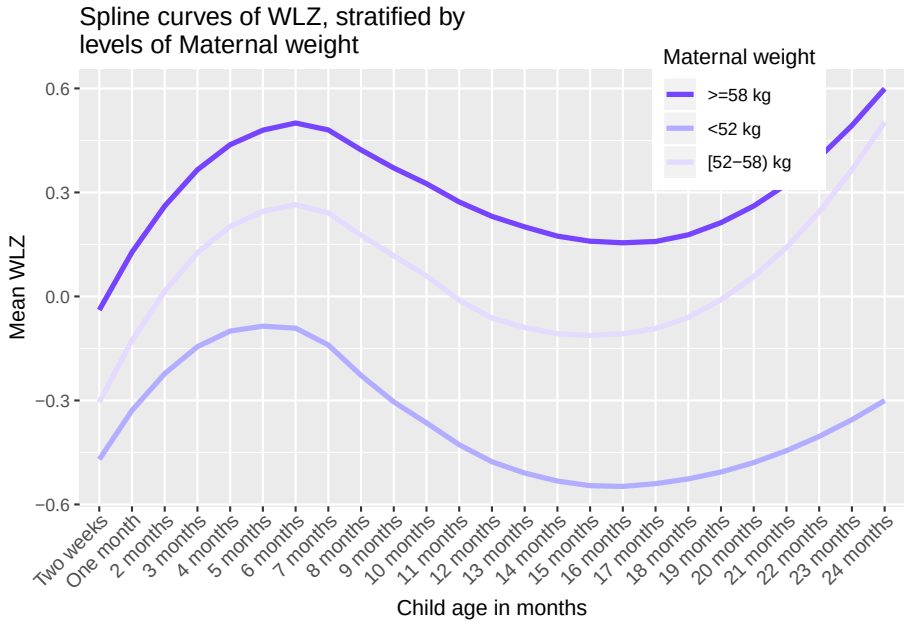
6.1.0.1 Primary plots



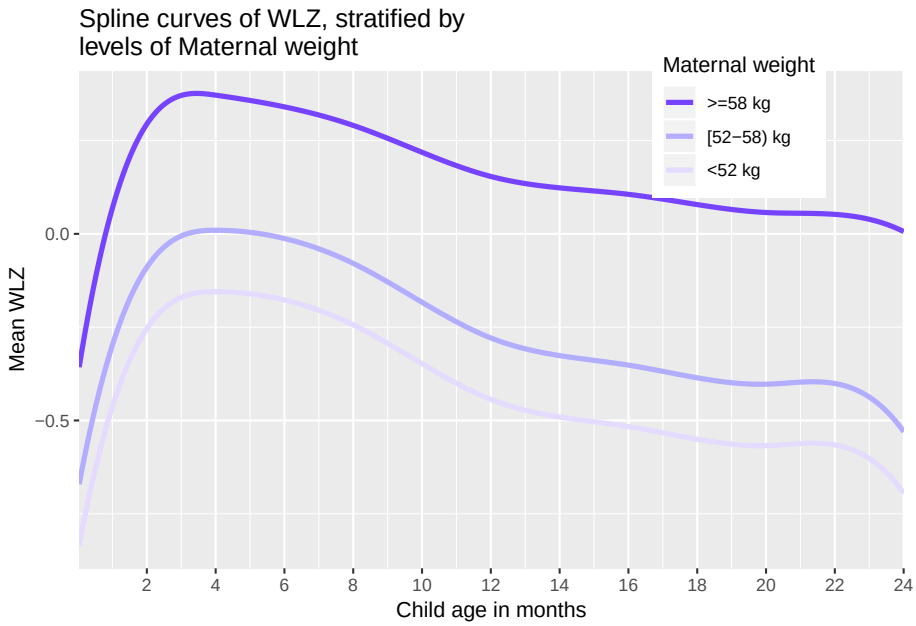
6.1.0.2 Splines fit to all data, naive to study membership



6.1.0.3 Splines fit to random-effect pooled monthly means

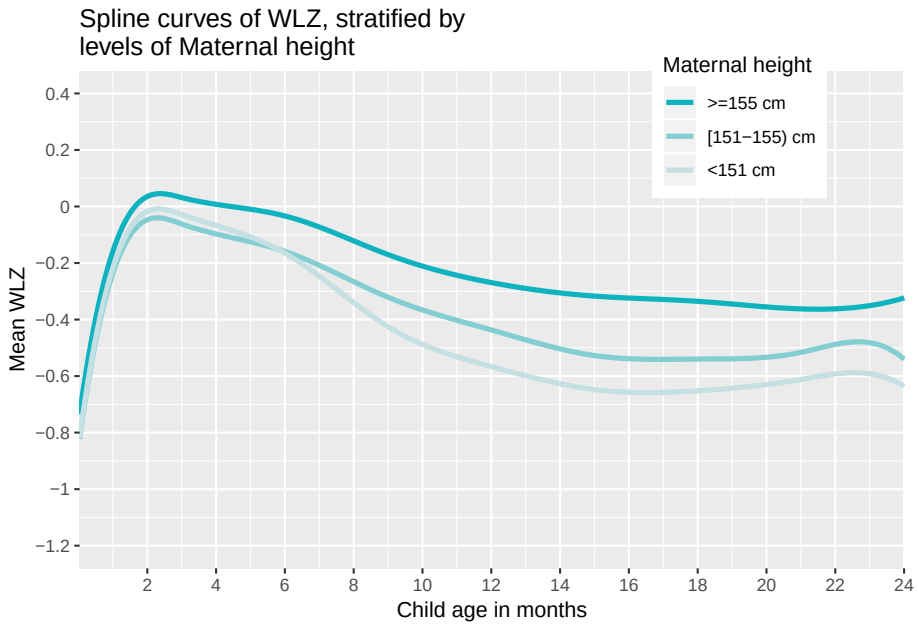


6.1.0.4 Random-effects meta-analysis of splines, sensitivity to parameters

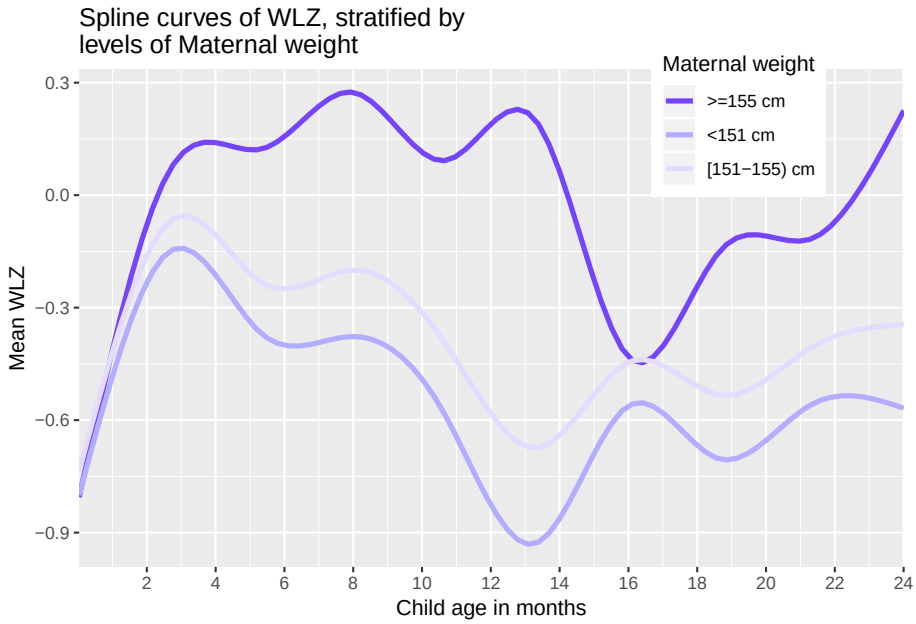


6.2 WLZ, stratified by maternal height

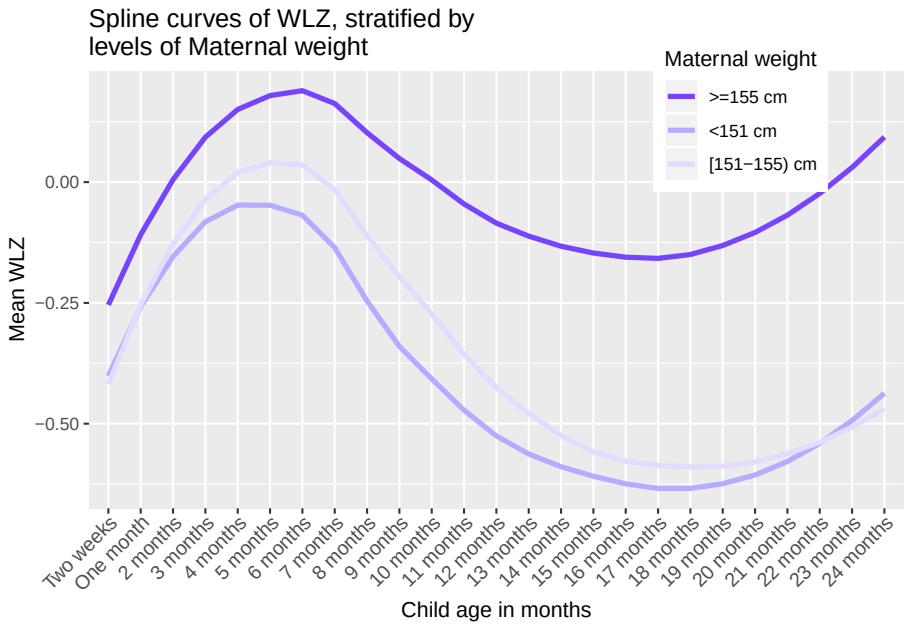
6.2.0.1 Primary plots



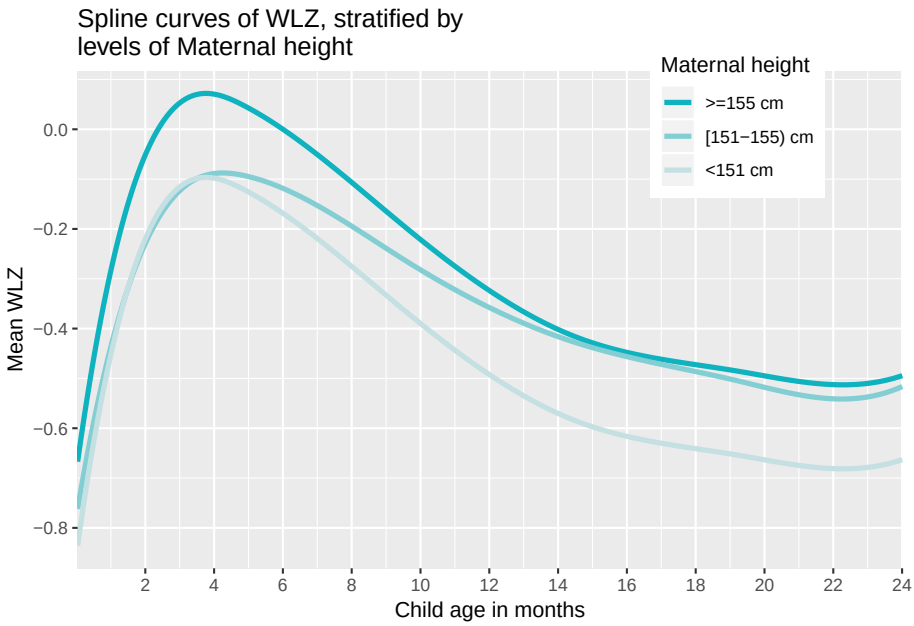
6.2.0.2 Splines fit to all data, naive to study membership



6.2.0.3 Splines fit to random-effect pooled monthly means

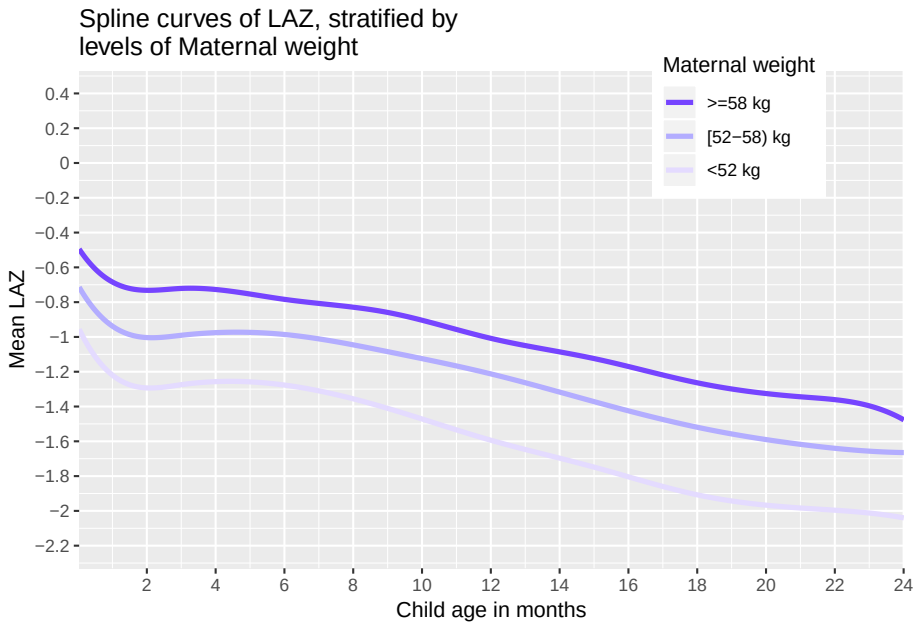


6.2.0.4 Random-effects meta-analysis of splines, sensitivity to parameters

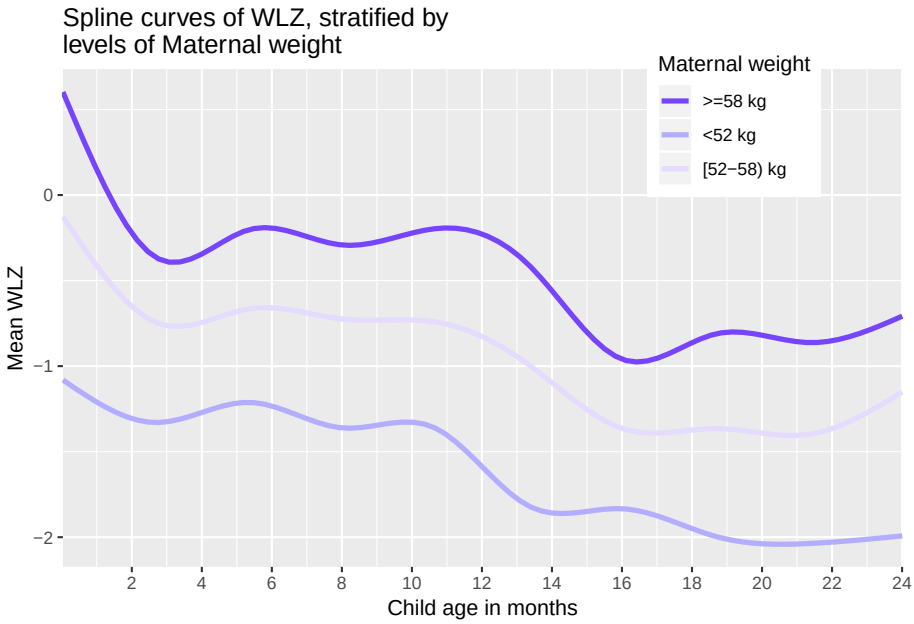


6.3 LAZ, stratified by maternal weight

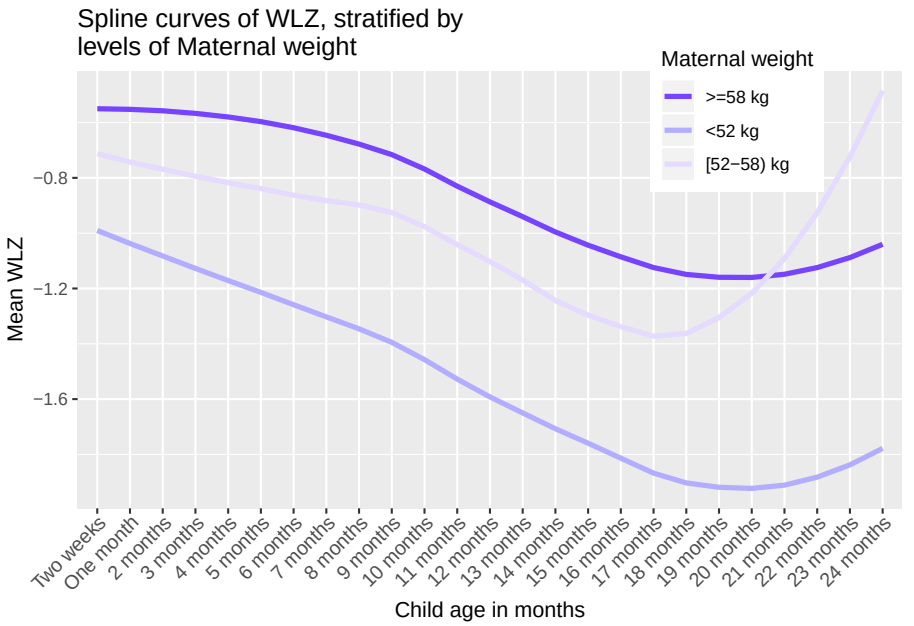
6.3.0.1 Primary plots



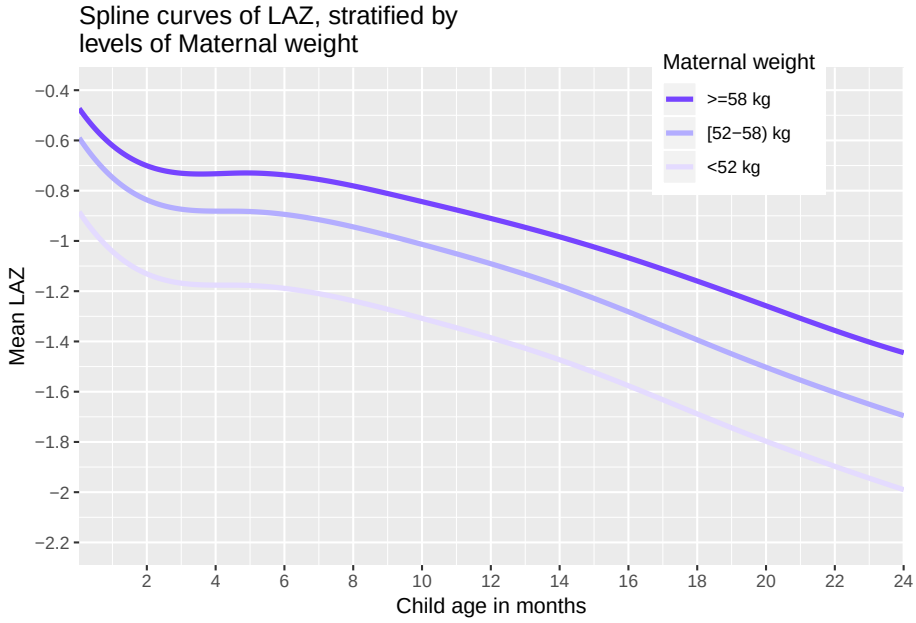
6.3.0.2 Splines fit to all data, naive to study membership



6.3.0.3 Splines fit to random-effect pooled monthly means



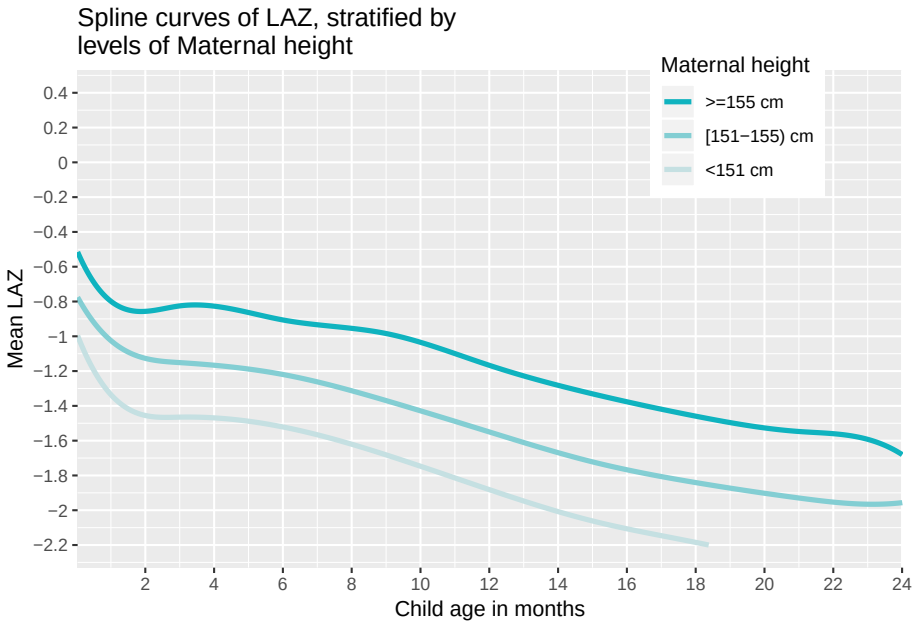
6.3.0.4 Random-effects meta-analysis of splines, sensitivity to parameters



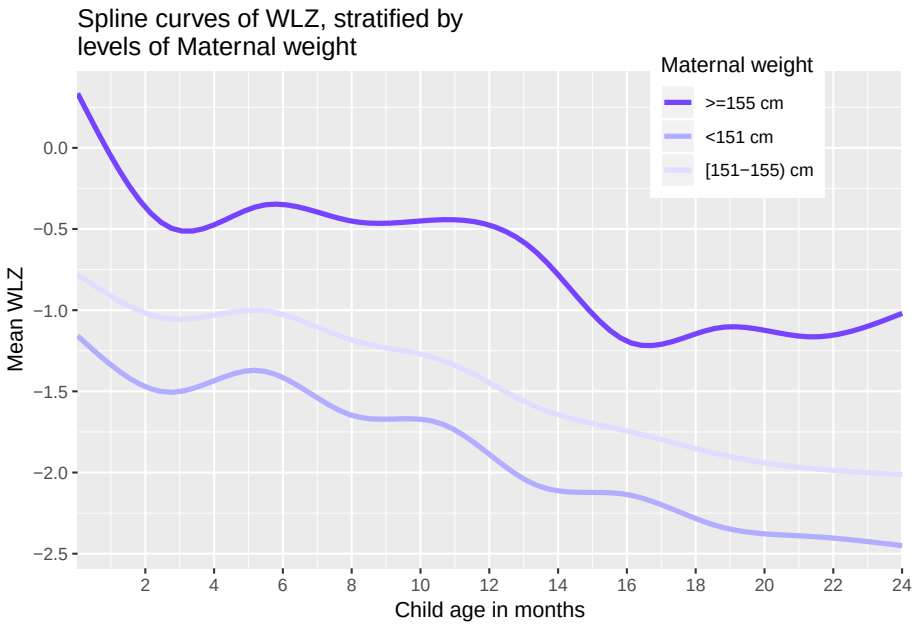
6.4 LAZ, stratified by maternal height

6.4.0.1 Primary plots

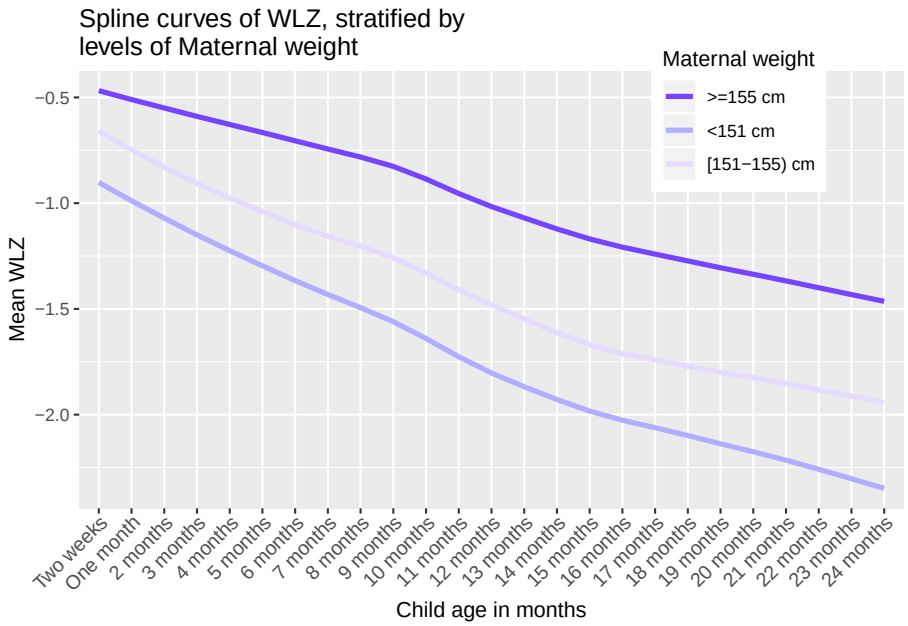
```
## Warning: Removed 1711 rows containing missing values (geom_path).
```



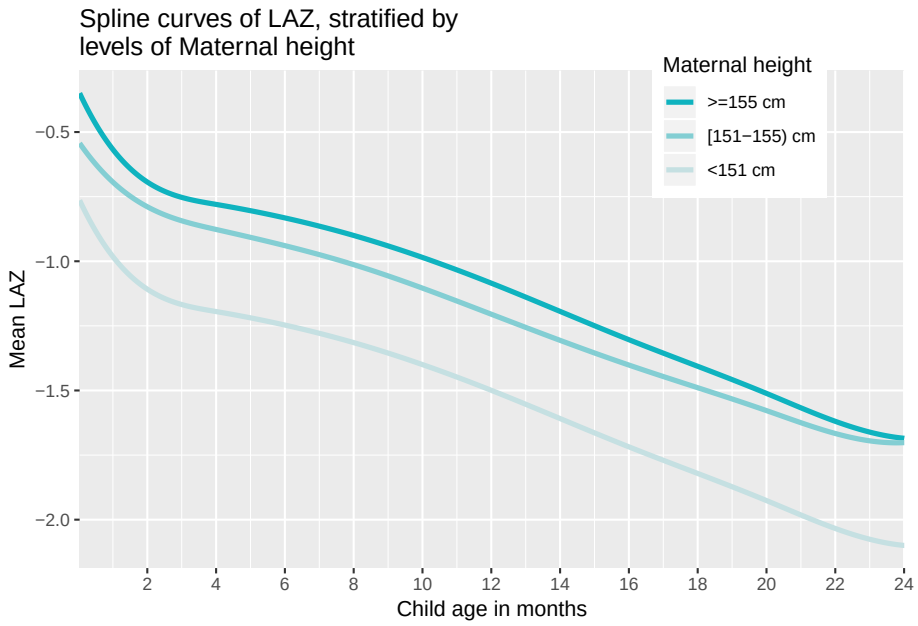
6.4.0.2 Splines fit to all data, naive to study membership



6.4.0.3 Splines fit to random-effect pooled monthly means



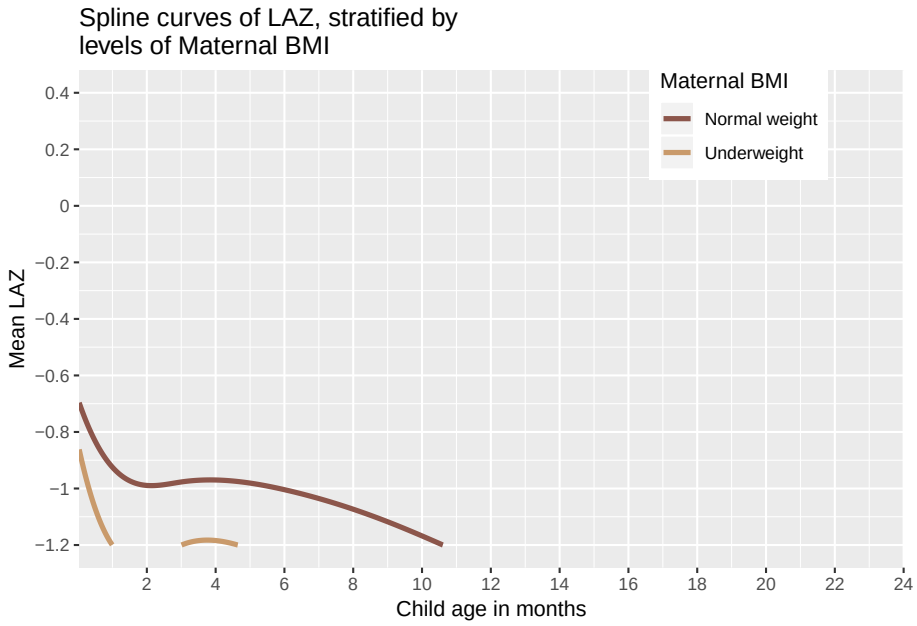
6.4.0.4 Random-effects meta-analysis of splines, sensitivity to parameters



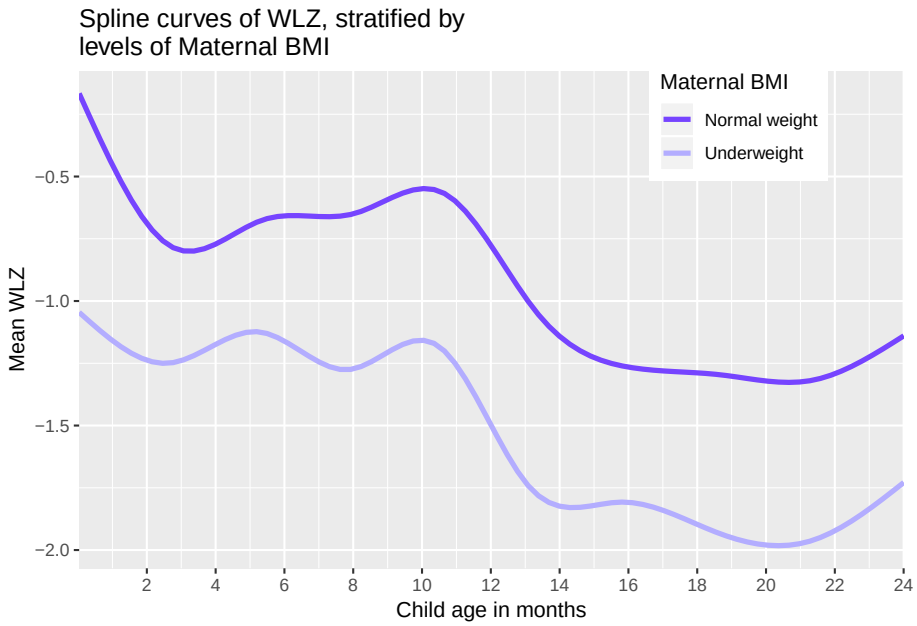
6.5 WLZ, stratified by maternal BMI

6.5.0.1 Primary plots

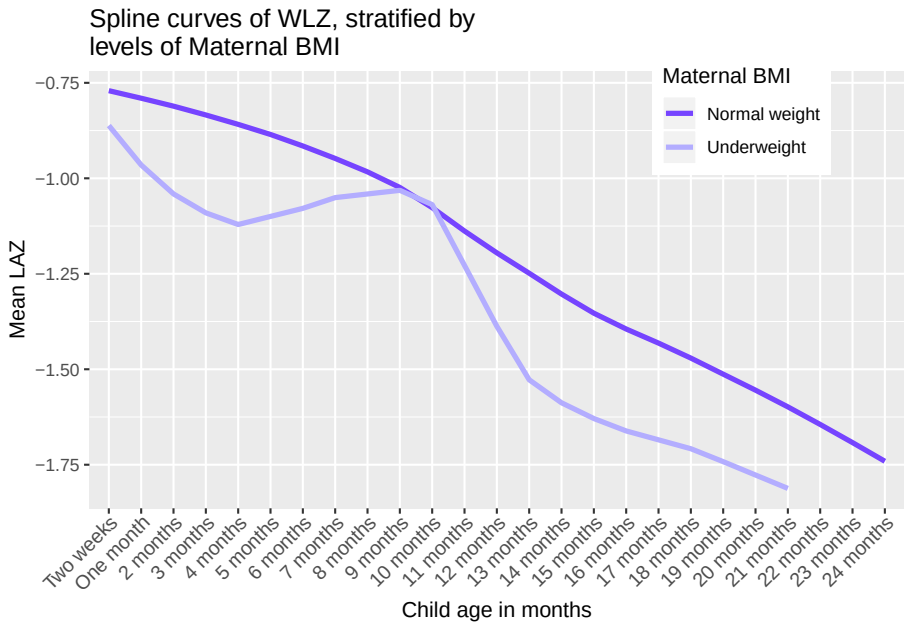
```
## Warning: Removed 9963 rows containing missing values (geom_path).
```



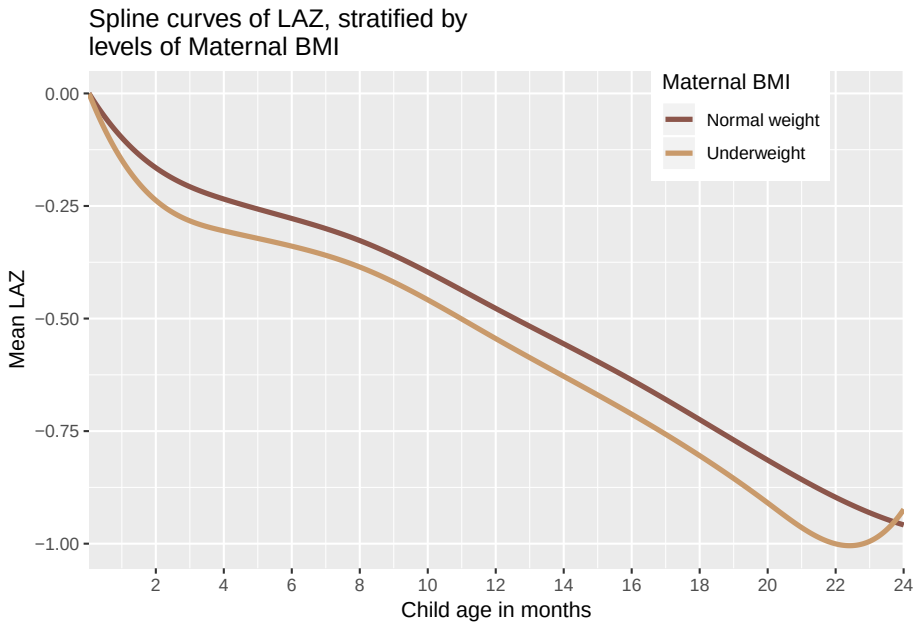
6.5.0.2 Splines fit to all data, naive to study membership



6.5.0.3 Splines fit to random-effect pooled monthly means

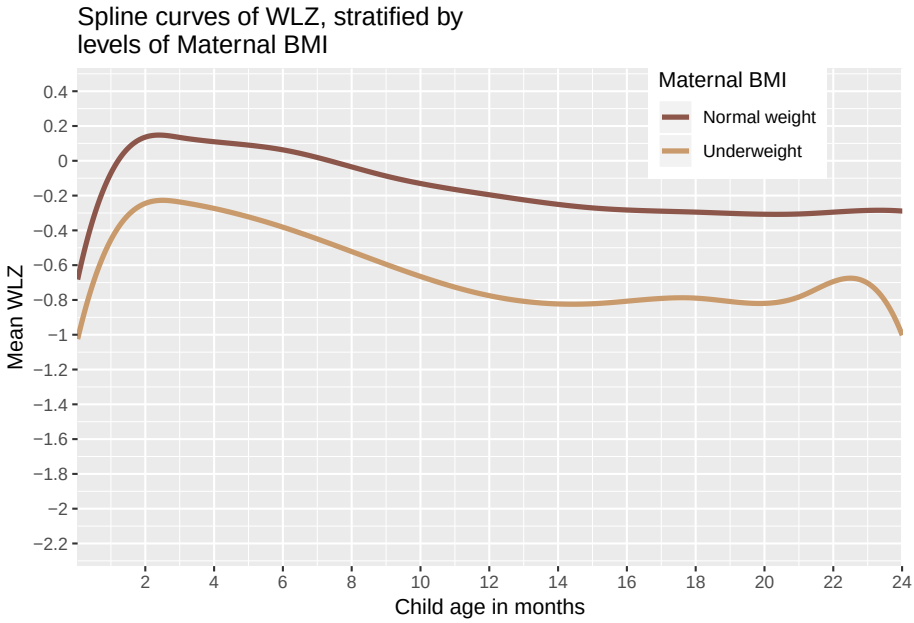


6.5.0.4 Random-effects meta-analysis of splines, sensitivity to parameters



6.6 LAZ, stratified by maternal BMI

6.6.0.1 Primary plots



6.6.0.2 Splines fit to all data, naive to study membership

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## Warning: Removed 195133 rows containing non-finite values (stat_smooth).
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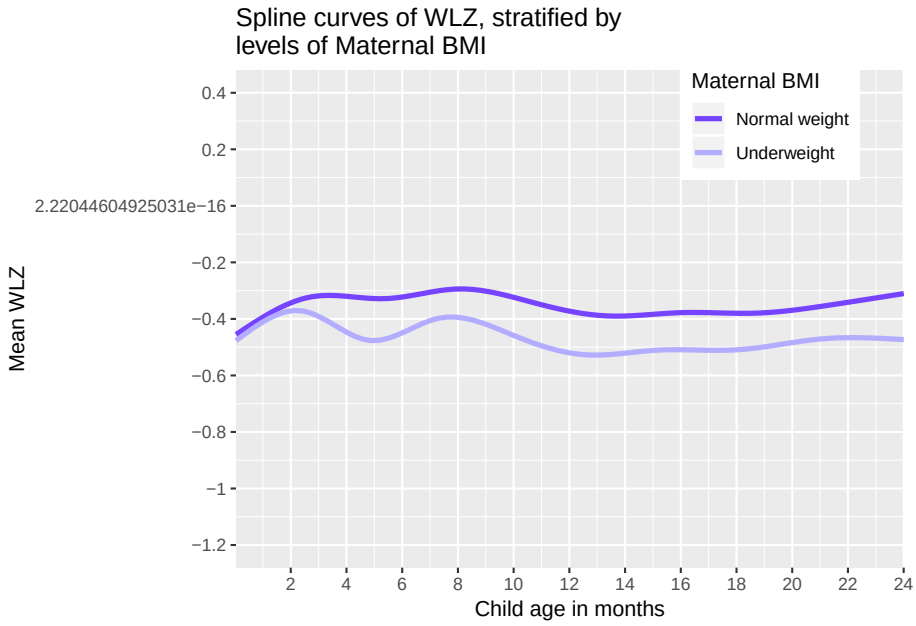
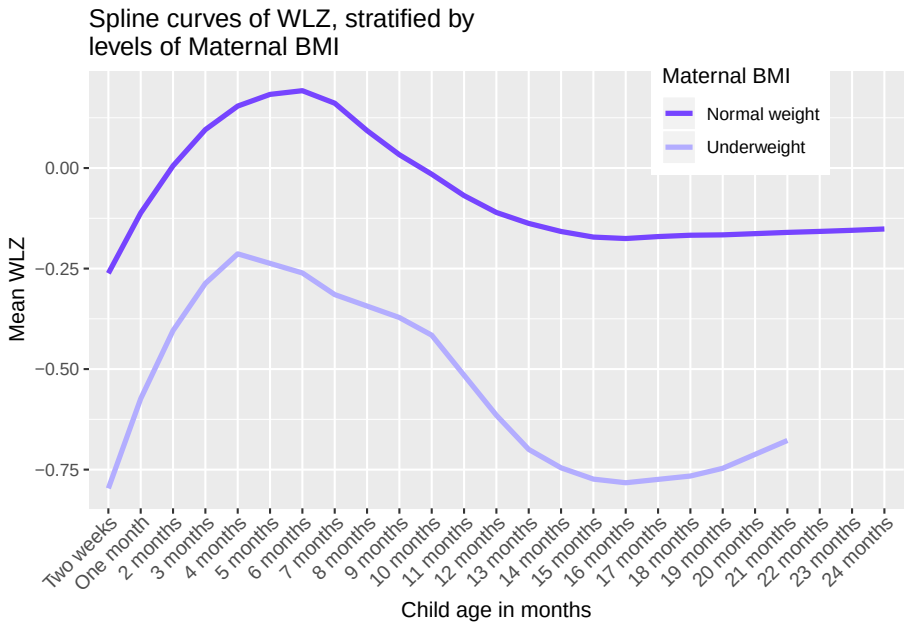
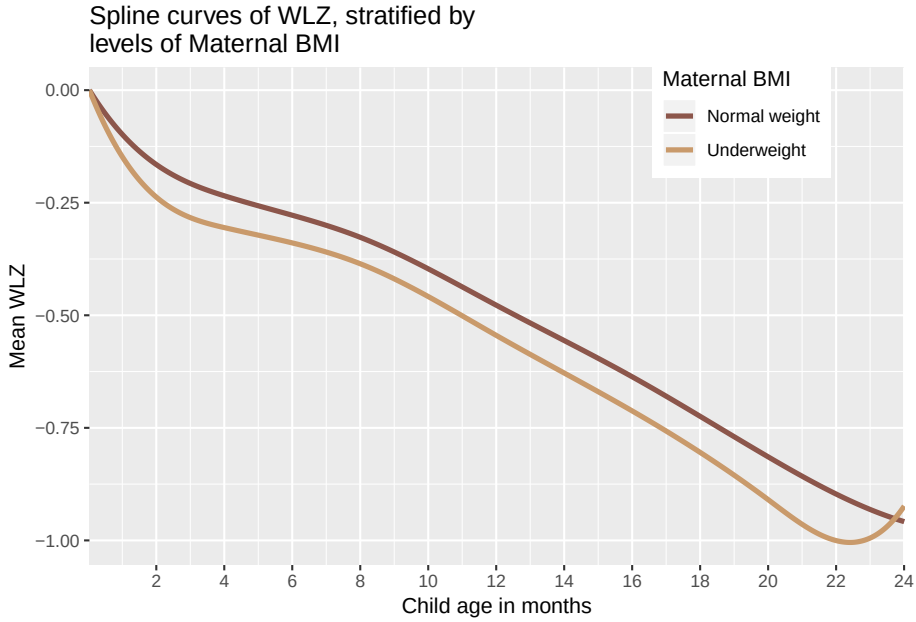


6.6.0.3 Splines fit to random-effect pooled monthly means



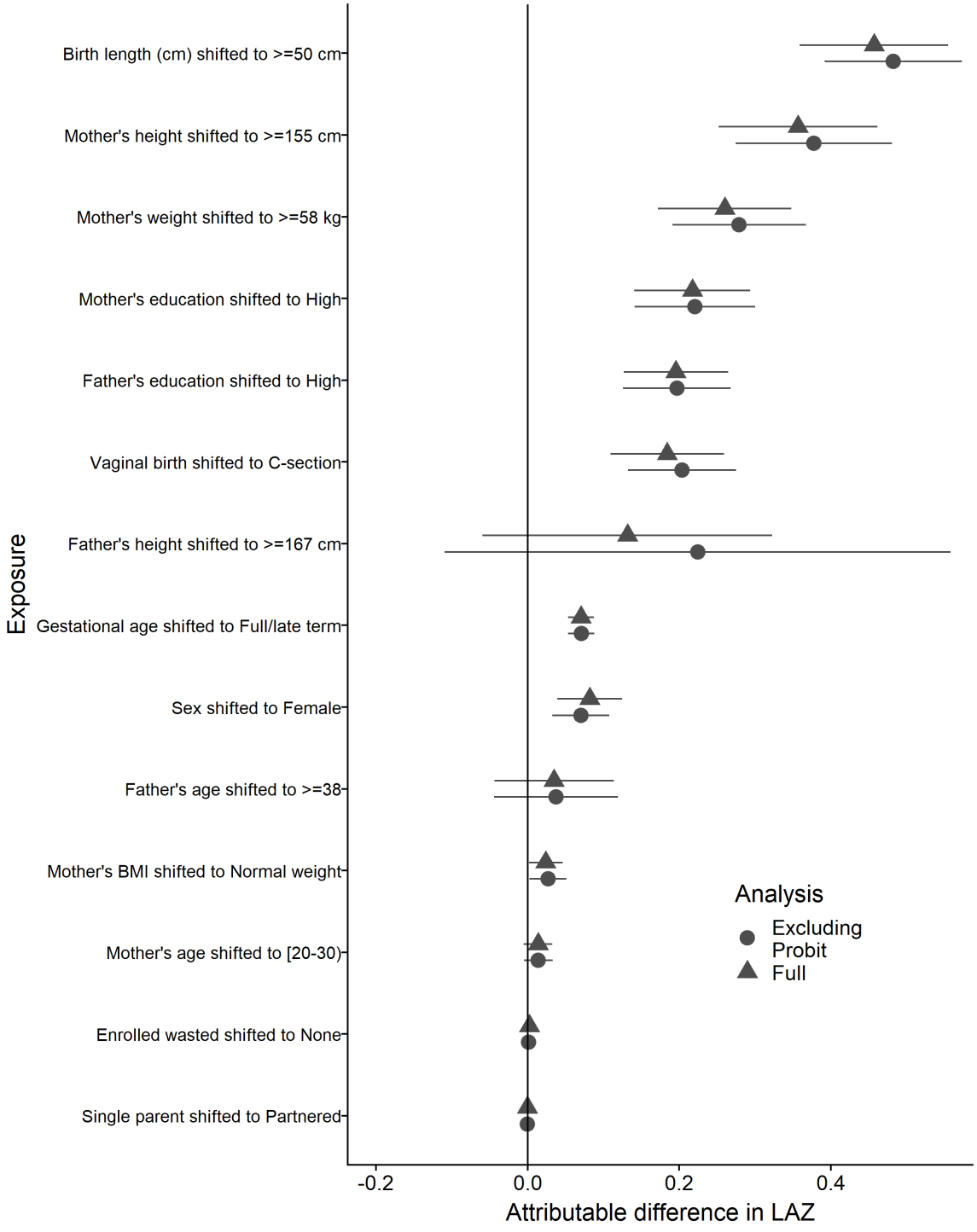
6.6.0.4 Random-effects meta-analysis of splines, sensitivity to parameters



Chapter 7

Dropping PROBIT Trial

The PROBIT randomized control trial, conducted in Belarus, is the only study from Europe included in the manuscript "Causes and consequences of child growth faltering in low resource settings". While Belarus was a middle-income country during the 1990's the environmental and nutritional conditions, as well as infectious diseases patterns, are different from other included studies from South Asia, Africa, and Latin America, and prevalence of stunting and wasting was far lower. Here, we examine random-effects pooled attributable differences in LAZ and WLZ at 24 months (the analysis presented in Figure 2 of the primary manuscript), calculated with and without estimates from the PROBIT trial. Only exposures measured in the PROBIT trial are included. While point estimates and rank ordering of risk factors vary slightly after excluding PROBIT, the changes are not consequential.

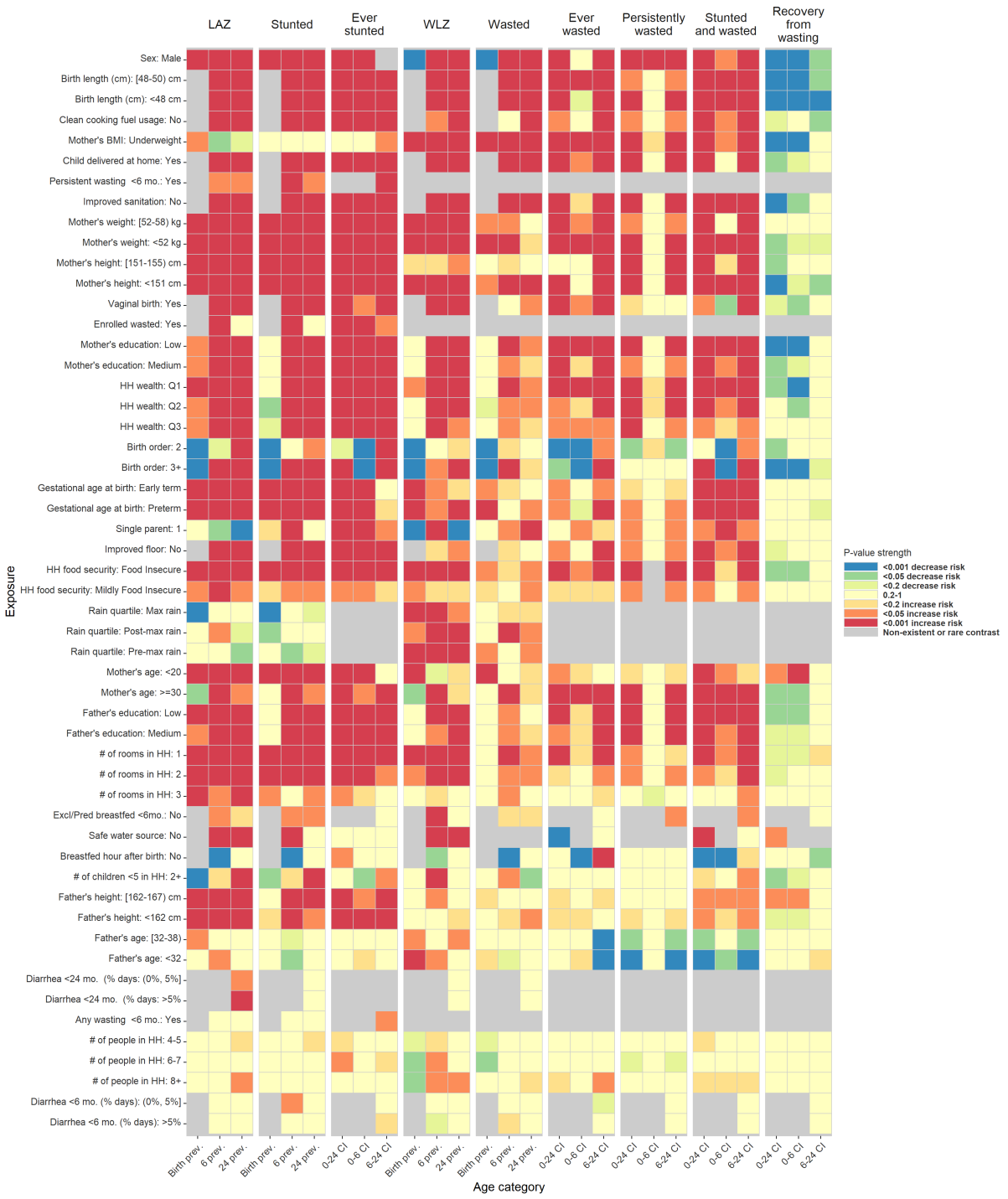

Birth length (cm) shifted to >=50 cm
Mother's height shifted to >=155 cm
Mother's weight shifted to >=58 kg
Mother's education shifted to High
Father's education shifted to High
Vaginal birth shifted to C-section
Father's height shifted to >=167 cm
Gestational age shifted to Full/late term
Sex shifted to Female
Father's age shifted to >=38
Mother's BMI shifted to Normal weight
Mother's age shifted to [20-30)
Enrolled wasted shifted to None
Single parent shifted to Partnered
Exposure
Analysis
Excluding
Probit
Full
-0.2
0.0
0.2
0.4
Attributable difference in LAZ

Chapter 8

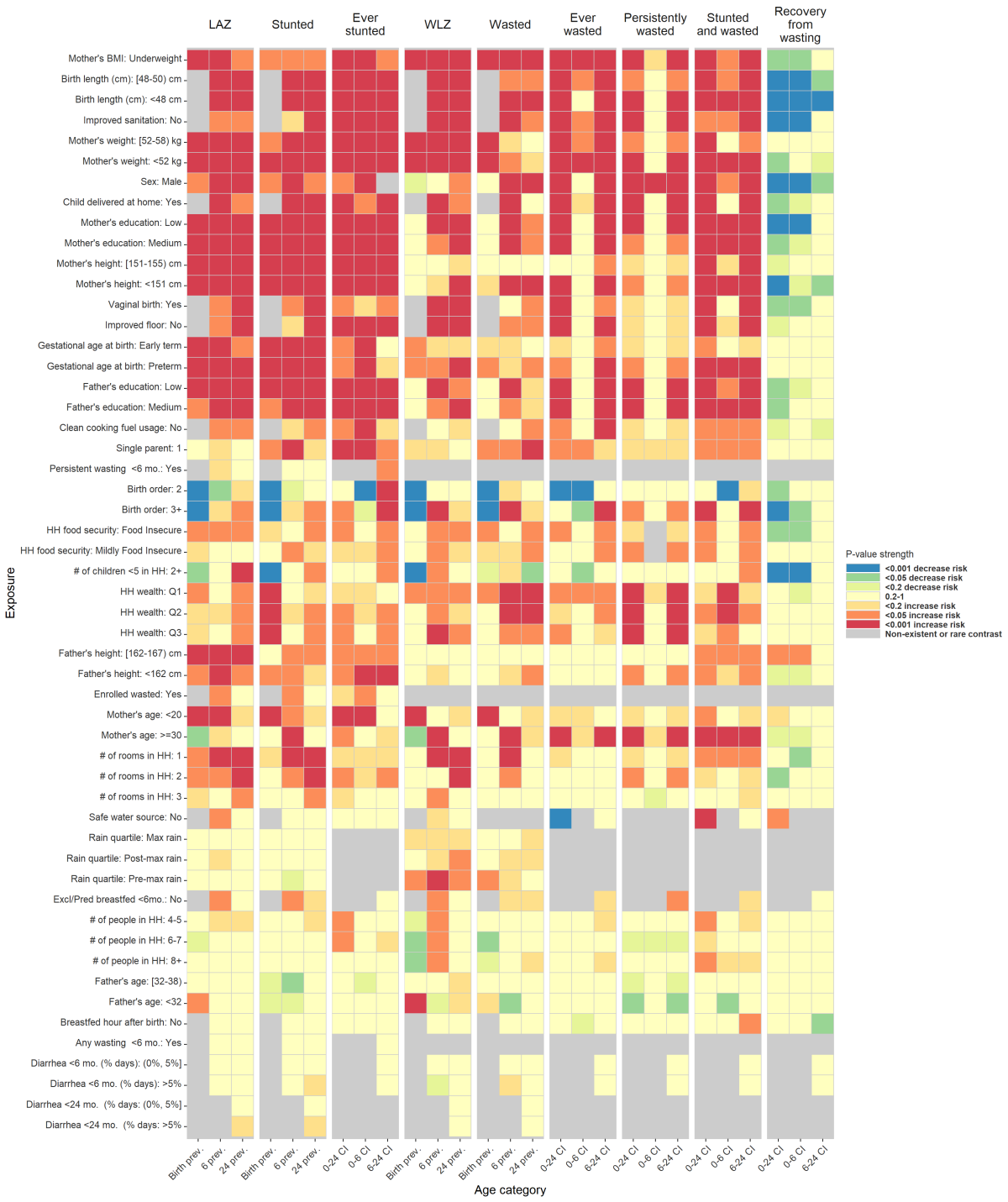
Heatmaps

8.1 Heatmap of significance of estimates, region stratified

8.2 Heatmap of significance of estimates pooled using fixed effects



8.3 Heatmap of significance of estimate, unadjusted

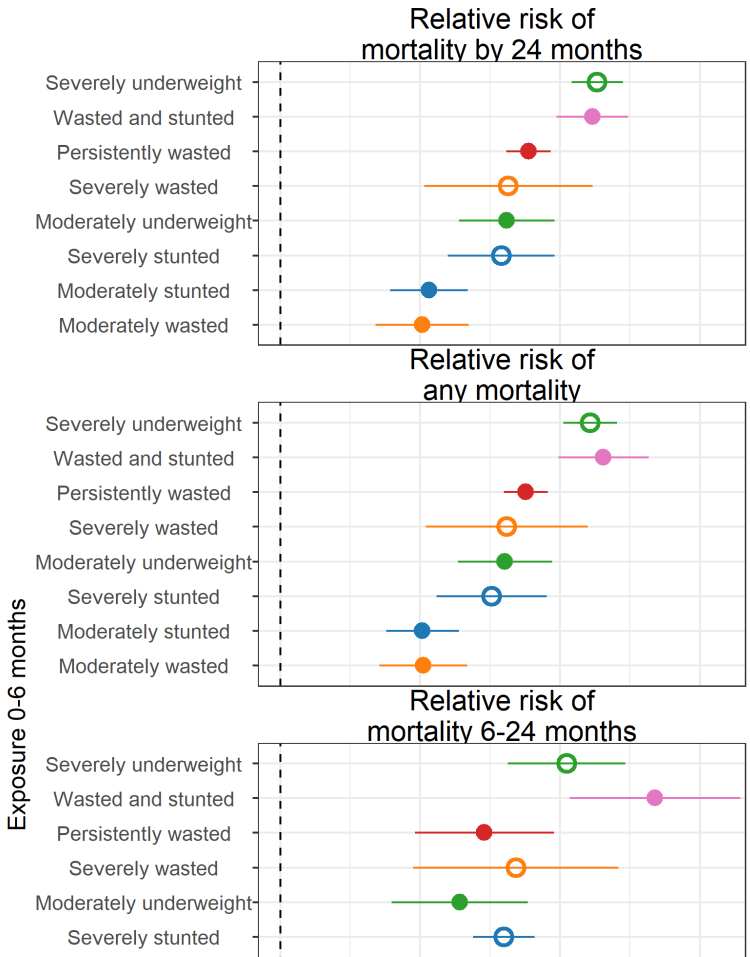


Chapter 9

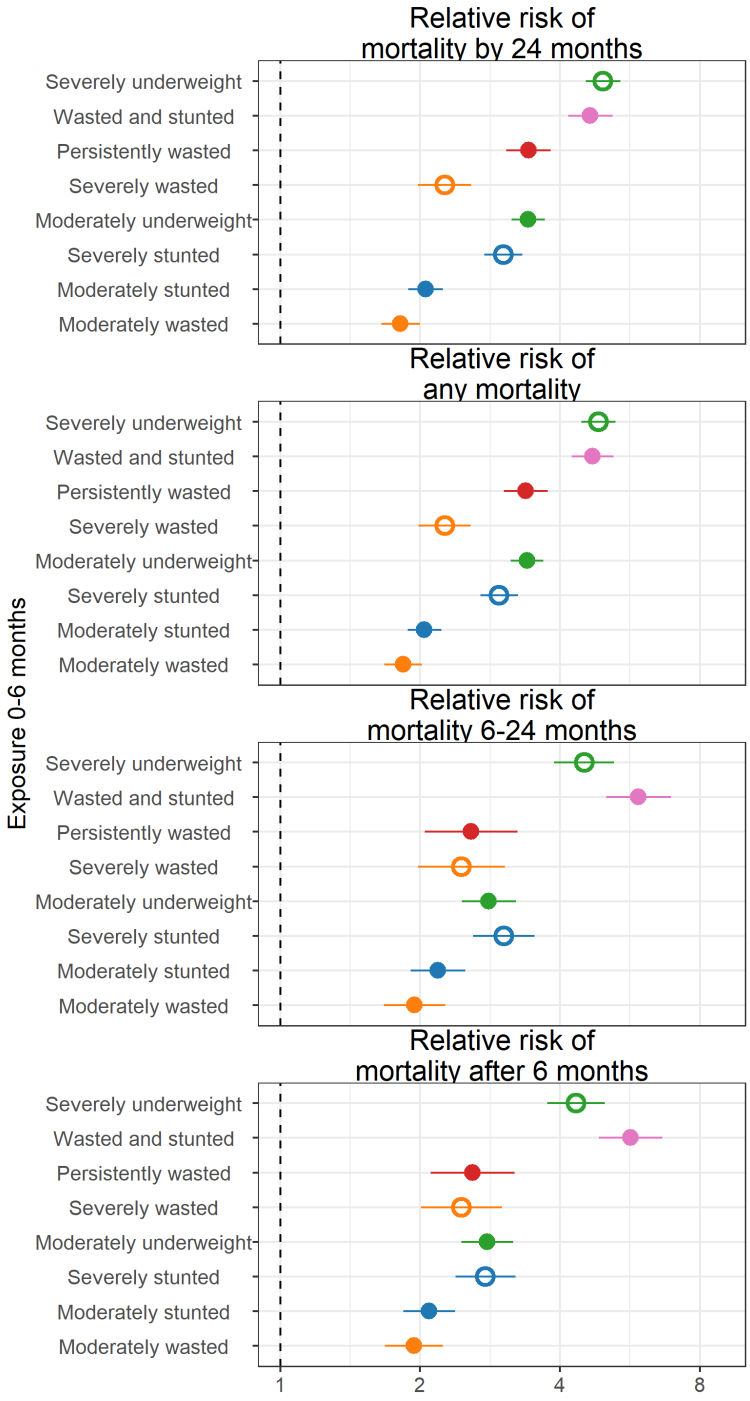
KI Kaplan-Meier Survival Curves

9.1 Associations between early growth failure and mortality

9.1.1 Random Effects Pooling

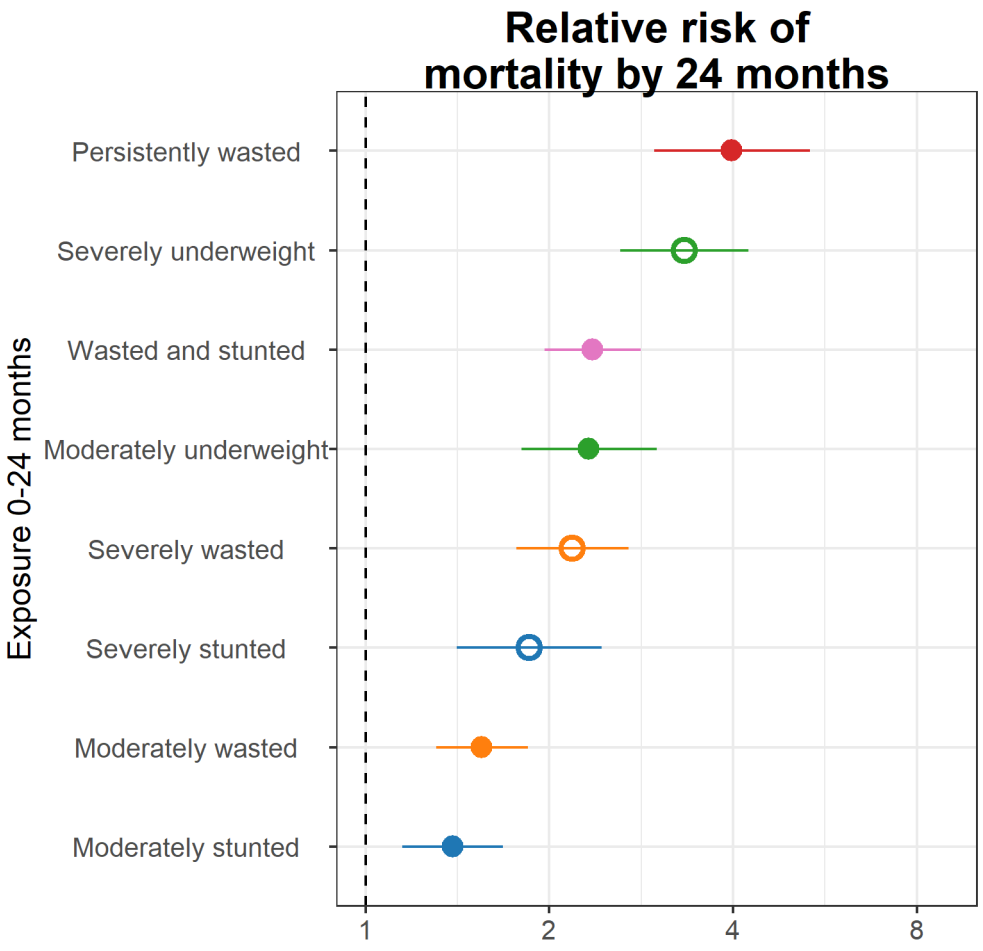


9.1.2 Fixed Effects Pooling

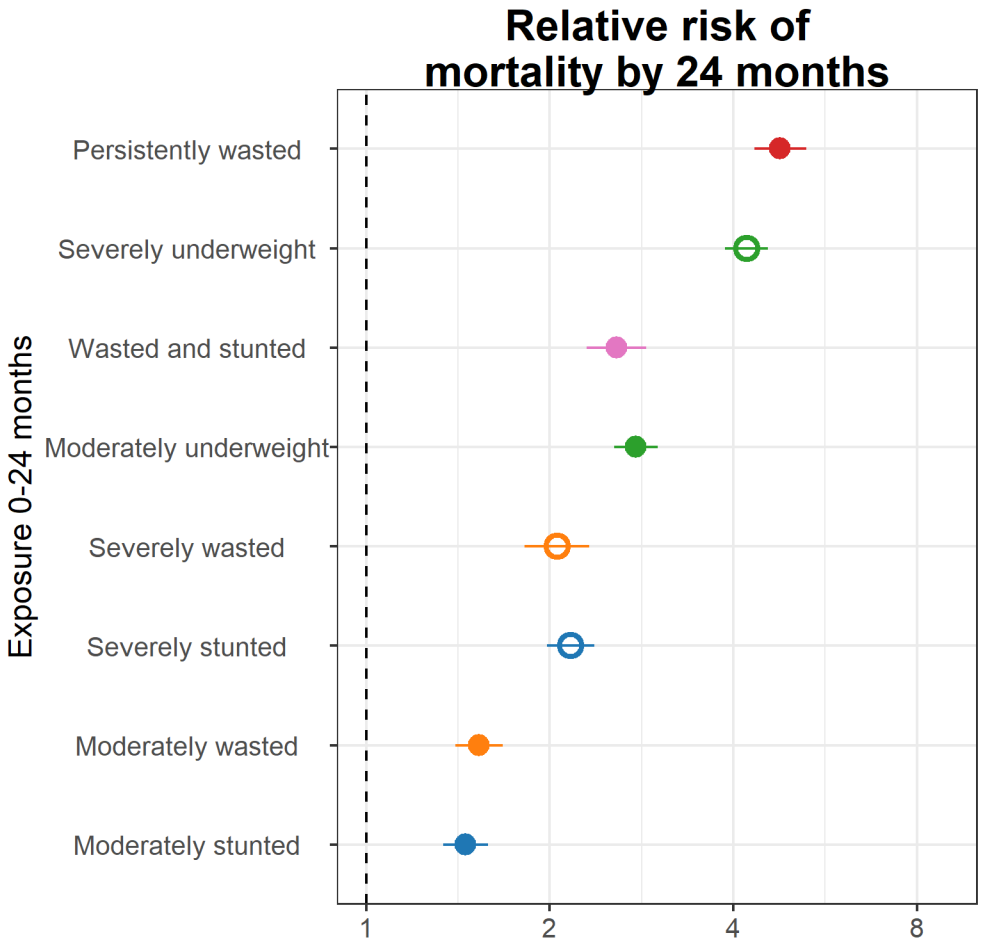


9.2 Associations between any growth failure and mortality

9.2.1 Random Effects Pooling

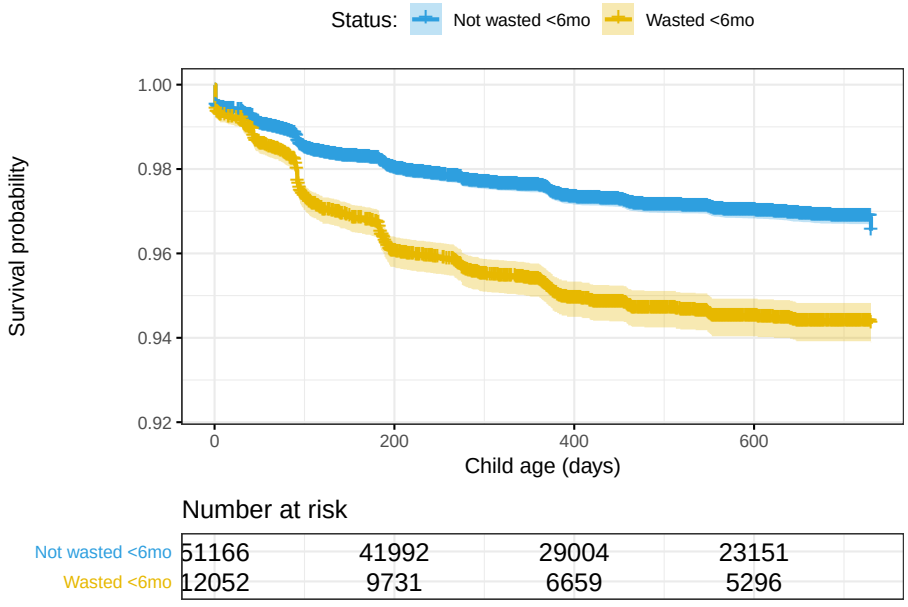


9.2.2 Fixed Effects Pooling

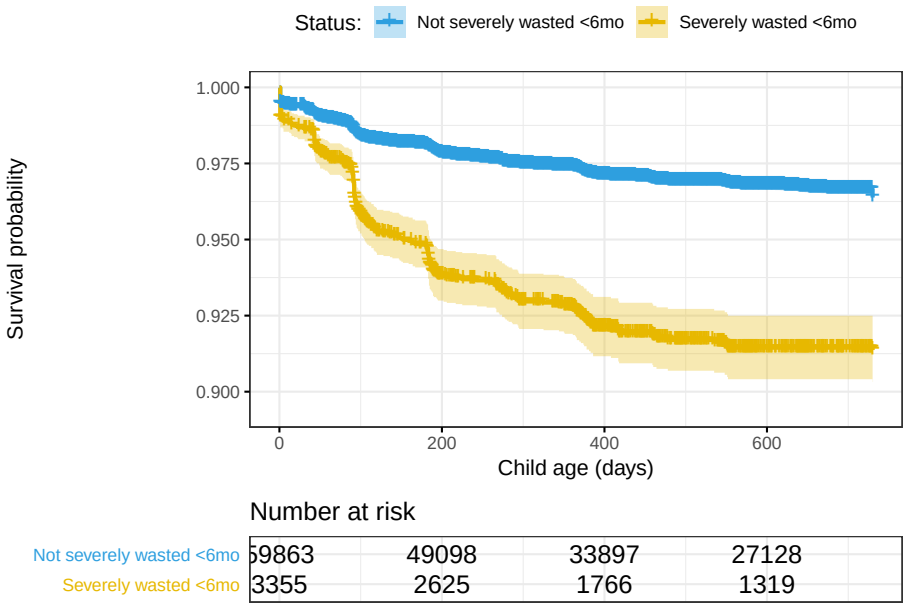


9.3 Kaplan-Meier curves

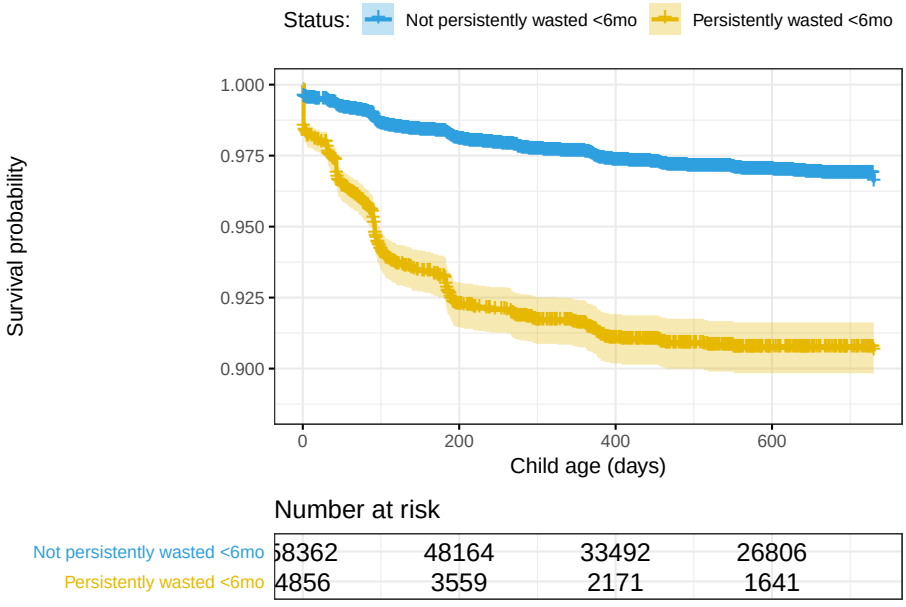
9.3.1 Wasting under 6mo



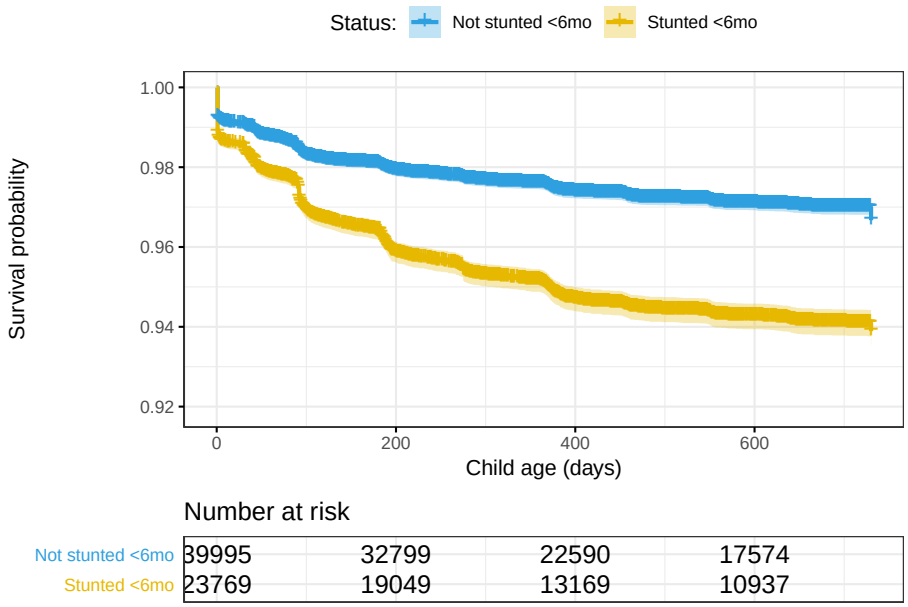
9.3.2 Severe wasting under 6mo



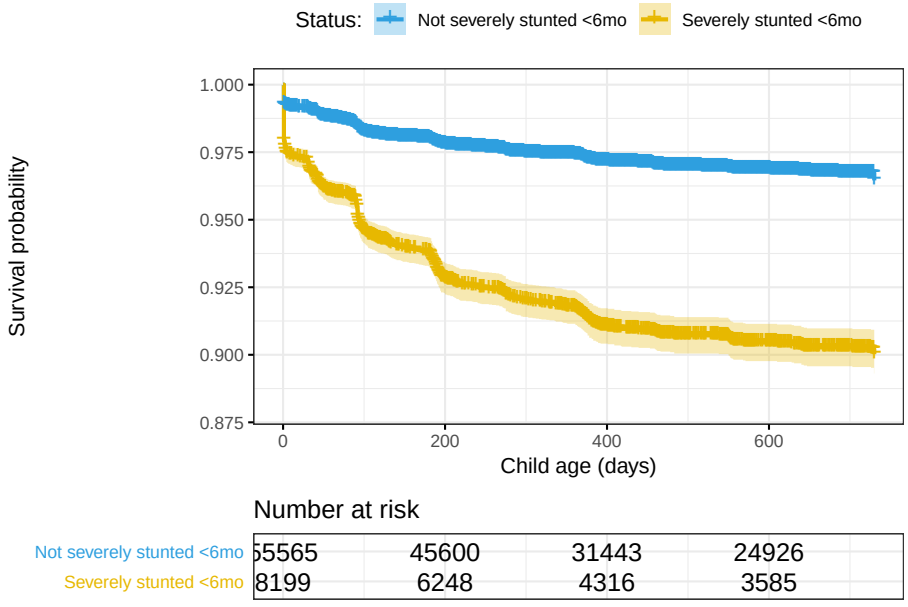
9.3.3 Persistent wasting under 6mo



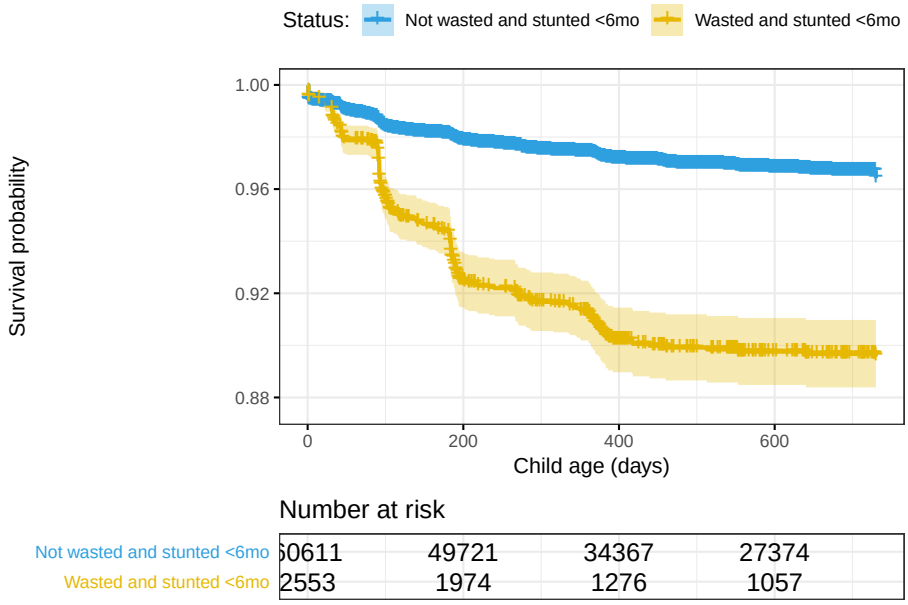
9.3.4 Stunting under 6mo



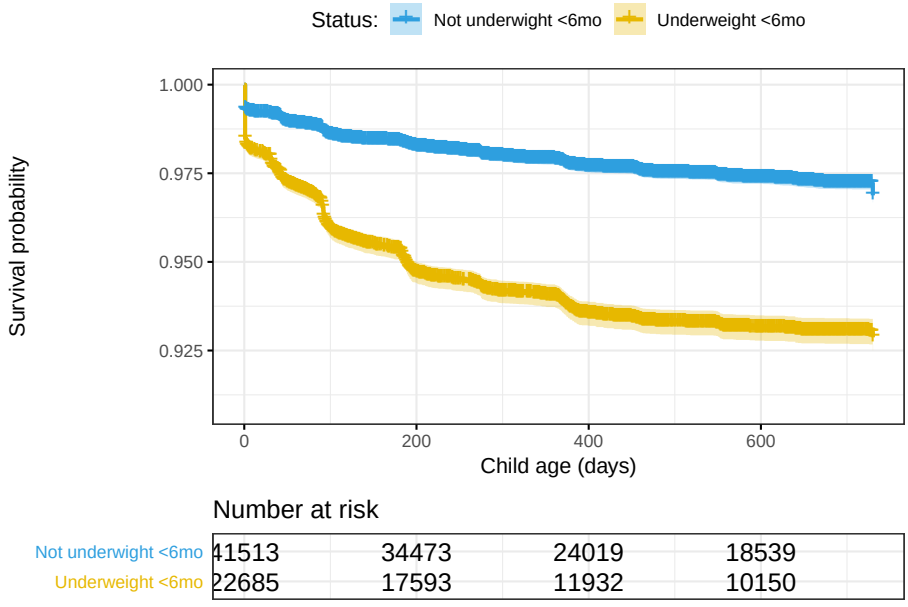
9.3.5 Severe stunting under 6mo



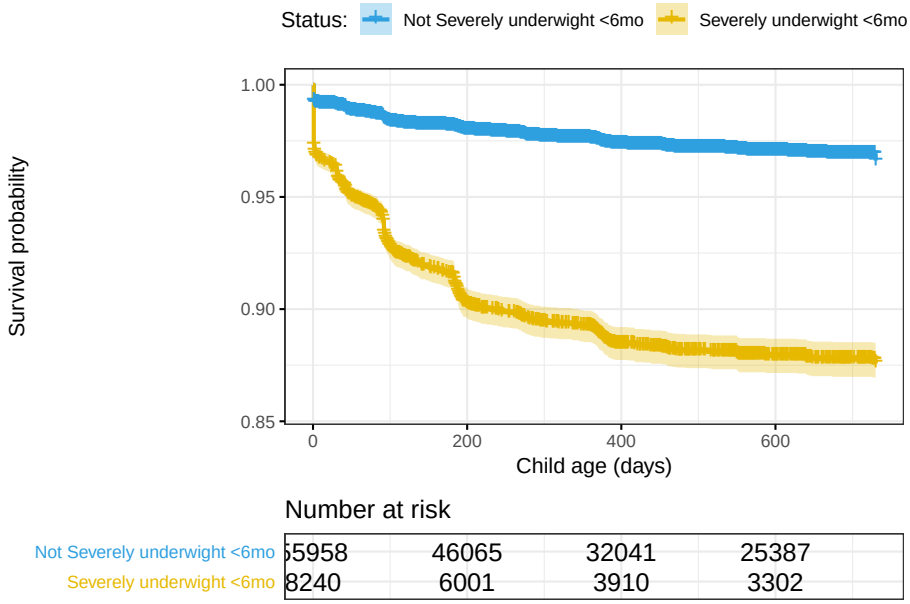
9.3.6 Wasted and stunted under 6mo



9.3.7 Underweight under 6mo



9.3.8 Severe underweight under 6mo



Chapter 10

Forest plots of relative risk

** [TEMP] Will fill in with all primary forest plots - right now just printing one for space/speed of publishing **