

Evidence on risk factors of stunting

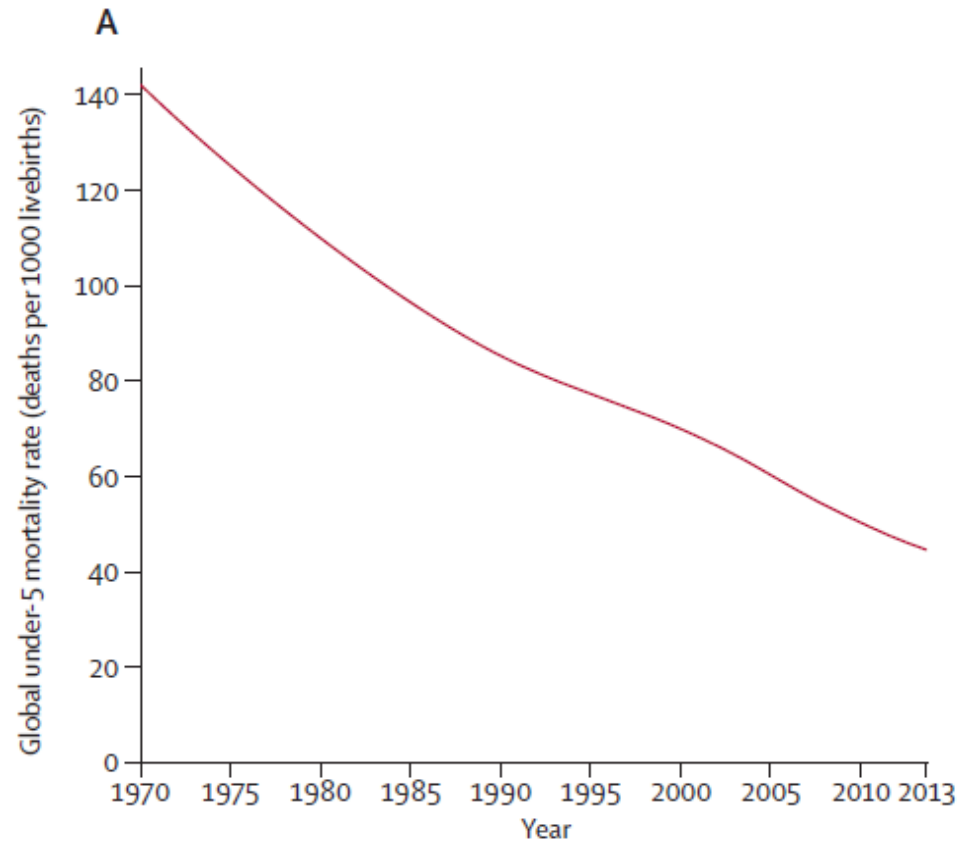
Goodarz Danaei

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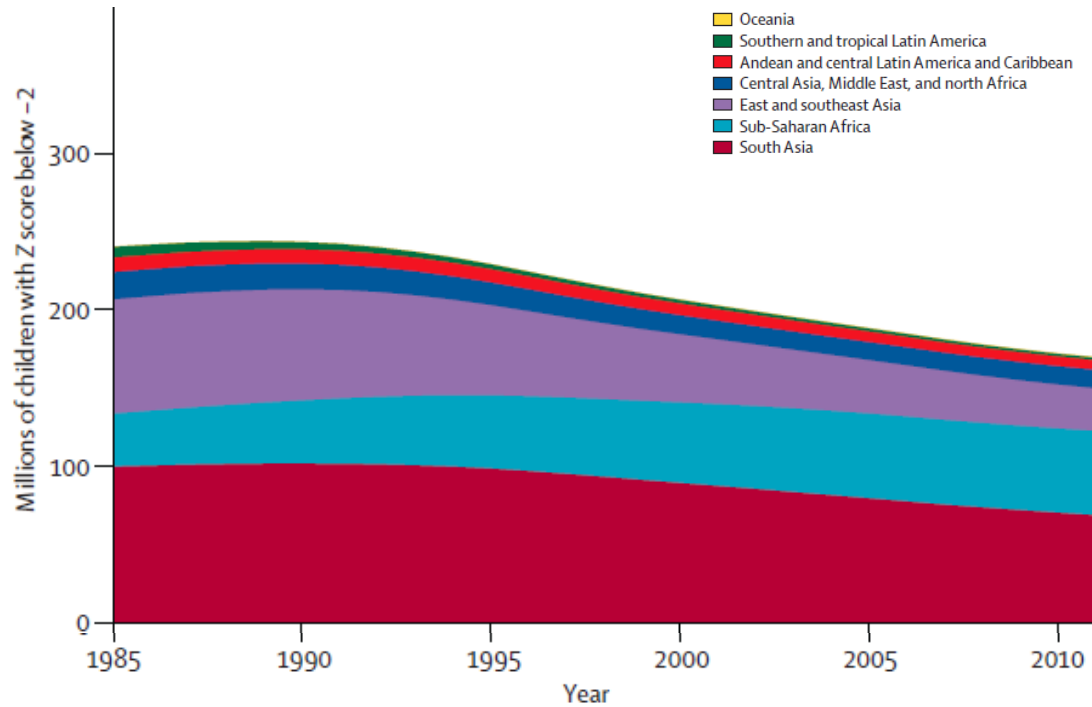
Outline

- ➔ Background and motivation
 - Methods and data sources
 - Results
 - Conclusion and next steps

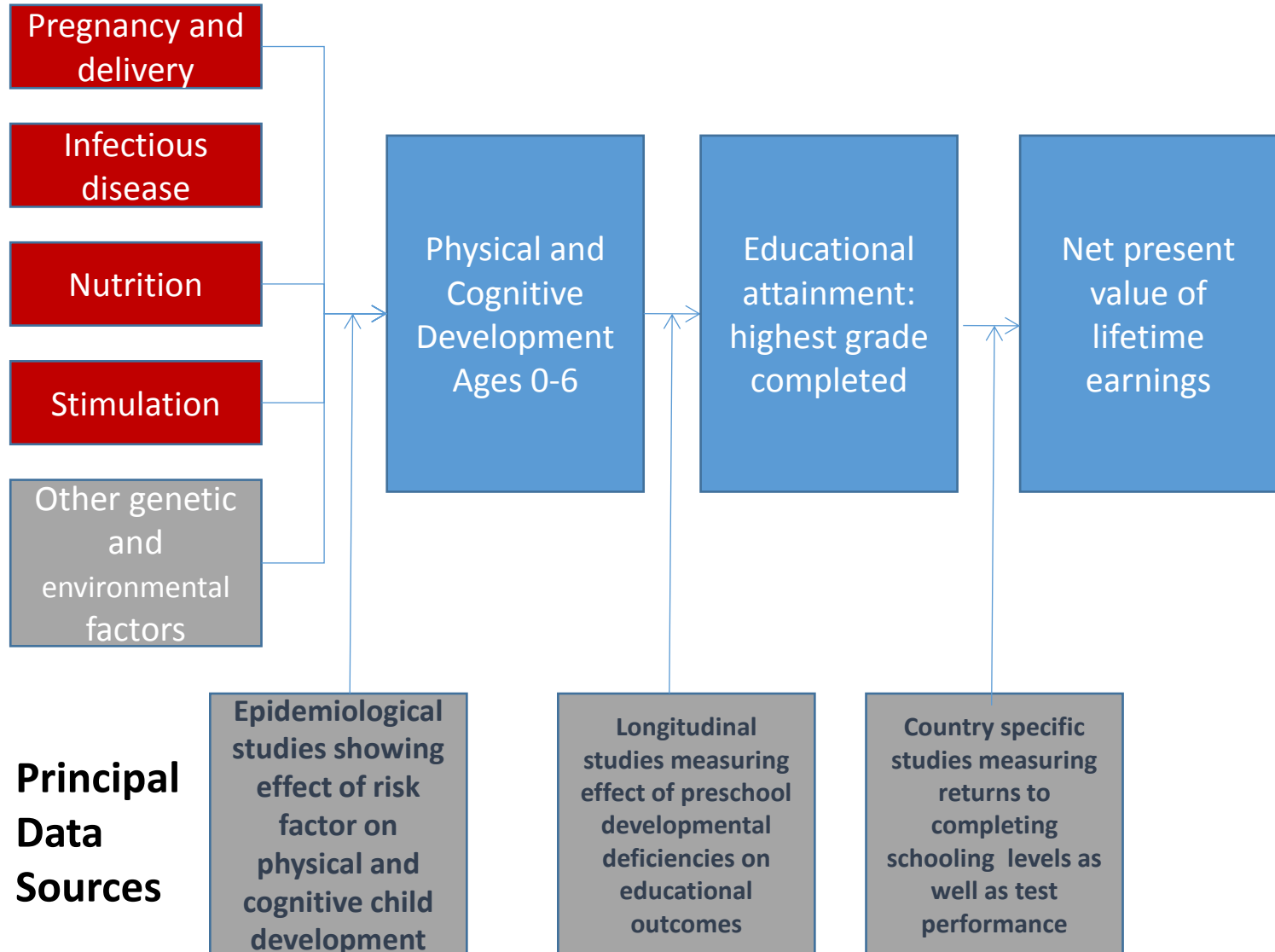
Background and motivation



Background and motivation



Conceptual model



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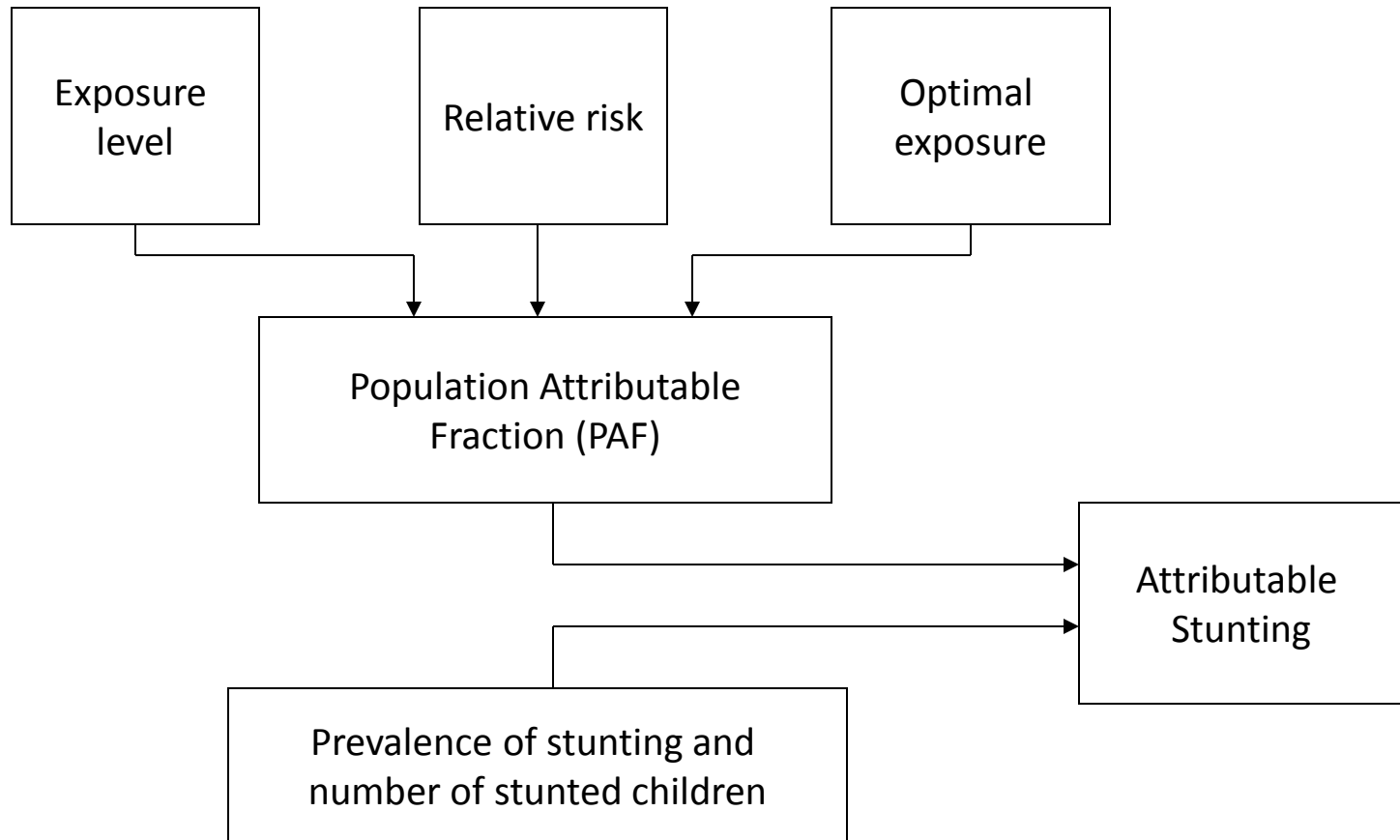
Risk factor selection

- 18 risks selected from an extensive list of modifiable risk factors for stunting based on
 - (i) availability of high-quality exposure data
 - (ii) convincing evidence for a causal impact on stunting
 - (iii) availability of evidence on the effect size on stunting from recent meta-analyses of epidemiological studies
- Grouped into 5 groups based on similarity of risk factor and interventions to address them

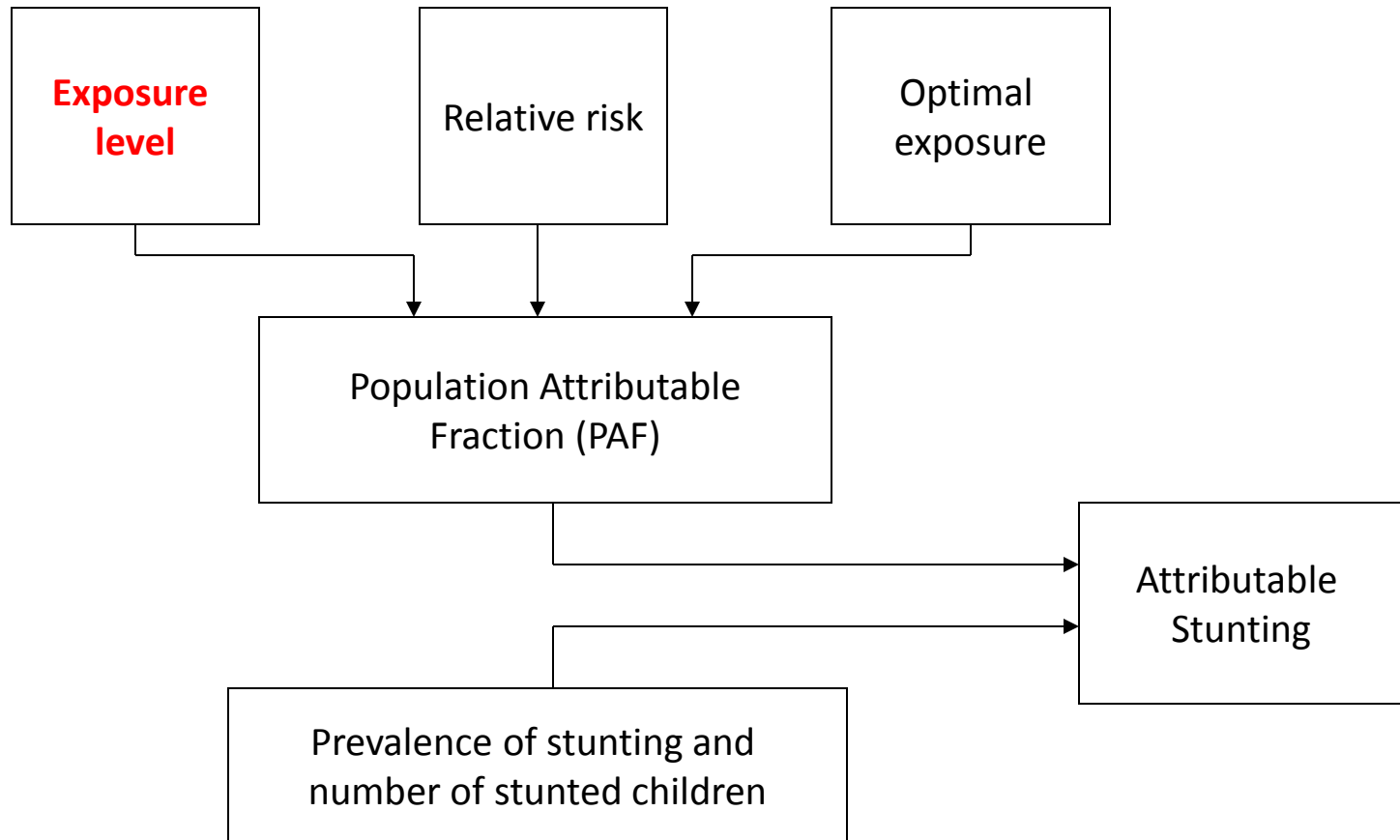
Selected risk factors and clusters

Risk factors	Definition
Maternal nutrition and infection	
Maternal short stature	Maternal height <160cm
Maternal underweight	Maternal BMI <18.5 kg/m ²
Maternal malaria	Malaria in pregnancy
Maternal anemia	Maternal hemoglobin <110g/L
Teenage motherhood and short birth intervals	
Teenage motherhood	Maternal age at delivery <20 years
Short birth intervals	<24 months between consecutive births
Fetal growth restriction and preterm birth	
Preterm, small-for-gestational age	Birth before 37 weeks of gestation and weight <10 th percentile for gestational age
Preterm, appropriate-for-gestational age	Birth before 37 weeks of gestation and weight ≥10 th percentile for gestational age
Term, small-for-gestational age	Birth at or after 37 weeks of gestation and weight <10 th percentile for gestational age
Low birth weight	Birthweight <2500g
Child nutrition and infection	
Childhood zinc deficiency	Deficient zinc intake during childhood based on age- and sex-specific zinc requirements
Childhood diarrhea	Mean number of diarrhea episodes per year during childhood
Non-exclusive breastfeeding	Non-exclusive breastfeeding of infants under 6 months of age
Discontinued breastfeeding	Discontinued breastfeeding of children 6-24 months of age
HIV infection without (HAART) before 2 years of age	Child HIV infection without initiation of HAART until after 2 years of age
Environmental factors	
Unimproved sanitation	Lack of access to safe sanitation in the community (based on WHO/UNICEF JMP definition of improved sanitation)
Unimproved water	Lack of access to clean water in the community (based on WHO/UNICEF JMP definition of improved water source)
Use of biomass fuels	Use of biomass fuels for cooking and heating

Analytical methods



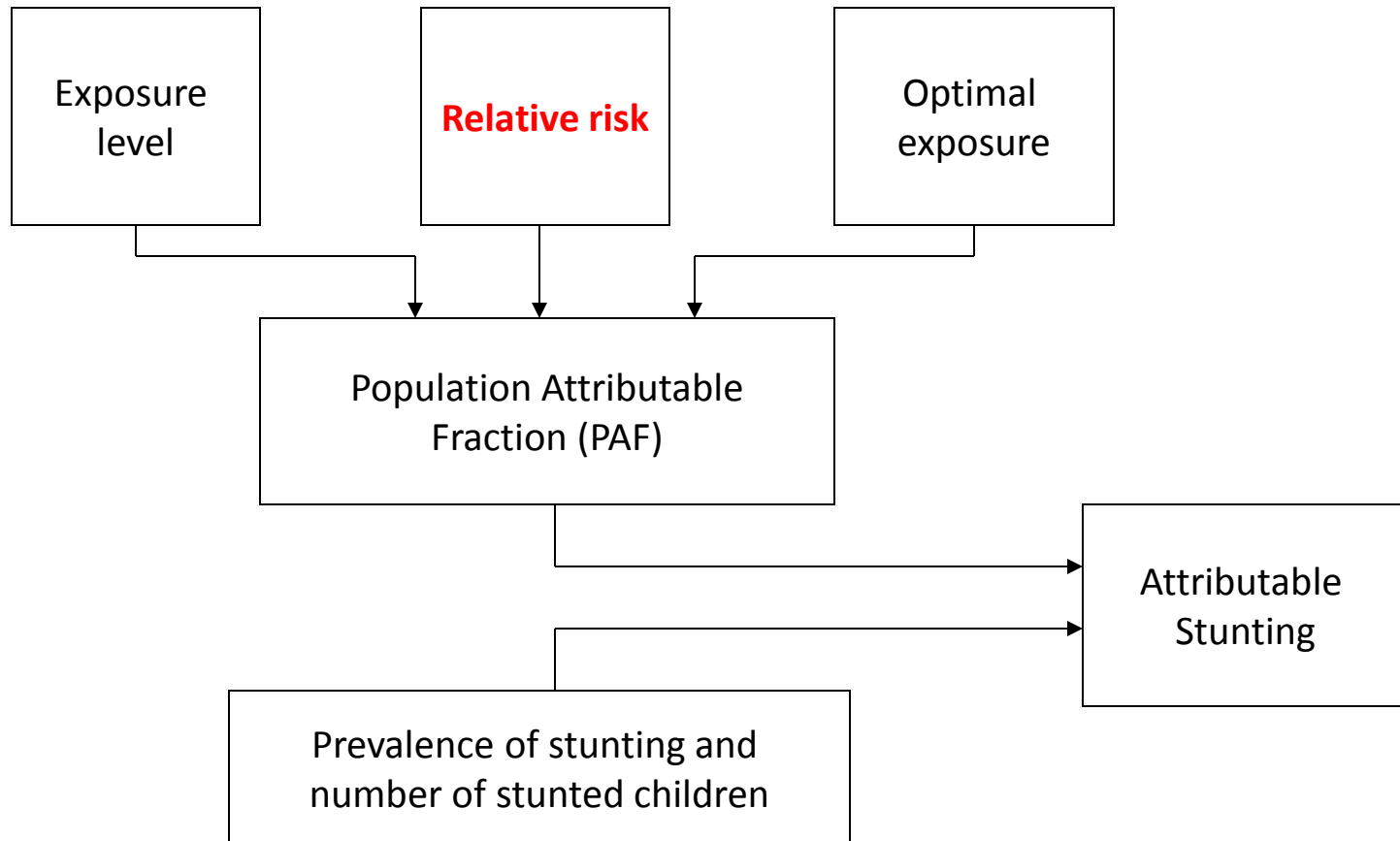
Analytical methods – data sources



Data sources: exposure levels

- Derived prevalence of exposure to each risk factor for ~2010 from published literature, available surveys (e.g. DHS)
 - Teenage motherhood, short birth intervals: 64 countries with recent DHS surveys; sub-regional or regional average when no data were available
 - Child HIV infection: analysis conducted only for 45 countries with available data

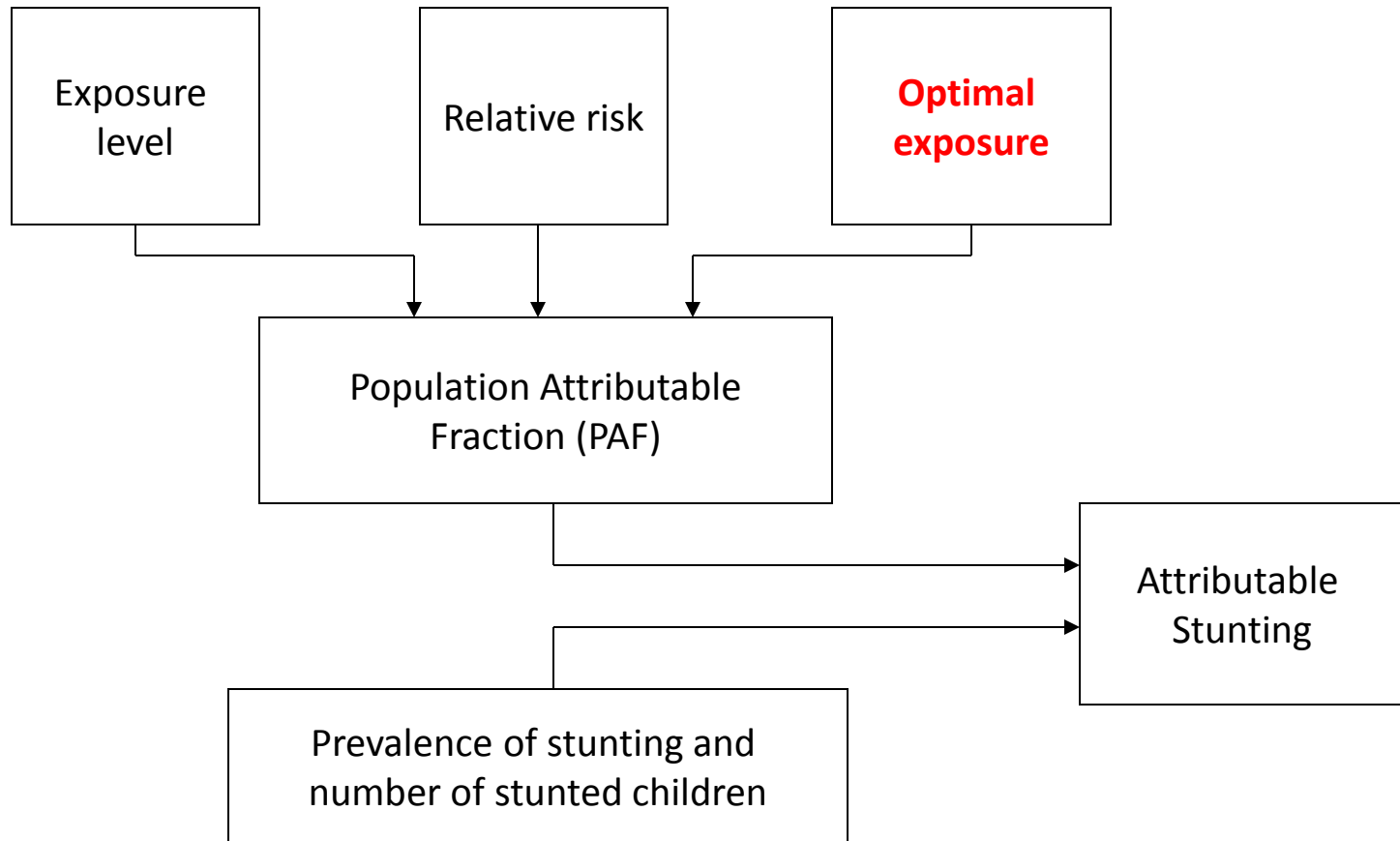
Analytical methods – data sources



Data sources: relative risks

- From published or de-novo systematic reviews of risk factors with effects on
 - Child HAZ, stunting (HAZ<-2)
 - Poor birth outcomes (low birth weight, small-for-gestational age)
- 12 risk factors had effect sizes on HAZ or stunting
- Mediated risks
 - Maternal malaria, underweight, anemia, biomass fuel use: meta-analyses of effect sizes only available on low birth-weight
 - Non-exclusive breastfeeding, discontinued breastfeeding: meta-analysis of effect size only available on diarrhea

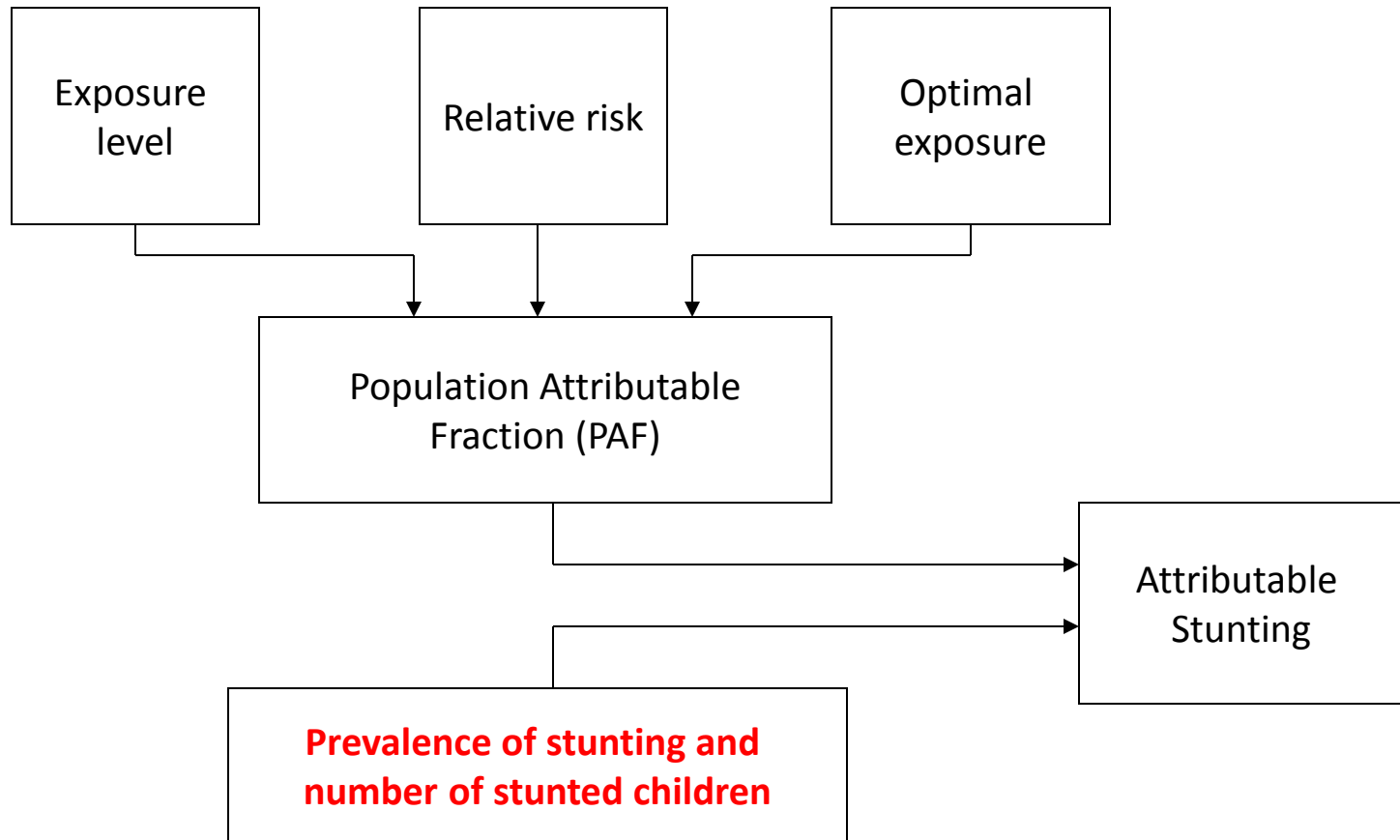
Analytical methods – data sources



Data sources: optimal exposure

- Used the Theoretical Minimum-Risk Exposure Distribution (TMRED)
- Assumed to be no exposure for most risk factors
 - Solid fuel use
 - Unimproved water and sanitation
 - Maternal malaria
- For others, the optimal level is less obvious. We used evidence from systematic reviews and meta-analyses to designate the optimal level or category
 - Maternal height
 - Short birth intervals

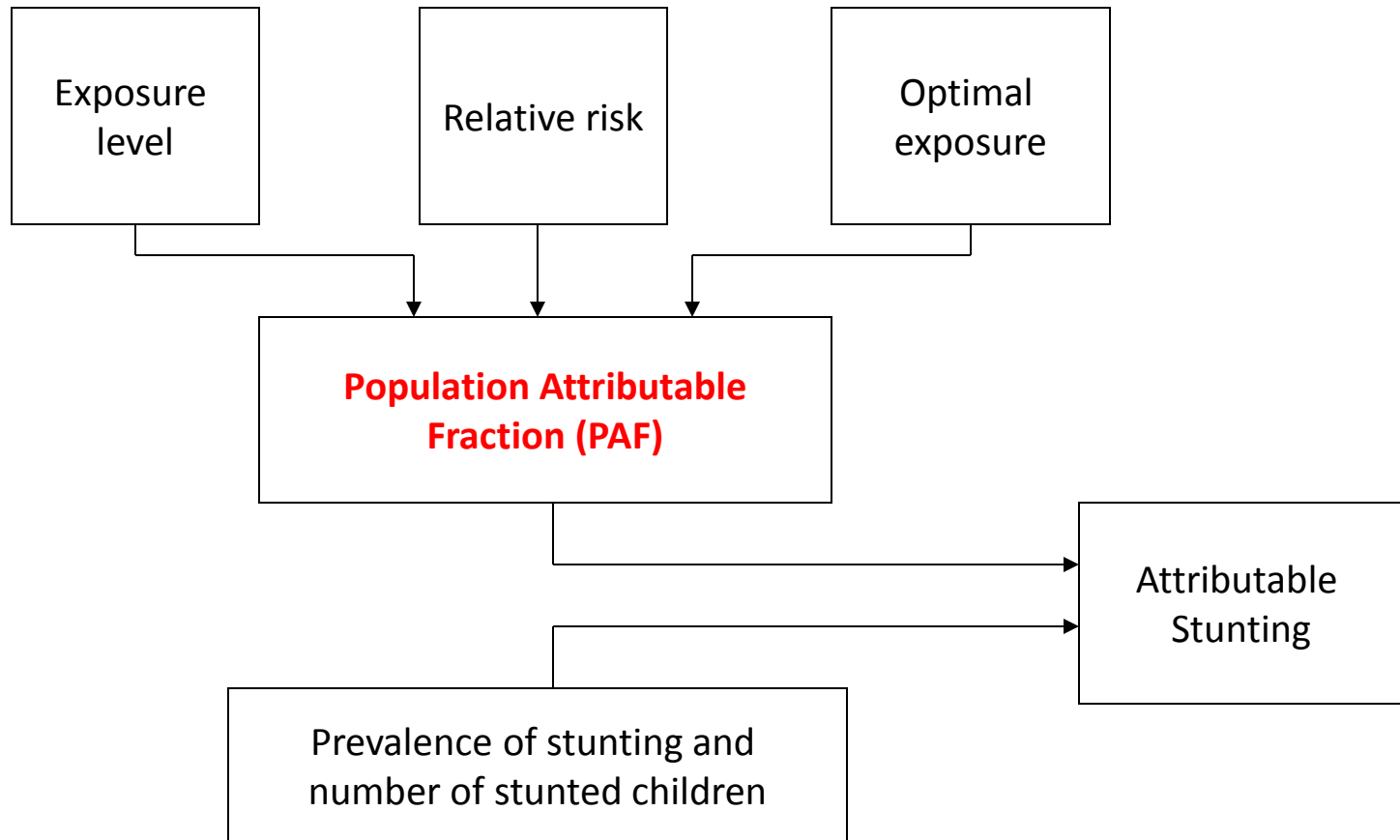
Analytical methods – data sources



Data sources: outcome

- Stunting prevalence: Nutrition Impact Model Study (NIMS)
(Stevens 2012)
 - Proportion of children under 5 with height-for-age more than 2SD below WHO Child Growth Standard median
 - Converted to stunting prevalence among 2 year olds using relationship between prevalence under-5 and at age 2 from child health surveys

Analytical methods



Analytical methods

- Estimated Population Attributable Fraction which quantifies the proportion of current disease burden (here stunting) that is attributable to current and past exposure.

$$PAF = \frac{\sum_i P_i \cdot (RR_i - 1)}{\sum_i P_i \cdot (RR_i - 1) + 1}$$

- Quantified uncertainty in the outputs by propagating uncertainty in the inputs via simulation.
 - This ignores other sources of uncertainty including whether relative risks can be extrapolated from one population to another.

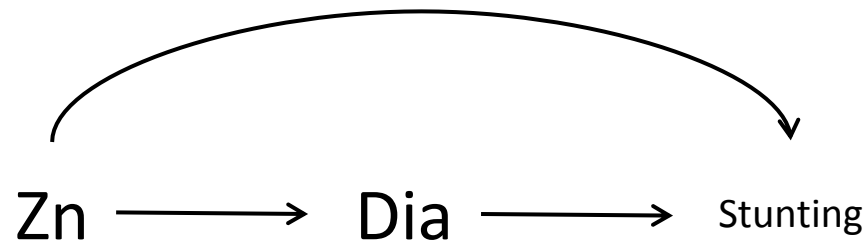
Analytical methods

- Joint effects of multiple risk factors within the same group:

$$PAF_j = 1 - \prod_{i=1}^R (1 - PAF_i)$$

This assumes no mediation, no correlation and no effect measure modification in multiplicative scale (i.e. similar relative risk)

- Adjusting for mediation for effect of zinc on diarrhea



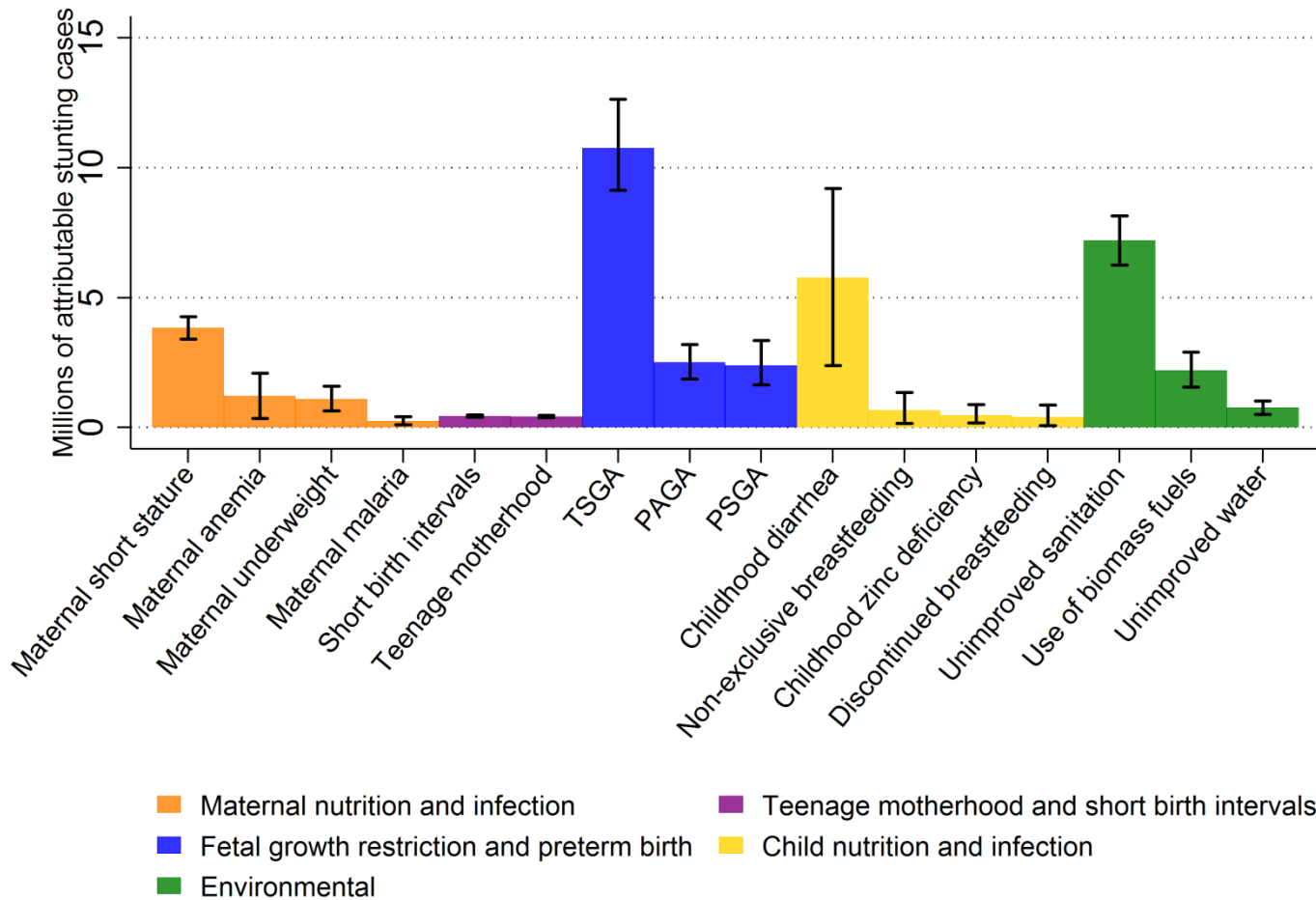
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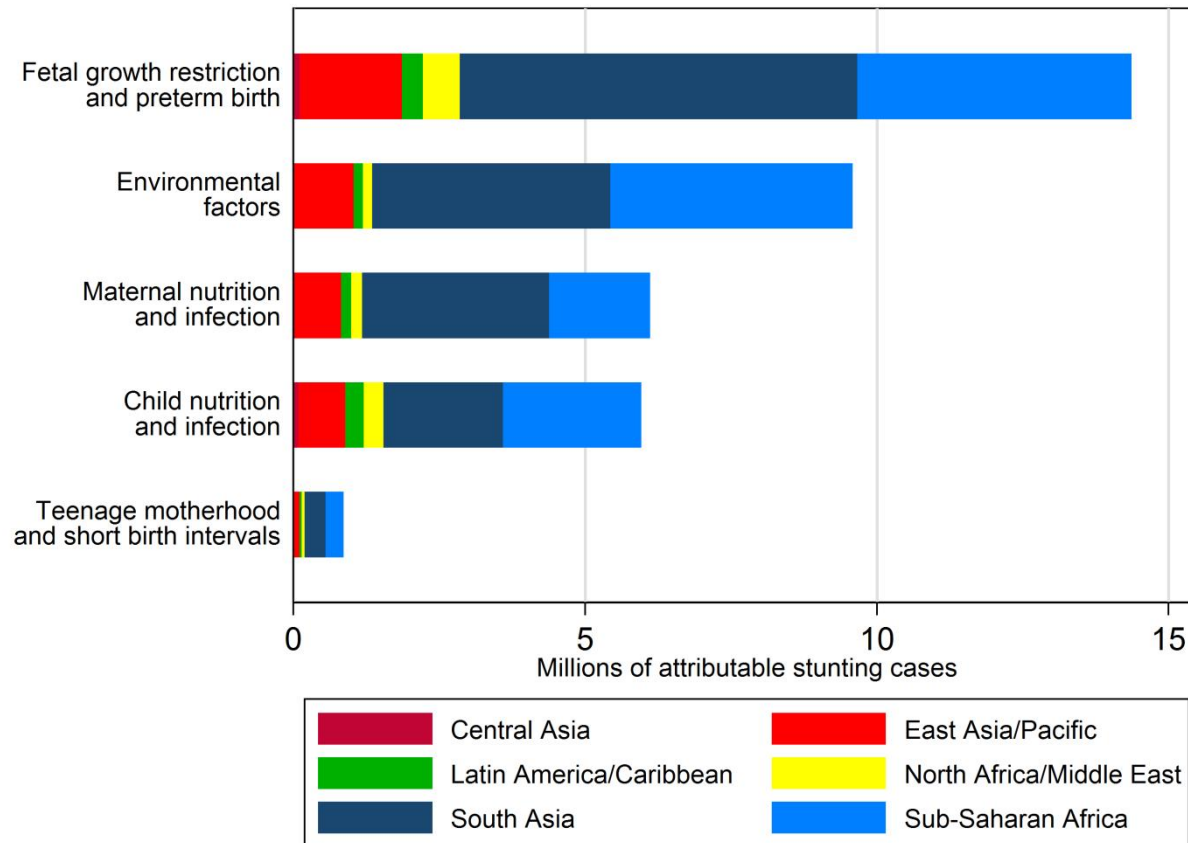
Results – proportion of stunting attributable by region and risk cluster

Region	Maternal nutrition and infection	Teenage motherhood and short birth intervals	Fetal growth restriction and preterm birth	Child nutrition and infection	Water, sanitation and biomass fuel use
All developing countries	13.8 (11.9, 16.0)	1.9 (1.9, 2.0)	32.5 (30.0, 35.2)	13.5 (5.9, 21.1)	21.7 (19.9, 23.5)
East Asia and Pacific	10.7 (9.8, 11.9)	1.3 (1.2, 1.4)	24.0 (21.0, 26.9)	10.9 (4.6, 17.2)	13.8 (11.3, 16.3)
South Asia	19.2 (16.2, 22.4)	2.2 (2.1, 2.3)	40.9 (37.5, 44.2)	12.3 (5.3, 20.1)	24.5 (22.2, 26.9)
Central Asia	5.9 (5.3, 6.7)	1.6 (1.5, 1.7)	22.6 (19.3, 25.5)	18.9 (8.4, 29.4)	4.2 (3.3, 5.1)
North Africa and Middle East	7.4 (6.4, 8.5)	1.8 (1.7, 2.0)	24.6 (22.2, 27.3)	12.9 (5.7, 20.6)	6.2 (5.2, 7.3)
Sub-Saharan Africa	11.3 (9.4, 13.2)	2.0 (1.9, 2.1)	30.6 (28.1, 33.3)	15.4 (6.9, 24.2)	27.0 (25.1, 29.1)
Latin America and Caribbean	9.9 (9.1, 10.7)	2.3 (2.2, 2.4)	20.5 (18.4, 23.0)	18.1 (7.9, 27.7)	8.9 (7.9, 9.9)

Results – cases of stunting attributable to individual risk factors



Results – cases of stunting attributable by region and risk cluster



Results by region and risk cluster

Region	Maternal nutrition and infection		Teenage motherhood and short birth intervals		Fetal growth restriction and preterm birth		Child nutrition and infection		Water, sanitation and biomass fuel use	
	PAF (%)	Number stunted	PAF (%)	Number stunted	PAF (%)	Number stunted	PAF (%)	Number stunted	PAF (%)	Number stunted
All developing countries	13.8 (11.9, 16.0)	6112 (5047, 7308)	1.9 (1.9, 2.0)	858 (774, 945)	32.5 (30.0, 35.2)	14366 (12553, 16209)	13.5 (5.9, 21.1)	5958 (2604, 9432)	21.7 (19.9, 23.5)	9584 (8364, 10783)
East Asia and Pacific	10.7 (9.8, 11.9)	786 (678, 896)	1.3 (1.2, 1.4)	96 (81, 110)	24.0 (21.0, 26.9)	1758 (1477, 2041)	10.9 (4.6, 17.2)	799 (343, 1322)	13.8 (11.3, 16.3)	1014 (787, 1282)
South Asia	19.2 (16.2, 22.4)	3207 (2375, 4113)	2.2 (2.1, 2.3)	361 (287, 437)	40.9 (37.5, 44.2)	6809 (5363, 8329)	12.3 (5.3, 20.1)	2053 (878, 3520)	24.5 (22.2, 26.9)	4082 (3163, 4992)
Central Asia	5.9 (5.3, 6.7)	27 (22, 32)	1.6 (1.5, 1.7)	7 (6, 8)	22.6 (19.3, 25.5)	102 (83, 123)	18.9 (8.4, 29.4)	85 (37, 135)	4.2 (3.3, 5.1)	19 (14, 24)
North Africa and Middle East	7.4 (6.4, 8.5)	190 (155, 226)	1.8 (1.7, 2.0)	48 (41, 54)	24.6 (22.2, 27.3)	635 (533, 743)	12.9 (5.7, 20.6)	333 (146, 548)	6.2 (5.2, 7.3)	161 (129, 195)
Sub-Saharan Africa	11.3 (9.4, 13.2)	1729 (1431, 2050)	2.0 (1.9, 2.1)	306 (285, 327)	30.6 (28.1, 33.3)	4703 (4257, 5141)	15.4 (6.9, 24.2)	2370 (1064, 3726)	27.0 (25.1, 29.1)	4153 (3777, 4544)
Latin America and Caribbean	9.9 (9.1, 10.7)	173 (153, 196)	2.3 (2.2, 2.4)	41 (36, 46)	20.5 (18.4, 23.0)	359 (308, 417)	18.1 (7.9, 27.7)	317 (141, 496)	8.9 (7.9, 9.9)	156 (135, 178)

Results by country

- See <http://www.healthychilddev.sph.harvard.edu/>

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Conclusions

- A substantial proportion of stunting in LMICs is attributable to fetal growth restriction and unimproved sanitation.
- Attention should now be focused on improving risk factors before and during pregnancy and on environmental factors.
- Effects on lost productivity due to lower education attainment are substantial (to be discussed in a subsequent presentation).
- Our estimates should be considered as conservative as they don't include the impact of non-physical growth.

Strengths and limitations

- Strengths
 - Comparable and consistent data sources and methods
 - Including only risk factors with strong evidence
 - Extensive review of literature on effect sizes
 - Quantified uncertainty in outcomes
- Limitations
 - Using proxy measures for exposure
 - Mediated effects through LBW and diarrhea lead to underestimation
 - Extrapolation of relative risks to all populations
 - Most effect sizes were reported as odds ratios which overestimate relative risks

Next steps

- Incorporating other risk factors whenever global data becomes available: e.g. environmental pollutants like pesticides, diet diversity, food security, maternal smoking.
- Examining the impact of the same risk factors on education and economic outcomes through early childhood development.
- Analysis of interventions that can improve exposure to these risk factors using cost-effectiveness models.
- Subnational analyses of risk factors to examine health disparities.

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