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Supplementary appendix

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Supplementary Information – Web Appendix

Health and Development from Preconception to 20 Years of Age and Human Capital

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Appendix Table A1. Examples of nurturing care policies and practices that support human capital from pre-conception through adolescence

	HEALTH	NUTRITION	SECURITY/ SAFETY	LEARNING	RESPONSIVE RELATIONSHIPS
Preconception/ Prenatal	Antenatal care, no smoking or drug use, prevent infections	Healthy diet, micronutrients, food assistance	Prevention of gender-based violence	Nutrition of girls and women, parental education	Preparation for parenting
Neonatal	Safe labor and delivery, management of small and sick newborn	Immediate and exclusive breastfeeding	Clean, water, air, and sanitation	Pregnancy and birth preparation	Promote skin-to-skin contact with mother
Infancy	Immunizations, prevention, and treatment of infectious diseases	Exclusive and continued breastfeeding, complementary feeding, micronutrients	Safe home environment	Patent-child interaction, identify and mitigate disabilities	Parent-infant attachment support
Preprimary	Well-child evaluations	Complementary feeding and diverse diets, food assistance	Injury prevention	Quality learning opportunities, parental support	Prevent harsh punishment
Middle Childhood	Promote physical activity	Healthy school meals, diverse diets	Injury and bullying prevention	Quality instruction and parent engagement	Promote prosocial peer relations
Adolescence	Access to sexual, reproductive, and mental health services	Healthy school meals, avoid obesogenic diets	Injury prevention, prevention of child marriage	Vocational and life skills training	Partnership and leadership opportunities

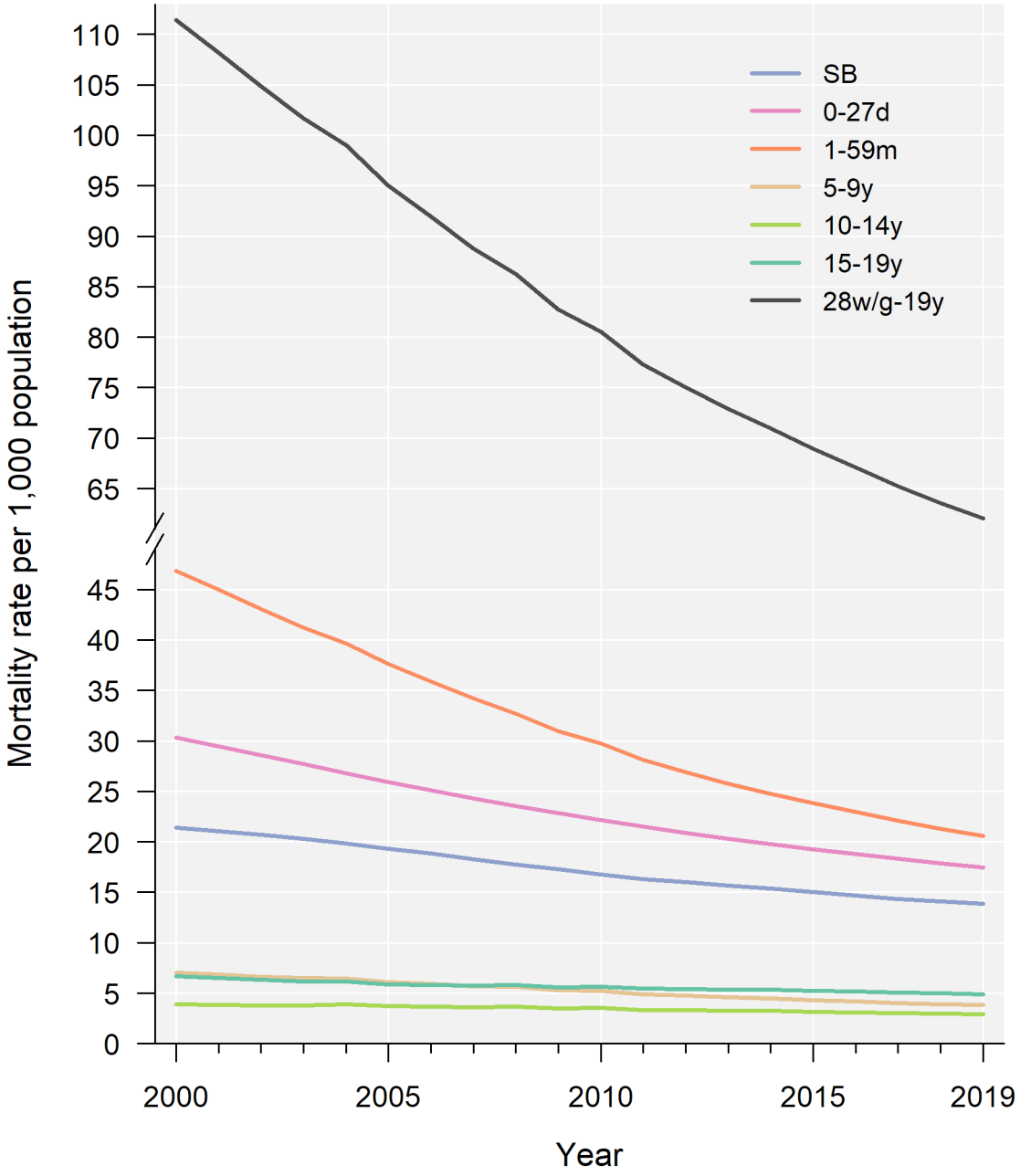
Data Source: Black MM, et al.[1]

Appendix Table A2. Global and regional all-cause number of deaths from 28 weeks of gestation to 20 years, by age group in 2019 (1000s)

Region	Stillbirths	0-27d	1-59m	5-9y	10-14y	15-19y	TOTAL
West and Central Africa (WCA)	466 [403-568] (17·1% [14·4-20·3%])	616 [536-737] (22·5% [20·4-24·8%])	1,220 [1,067-1,444] (44·6% [41·2-47·7%])	194 [176-215] (7·1% [6·1-8·0%])	111 [83-152] (4·1% [3·0-5·5%])	127 [111-151] (4·7% [3·9-5·6%])	2,735 [2,527-3,091] (100%)
Eastern and Southern Africa (ESA)	390 [355-450] (22·9% [20·2-25·6%])	444 [403-521] (26·1% [24·0-28·6%])	565 [509-663] (33·2% [30·6-36·1%])	115 [104-126] (6·8% [5·9-7·4%])	70 [56-101] (4·1% [3·2-5·8%])	115 [104-130] (6·8% [5·9-7·6%])	1,700 [1,618-1,884] (100%)
South Asia (SA)	651 [630-796] (26·9% [25·8-31·3%])	882 [810-960] (36·4% [33·3-37·6%])	524 [475-578] (21·6% [19·5-22·7%])	105 [94-115] (4·3% [3·8-4·7%])	100 [72-145] (4·1% [2·9-5·7%])	162 [142-186] (6·7% [5·7-7·5%])	2,425 [2,345-2,643] (100%)
Middle East and North Africa (MENA)	104 [92-124] (26·5% [22·9-30·5%])	123 [107-147] (31·3% [28·3-34·4%])	95 [80-118] (24·2% [21·0-27·4%])	21 [18-23] (5·3% [4·4-5·9%])	18 [14-24] (4·5% [3·6-6·1%])	32 [30-35] (8·2% [7·1-9·1%])	393 [365-445] (100%)
Latin America and Caribbean (LAC)	83 [78-92] (24·8% [23·1-26·7%])	94 [88-104] (28·1% [26·2-30·1%])	75 [68-84] (22·4% [20·5-24·2%])	13 [13-14] (3·9% [3·7-4·1%])	16 [15-18] (4·9% [4·4-5·4%])	54 [52-56] (16·0% [15·1-16·8%])	336 [325-354] (100%)
East Asia and the Pacific (EAP)	210 [193-233] (26·4% [24·1-28·7%])	216 [196-244] (27·1% [24·9-29·4%])	214 [193-241] (26·9% [24·6-29·1%])	46 [40-52] (5·7% [4·9-6·4%])	40 [30-57] (5·0% [3·7-7·0%])	71 [61-84] (8·9% [7·6-10·4%])	795 [759-856] (100%)
Eastern Europe and Central Asia (EECA)	30 [28-33] (24·2% [22·2-26·1%])	36 [32-41] (28·8% [25·9-31·4%])	33 [30-40] (26·7% [24·2-30·4%])	6 [6-6] (5·0% [4·6-5·1%])	7 [6-7] (5·2% [4·8-5·5%])	13 [12-13] (10·1% [9·4-10·6%])	125 [121-134] (100%)
High Income Countries (HIC)	31 [29-32] (26·6% [25·4-27·8%])	30 [29-31] (25·9% [25·0-26·9%])	22 [21-23] (19·1% [18·2-20·0%])	5 [5-5] (4·6% [4·5-4·7%])	7 [6-7] (5·8% [5·4-6·2%])	21 [20-21] (18·0% [17·3-18·7%])	115 [112-118] (100%)
GLOBAL	**1,966 [1,919-2,189] (22·8% [21·8-24·7%])**	**2,441 [2,321-2,650] (28·3% [26·7-29·6%])**	**2,748 [2,577-3,029] (31·9% [30·0-33·4%])**	**506 [480-532] (5·9% [5·4-6·1%])**	**368 [335-449] (4·3% [3·8-5·1%])**	**595 [568-637] (6·9% [6·4-7·3%])**	**8,624 [8,474-9,186] (100%)**
World Bank Fragile States	592 [528-700] (18·3% [15·8-21·1%])	772 [687-915] (23·8% [21·6-26·3%])	1,366 [1,211-1,607] (42·1% [38·9-45·2%])	213 [194-233] (6·6% [5·7-7·2%])	128 [102-173] (4·0% [3·1-5·2%])	170 [153-196] (5·2% [4·5-6·0%])	3,241 [3,035-3,638] (100%)

Data source: UN IGME[2,3], Masquelier et al[4], Figure 2 in main text. Number of deaths expressed in thousands. Values within square brackets refer to the 90% credible intervals of the corresponding point estimates. List of the World Bank Fragile and Conflict-affected Situations available at http://pubdocs.worldbank.org/en/888211594267968803/FCSList-FY21.pdf, and in Table A5.

Appendix Figure A1. Global age-specific mortality rate per 1,000 population from 28 weeks of gestation to 20 years, 2000-2019



Data source: UN IGME[2,3], Masquelier et al[4]. Mortality rates expressed in the unit of deaths per 1,000 population at the beginning of each age group and who are subject to risk of dying in that group. The dark-grey line refers to the risk of death between 28 weeks of gestation and 19 years completed (i.e., 20th birthday). Data for this figure available in Table A3.

Appendix Table A3. Global age-specific mortality rate per 1,000 population from 28 weeks of gestation to 20 years, 2000-2019

Year	SB	0-27d	1-59m	5-9y	10-14y	15-19y	28w/g-19y
2000	21·39 [20·00, 23·73]	30·35 [29·62, 31·17]	46·84 [45·03, 46·93]	7·04 [6·91, 7·22]	3·92 [3·68, 4·26]	6·71 [6·58, 6·91]	111·43 [108·96, 112·95]
2001	21·03 [19·72, 23·22]	29·48 [28·78, 30·28]	45·00 [43·29, 45·12]	6·85 [6·72, 7·02]	3·84 [3·61, 4·16]	6·51 [6·39, 6·70]	108·17 [105·85, 109·63]
2002	20·68 [19·44, 22·71]	28·60 [27·92, 29·38]	43·09 [41·39, 43·11]	6·65 [6·53, 6·82]	3·79 [3·56, 4·09]	6·32 [6·20, 6·49]	104·86 [102·66, 106·30]
2003	20·32 [19·14, 22·22]	27·71 [27·05, 28·46]	41·20 [39·61, 41·30]	6·50 [6·38, 6·66]	3·80 [3·57, 4·08]	6·19 [6·08, 6·36]	101·69 [99·68, 103·09]
2004	19·86 [18·75, 21·63]	26·80 [26·15, 27·53]	39·65 [38·15, 39·83]	6·45 [6·33, 6·62]	3·90 [3·67, 4·18]	6·16 [6·04, 6·34]	98·99 [97·11, 100·37]
2005	19·34 [18·34, 21·02]	25·92 [25·27, 26·64]	37·61 [36·21, 37·84]	6·08 [5·96, 6·23]	3·71 [3·49, 3·98]	5·89 [5·78, 6·05]	95·03 [93·30, 96·41]
2006	18·83 [17·87, 20·42]	25·08 [24·45, 25·80]	35·90 [34·57, 36·18]	5·91 [5·79, 6·07]	3·69 [3·47, 3·97]	5·82 [5·71, 5·99]	91·93 [90·33, 93·34]
2007	18·29 [17·46, 19·78]	24·30 [23·69, 24·99]	34·20 [32·93, 34·53]	5·71 [5·59, 5·87]	3·63 [3·42, 3·91]	5·74 [5·63, 5·92]	88·79 [87·31, 90·21]
2008	17·78 [17·05, 19·19]	23·55 [22·96, 24·23]	32·71 [31·49, 33·09]	5·66 [5·54, 5·83]	3·69 [3·47, 3·99]	5·81 [5·70, 6·01]	86·27 [84·90, 87·71]
2009	17·26 [16·60, 18·60]	22·83 [22·26, 23·51]	30·95 [29·74, 31·36]	5·29 [5·17, 5·45]	3·48 [3·27, 3·76]	5·61 [5·49, 5·82]	82·73 [81·42, 84·15]
2010	16·76 [16·17, 18·03]	22·16 [21·59, 22·83]	29·74 [28·55, 30·19]	5·24 [5·12, 5·42]	3·55 [3·32, 3·84]	5·66 [5·52, 5·89]	80·55 [79·29, 82·01]
2011	16·32 [15·80, 17·57]	21·50 [20·93, 22·19]	28·12 [26·90, 28·61]	4·90 [4·78, 5·07]	3·34 [3·13, 3·65]	5·45 [5·31, 5·68]	77·29 [76·04, 78·80]
2012	16·00 [15·53, 17·25]	20·89 [20·32, 21·60]	26·89 [25·64, 27·43]	4·75 [4·62, 4·92]	3·32 [3·09, 3·65]	5·42 [5·27, 5·67]	75·04 [73·79, 76·65]
2013	15·68 [15·26, 16·95]	20·30 [19·73, 21·07]	25·76 [24·50, 26·40]	4·60 [4·46, 4·77]	3·28 [3·05, 3·64]	5·37 [5·22, 5·63]	72·91 [71·66, 74·65]
2014	15·36 [14·95, 16·61]	19·76 [19·16, 20·58]	24·76 [23·44, 25·50]	4·46 [4·32, 4·64]	3·25 [3·01, 3·66]	5·35 [5·18, 5·62]	70·96 [69·68, 72·88]
2015	15·03 [14·62, 16·31]	19·25 [18·62, 20·16]	23·84 [22·48, 24·70]	4·30 [4·15, 4·48]	3·17 [2·93, 3·62]	5·25 [5·07, 5·53]	68·96 [67·65, 71·11]
2016	14·66 [14·29, 15·98]	18·78 [18·12, 19·79]	22·96 [21·56, 23·99]	4·17 [4·01, 4·35]	3·10 [2·87, 3·61]	5·18 [4·98, 5·47]	67·07 [65·75, 69·52]
2017	14·34 [14·00, 15·75]	18·32 [17·60, 19·45]	22·10 [20·65, 23·33]	4·04 [3·87, 4·23]	3·03 [2·80, 3·58]	5·09 [4·89, 5·40]	65·24 [63·91, 68·03]
2018	14·08 [13·76, 15·59]	17·89 [17·11, 19·19]	21·31 [19·77, 22·75]	3·93 [3·75, 4·11]	2·96 [2·72, 3·56]	4·98 [4·77, 5·31]	63·55 [62·22, 66·72]
2019	13·87 [13·55, 15·43]	17·48 [16·61, 18·97]	20·57 [18·93, 22·26]	3·83 [3·63, 4·02]	2·90 [2·67, 3·57]	4·89 [4·67, 5·24]	62·02 [60·63, 65·60]

Data source: UN IGME[2,3], Masquelier et al[4]. Mortality rates, and the corresponding 90% credible intervals (within square brackets), are expressed in the unit of deaths per 1,000 population at the beginning of each age group and who are subject to risk of dying in that group. Estimates in the right-end column refer to the risk of death between 28 weeks of gestation and 19 years completed (i.e., 20th birthday).

Appendix Table A4. Global and regional age-specific AARR, 2000-2019

Region	SB	0-27d	1-59m	5-9y	10-14y	15-19y	28w/g-19y
West and Central Africa (WCA)	1·30 [0·50, 2·10]	1·67 [0·79, 2·50]	3·54 [2·71, 4·31]	2·70 [2·23, 3·25]	1·05 [-0·58, 2·70]	1·22 [0·30, 2·07]	2·40 [1·87, 2·86]
Eastern and Southern Africa (ESA)	1·53 [0·92, 2·17]	2·21 [1·50, 2·89]	5·82 [5·09, 6·49]	4·98 [4·53, 5·57]	2·55 [0·79, 4·32]	3·12 [2·53, 3·69]	3·67 [3·28, 4·03]
South Asia (SA)	2·59 [1·60, 3·66]	3·22 [2·73, 3·74]	6·11 [5·54, 6·67]	5·29 [4·80, 5·87]	3·08 [1·20, 5·07]	2·80 [2·10, 3·62]	3·76 [3·41, 4·14]
Middle East and North Africa (MENA)	2·30 [1·57, 3·04]	2·73 [1·85, 3·55]	4·21 [3·12, 5·22]	2·17 [1·78, 2·68]	0·56 [-0·84, 1·78]	0·13 [-0·27, 0·52]	2·61 [2·08, 3·07]
Latin America and Caribbean (LAC)	1·83 [1·32, 2·35]	2·93 [2·40, 3·43]	4·57 [3·99, 5·15]	2·65 [2·40, 2·89]	1·36 [0·80, 1·85]	0·38 [0·18, 0·58]	2·68 [2·43, 2·91]
East Asia and the Pacific (EAP)	3·79 [3·20, 4·37]	5·36 [4·73, 5·99]	5·43 [4·79, 6·07]	4·51 [3·79, 5·31]	2·59 [0·40, 4·73]	2·79 [1·92, 3·71]	4·55 [4·22, 4·89]
Eastern Europe and Central Asia (EECA)	3·48 [2·96, 4·03]	5·35 [4·71, 5·98]	6·47 [5·66, 7·18]	5·59 [5·45, 5·73]	3·34 [2·86, 3·85]	4·04 [3·75, 4·32]	5·01 [4·70, 5·29]
High Income Countries (HIC)	1·24 [0·91, 1·56]	1·69 [1·48, 1·91]	2·53 [2·28, 2·78]	2·79 [2·68, 2·91]	2·33 [1·93, 2·70]	2·22 [2·01, 2·41]	1·92 [1·79, 2·05]
GLOBAL	2·15 [1·67, 2·65]	2·84 [2·47, 3·19]	4·25 [3·80, 4·65]	3·23 [2·97, 3·50]	1·32 [0·46, 2·18]	1·63 [1·31, 1·94]	2·98 [2·75, 3·19]

Data source: Own calculations using data from UN IGME[2,3], Masquelier et al[4]. Annual average rate of mortality reduction (AARR) for the period 2000-2019 computed using global and regional age-specific mortality rates from 2000 and 2019. Values within square brackets refer to the 90% credible intervals of the corresponding point estimates.

Appendix Table A5. Regional Country Classifications

Country Name	ISO3	Region	Fragile State
Cambodia	KHM	East Asia and the Pacific	NO
China	CHN	East Asia and the Pacific	NO
Cook Islands	COK	East Asia and the Pacific	NO
Federated States of Micronesia	FSM	East Asia and the Pacific	YES
Fiji	FJI	East Asia and the Pacific	NO
Indonesia	IDN	East Asia and the Pacific	NO
Kiribati	KIR	East Asia and the Pacific	YES
Korea DPR	PRK	East Asia and the Pacific	NO
Lao PDR	LAO	East Asia and the Pacific	YES
Malaysia	MYS	East Asia and the Pacific	NO
Marshall Islands	MHL	East Asia and the Pacific	YES
Mongolia	MNG	East Asia and the Pacific	NO
Myanmar	MMR	East Asia and the Pacific	YES
Nauru	NRU	East Asia and the Pacific	NO
Niue	NIU	East Asia and the Pacific	NO
Palau	PLW	East Asia and the Pacific	NO
Papua New Guinea	PNG	East Asia and the Pacific	YES
Philippines	PHL	East Asia and the Pacific	NO
Samoa	WSM	East Asia and the Pacific	NO
Solomon Islands	SLB	East Asia and the Pacific	YES
Thailand	THA	East Asia and the Pacific	NO
Timor Leste	TLS	East Asia and the Pacific	YES
Tonga	TON	East Asia and the Pacific	NO
Tuvalu	TUV	East Asia and the Pacific	YES
Vanuatu	VUT	East Asia and the Pacific	NO
Vietnam	VNM	East Asia and the Pacific	NO
Angola	AGO	Eastern and Southern Africa	NO
Botswana	BWA	Eastern and Southern Africa	NO
Burundi	BDI	Eastern and Southern Africa	YES
Comoros	COM	Eastern and Southern Africa	YES
Djibouti	DJI	Eastern and Southern Africa	NO
Eritrea	ERI	Eastern and Southern Africa	YES
Ethiopia	ETH	Eastern and Southern Africa	NO
Kenya	KEN	Eastern and Southern Africa	NO
Lesotho	LSO	Eastern and Southern Africa	NO
Madagascar	MDG	Eastern and Southern Africa	NO

Country Name	ISO3	Region	Fragile State
Malawi	MWI	Eastern and Southern Africa	NO
Mauritius	MUS	Eastern and Southern Africa	NO
Mozambique	MOZ	Eastern and Southern Africa	YES
Namibia	NAM	Eastern and Southern Africa	NO
Rwanda	RWA	Eastern and Southern Africa	NO
Seychelles	SYC	Eastern and Southern Africa	NO
Somalia	SOM	Eastern and Southern Africa	YES
South Africa	ZAF	Eastern and Southern Africa	NO
South Sudan	SSD	Eastern and Southern Africa	YES
Sudan	SDN	Eastern and Southern Africa	YES
Swaziland	SWZ	Eastern and Southern Africa	NO
Tanzania	TZA	Eastern and Southern Africa	NO
Uganda	UGA	Eastern and Southern Africa	NO
Zambia	ZMB	Eastern and Southern Africa	NO
Zimbabwe	ZWE	Eastern and Southern Africa	YES
Albania	ALB	Eastern Europe and Central Asia	NO
Armenia	ARM	Eastern Europe and Central Asia	NO
Azerbaijan	AZE	Eastern Europe and Central Asia	NO
Belarus	BLR	Eastern Europe and Central Asia	NO
Bosnia & Herzegovina	BIH	Eastern Europe and Central Asia	NO
Bulgaria	BGR	Eastern Europe and Central Asia	NO
Georgia	GEO	Eastern Europe and Central Asia	NO
Kazakhstan	KAZ	Eastern Europe and Central Asia	NO
Kyrgyzstan	KGZ	Eastern Europe and Central Asia	NO
Macedonia	MKD	Eastern Europe and Central Asia	NO
Moldova	MDA	Eastern Europe and Central Asia	NO
Montenegro	MNE	Eastern Europe and Central Asia	NO
Romania	ROU	Eastern Europe and Central Asia	NO
Russian Federation	RUS	Eastern Europe and Central Asia	NO
Serbia	SRB	Eastern Europe and Central Asia	NO
Tajikistan	TJK	Eastern Europe and Central Asia	NO
Turkey	TUR	Eastern Europe and Central Asia	NO
Turkmenistan	TKM	Eastern Europe and Central Asia	NO
Ukraine	UKR	Eastern Europe and Central Asia	NO
Uzbekistan	UZB	Eastern Europe and Central Asia	NO
Andorra	AND	High Income Countries	NO
Australia	AUS	High Income Countries	NO
Austria	AUT	High Income Countries	NO
Bahamas	BHS	High Income Countries	NO

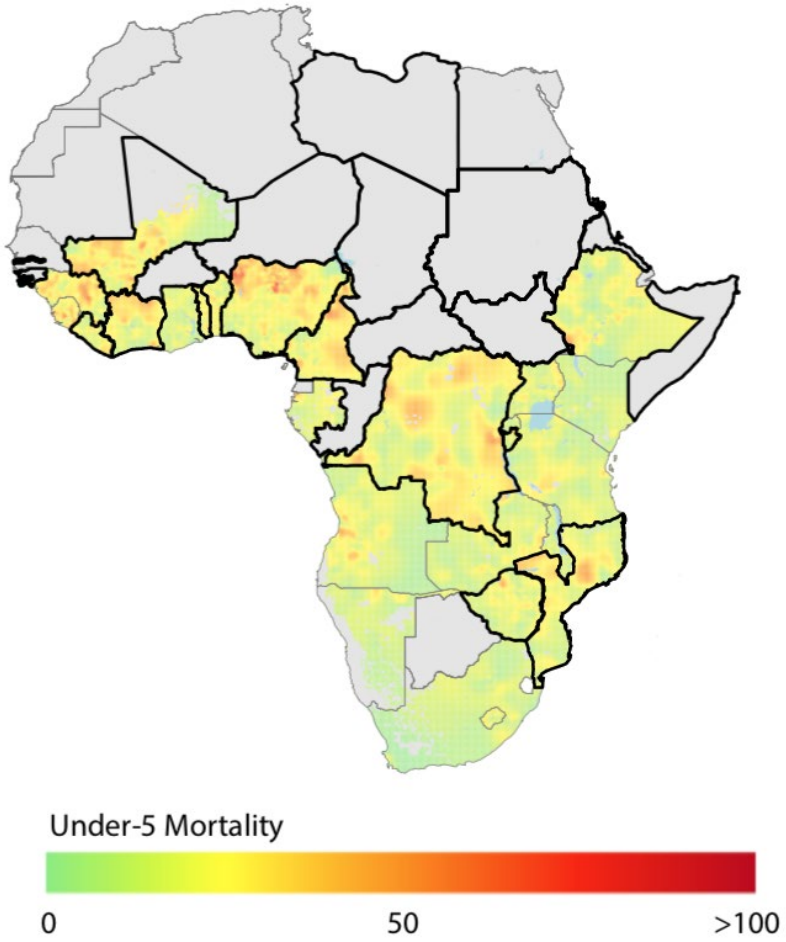
Country Name	ISO3	Region	Fragile State
Belgium	BEL	High Income Countries	NO
Brunei	BRN	High Income Countries	NO
Canada	CAN	High Income Countries	NO
Croatia	HRV	High Income Countries	NO
Cyprus	CYP	High Income Countries	NO
Czech Republic	CZE	High Income Countries	NO
Denmark	DNK	High Income Countries	NO
Estonia	EST	High Income Countries	NO
Finland	FIN	High Income Countries	NO
France	FRA	High Income Countries	NO
Germany	DEU	High Income Countries	NO
Greece	GRC	High Income Countries	NO
Hungary	HUN	High Income Countries	NO
Iceland	ISL	High Income Countries	NO
Ireland	IRL	High Income Countries	NO
Israel	ISR	High Income Countries	NO
Italy	ITA	High Income Countries	NO
Japan	JPN	High Income Countries	NO
Korea Rep	KOR	High Income Countries	NO
Latvia	LVA	High Income Countries	NO
Liechtenstein	LIE	High Income Countries	NO
Lithuania	LTU	High Income Countries	NO
Luxembourg	LUX	High Income Countries	NO
Malta	MLT	High Income Countries	NO
Monaco	MCO	High Income Countries	NO
Netherlands	NLD	High Income Countries	NO
New Zealand	NZL	High Income Countries	NO
Norway	NOR	High Income Countries	NO
Poland	POL	High Income Countries	NO
Portugal	PRT	High Income Countries	NO
San Marino	SMR	High Income Countries	NO
Singapore	SGP	High Income Countries	NO
Slovakia	SVK	High Income Countries	NO
Slovenia	SVN	High Income Countries	NO
Spain	ESP	High Income Countries	NO
Sweden	SWE	High Income Countries	NO
Switzerland	CHE	High Income Countries	NO
United Kingdom	GBR	High Income Countries	NO
United States of America	USA	High Income Countries	NO

Country Name	ISO3	Region	Fragile State
Antigua & Barbuda	ATG	Latin America and Caribbean	NO
Argentina	ARG	Latin America and Caribbean	NO
Barbados	BRB	Latin America and Caribbean	NO
Belize	BLZ	Latin America and Caribbean	NO
Bolivia	BOL	Latin America and Caribbean	NO
Brazil	BRA	Latin America and Caribbean	NO
Chile	CHL	Latin America and Caribbean	NO
Colombia	COL	Latin America and Caribbean	NO
Costa Rica	CRI	Latin America and Caribbean	NO
Cuba	CUB	Latin America and Caribbean	NO
Dominica	DMA	Latin America and Caribbean	NO
Dominican Republic	DOM	Latin America and Caribbean	NO
Ecuador	ECU	Latin America and Caribbean	NO
El Salvador	SLV	Latin America and Caribbean	NO
Grenada	GRD	Latin America and Caribbean	NO
Guatemala	GTM	Latin America and Caribbean	NO
Guyana	GUY	Latin America and Caribbean	NO
Haiti	HTI	Latin America and Caribbean	YES
Honduras	HND	Latin America and Caribbean	NO
Jamaica	JAM	Latin America and Caribbean	NO
Mexico	MEX	Latin America and Caribbean	NO
Nicaragua	NIC	Latin America and Caribbean	NO
Panama	PAN	Latin America and Caribbean	NO
Paraguay	PRY	Latin America and Caribbean	NO
Peru	PER	Latin America and Caribbean	NO
Saint Kitts & Nevis	KNA	Latin America and Caribbean	NO
Saint Lucia	LCA	Latin America and Caribbean	NO
St Vincent & the Grenadines	VCT	Latin America and Caribbean	NO
Suriname	SUR	Latin America and Caribbean	NO
Trinidad & Tobago	TTO	Latin America and Caribbean	NO
Uruguay	URY	Latin America and Caribbean	NO
Venezuela	VEN	Latin America and Caribbean	YES
Algeria	DZA	Middle East and North Africa	NO
Bahrain	BHR	Middle East and North Africa	NO
Egypt	EGY	Middle East and North Africa	NO
Iran	IRN	Middle East and North Africa	NO
Iraq	IRQ	Middle East and North Africa	YES
Jordan	JOR	Middle East and North Africa	NO
Kuwait	KWT	Middle East and North Africa	NO

Country Name	ISO3	Region	Fragile State
Lebanon	LBN	Middle East and North Africa	YES
Libya	LBY	Middle East and North Africa	YES
Morocco	MAR	Middle East and North Africa	NO
Oman	OMN	Middle East and North Africa	NO
Qatar	QAT	Middle East and North Africa	NO
Saudi Arabia	SAU	Middle East and North Africa	NO
State of Palestine	PSE	Middle East and North Africa	YES
Syria	SYR	Middle East and North Africa	YES
Tunisia	TUN	Middle East and North Africa	NO
United Arab Emirates	ARE	Middle East and North Africa	NO
Yemen	YEM	Middle East and North Africa	YES
Afghanistan	AFG	South Asia	YES
Bangladesh	BGD	South Asia	NO
Bhutan	BTN	South Asia	NO
India	IND	South Asia	NO
Maldives	MDV	South Asia	NO
Nepal	NPL	South Asia	NO
Pakistan	PAK	South Asia	NO
Sri Lanka	LKA	South Asia	NO
Benin	BEN	West and Central Africa	NO
Burkina Faso	BFA	West and Central Africa	YES
Cameroon	CMR	West and Central Africa	YES
Cape Verde	CPV	West and Central Africa	NO
Central African Republic	CAF	West and Central Africa	YES
Chad	TCD	West and Central Africa	YES
Congo	COG	West and Central Africa	YES
Congo DR	COD	West and Central Africa	YES
Cote d Ivoire	CIV	West and Central Africa	NO
Equatorial Guinea	GNQ	West and Central Africa	NO
Gabon	GAB	West and Central Africa	NO
Gambia The	GMB	West and Central Africa	YES
Ghana	GHA	West and Central Africa	NO
Guinea	GIN	West and Central Africa	NO
Guinea-Bissau	GNB	West and Central Africa	YES
Liberia	LBR	West and Central Africa	YES
Mali	MLI	West and Central Africa	YES
Mauritania	MRT	West and Central Africa	NO
Niger	NER	West and Central Africa	YES
Nigeria	NGA	West and Central Africa	YES

Country Name	ISO3	Region	Fragile State
Sao Tome & Principe	STP	West and Central Africa	NO
Senegal	SEN	West and Central Africa	NO
Sierra Leone	SLE	West and Central Africa	NO
Togo	TGO	West and Central Africa	NO

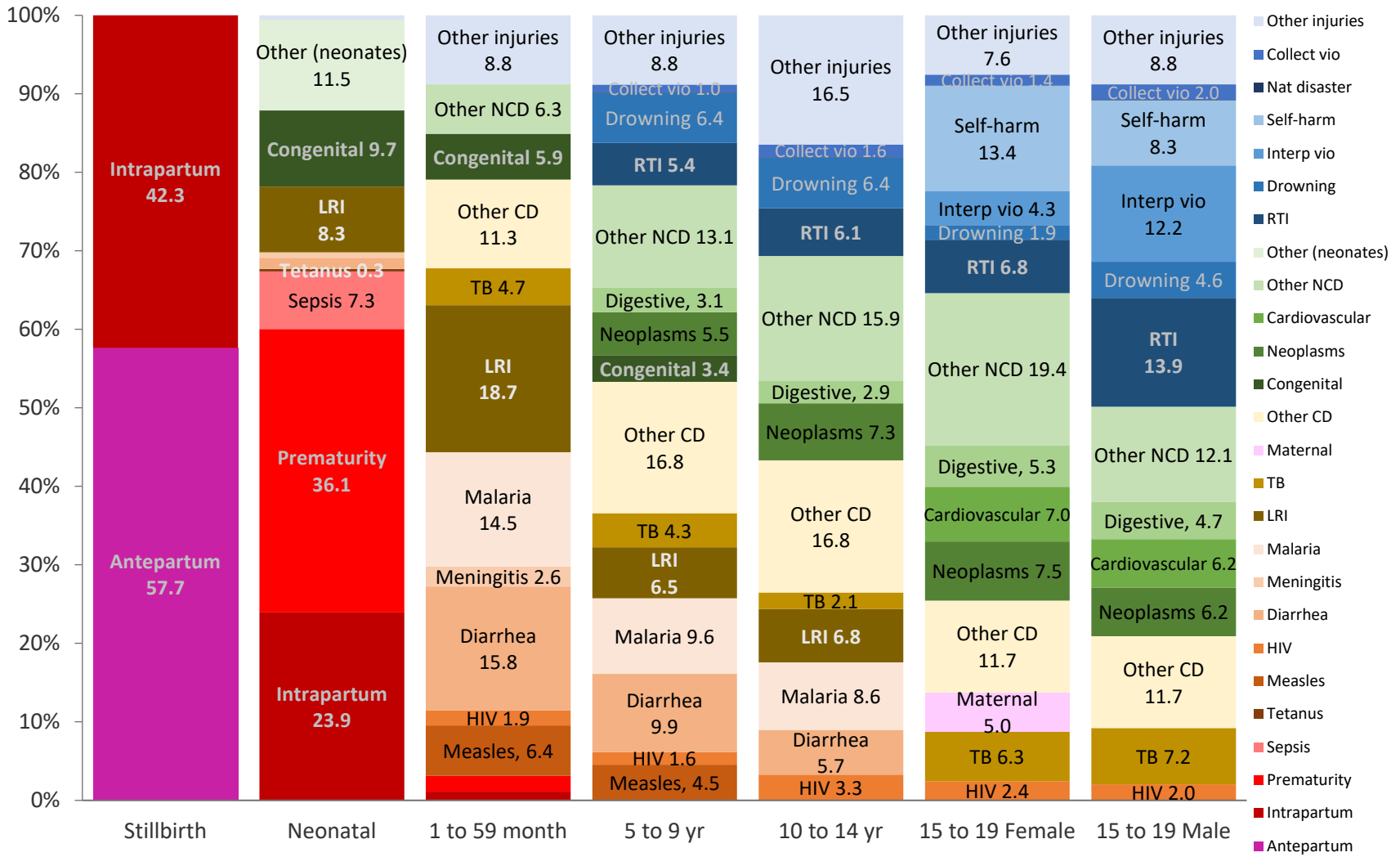
Appendix Figure A2. Map of child mortality hot spots in Africa



*Bold national borders indicate fragile and conflict countries

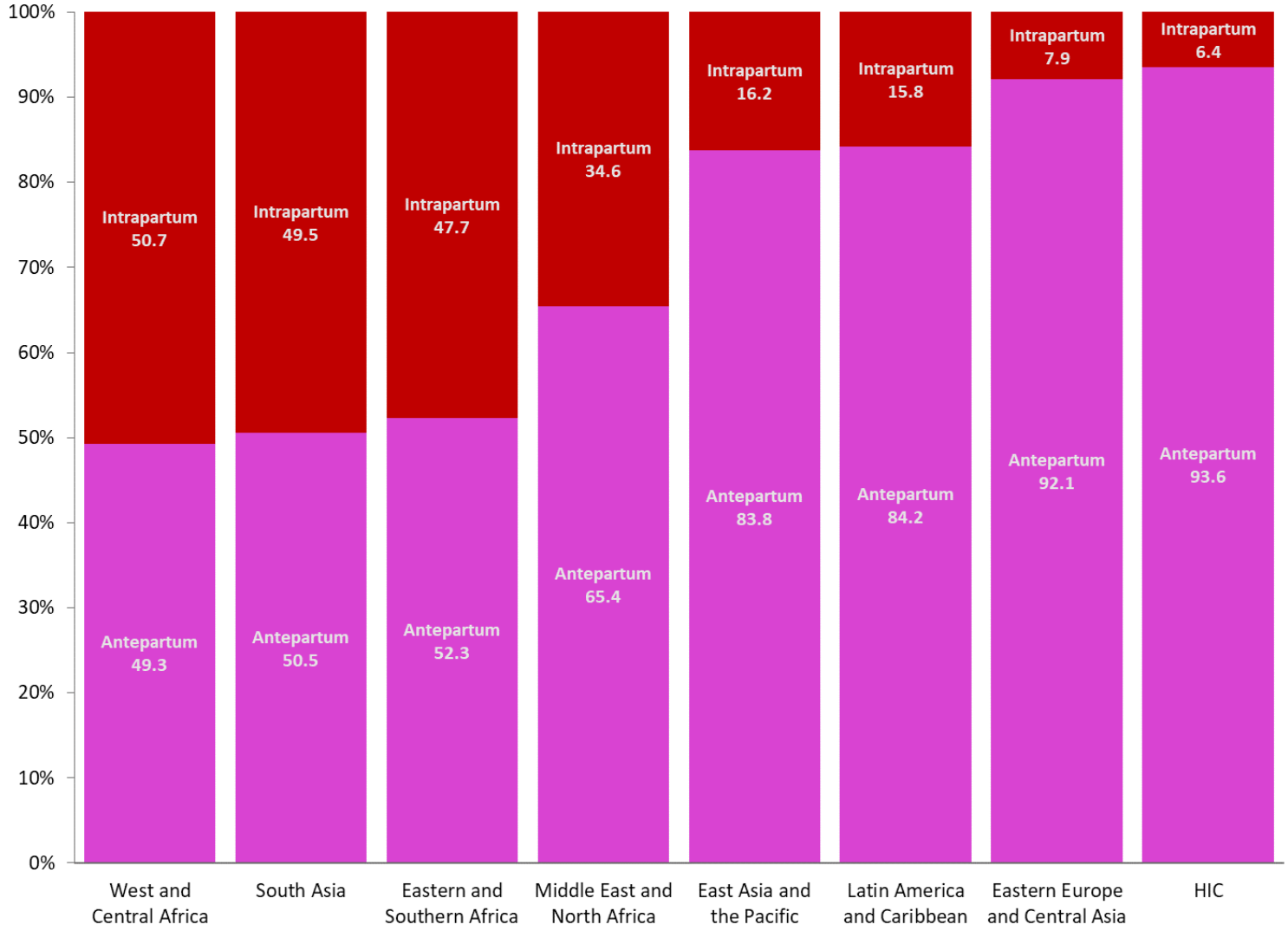
Source: Updated analysis using methods of Burke et al.[5]

Appendix Figure A3. Global cause-specific mortality fractions by age and sex in 2019



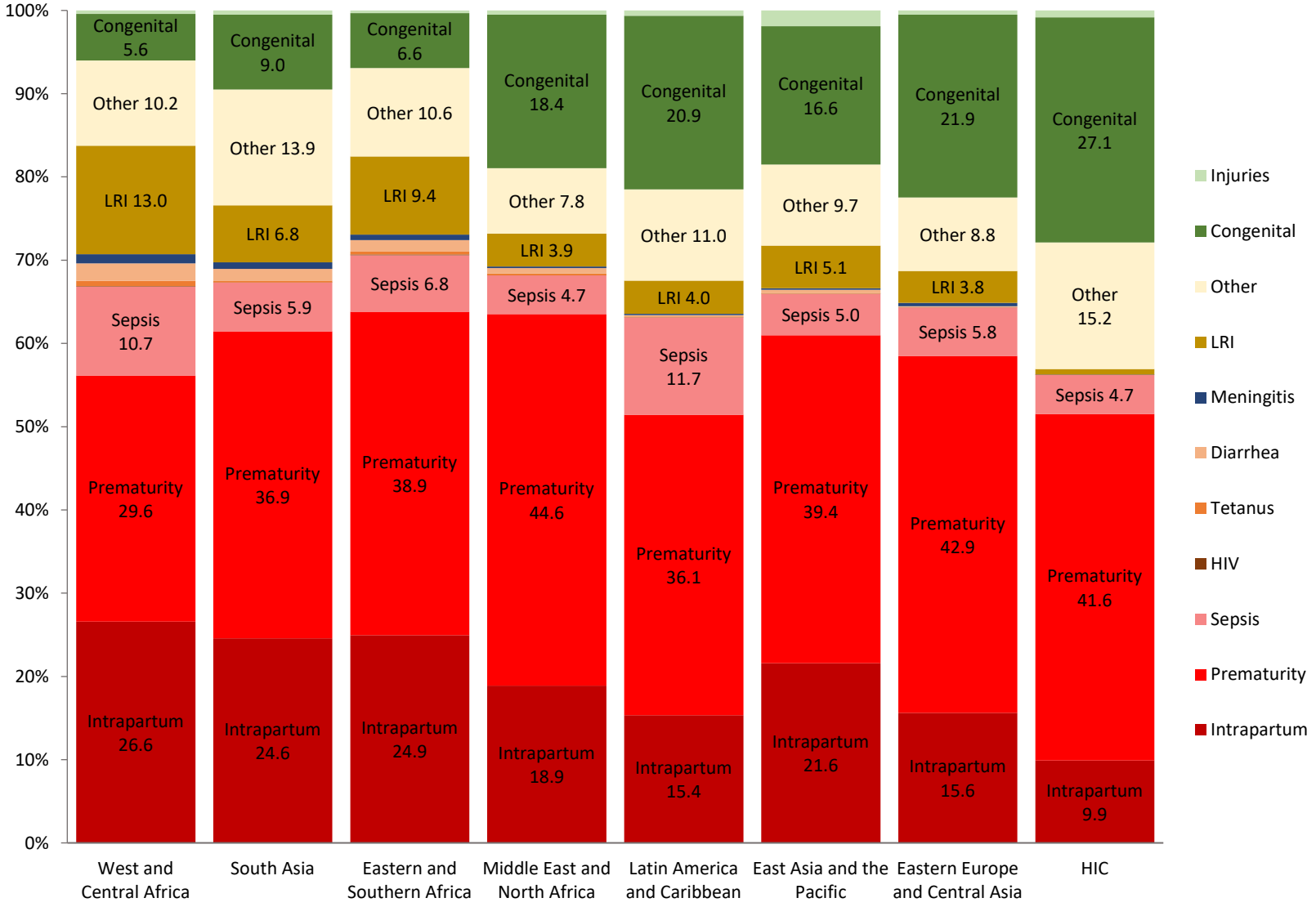
Data source: Cause-of-death distribution in stillbirths from UN IGME[2], in under-fives from Mulick et al[6], Perin et al[7] and in 5-19 years-old from Liu, Villavicencio et al.[8]

Appendix Figure A4. Regional cause-specific mortality fractions in stillbirths in 2019



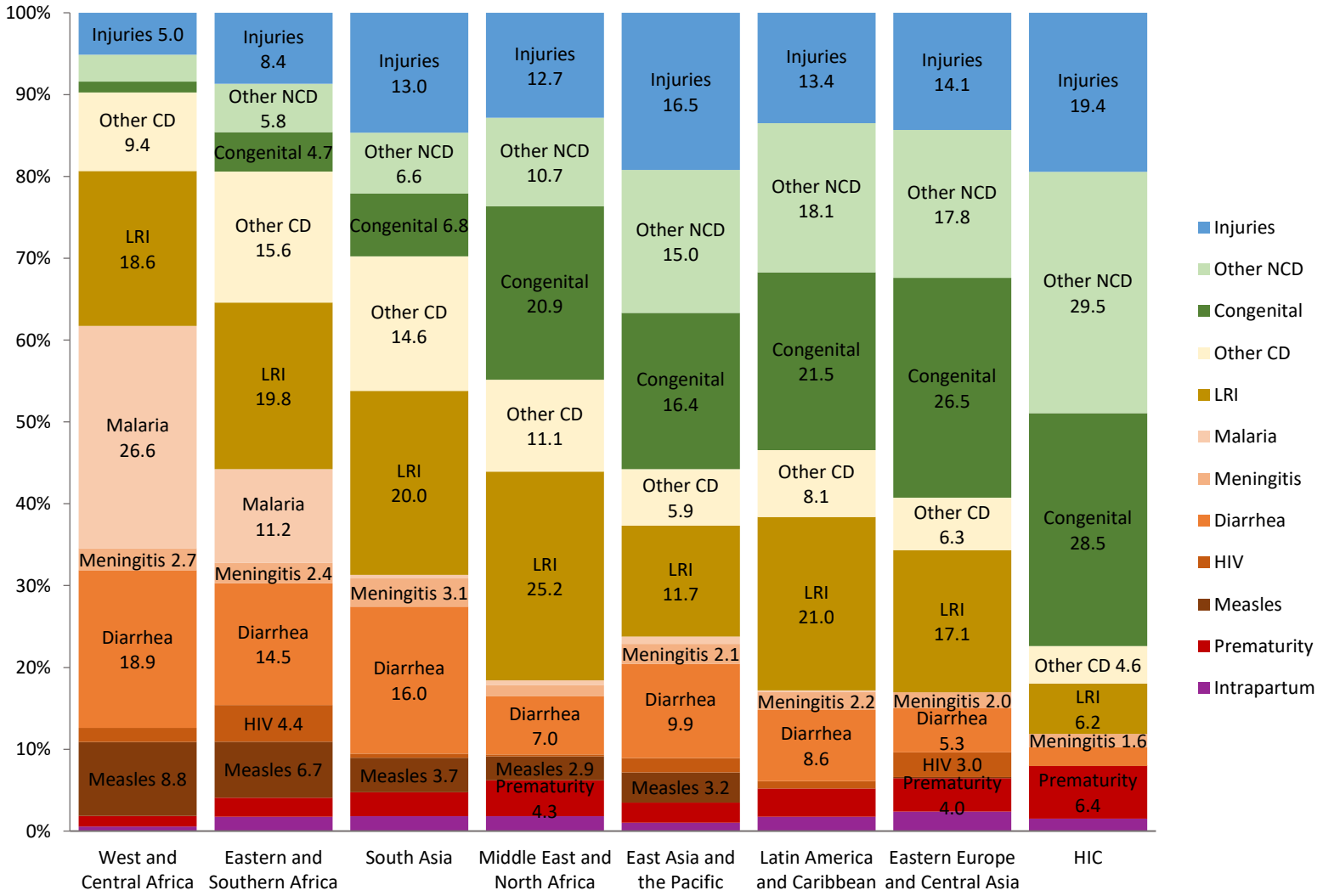
Data source: Cause-of-death distribution in stillbirths from UN IGME.[2]

Appendix Figure A5. Regional cause-specific mortality fractions in neonates 2019



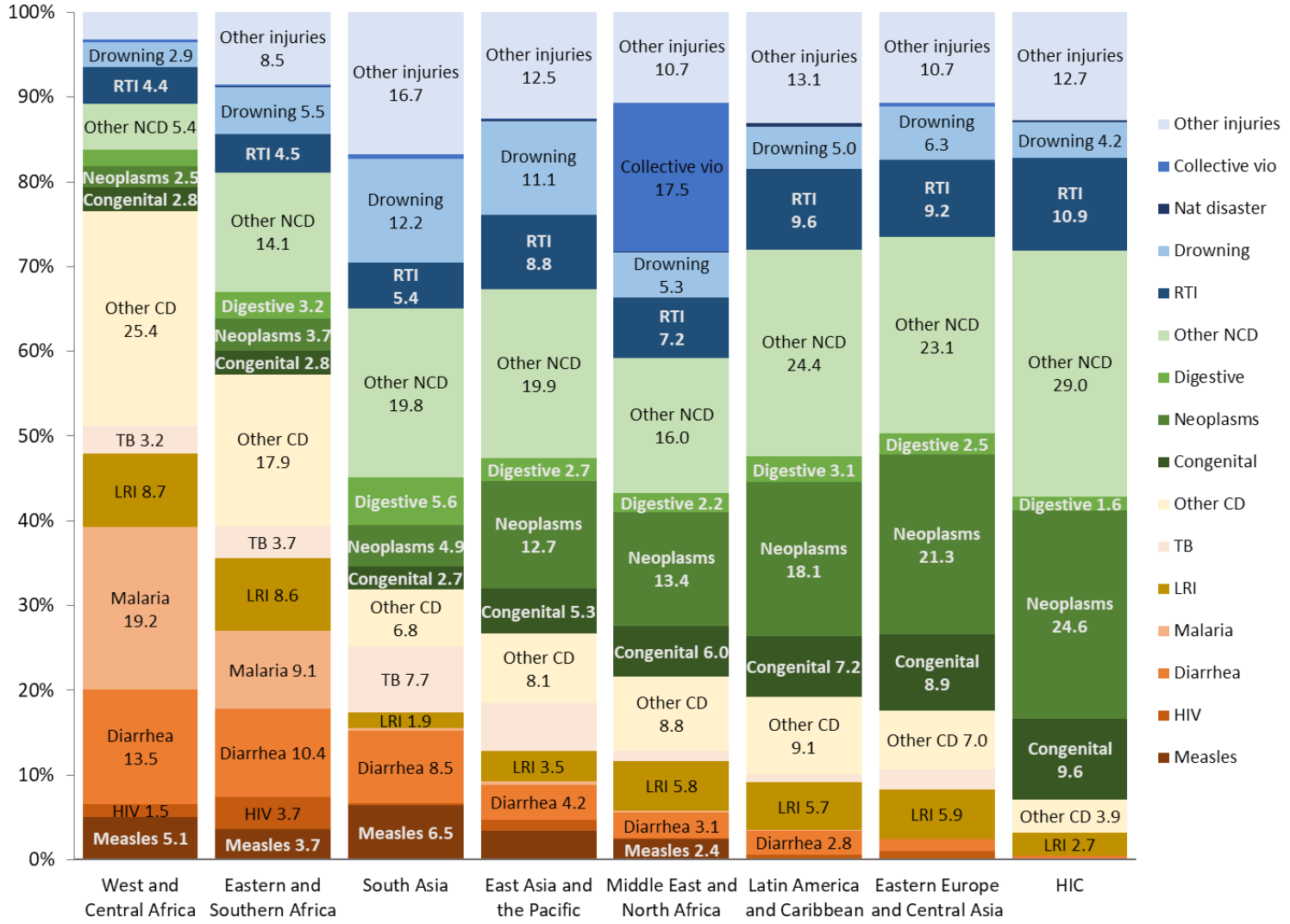
Data source: Cause-of-death distribution in neonates from Mulick et al[6], Perin et al.[7]

Appendix Figure A6. Regional cause-specific mortality fractions in 1-59 months, 2019



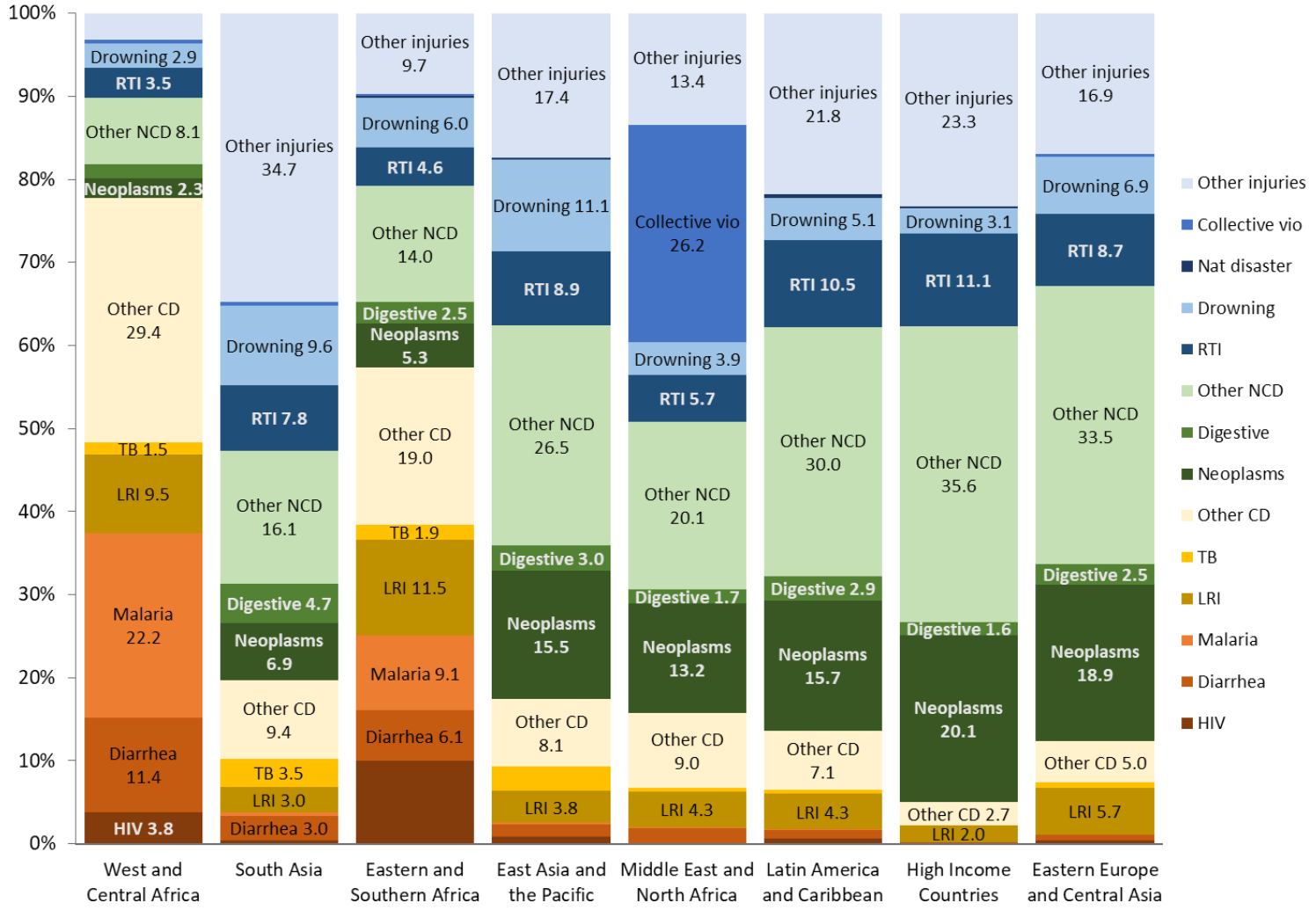
Data source: Cause-of-death distribution in 1-59 month-olds from Perin et al.[7]

Appendix Figure A7. Regional cause-specific mortality fractions in 5-9 years-old, 2019



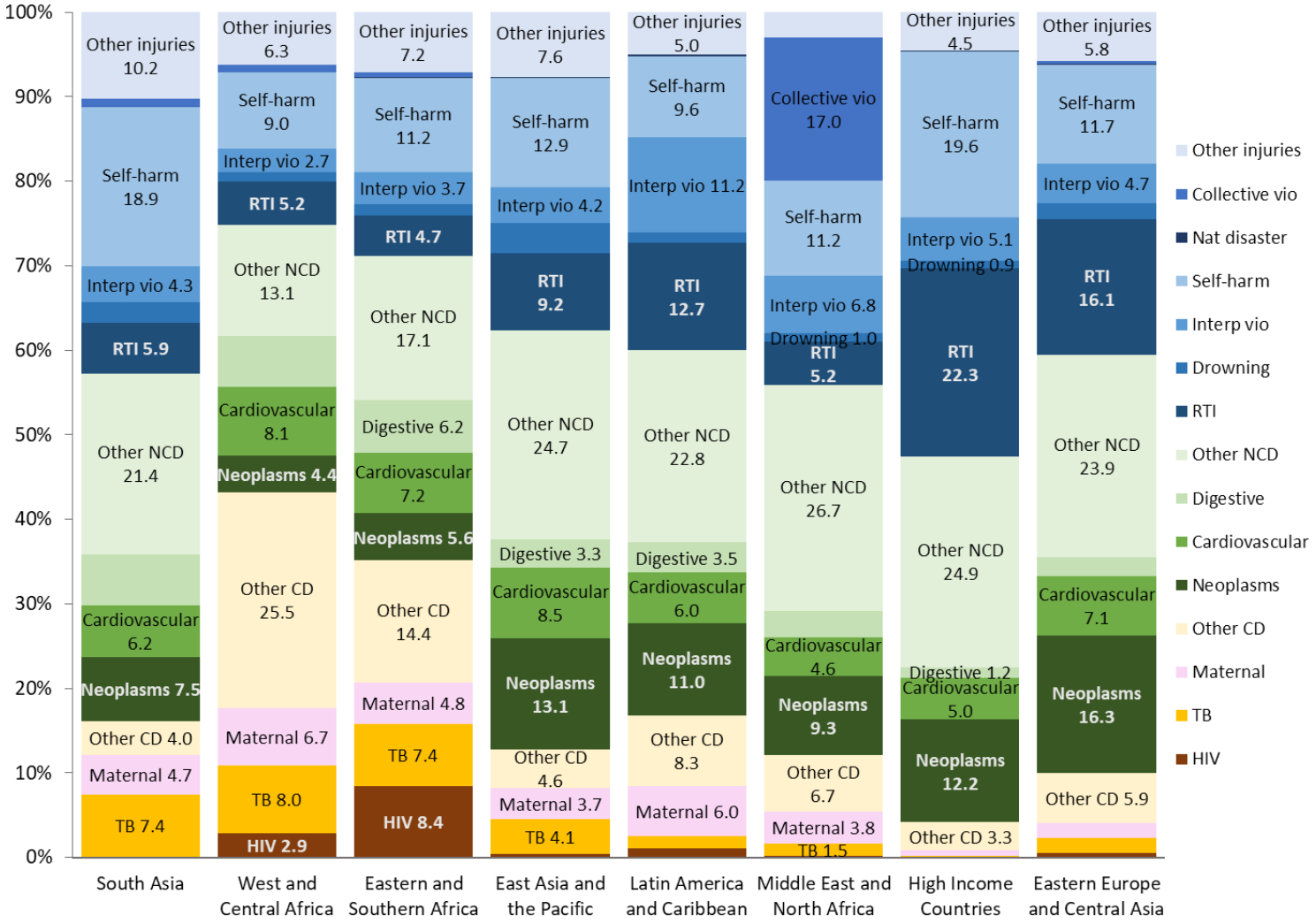
Data source: Cause-of-death distribution in 5-9 years-old from Liu, Villavicencio et al.[8]

Appendix Figure A8. Regional cause-specific mortality fractions in 10-14 years-old, 2019



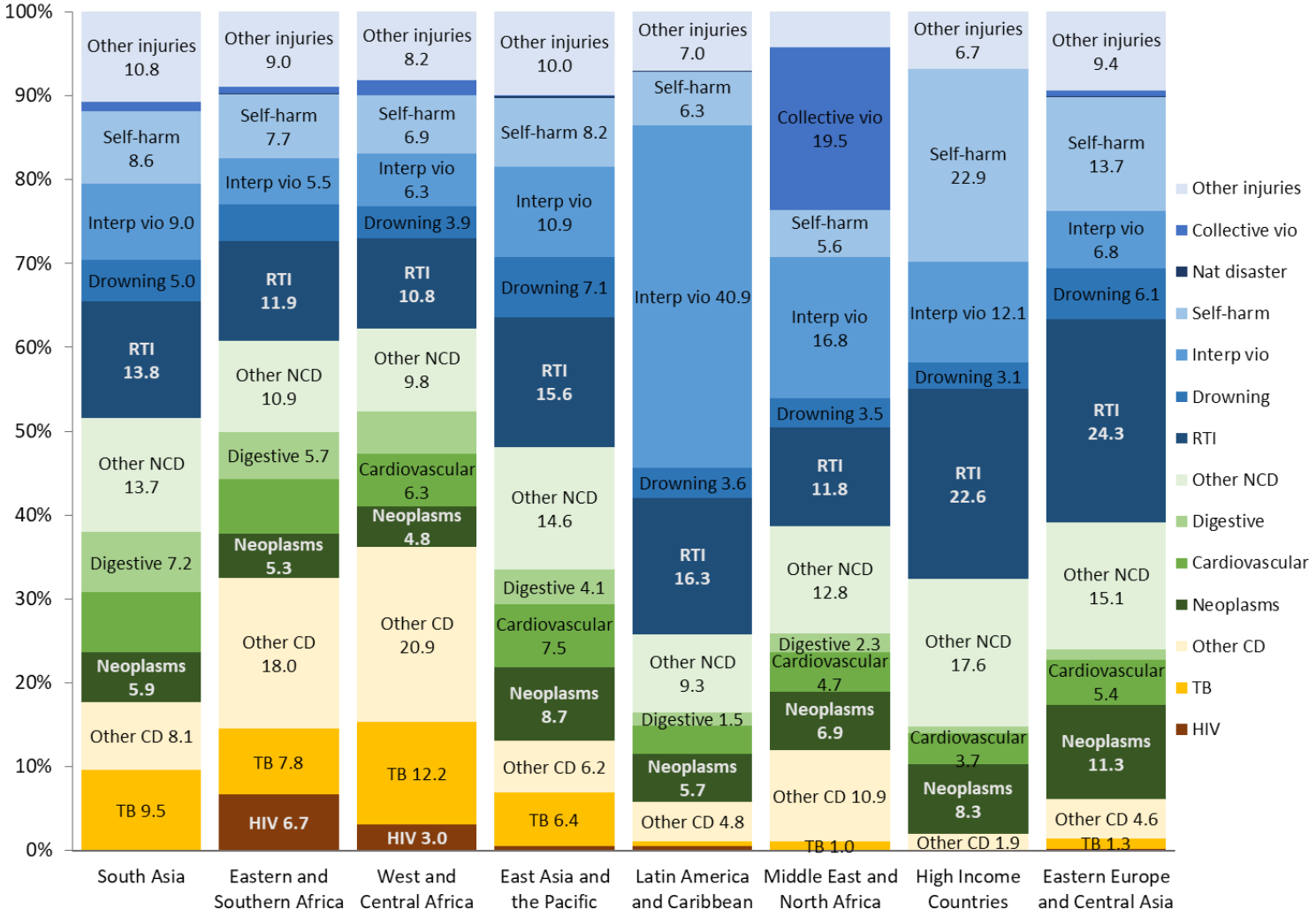
Data source: Cause-of-death distribution in 10-14 years-old from Liu, Villavicencio et al.[8]

Appendix Figure A9. Regional cause-specific mortality fractions in females 15-19, 2019



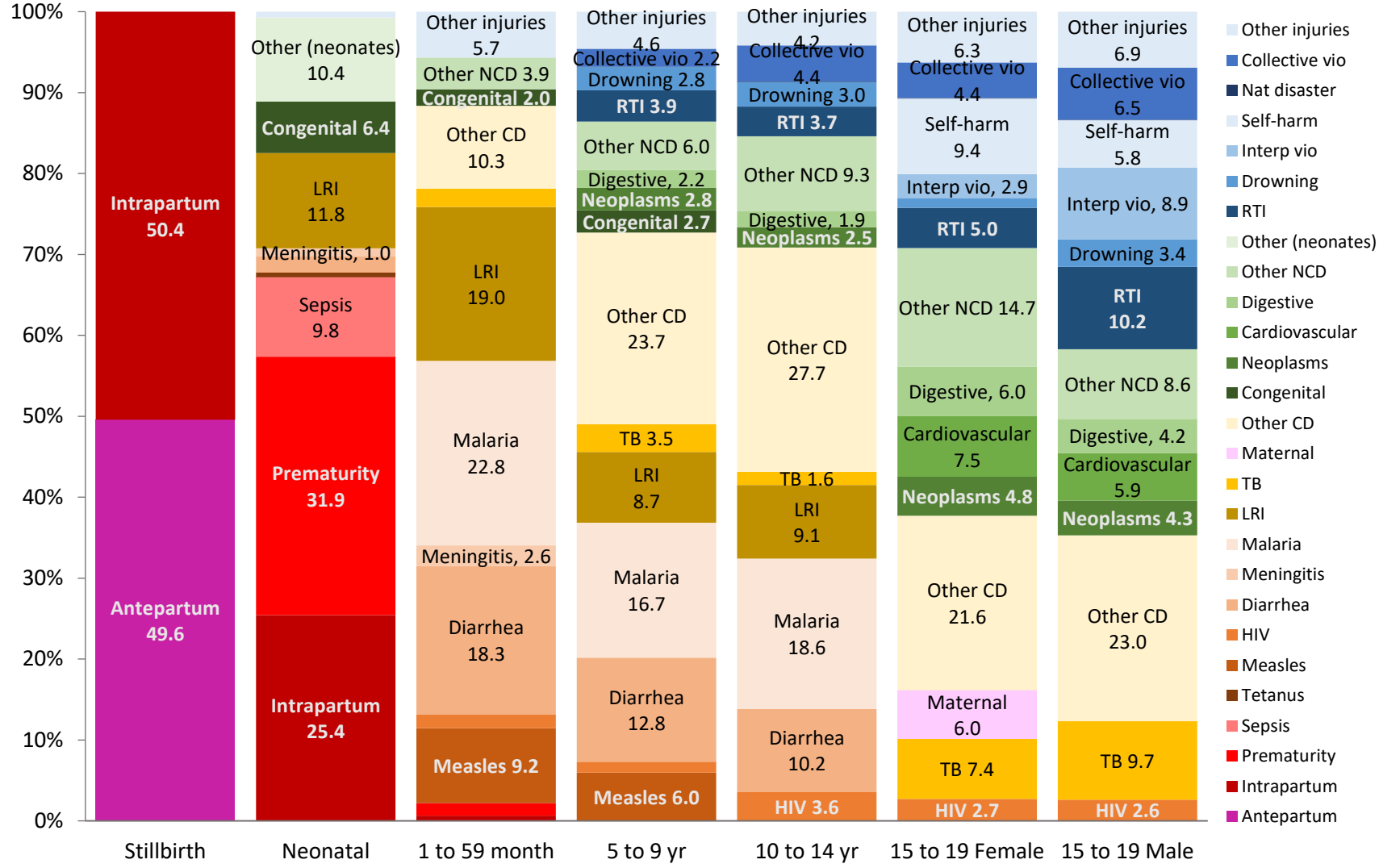
Data source: Cause-of-death distribution in females 15-19 from Liu, Villavicencio et al.[8]

Appendix Figure A10. Regional cause-specific mortality fractions in males 15-19, 2019



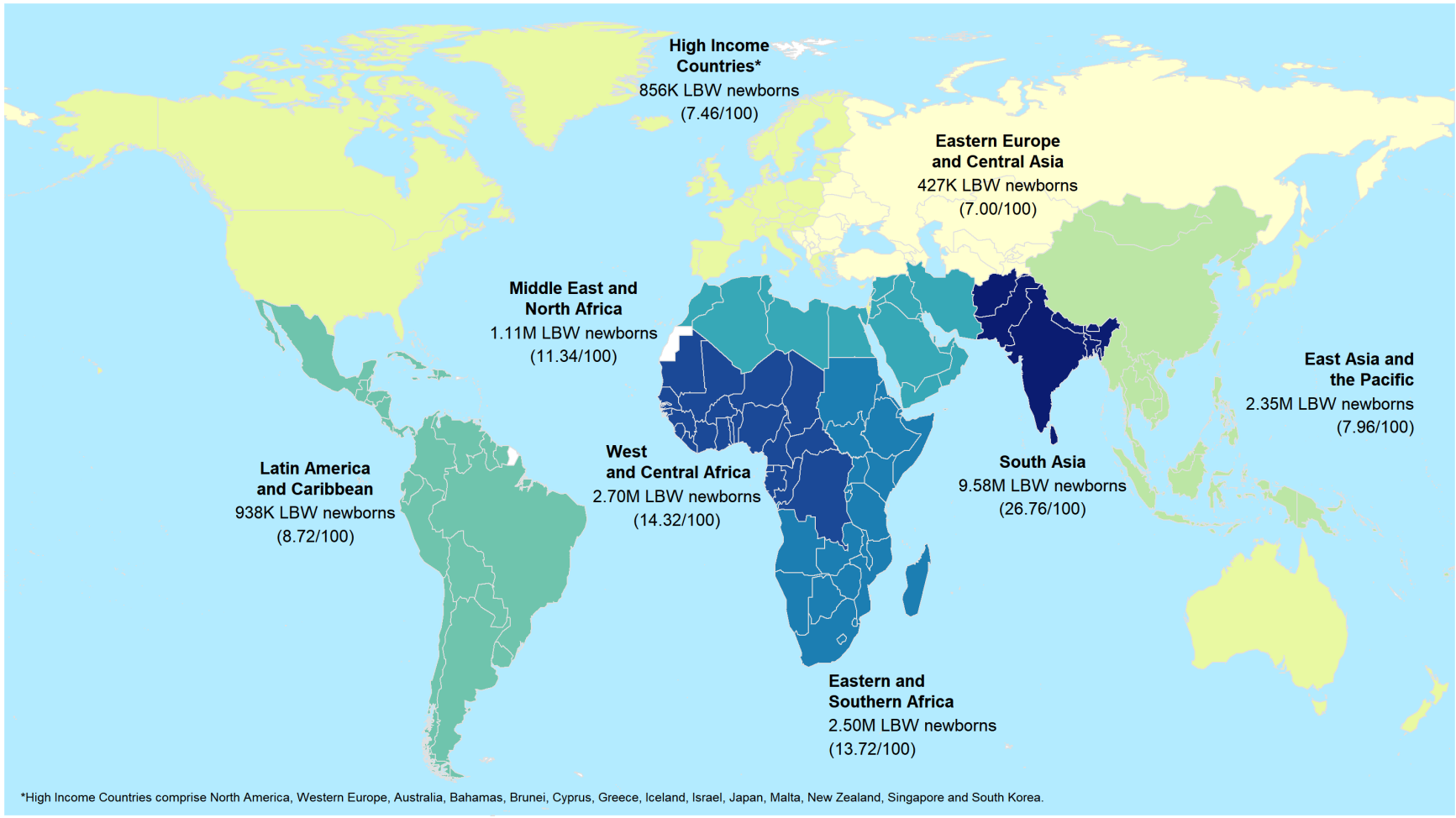
Data source: Cause-of-death distribution in males 15-19 from Liu, Villavicencio et al.[8]

Appendix Figure A11. Age-specific mortality fractions in fragile states, 2019



Data source: Cause-of-death distribution in stillbirths from UN IGME[2], in under-fives from Mulick et al[6], Perin et al[7] and in 5-19 years-old from Liu, Villavicencio et al.[8]

Appendix Figure A12. Low Birth Weight (LBW) newborns and rates by world regions in 2015



Data source: Blencowe et al.[9]

Appendix Methods A1. Methods for analysis of national surveys for length/height and Body Mass Index in children under 5y

The International Center for Equity in Health database for the Countdown to 2030 Initiative (www.equidade.org) maintains a database with over 380 nationally representative child health and nutrition surveys, mostly Demographic and Health Surveys (DHS) (https://dhsprogram.com/what-we-do/survey-Types/dHs.cfm)and Multiple Indicator Cluster Survey (MICS) (http://mics.unicef.org/). Both types of survey programs are highly comparable in terms of sampling, questionnaires and anthropometric methods.[10,11] For the present analyses the most recent survey per country, carried out in 2010 or later, was selected. The median year of the surveys was 2014.

Within each sampled household, children under the age of five years are examined. Measuring boards are used to obtain recumbent length for children under two years and standing height for older children. Weight is measured using portable digital scales. Children under two years of age are weighted while on an adult's lap, and adult's weight is subtracted.[12,13] Length or height for age and body mass index (BMI) for age are expressed as Z scores relative to the median of the WHO Child Growth Standards.[14] Ages of the children were estimated by subtracting the birth date from the interview date; if information is only available for the month of birth, and the 15th of each month was used as the day of birth. All analyses took into account the complex nature of the samples.

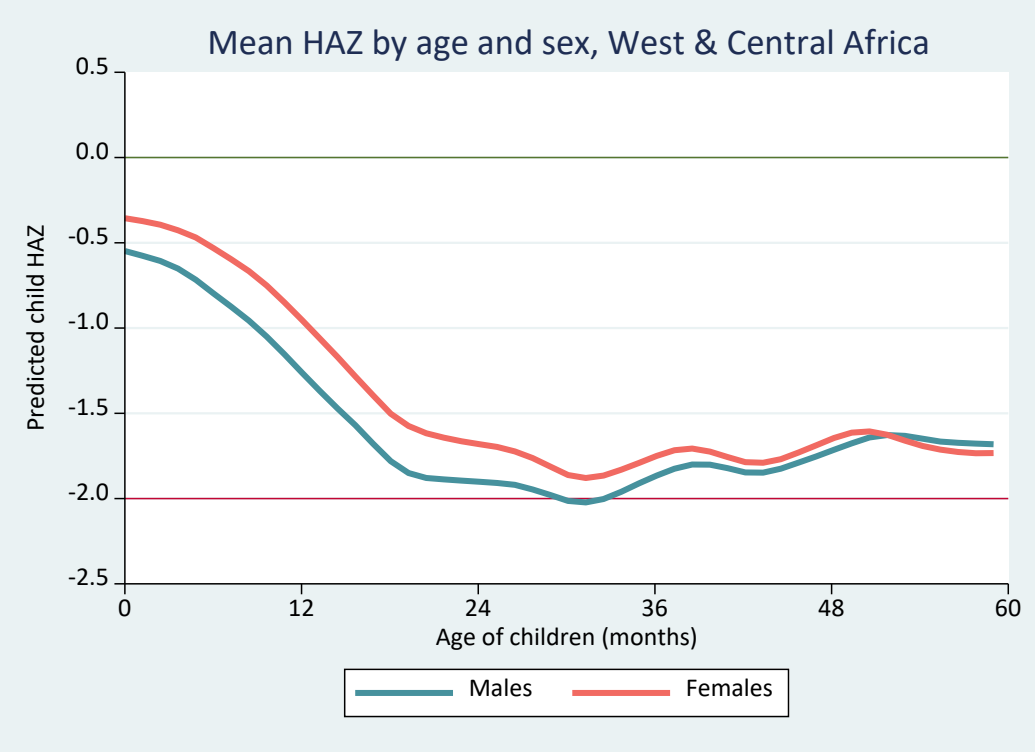
Mean height or length, and mean BMI was calculated for each month of age, in each national sample. Regional means were calculated as the weighted average of countries in each region, using under-five population as weights (https://data.unicef.org/resources/dataset/malnutrition-data/). Local polynomial modeling[15] was used to produce graphs of mean length or height and mean BMI by age using the Stata command lpoly (version 15·0, StataCorp, College Station, TX, USA).

Data were available for 87 countries. These account for **87%** of all low-income, **67**% of lower-middle income, and **49**% of upper-middle income countries according to the World Bank classification in 2015. The table below shows their distribution by region of the world.

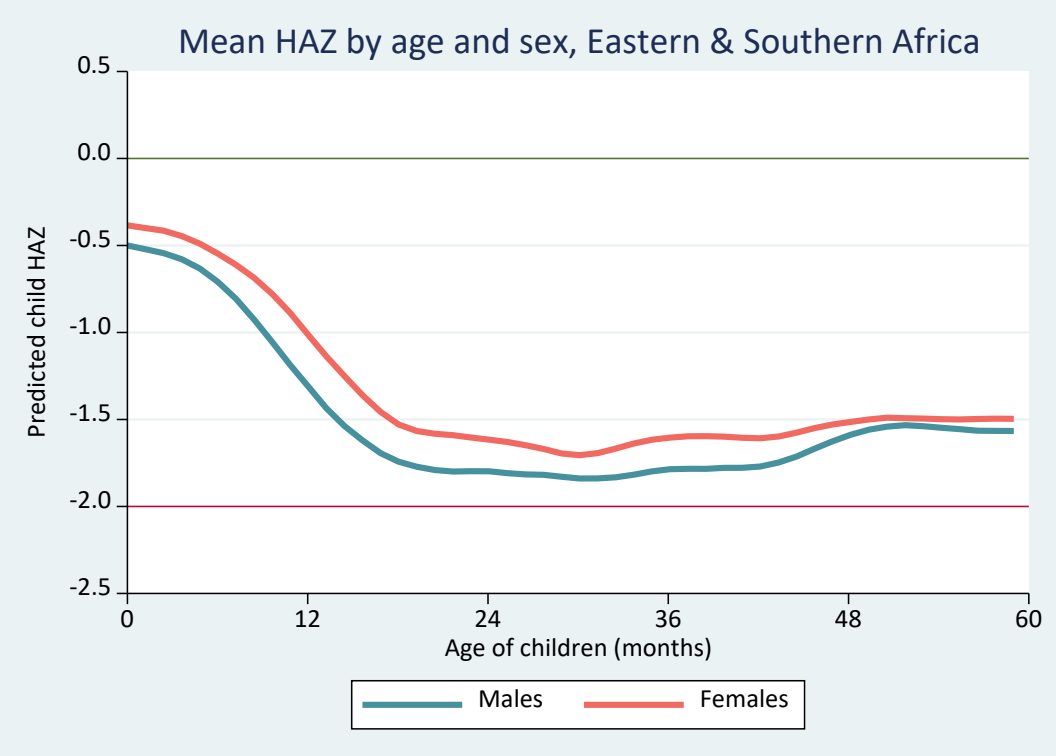
Distribution of countries with information on length/height or BMI included in the analyses, by region of the world.

UNICEF region	**countries**
West & Central Africa	22
Eastern & Southern Africa	17
Middle East & North Africa	8
Eastern Europe & Central Asia	12
South Asia	6
East Asia & the Pacific	7
Latin America & Caribbean	15
All regions	**87**

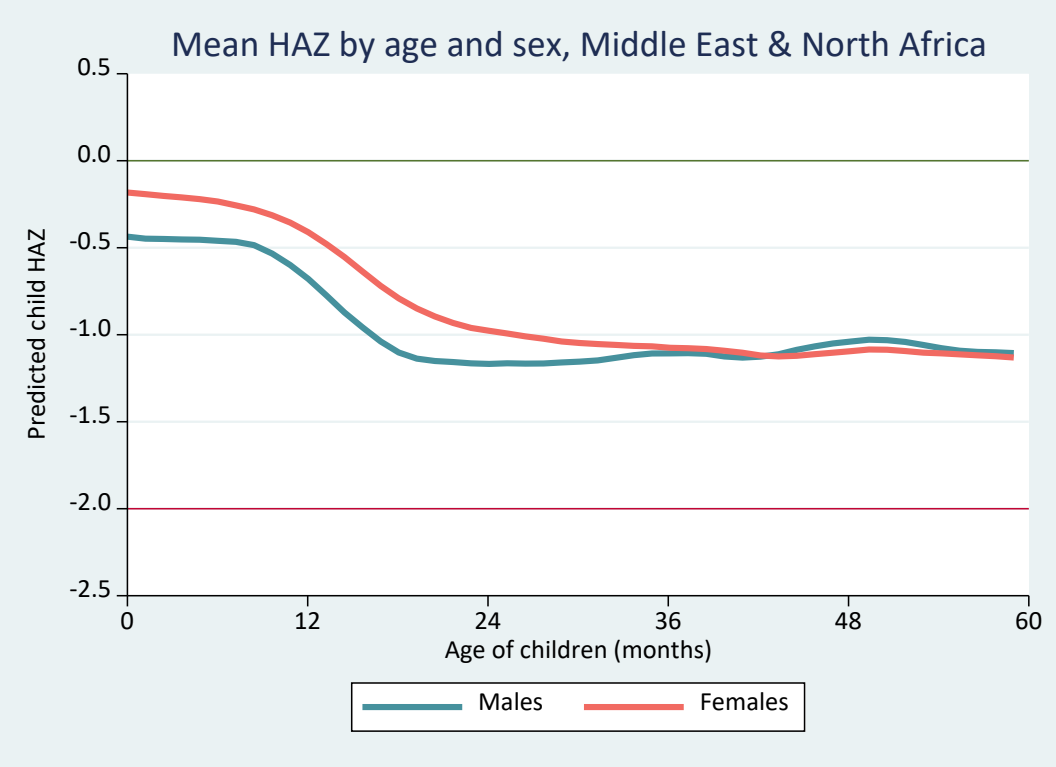
Appendix Figure A13. Mean HAZ by age and sex, West & Central Africa



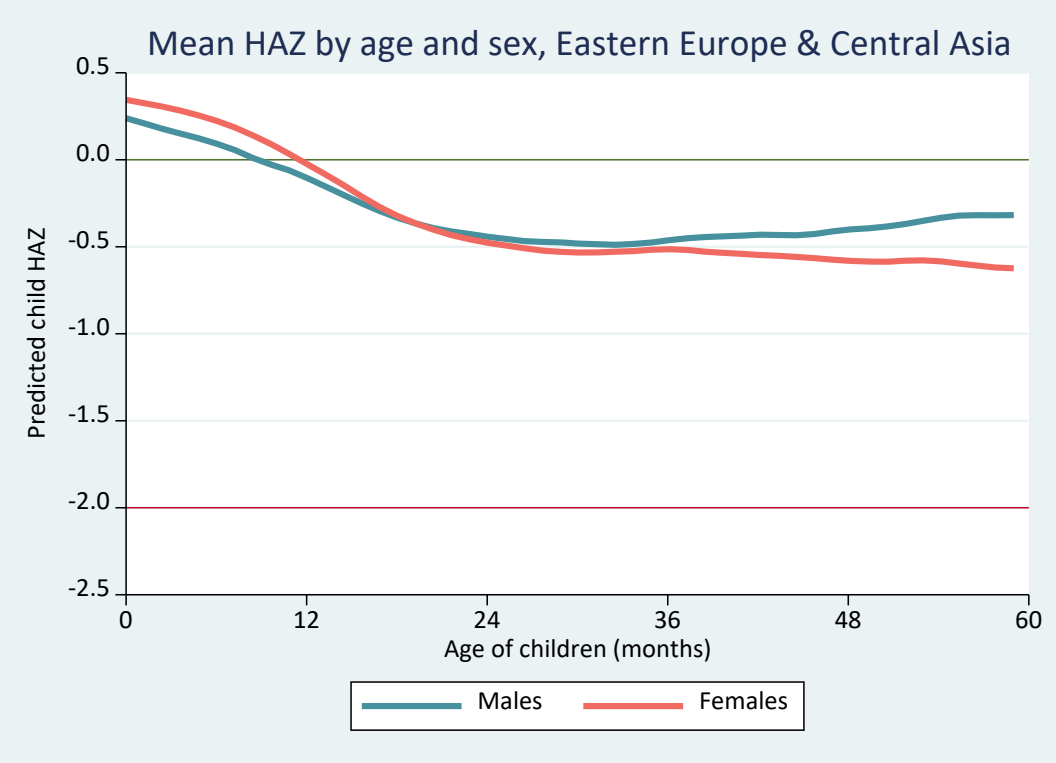
Appendix Figure A14. Mean HAZ by age and sex, Eastern & Southern Africa



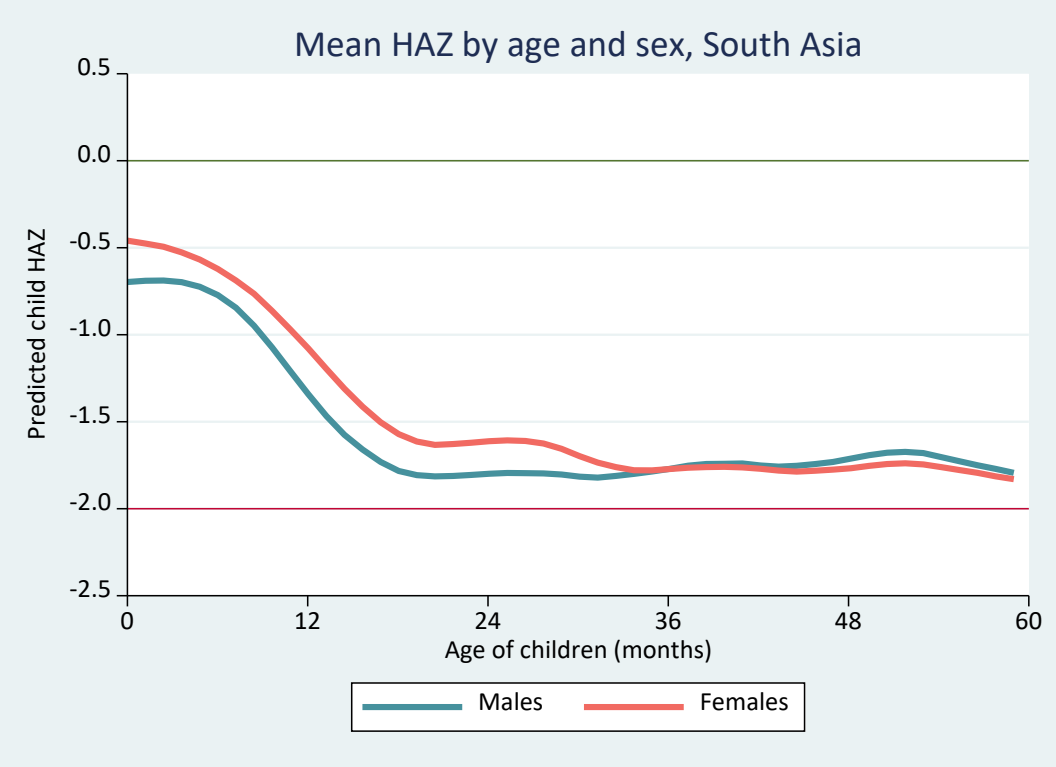
Appendix Figure A15. Mean HAZ by age and sex, Middle East & North Africa



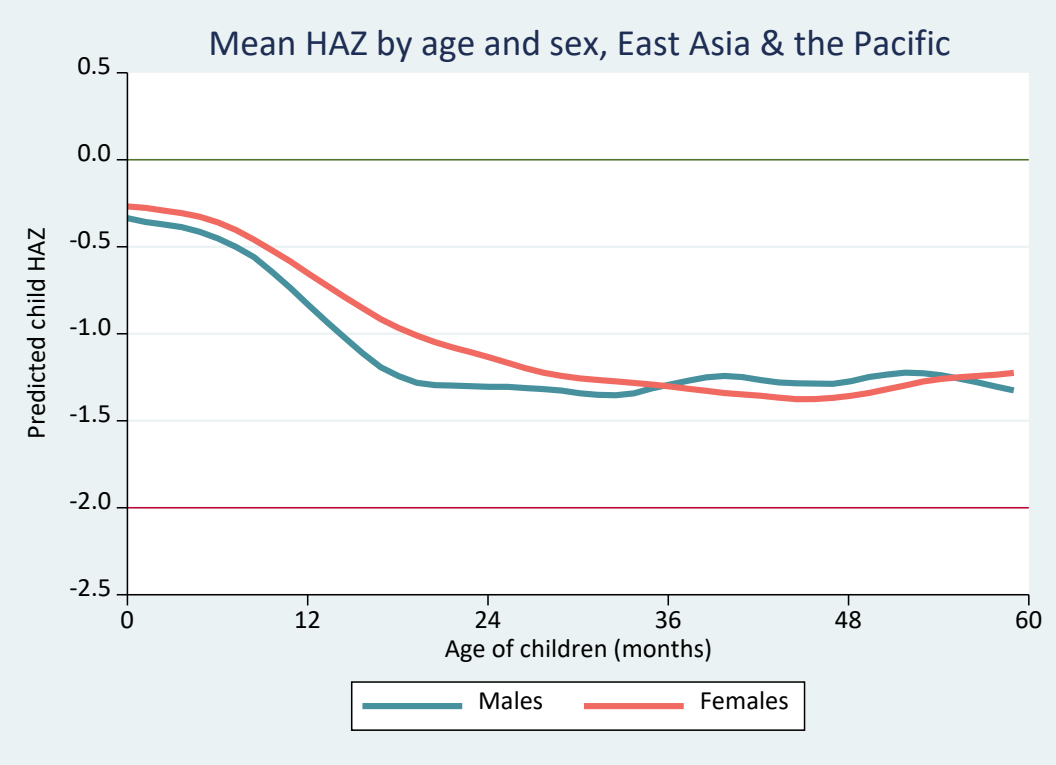
Appendix Figure A16. Mean HAZ by age and sex, Eastern Europe & Central Asia



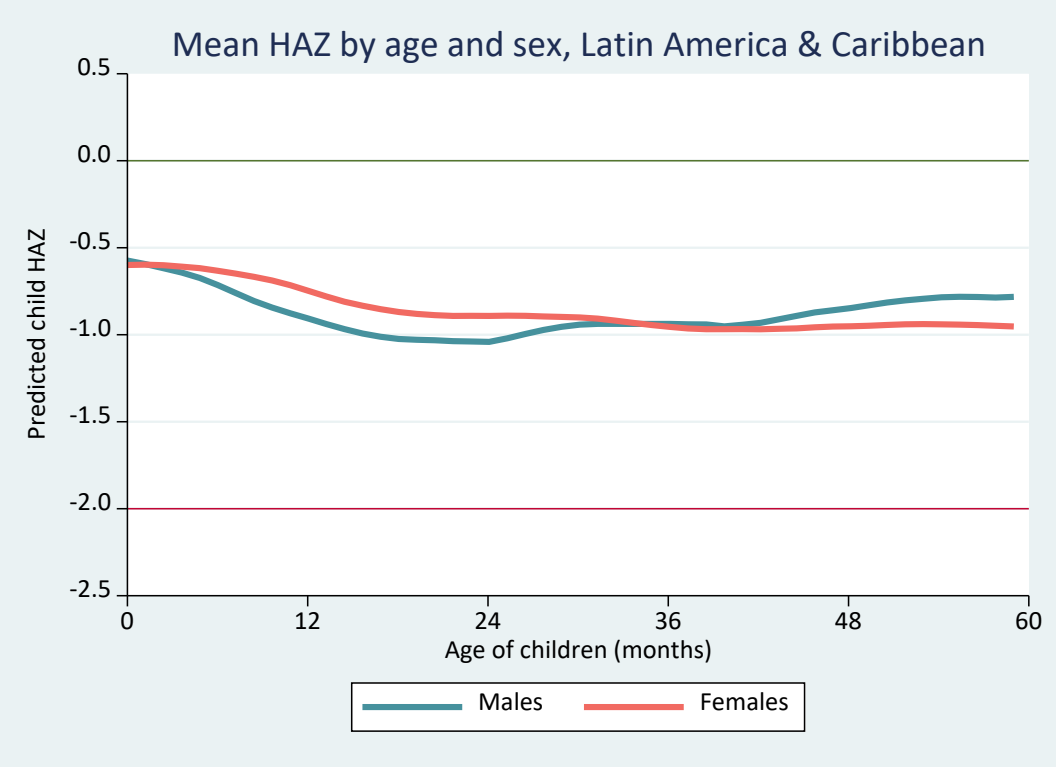
Appendix Figure A17. Mean HAZ by age and sex, South Asia



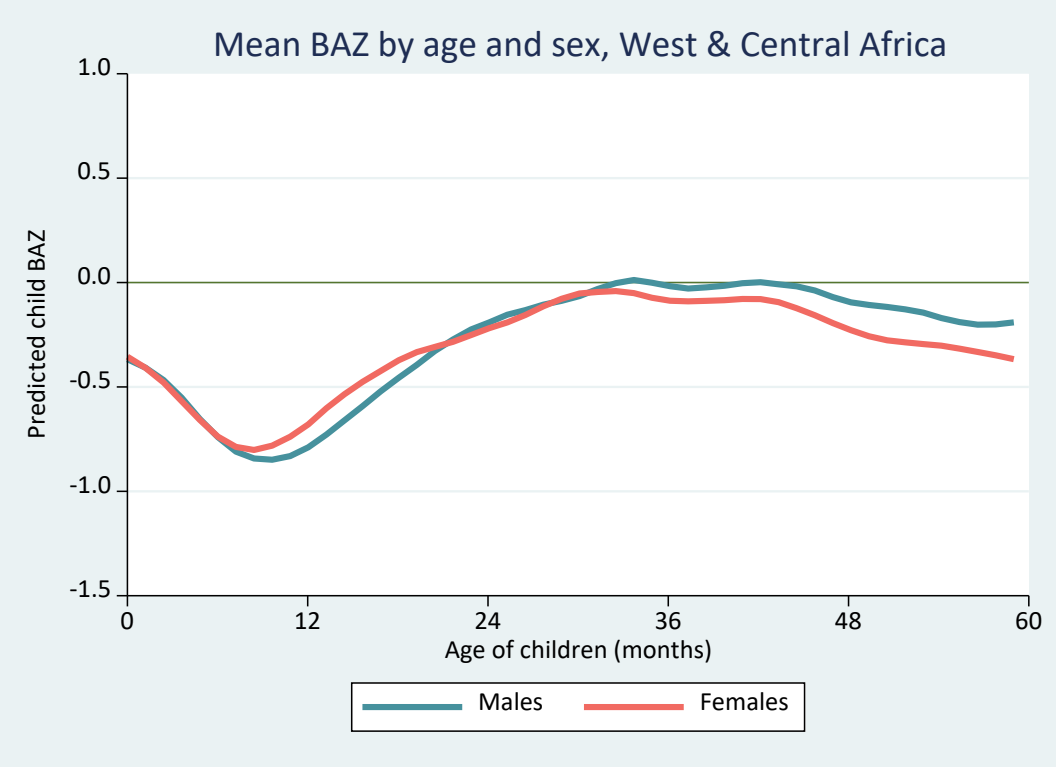
Appendix Figure A18. Mean HAZ by age and sex, East Asia & the Pacific



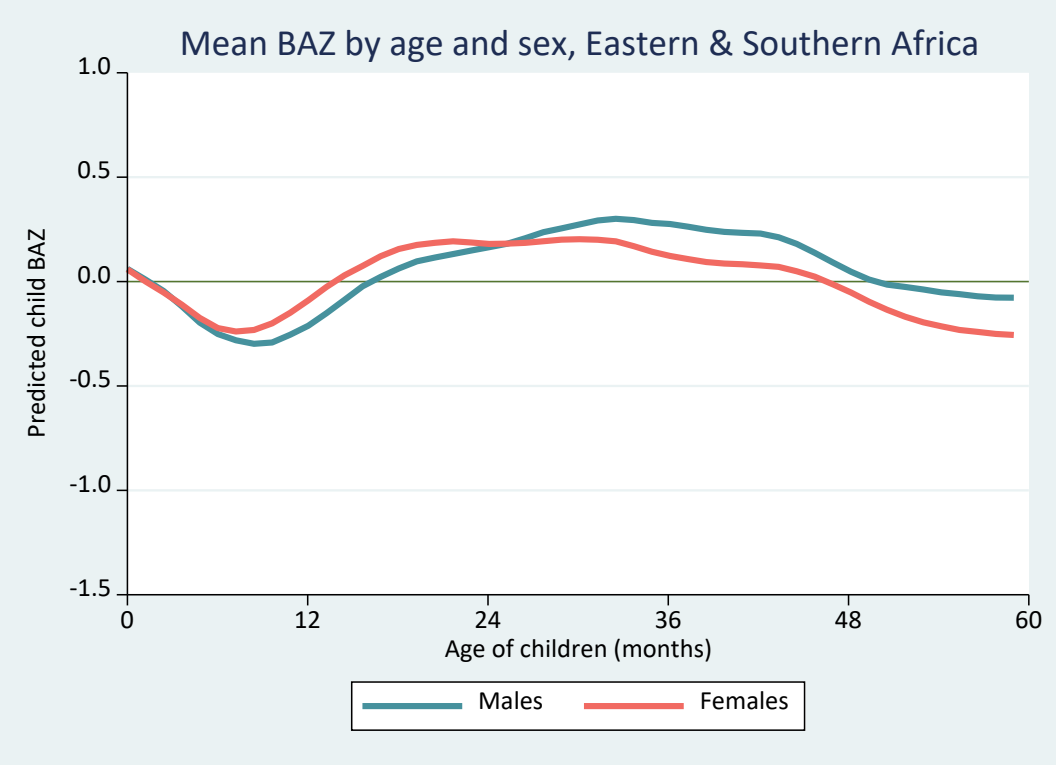
Appendix Figure A19. Mean HAZ by age and sex, Latin America & Caribbean



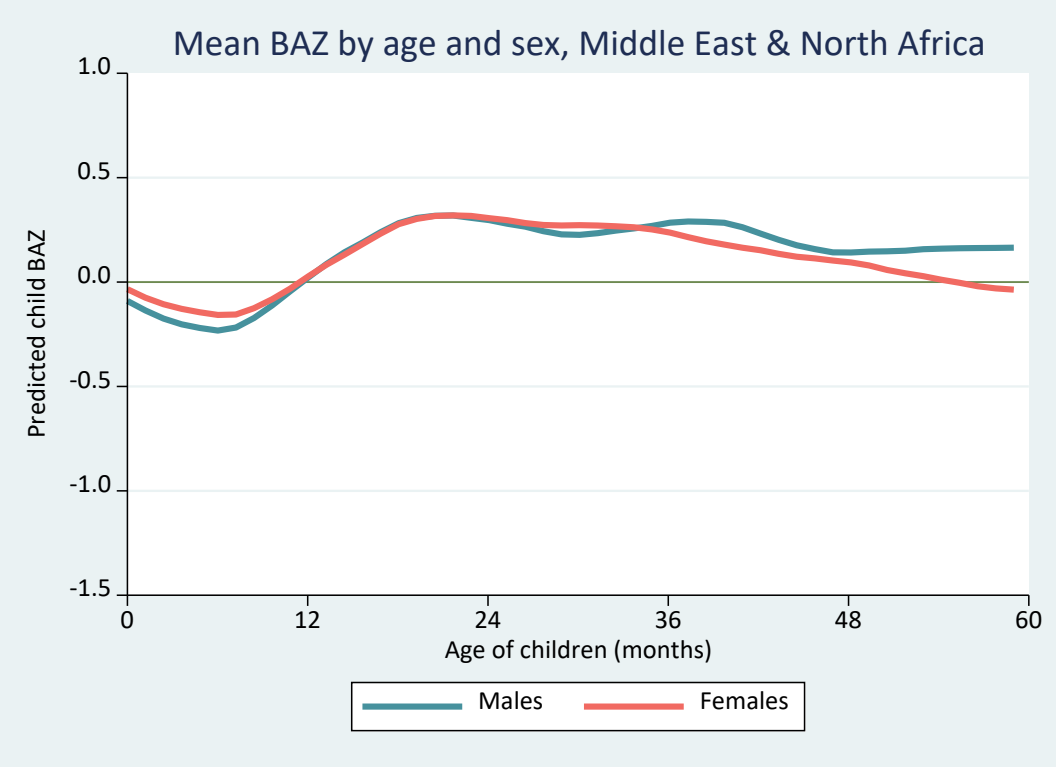
Appendix Figure A20. Mean BAZ by age and sex, West & Central Africa



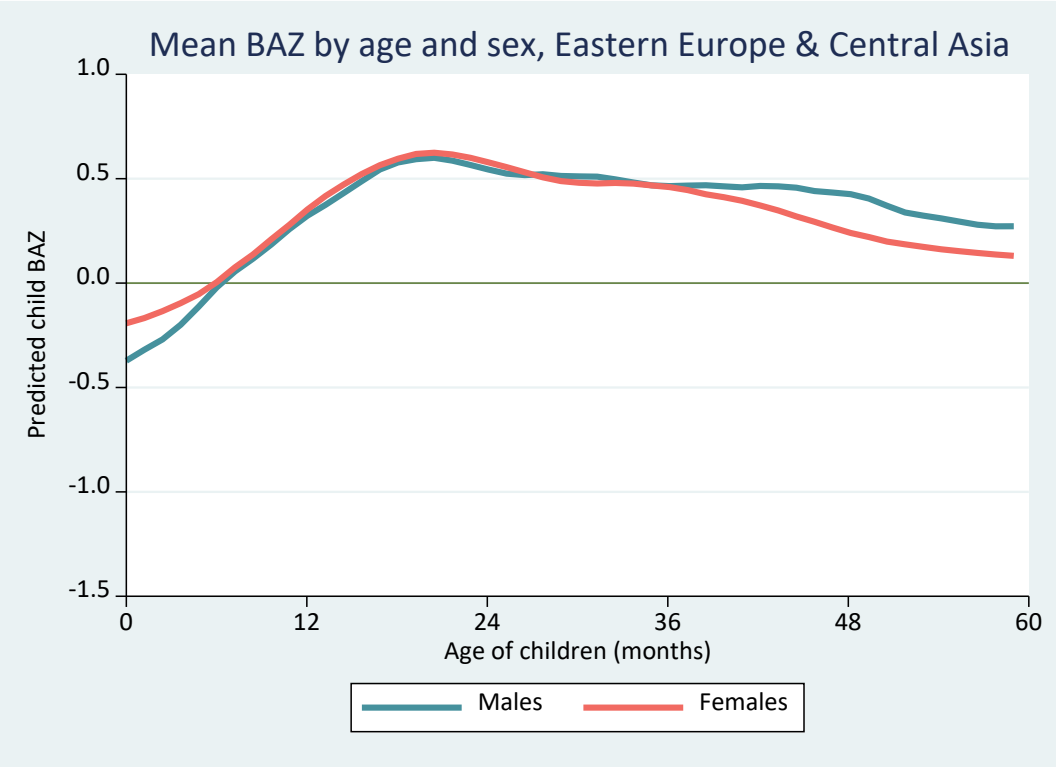
Appendix Figure A21. Mean BAZ by age and sex, Eastern & Southern Africa



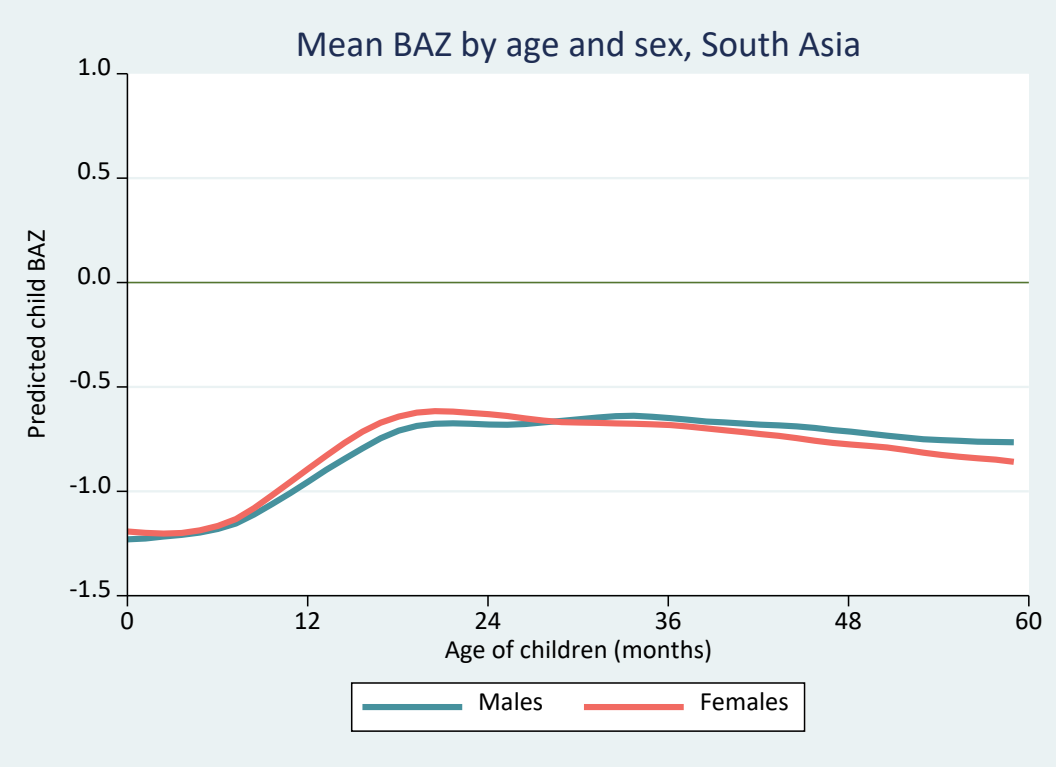
Appendix Figure A22. Mean BAZ by age and sex, Middle East & North Africa



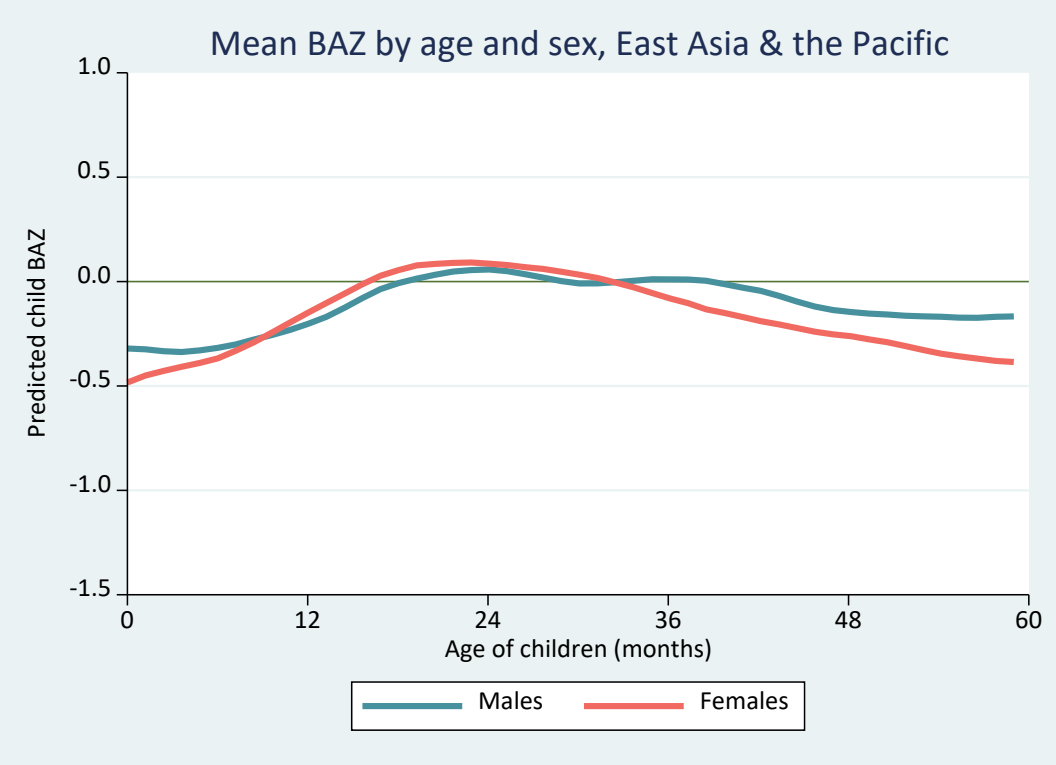
Appendix Figure A23. Mean BAZ by age and sex, Eastern Europe & Central Asia



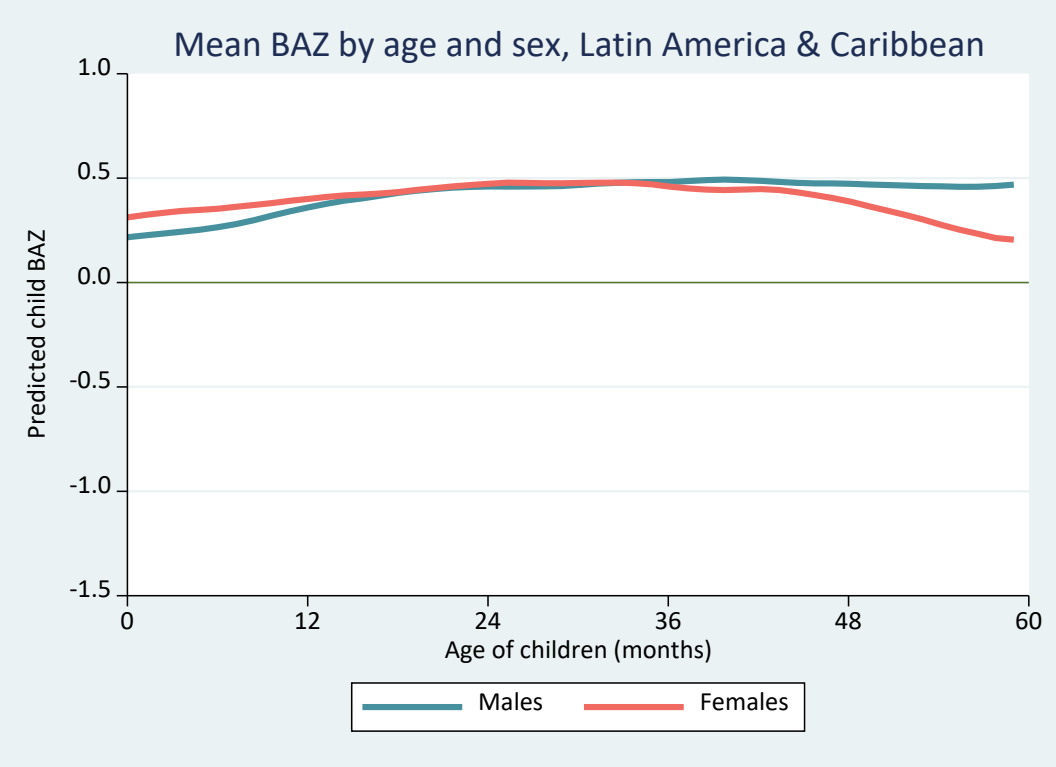
Appendix Figure A24. Mean BAZ by age and sex, South Asia



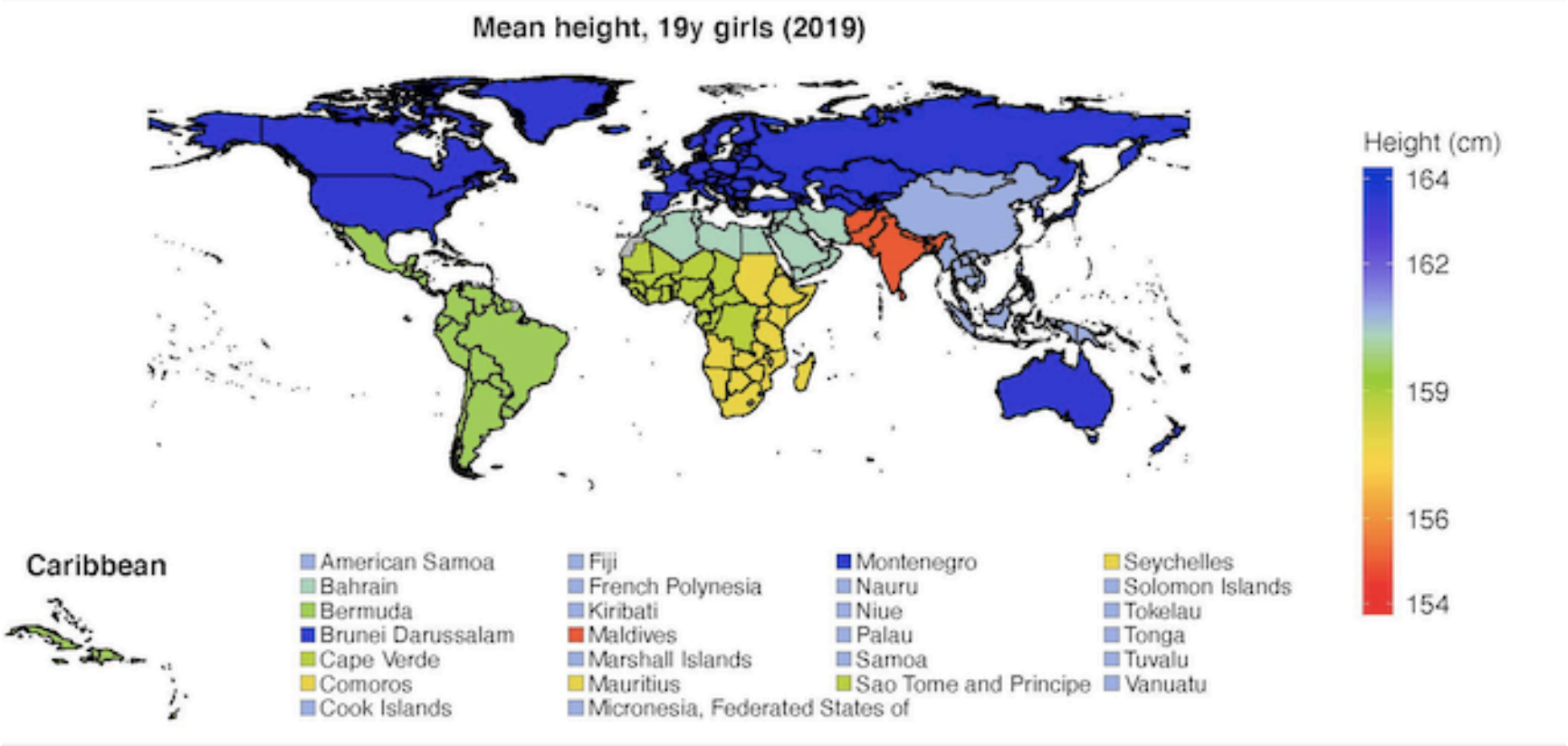
Appendix Figure A25. Mean BAZ by age and sex, East Asia & the Pacific



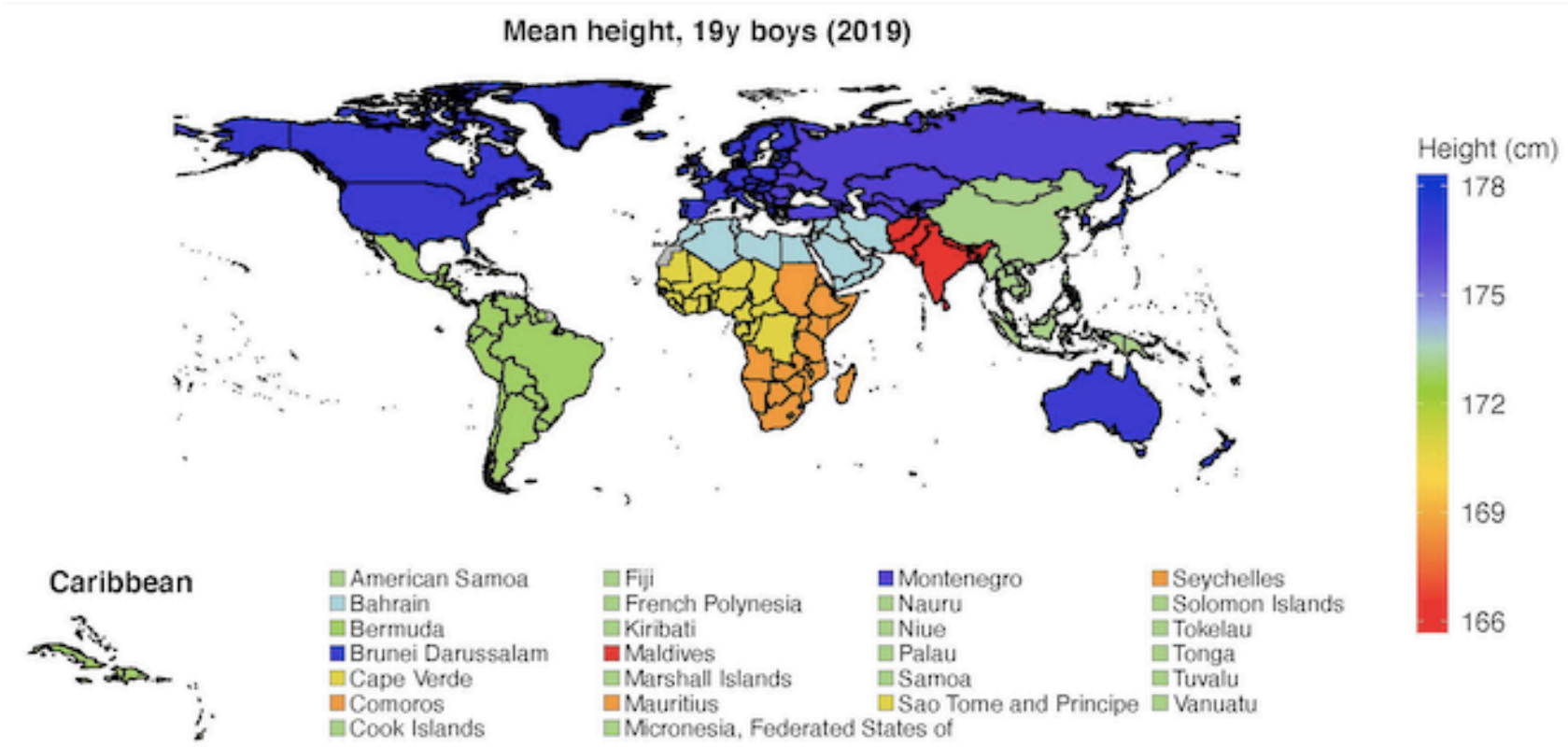
Appendix Figure A26. Mean BAZ by age and sex, Latin America & Caribbean



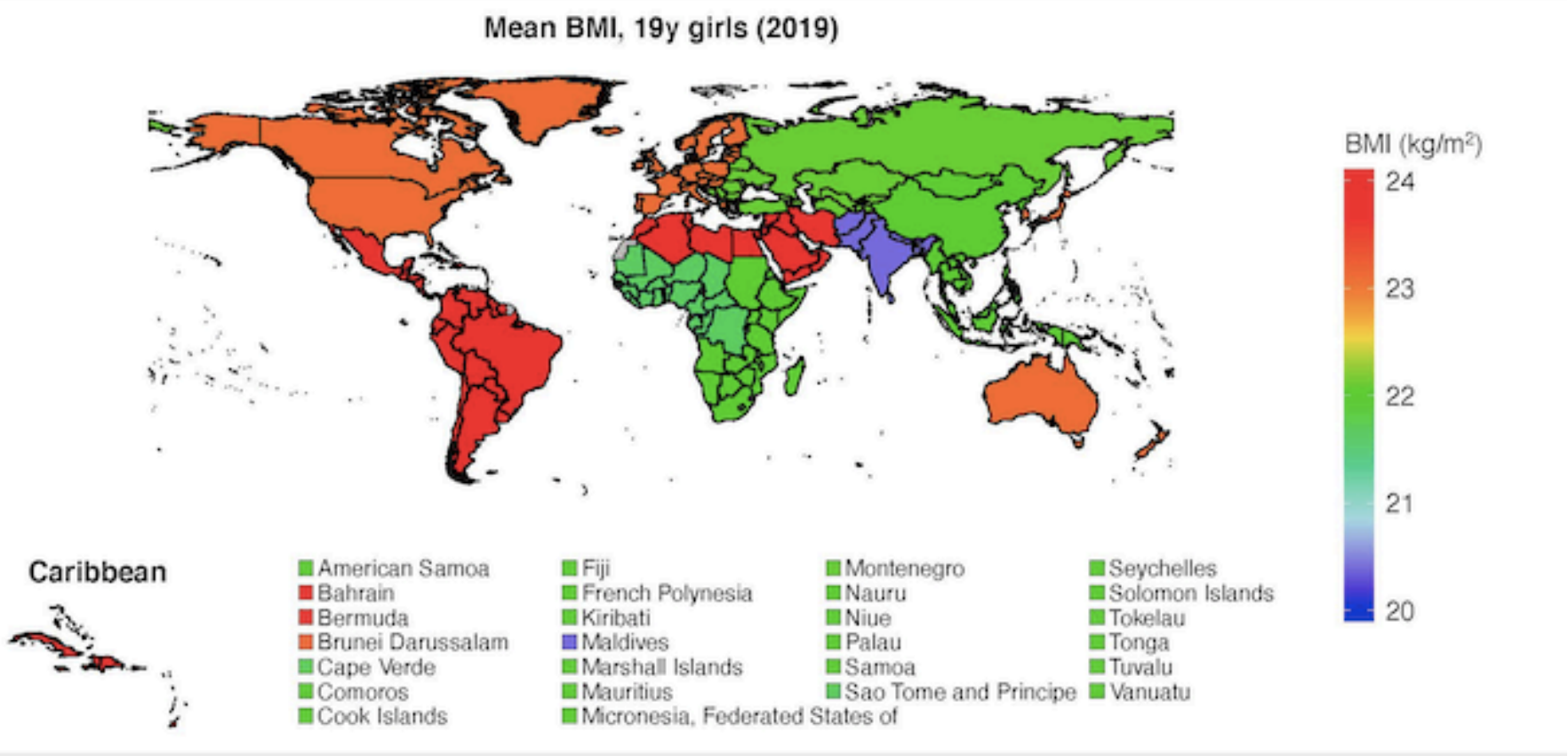
Appendix Figure A27. World map of height for 19-year-old girls by world region



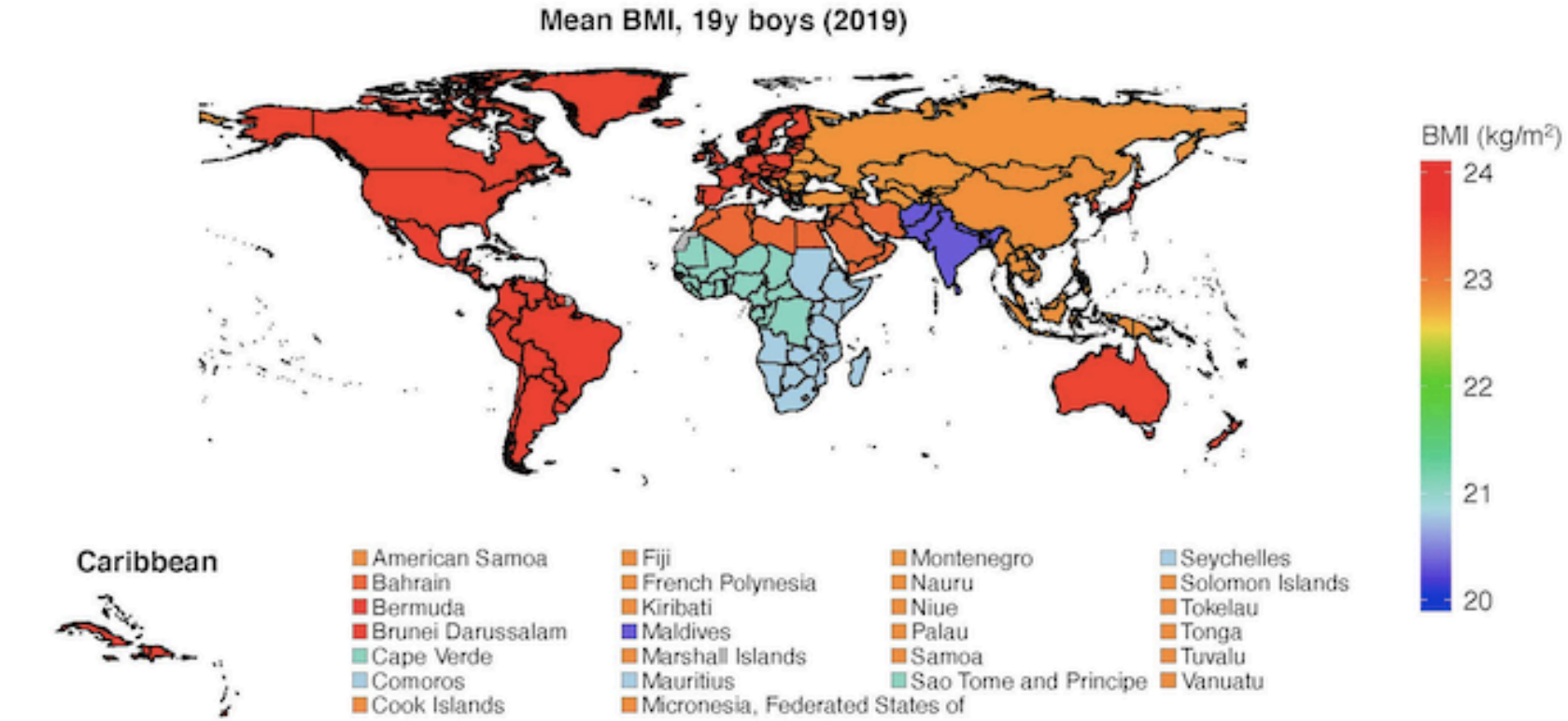
Appendix Figure A28. World map of height for 19-year-old boys by world region



Appendix Figure A29. World map of Body Mass Index (BMI) for 19-year-old girls by world region



Appendix Figure A30.World map of Body Mass Index (BMI) for 19-year-old boys by world region



Appendix Methods A2. Analysis of data from six LMIC cohorts on life-course relationships from birth to adulthood

Methods

Data

Data were obtained from six cohorts (Cebu, Delhi, Guatemala, Pelotas 1982, Pelotas 1993, Soweto) including the most recent data collection wave in each. Ethical approval for data collection and analyses was obtained at each site, prior to each wave of data collection. Ethical clearance for the current pooled analyses was granted by the Research Ethics Committee of the School of Medicine, Federal University of Pelotas.

Cohort members were measured at birth, at ~2 years of age (except in the 1993 Pelotas cohort where the age was 1 year), at ~4 years of age (except in Cebu where the age was 8·5 years) and during adulthood. For simplicity, we refer to these visits as follow ups at birth, 2 and 4 years, and adulthood. Cognitive development was measured at different ages in each cohort, ranging from 4-8·5 years. Table A4 provides an overview of the exposure and outcomes variables.

The exposure variables were:

- Length and weight at birth, length-for-age (Z-scores) and BMI-for-age (Z scores) at 2 and 4 years. Birth length was not available for the 1982 Pelotas and Soweto cohorts. For the 2-year measurement, length-for-age was calculated using height (in South Africa) or recumbent length (other sites). These measurements were converted into *Z* scores with the WHO Growth Standards. (www.who.int/childgrowth)
- Conditional variables: these variables include conditional height and relative weight at 2 years (reflecting growth from birth to 2 years), at 4 years (reflecting growth from 2-4 years), and in adulthood (reflecting growth after 4 y). Conditionals may be interpreted as representing faster (if positive) or slower (if negative) weight gain or linear growth relative to the overall cohort. Conditional height corresponds to the sex-specific standardized residuals from a linear regression of current height-for-age WHO Z scores on all previous height/length and weight measures. Conditional relative weight corresponds to the sex-specific standardized residuals from a linear regression of current weight WHO Z scores on all previous height/length and weight measures, and on concurrent height. For example, conditional height at 4 years is obtained by regressing height-for-age at 4 y on length and weight at birth and at 2 y. Conditional relative weight at 4 y was calculated by regressing weight at 4 y on these same variables, plus height at 4 y. For conditional variables in adulthood, the raw outcome variable was used because the conditionals were generated for each sex separately. Since two cohorts did not measure birth length, only weight at birth was used. The results were virtually identical in sensitivity analyses using birth length for cohorts that measured this variable.
- Development Quotient (DQ) in childhood was measured by the research teams and standardized to Z scores. The Cebu cohort (average age of 8·5 years) were administered the Philippine Nonverbal Intelligence Test (PNIT), modelled on the Raven's Coloured Progressive Matrices. The Guatemala cohort (between 4 and 7 years of age) were administered a Preschool Battery consisting of 22 sub-test tests, drawn from a variety of sources including the Wechsler Preschool and Primary Scale of Intelligence (WPPSI). The 1982 and 1993 Pelotas cohort (4 years of age in both) were administered the Griffiths Scales and the WPPSI, respectively. The Soweto cohort (average age of 5 years) were administered 32 items from the Revised Denver Pre-screening Questionnaire (R-DPDQ)

covering personal-social, fine motor, gross motor, and language abilities. DQ was not measured in the Delhi cohort.

Overview of the exposure and outcomes variables

11 early-life exposures	6 adult outcomes
Birth length (WHO Z scores)	Attained schooling (years)
Length at 2 years (WHO Z scores)	Intelligence (IQ, harmonized units)
Height at 4 years (WHO Z scores)	Height (cm)
Conditional length at 2 years (Z scores)	Psychiatric problems score (SRQ points)
Conditional height at 4 years (Z scores)	Overweight/obesity (yes/no)
Conditional height in adulthood (Z scores)	Metabolic syndrome score (0-5 points)
Birth weight (WHO Z scores)	
BMI t 2 years (WHO Z scores)	
BMI at 4 years (WHO Z scores)	
Conditional relative weight at 2 years (Z scores)	
Conditional relative weight at 4years (Z scores)	
Conditional relative weight in adulthood (Z scores)	
Cognitive development at 4-8.5 years (Z scores)	

The adult outcomes were:

- Attained schooling: number of years of schooling completed.
- Intelligence (IQ points, standardized to mean=100 and standard deviation=15): Wechsler Adult Intelligence Scale (Pelotas 1982 and 1993 cohorts) and Ravens Scale (Cebu, Guatemala and Soweto). IQ was not measured in the Delhi cohort.
- Height: measured in cm.
- Psychological symptoms: number of symptoms reported in the Self-Reported Questionnaire (SRQ) scale. Not available for the Delhi cohort.
- Overweight/obesity (yes/no): body mass index equal to or above 25 kg/m^2.
- Metabolic syndrome: number of signs presented by each subject, including: abdominal adiposity (waist circumference ≥102 cm for males or ≥89 cm for females), raised blood pressure (systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg or taking hypotensive medication), raised triglycerides (≥150 mg/dL or taking triglyceride-lowering medication), raised plasma glucose (≥100 mg/dL for fasting glucose [all but the Pelotas cohorts] or ≥200 mg/dL for random glucose or taking diabetes medication) and reduced HDL (<40 mg/dL for males or <50 mg/dL for females).

Most outcomes were measured when participants were 34, 35-39, 47-57, 30, 30 and 24 years of age for the Cebu, Delhi, Guatemala, Pelotas 1982, Pelotas 1993 and Soweto cohorts, respectively. For Cebu, triglycerides, HDL and

glucose were measured at 21.5 years of age. For Pelotas 1993, IQ and psychological symptoms were measured at 18 years of age. For Soweto, schooling, IQ and psychological symptoms were measured at 28 years of age.

Statistical analyses

All statistical analyses were performed using R (https://www.r-project.org/). For data description, central tendency (mean and median) and dispersion (minimum, maximum, range and interquartile range) measures were calculated for continuous variables and proportions for categorical variables for each cohort separately.

Association analyses were performed using regression models: linear regression for continuous outcomes and Quasi-Poisson regression for binary (estimating prevalence ratios) and count outcomes (estimating average ratios). To account for the fact that the 1993 Pelotas Birth Cohort collected data in subsamples enriched for low birth weight cases at ages 1 and 4 years, analyses in this cohort involving any variables collected at one or more of these ages (more specifically, length-for-age, BMI-for-age conditional variables and cognitive scores) were weighted using inverse sampling weights.

All association analyses were performed for each cohort and each sex separately. Cohort-specific sex-combined estimates were generated by pooling the corresponding sex-specific results using weighted random effects meta-analysis, where each sex was weighted according to sample size. The cohort-specific results were combined using random effects meta-analysis. Pooled sex-combined estimates were generated by pooling the corresponding pooled sex-specific estimates. The variation between cohorts was estimated using I^2 statistic and Cochran's Q test (in sex-combined analyses, these were calculated based on all cohort- and sex-specific estimates, so that the heterogeneity statistics capture heterogeneity by site and by sex), and random effects meta-regression was used to test for effect modification by sex (calculated based on all cohort and sex-specific estimates rather than pooled sex-specific estimates).

In these analyses, we estimated the association of 11 early-life exposures on 6 adult outcomes. These analyses were classified in two main groups:

- Tracking analyses: associations within the same domain – i.e., association of early-life variables with its respective counterpart in adulthood (e.g., length at birth and adult height). These analyses are summarized in the table below.
- Early determinants analyses: cross-domain associations – i.e., associations of every exposure with every outcome, except for those included in the tracking analyses. These analyses also did not include length and BMI at 2 y and 4 y as exposures.

Overview of the tracking analyses

Adult outcome	Early-life exposure
Height	Birth length
	Length at 2 years
	Length at 4 years
	Conditional length at 2 years
	Conditional height at 4 years
Overweight/obesity	Birth weight
	BMI at 2 years
	BMI at 4 years
	Conditional relative weight at 2 years
	Conditional relative weight at 4 years
IQ	Cognitive development quotient at 4-8·5 years

Tracking analyses quantify how much a given early-life variable predicts its adult counterpart. Since this is an associational (rather than causal) question, these analyses were only adjusted for sex and, for Guatemala, year of birth and intervention group.

Early determinants analyses estimate causal effects. Therefore, a more comprehensive approach was performed to control for confounding. First, these analyses were adjusted for a wider set of covariates. In addition to the covariates included in the tracking analysis, early determinants analyses were adjusted for maternal height (cm), maternal age at birth of the cohort participant (years), maternal schooling (years), paternal schooling (years), child birth order, and early-life socioeconomic quintiles (family income quintiles in Cebu, Delhi and Pelotas (1982 and 1993) cohorts, and wealth quintiles in Guatemala and Soweto cohorts).

In addition to using a wide set of covariates, a doubly robust covariate adjustment strategy was used, where adjustment was performed via multivariable regression after inverse probability of treatment weighting (IPTW). IPTW allows estimating marginal structural models, where the exposure is independent of measured covariates. Since all exposure variables we analyzed are continuous, the weights correspond to $\frac{f(X)}{f(X|C)}$, where $f(X)$ is the probability density function of the continuous exposure X and $f(X|C)$ is the conditional probability density function of X given measured covariates C. We assumed that the densities $f(X)$ and $f(X|C)$ were normal, thus allowing straightforward calculation of the weights using the "ipwpoint" function from the "ipw" package, applying linear regression to model the relationship between the exposure variable and the covariates. This regression was specified to include a "main effect" term for all covariates, as well as all pairwise product terms between covariates. To mitigate the possibility that individuals with large weights could substantially influence the results, the left tail of the weights was truncated at the $0{\cdot}5^{th}$ percentile, and the right tail at the $99{\cdot}5^{th}$ percentile.

Weighting the study sample using IPT weights is expected to yield a pseudo-sample where the treatment is independent of measured covariates. However, this is not guaranteed to be the case in practice due to the possibility of model misspecification. To mitigate this possibility, the causal effect of the exposure on the outcome was estimated in the weighted sample using multivariable regression including the same covariates as an additional form of confounding adjustment.

Results: Tracking analyses

The main results of the tracking analyses are shown in Table A6. Forest plots are shown in Figures A32-A34.

There was no strong statistical evidence for effect modification by sex in the pooled tracking analyses (P>0·1 for all associations). There was strong statistical evidence of positive association for all domains (P<0·0001 for all pooled tracking analyses). For height and overweight/obesity domains, the magnitude of the association increased with age of the child at the early exposure measurement when unconditional measures of size were examined. For height, point estimates ranged from 1·68 (95% CI: 1·52; 1·84) to 4·40 cm (95% CI: 4·21; 4·60) per Z score increment in length at birth and height at 4 years, respectively. For overweight/obesity, the estimates ranged from 1·07 (95% CI: 1·05; 1·09) to 1·28 (95% CI: 1·21; 1·36) times higher per Z score increment in birth weight and BMI at 4 years, respectively. For intelligence, the only early-life measure available was at 4-8·5 years. The estimate was 7·30 (95% CI: 5·85; 8·76) points per Z score increment in cognitive development scores.

In the case of conditional exposures, the association with adult height was stronger for conditional height at 2 years than at 4 years: 3·35 (95% CI: 3·06; 3·63) vs. 2·30 (95% CI: 2·03; 2·58), respectively. This suggests that linear growth from birth to 2 years is more strongly associated with adult height than growth from 2 years to 4 years. For adult overweight/obesity, the association with conditional variables was similar for both ages (if not slightly stronger at 4 years).

The I^2 statistic (Table A6) shows that there was substantial heterogeneity (P<0·05) among cohorts in all associations, except for the association between birth weight and adult overweight/obesity. I^2 values must be interpreted with caution as they are influenced by sample sizes (which are very large in our analyses) and also because what really matters is whether the effects observed in all cohorts were in the same direction and of similar magnitudes.

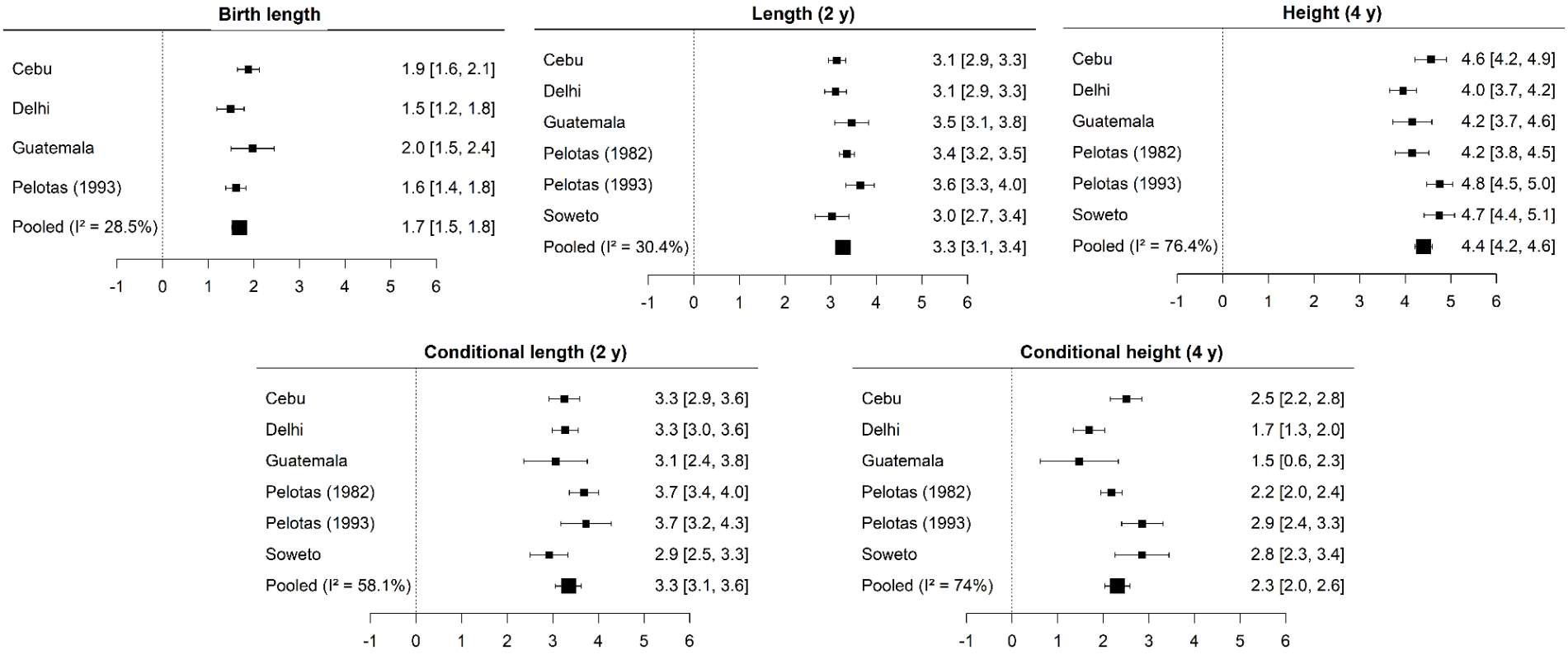
Appendix Table A6. Main results of the tracking analyses. See next pages for the forest plots

[A] Estimates correspond to a Z score increment in the exposure

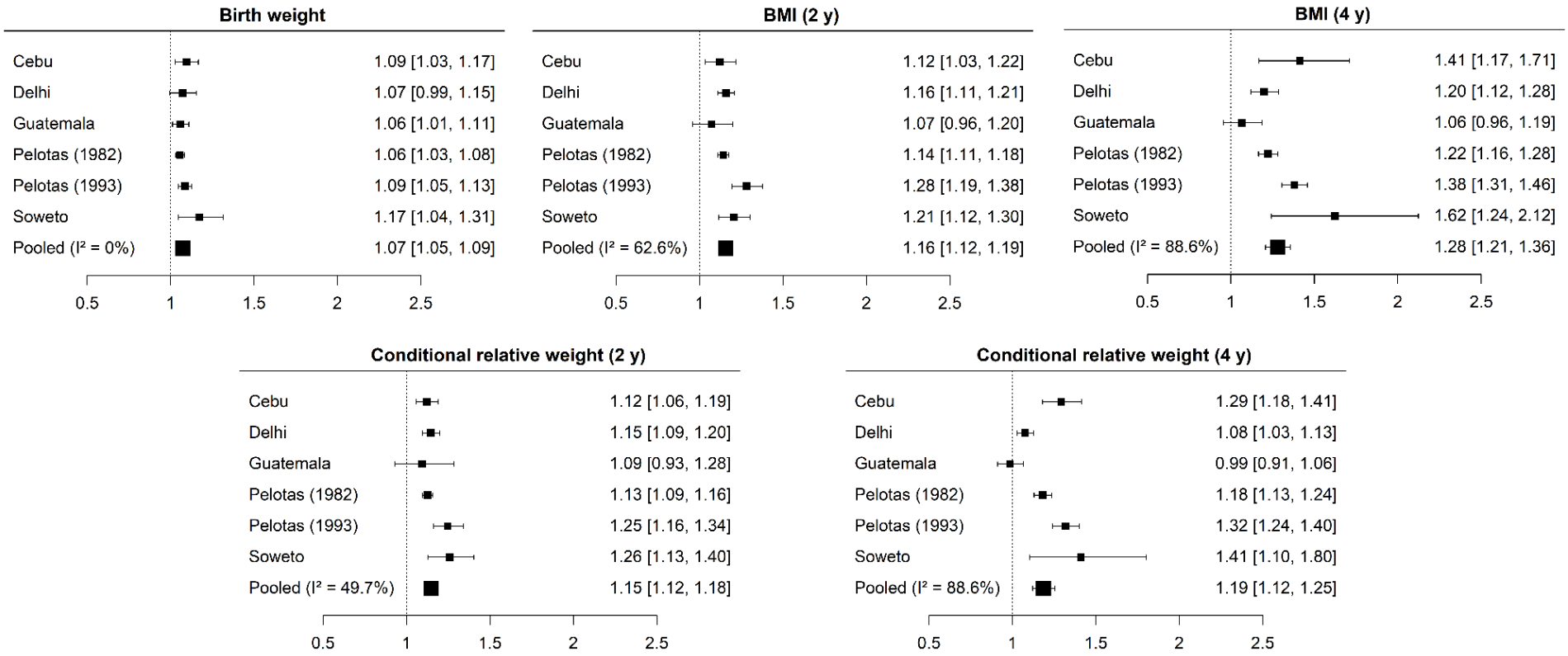
Adult outcome	Early-life exposure	Effect measure	# sites	Pooled sample size	Pooled effect			Interaction with sex (P-value)
					I^2 (%)	Beta or PR (95% CI)[A]	P-value	
Height (cm)	Birth length	Beta	4	7565	28·5	1·68 (1·52; 1·84)	<0·0001	0·437
	Length at 2 years	Beta	6	10359	30·4	3·27 (3·15; 3·39)	<0·0001	0·360
	Height at 4 years	Beta	6	10429	76·4	4·40 (4·21; 4·60)	<0·0001	0·351
	Conditional length at 2 years	Beta	6	9148	58·1	3·34 (3·06; 3·63)	<0·0001	0·101
	Conditional height at 4 years	Beta	6	9148	74·0	2·30 (2·03; 2·58)	<0·0001	0·337
Overweight/ obesity (yes/no)	Birth weight	PR	6	11316	0·0	1·07 (1·05; 1·09)	<0·0001	0·524
	BMI at 2 years	PR	6	8129	62·6	1·16 (1·12; 1·19)	<0·0001	0·569
	BMI at 4 years	PR	6	8136	88·6	1·28 (1·21; 1·36)	<0·0001	0·986
	Conditional relative weight at 2 years	PR	6	7210	49·7	1·15 (1·12; 1·18)	<0·0001	0·618
	Conditional relative weight at 4 years	PR	6	7210	88·6	1·19 (1·12; 1·25)	<0·0001	0·920
IQ (points)	Cognitive development at 4 years	Beta	5	3646	88·9	7·30 (5·85; 8·76)	<0·0001	0·880

Beta: linear regression coefficient. BMI: body mass index. PR: prevalence ratio. CI: confidence interval.
IQ: intelligence quotient, standardized to have mean=100 and standard deviation=15 within each cohort.

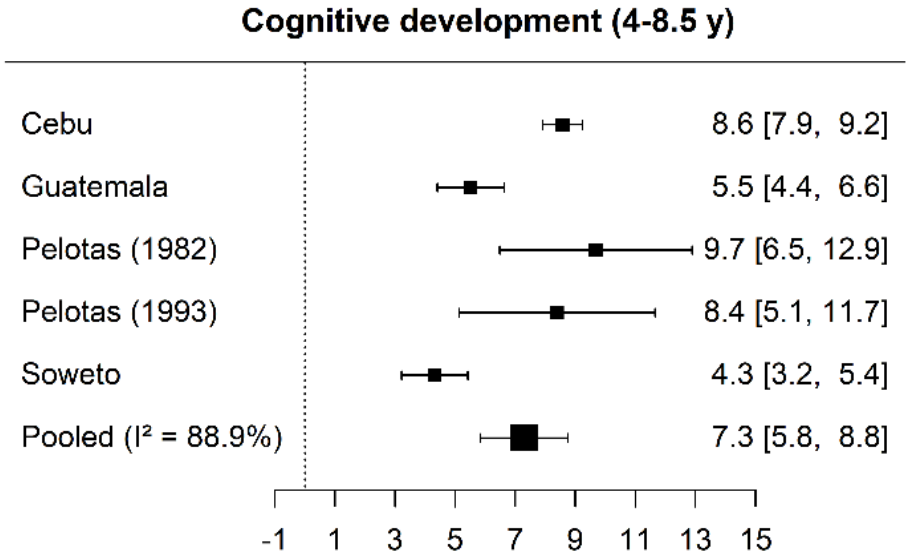
Appendix Figure A31. Forest plots of the height tracking analyses. The estimates can be interpreted as changes in adult height (in cm) per Z score increment length/height at 2 (2y) and 4 (4y) years of age



Appendix Figure A32. Forest plots of the overweight/obesity tracking analyses. The estimates can be interpreted as prevalence ratios of overweight/obesity in adulthood per Z score increment in weight or body mass index (BMI) at 2 (2y) and 4 (4y) years of age



Appendix Figure A33. Forest plot of the intelligence tracking analyses. The estimates can be interpreted as changes in adult IQ (in standardized units so that mean=100 and standard deviation=15) per Z score increment in cognitive development at 4-8.5 years of age



Appendix Panel A1. The Young Lives Study

Young Lives (YL) is a prospective longitudinal study of childhood poverty in four differing LMICs and world regions: Ethiopia, India, Peru, and Vietnam. YL samples provide broad representation of all but highest-income families. YL aims to illuminate child poverty drivers and impacts, and thereby enhance program/policy design. Younger cohorts of ~8,000 6-18 months old children born in 2001-02 and older cohorts of ~4,000 eight-year olds born in 1994-95 have been followed in five survey rounds since 2002 designed to permit comparisons of the same children at different ages and different children at the same age. The simultaneous four-country study with comparable survey instruments enables YL to report on trends and explore cross-country similarities and differences. The YL public-access data have been used in hundreds of analyses. Some salient results based on YL data for this paper's themes are:

Nutritional status during childhood and adolescence: Nutritional status at 1 year of age (height-for-age z-score, HAZ) significantly predicted HAZ at 5 and 8 years, and nutritional status changes from 1 to 5 years were also predictive of HAZ at age 8 years.[1-5] Analysis of subgroups of children for each country-cohort revealed trajectories showing increases in HAZ for some study children between 12y and adulthood in the older cohort in Ethiopia (20·1% of the cohort), India (20·5%), Peru (16·9%), and Vietnam (14·0%). On the other hand, there were subgroups having increasing probabilities of stunting (HAZ < -2) as children aged from 12y to adulthood in the older cohort in India (22·2%) and Peru (30·7%). Comparing the older and younger cohorts, there were increases in overweight prevalence at 8y in Vietnam (1·2 to 8·1%) and Peru (15·6 to 18·5%), but not in the other countries, and increases in adolescent (age 15y) overweight prevalence in India (3·5 to 5·7%), Peru (18·5 to 22·5%) and Vietnam (3·3 to 7·8%), but not in Ethiopia.[6] The findings of these studies, though variable among counties, suggest that critical nutritional investments are important in the first 1,000 days but also that there are opportunities at later ages for the prevention of stunting and overweight.

Cognitive skills and prior nutritional status, household characteristics and policies: HAZ of one-year-old girls and boys significantly predicted cognitive achievement at 5, 8 and 15 years in all four countries. Increases in HAZ up to 15 years were associated with increases in cognitive function that varied by sex, being stronger for boys in India and Peru, and for girls in Vietnam, with no sex difference in Ethiopia.[1-3] Unfortunately, there are no measurements at birth nor at the critical age of two years. In the Peru sample, formal preschool attendance predicted better language performance, more so for children with better infant nutritional status.[7] Across the four countries, school enrollment and time spent in educational activities were more strongly associated with adolescent cognitive performance than were HAZ at 1 year and change in HAZ from 1 to 15 years.[3] These studies suggest that early-life nutritional deprivation has adverse effects on learning, but also that there can be beneficial effects of nutritional gains and of learning opportunities later in childhood. Thus, consistent with NC, investments in health, nutrition and education are necessary throughout childhood and adolescence to enhance human capital.

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Appendix Panel A2. The Dunedin Multidisciplinary Health and Development Study

The Dunedin Study is an ongoing longitudinal investigation of the health and behavior of a birth cohort that was drawn from the greater Dunedin metropolitan area, located in the southern coastal region of New Zealand's South Island. Study participants (n=1037) were born between April 1st, 1972 and March 30th, 1973, and first followed up at age three, forming the base sample for the longitudinal study. The cohort represents the full range of socioeconomic status on New Zealand's South Island and matches the New Zealand National Health and Nutrition Survey on several key health indicators, including BMI, smoking, and general practitioner visits.[1] The cohort is primarily white; fewer than 7% self-identify as having non-Caucasian ancestry. Assessments were carried out at birth and ages 3, 5, 7, 9, 11, 13, 15, 18, 21, 26, 32, 38, and, in 2019, age 45 years, when 938 of 997 (94·1%) survivors participated.[2]

Health outcomes: Childhood cognitive ability, self-control, and socioeconomic advantage in the first decade of life predicted cardiovascular health at 38 years.[3] Higher BMI at 3 years was associated with increased risk of endothelial dysfunction (a predictor of cardiovascular disease and all-cause mortality) at age 38.[4] Higher childhood IQ at ages 7-13 predicted better adult cardiorespiratory fitness at age 38.[5] Children who were socially isolated between 5-11 years were at significantly higher risk of poor health in young adulthood compared with non-isolated children (RR 1·37, 95% CI 1·17-1·61).[6] Maltreatment in the first decade of life was related to increases in low-grade inflammation at 32 years, as measured by clinically relevant C-reactive protein levels (RR 1·80, 95% CI 1·26–2·58).

Cognition, educational attainment, and socio-economic outcomes: Early self-control (ages 3-11 years) appeared as an important predictor of educational attainment, as children with lower self-control tended to leave school early with no educational qualifications.[7] Lack of high school qualification, family conflict, low IQ and difficult temperament, including poor self-control in the first decade of life, were associated with later unemployment[8] and dependency on social welfare.[9]

Social relationships and mental health outcomes: Poor self-control in the first decade of life was associated with early smoking,[7] adult conduct problems, criminal convictions,[9] and disordered gambling.[10] Children assessed as being 'undercontrolled' at age 3 grew up to be more impulsive, unreliable, and antisocial.[11] Conduct disorder assessed at age 11 was associated with socioeconomic disadvantage and behavior problems in adulthood, such as intimate partner violence.[12] Being the victim of maltreatment in the first decade of life was also associated with having more criminal convictions at age 38.[9] Children exposed to adverse psychosocial experiences, including socioeconomic disadvantage, maltreatment or social isolation in the first decade of life were at higher risk of developing depression.[13] Lower childhood IQ at 7-11 years was associated with a higher risk of developing schizophrenia spectrum disorder, depression, and anxiety in adulthood.[14] Children who exhibited developmental impairment in the first decade of life were more likely to develop psychotic symptoms at 11 years and schizophrenia as adults.[15] There is also evidence suggesting social connectedness in adolescence represents a pathway indirectly linking adolescent academic achievement and adult well-being at 32 years (as measured by positive coping styles, social participation, and prosocial behaviour).[16]

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