Supplementary Text

The association of metabolic risk factors with income, urbanization, and western diet: statistical methods and considerations

All of our graphical and statistical analyses are based on a Bayesian multiple imputation approach. Specifically, the Bayesian statistical model for estimating risk factor levels borrowed information based on a hierarchy of countries within subregions and regions, across time and age groups, and using a small set of country-specific covariates. These covariates included the country-level characteristics considered in this paper's analyses, namely metrics of national income, urbanization, and western diet. This may appear to introduce circularity and potentially overestimate the association. Below, we provide the statistical justification for this approach and specify how we took into consideration the fact that the risk factor data were estimated using a Bayesian statistical model with covariates. In our explanation below, we conceptually divide our risk factor estimates into those that are essentially "known" based on good data for a given country-year and those that are imputed in the absence of such data; in reality there is a continuum of uncertainty.

First, we note that the covariates in the Bayesian model were chosen with the goal of best predicting country risk factor levels. The predicted risk factor levels used here are based on the posterior predictive distribution from the Bayesian hierarchical model, which conditions on all available information, both risk factor data and explanatory variables. As such, the posterior draws of country risk factor levels are a Bayesian multiple imputation. It is well known in the statistical literature that a correct multiple imputation procedure should condition on all available information[1]. Further, we note that the imputed country risk factor levels are based on the estimated relationship with covariates and the variability of country risk factor levels around the relationship, hence incorporating the variation around the estimated relationship. In other words, we draw from the posterior predictive distribution, which is the model's estimate of the distribution of the country risk factor levels, and therefore includes all of the appropriate sources of variation.

We can motivate the approach further by considering an example of why it would be incorrect to exclude the country-level characteristics of interest from the Bayesian hierarchical model. Suppose that we exclude a country covariate that is correlated with the risk factor of interest, and that none of the other covariates in the model are correlated with that characteristic. The result will be that our imputed values for missing country risk factor levels will not be correlated with the characteristic. When we produce figures such as Figures 1-3, those countries with data-driven, essentially-known risk factor levels would show a correlation with the characteristic but the imputed values would not, so the overall association would appear weaker than if we knew the true country risk factor levels. Now suppose that the characteristic of interest is not correlated with the risk factor of interest but that we include it in the Bayesian model. In the Bayesian model, we will estimate a near-zero coefficient based on the available country data, and the imputed values will be uncorrelated with the characteristic. Then in the subsequent analyses, neither the data-driven risk factor levels nor the imputed values will be correlated with the characteristic, and there will not be a circularity problem.

Given the uncertainty in the country-specific risk factor levels, including in relation to the covariates, our assessment of associations takes a missing data perspective and is based on a Bayesian multiple imputation approach[1, 2]. Specifically, we present the Loess fits, and the correlation and regression coefficients, in Figures 1-4 based on 500 posterior draws from the Bayesian model. Uncertainty intervals were calculated as the 2.5th to 97.5th percentiles of these 500 draws.

Supplementary Table

Table S1: Country data used in Figures 1-4 of the main paper. Data are from a systematic analysis of population-based data, by sex, for 199 countries and territories, as described in detail in previous publications[3-6] and in the main paper.

Country	Proportion urban 1980	Proportion urban 2008	Proportion urban Change per decade	Per capita GDP (2005 Int $) 1980	Per capita GDP (2005 Int $) 2008	Per capita GDP Change per decade	Percentile of Western Diet 1980	Percentile of Western Diet 2008	Percentile of Western Diet Change per decade	SBP (mmHg) 1980 (Female)	SBP (mmHg) 2008 (Female)	SBP Change per decade (Female)
Asia-Pacific high income												
Brunei Darussalam	0.60	0.75	0.05	84314	45700	-13793	0.60	0.72	0.04	132.4 (120.3, 144.1)	120.9 (113.6, 130.0)	-4.11
Japan	0.60	0.66	0.02	18545	32109	4844	0.67	0.73	0.02	131.2 (128.1, 134.3)	122.0 (118.6, 125.2)	-3.30
Republic of Korea	0.57	0.82	0.09	5244	25525	7243	0.26	0.58	0.11	120.6 (111.9, 128.7)	116.9 (111.6, 121.8)	-1.33
Singapore	1.00	1.00	0.00	14623	48389	12059	0.55	0.61	0.02	129.7 (122.4, 136.7)	121.2 (116.6, 125.8)	-3.06
Australasia												
Australia	0.86	0.89	0.01	21026	36606	5636	0.56	0.93	0.05	128.8 (122.7, 135.0)	117.9 (113.5, 122.9)	-4.08
New Zealand	0.83	0.86	0.01	17286	25950	3094	0.97	0.88	-0.03	128.1 (121.6, 134.6)	118.7 (110.7, 126.5)	-3.35
Europe, Western												
Andorra	0.92	0.89	-0.01	45502	56098	4106	0.91	0.93	0.01	136.6 (126.5, 146.7)	121.8 (112.6, 130.7)	-5.27
Austria	0.65	0.67	0.01	21754	37304	5554	0.97	0.95	-0.01	133.8 (125.4, 142.6)	124.3 (116.1, 132.3)	-3.45
Belgium	0.95	0.97	0.01	20678	34174	4764	0.97	0.95	-0.01	131.2 (124.5, 138.3)	121.8 (114.8, 129.7)	-3.36
Cyprus	0.59	0.70	0.04	10421	24392	4950	0.66	0.89	0.08	130.5 (121.1, 139.9)	122.6 (115.4, 131.1)	-2.81
Denmark	0.84	0.86	0.01	23021	34845	4324	0.97	0.99	0.01	132.0 (124.0, 139.6)	119.6 (113.1, 125.0)	-3.87
Finland	0.72	0.85	0.05	18334	34029	5654	0.96	0.92	-0.01	138.4 (132.6, 144.3)	126.6 (121.5, 131.9)	-4.21
France	0.73	0.84	0.04	20703	31331	3796	1.00	0.97	-0.01	132.1 (124.9, 139.7)	120.0 (115.8, 124.6)	-4.31
Germany	0.73	0.74	0.00	20630	33553	4523	0.93	0.95	0.01	135.3 (130.1, 140.2)	124.9 (119.4, 130.1)	-3.72
Greece	0.58	0.61	0.01	17337	27732	3691	0.74	0.85	0.04	131.7 (123.7, 140.1)	122.9 (116.5, 129.6)	-3.13
Greenland	0.76	0.84	0.03	42977	57460	5180	0.92	0.93	0.00	137.3 (128.5, 146.3)	125.0 (118.7, 131.1)	-4.40
Iceland	0.88	0.93	0.02	22623	38813	5783	1.00	1.00	0.00	131.4 (125.3, 138.2)	118.7 (112.2, 125.1)	-4.52
Ireland	0.55	0.61	0.02	13537	38311	8655	1.00	0.96	-0.01	130.4 (121.6, 138.8)	124.8 (120.2, 129.4)	-2.02
Israel	0.89	0.92	0.01	15597	26084	3746	0.73	0.81	0.03	130.4 (125.4, 135.6)	121.5 (115.2, 127.0)	-3.33
Italy	0.67	0.68	0.01	19084	28609	3399	0.83	0.86	0.01	135.4 (130.3, 141.1)	123.7 (118.8, 128.3)	-4.19
Luxembourg	0.80	0.85	0.02	27681	79507	18510	0.97	0.95	-0.01	133.7 (124.2, 143.7)	124.2 (115.9, 131.8)	-4.05
Malta	0.90	0.94	0.02	9553	22431	4592	0.87	0.92	0.02	135.0 (127.2, 143.2)	124.2 (119.9, 132.2)	-3.87
Netherlands	0.65	0.82	0.06	23004	39331	5831	0.93	0.90	-0.01	131.9 (125.0, 138.8)	121.7 (115.8, 127.6)	-3.65
Norway	0.71	0.79	0.03	26015	49613	8428	0.97	0.91	-0.02	137.0 (130.4, 143.8)	126.0 (119.6, 132.5)	-3.91
Portugal	0.43	0.59	0.06	11272	21285	3576	0.71	0.96	0.09	135.3 (127.6, 143.5)	127.3 (121.4, 133.1)	-2.87
Spain	0.73	0.77	0.02	15348	28568	4722	0.79	0.87	0.03	133.5 (127.6, 140.1)	122.0 (117.3, 126.9)	-4.08
Sweden	0.83	0.85	0.01	21127	35493	5131	0.91	0.88	-0.01	132.9 (126.6, 139.0)	122.9 (117.7, 128.5)	-3.56
Switzerland	0.57	0.73	0.06	28943	38922	3564	0.98	0.96	-0.01	131.3 (124.1, 139.4)	119.6 (113.6, 126.0)	-4.16
United Kingdom	0.78	0.79	0.00	18512	34233	5615	0.94	0.92	-0.01	131.0 (125.0, 136.6)	124.1 (120.0, 128.1)	-2.48
North America high income												
Canada	0.76	0.80	0.02	23325	36448	4687	0.87	0.84	-0.01	124.9 (120.2, 129.4)	118.1 (111.3, 124.4)	-2.43
United States of America	0.74	0.82	0.03	25425	43133	6396	0.89	0.91	0.00	125.4 (121.1, 129.6)	118.5 (115.0, 122.0)	-2.45
Asia, Central												
Armenia	0.66	0.64	-0.01	2563	5567	1073	0.67	0.69	0.01	136.2 (125.4, 146.7)	132.8 (126.9, 138.9)	-1.21
Azerbaijan	0.53	0.52	0.00	4249	8273	1437	0.70	0.59	-0.04	132.2 (121.9, 142.8)	128.6 (123.2, 134.2)	-1.27
Georgia	0.52	0.53	0.00	5048	4748	-107	0.69	0.72	0.01	135.1 (124.4, 146.2)	130.6 (122.3, 139.0)	-1.63
Kazakhstan	0.54	0.58	0.01	6218	10802	1637	0.68	0.86	0.06	134.3 (123.1, 145.7)	128.9 (119.9, 138.2)	-1.95
Kyrgyzstan	0.39	0.35	-0.01	2199	2087	-40	0.69	0.66	-0.01	130.5 (119.1, 141.7)	129.6 (120.4, 138.9)	-0.32
Mongolia	0.52	0.61	0.03	1915	3286	490	0.77	0.84	0.02	129.2 (117.8, 140.5)	129.8 (125.5, 133.8)	0.20
Tajikistan	0.34	0.26	-0.03	2611	1790	-293	0.71	0.32	-0.14	130.5 (118.7, 142.4)	130.0 (120.6, 139.0)	-0.18
Turkmenistan	0.47	0.49	0.01	4135	6061	688	0.70	0.53	-0.06	132.2 (120.7, 143.5)	129.2 (119.9, 138.1)	-1.07
Uzbekistan	0.41	0.36	-0.02	1779	2367	210	0.69	0.51	-0.06	127.0 (115.9, 137.8)	124.3 (117.1, 131.7)	-0.93
Europe, Central												
Albania	0.34	0.50	0.06	3621	6714	1105	0.38	0.77	0.14	132.2 (122.0, 142.6)	129.2 (121.1, 137.5)	-1.09
Bosnia and Herzegovina	0.36	0.47	0.04	1039	7163	2187	0.76	0.69	-0.03	131.9 (121.5, 142.3)	133.2 (126.4, 140.4)	0.45
Bulgaria	0.62	0.71	0.03	6342	11516	1848	0.80	0.78	-0.01	135.5 (127.8, 143.4)	128.5 (120.4, 136.7)	-2.52
Croatia	0.50	0.57	0.03	12156	16820	1665	0.81	0.80	0.00	136.2 (126.3, 146.1)	130.4 (122.8, 137.8)	-2.08
Czech Republic	0.75	0.74	-0.01	14614	23461	3159	0.78	0.93	0.05	136.0 (128.3, 143.9)	125.7 (121.0, 130.5)	-3.67
Hungary	0.64	0.67	0.01	10635	17874	2585	0.96	0.95	0.00	135.2 (128.8, 141.5)	128.7 (121.3, 136.2)	-2.34
Macedonia (Former Yugoslav Republic of)	0.53	0.59	0.02	7700	8328	224	0.80	0.80	0.00	134.9 (124.7, 145.3)	129.9 (120.5, 139.1)	-1.79
Montenegro	0.37	0.62	0.09	10372	9316	-377	0.78	0.82	0.01	134.7 (124.1, 145.8)	129.4 (120.3, 139.1)	-1.89
Poland	0.58	0.61	0.01	8559	16221	2737	0.90	0.86	-0.02	137.5 (131.1, 144.4)	129.7 (124.5, 135.3)	-2.78
Romania	0.46	0.56	0.04	7607	11219	1290	0.76	0.86	0.04	133.7 (124.5, 143.1)	128.8 (119.8, 137.2)	-1.78
Serbia	0.46	0.55	0.03	11233	9638	-570	0.78	0.82	0.01	136.6 (128.7, 144.5)	130.4 (122.3, 138.3)	-2.24
Slovakia	0.52	0.55	0.01	10346	20529	3637	0.81	0.84	0.01	135.8 (125.6, 146.4)	129.5 (120.2, 138.8)	-2.24
Slovenia	0.48	0.50	0.01	13892	27346	4805	0.81	0.89	0.03	136.5 (126.1, 147.3)	129.9 (120.2, 139.4)	-2.35
Europe, Eastern												
Belarus	0.56	0.74	0.06	5675	11851	2206	0.66	0.87	0.08	134.4 (124.0, 145.0)	129.8 (120.7, 139.3)	-1.64
Estonia	0.70	0.69	0.00	8797	18585	3496	0.72	0.93	0.08	137.7 (129.3, 146.7)	129.5 (121.8, 137.4)	-2.93
Latvia	0.67	0.68	0.00	8957	15525	2346	0.73	0.93	0.07	136.5 (126.0, 147.1)	129.6 (120.1, 138.8)	-2.48
Lithuania	0.61	0.67	0.02	11174	17128	2127	0.71	0.90	0.07	137.8 (130.7, 145.2)	130.8 (122.7, 138.6)	-2.48
Moldova	0.40	0.45	0.02	3640	2699	-336	0.73	0.74	0.00	132.3 (121.7, 142.8)	129.9 (120.7, 139.3)	-0.86
Russian Federation	0.70	0.73	0.01	11706	14948	1158	0.69	0.86	0.06	133.8 (128.4, 139.1)	128.5 (123.0, 134.0)	-1.89
Ukraine	0.62	0.68	0.02	7130	6950	-64	0.71	0.82	0.04	136.1 (126.4, 145.4)	131.5 (126.2, 136.8)	-1.64
Sub-Saharan Africa, Central												
Angola	0.24	0.57	0.12	2833	5333	893	0.20	0.25	0.02	130.1 (118.6, 142.0)	130.1 (120.4, 139.8)	0.01
Central African Republic	0.34	0.39	0.02	927	666	-93	0.19	0.26	0.03	129.7 (118.1, 141.5)	130.6 (120.5, 140.3)	0.31
Congo	0.48	0.61	0.05	2566	3085	185	0.12	0.31	0.07	132.7 (121.7, 143.8)	131.7 (123.9, 139.8)	-0.36
Democratic Republic of the Congo	0.29	0.34	0.02	715	275	-157	0.01	0.04	0.01	129.7 (120.3, 139.0)	129.4 (121.1, 137.1)	-0.12
Equatorial Guinea	0.28	0.39	0.04	1384	23152	7774	0.20	0.23	0.01	130.4 (118.9, 141.9)	132.0 (121.5, 142.4)	0.57
Gabon	0.55	0.85	0.11	15292	12463	-1011	0.39	0.56	0.06	138.8 (127.0, 151.1)	130.4 (123.8, 137.0)	-3.02
Sub-Saharan Africa, East												
Burundi	0.04	0.10	0.02	407	361	-17	0.00	0.01	0.00	127.0 (114.9, 138.9)	134.2 (124.2, 144.4)	2.58
Comoros	0.23	0.28	0.02	1245	1025	-79	0.02	0.04	0.01	126.6 (115.4, 137.4)	132.1 (123.0, 141.5)	1.96
Djibouti	0.72	0.76	0.01	3505	2063	-515	0.41	0.36	-0.02	130.6 (119.5, 141.7)	129.3 (119.8, 138.8)	-0.46
Eritrea	0.14	0.21	0.02	496	579	30	0.03	0.07	0.01	117.5 (106.9, 128.3)	125.8 (119.1, 132.5)	2.96
Ethiopia	0.10	0.16	0.02	559	752	69	0.03	0.04	0.00	116.6 (107.7, 125.1)	126.6 (120.5, 132.6)	3.57
Kenya	0.16	0.22	0.02	1281	1400	42	0.28	0.29	0.01	123.7 (117.8, 129.6)	129.9 (122.1, 137.8)	2.23
Madagascar	0.19	0.30	0.04	1223	900	-115	0.28	0.17	-0.04	126.7 (116.4, 136.5)	132.8 (126.0, 139.6)	2.17
Malawi	0.09	0.19	0.03	767	687	-29	0.01	0.01	0.00	124.9 (114.7, 135.2)	133.9 (129.1, 138.9)	3.22
Mauritius	0.42	0.42	0.00	3533	10742	2575	0.36	0.52	0.06	130.6 (119.7, 141.8)	130.9 (121.0, 140.8)	0.08
Mozambique	0.13	0.37	0.08	433	778	123	0.07	0.08	0.00	127.8 (117.4, 137.8)	135.4 (129.2, 141.7)	2.70
Rwanda	0.05	0.18	0.05	797	1016	78	0.00	0.01	0.00	129.2 (116.7, 141.9)	135.1 (124.9, 145.3)	2.12
Seychelles	0.49	0.54	0.02	10424	22264	4229	0.35	0.53	0.06	130.4 (121.3, 139.2)	128.8 (122.7, 135.0)	-0.55
Somalia	0.27	0.37	0.03	869	634	-84	0.14	0.14	0.00	126.9 (116.3, 137.8)	131.5 (122.6, 140.3)	1.67
Sudan	0.20	0.39	0.07	1242	2074	297	0.39	0.51	0.04	124.5 (113.6, 135.3)	129.7 (120.5, 139.0)	1.86
Uganda	0.08	0.13	0.02	531	1085	198	0.11	0.14	0.01	126.3 (114.7, 137.9)	134.5 (124.6, 144.6)	2.93
United Republic of Tanzania	0.15	0.26	0.04	789	1195	145	0.13	0.10	-0.01	122.6 (114.8, 130.5)	130.8 (123.8, 138.1)	2.94
Zambia	0.40	0.35	-0.02	1694	1226	-167	0.22	0.15	-0.03	127.2 (117.3, 136.8)	132.4 (125.9, 139.2)	1.87
Sub-Saharan Africa, Southern												
Botswana	0.16	0.60	0.15	3423	12491	3239	0.33	0.42	0.03	128.9 (118.7, 138.8)	133.2 (127.8, 138.4)	1.52
Lesotho	0.11	0.25	0.05	760	1263	180	0.22	0.14	-0.03	124.9 (113.5, 135.8)	131.1 (121.8, 140.6)	2.24
Namibia	0.25	0.37	0.04	4748	5688	336	0.43	0.45	0.01	132.4 (122.0, 142.3)	133.4 (127.1, 139.6)	0.35
South Africa	0.48	0.61	0.04	7725	9032	467	0.61	0.61	0.00	133.2 (127.1, 139.4)	131.0 (126.9, 135.2)	-0.80
Swaziland	0.18	0.22	0.01	2324	4397	740	0.51	0.35	-0.06	128.8 (117.6, 139.9)	131.9 (122.5, 141.2)	1.09
Zimbabwe	0.22	0.37	0.05	583	315	-96	0.29	0.30	0.00	128.7 (119.3, 137.9)	132.0 (124.2, 140.2)	1.15
Sub-Saharan Africa, West												
Benin	0.27	0.41	0.05	1108	1319	75	0.06	0.02	-0.02	126.3 (116.1, 137.1)	130.3 (125.2, 135.2)	1.40
Burkina Faso	0.09	0.24	0.05	663	1052	139	0.08	0.11	0.01	124.0 (112.0, 135.6)	130.7 (121.4, 139.8)	2.39
Cameroon	0.32	0.57	0.09	2030	1939	-33	0.12	0.11	0.00	125.9 (116.0, 135.9)	127.3 (121.2, 133.7)	0.51
Cape Verde	0.24	0.60	0.13	1118	3346	796	0.14	0.56	0.15	128.6 (118.2, 138.8)	133.4 (128.3, 138.7)	1.72
Chad	0.19	0.27	0.03	686	1316	225	0.11	0.10	-0.01	122.6 (111.7, 133.8)	127.9 (120.5, 135.1)	1.88
Côte d'Ivoire	0.37	0.49	0.04	2183	1446	-263	0.17	0.19	0.01	130.3 (119.8, 140.9)	131.5 (124.4, 138.4)	0.45
Gambia	0.28	0.56	0.10	1199	1461	93	0.19	0.30	0.04	126.4 (116.2, 136.6)	130.2 (123.1, 137.3)	1.36
Ghana	0.31	0.50	0.07	912	1329	149	0.05	0.05	0.00	125.7 (115.5, 136.0)	128.3 (124.0, 132.6)	0.92
Guinea-Bissau	0.18	0.30	0.04	830	913	30	0.21	0.22	0.00	125.9 (114.5, 137.3)	130.8 (121.9, 139.2)	1.74
Guinea	0.24	0.34	0.04	824	988	58	0.06	0.14	0.03	128.7 (117.4, 140.3)	132.3 (123.5, 140.9)	1.27
Liberia	0.35	0.47	0.04	1506	369	-406	0.11	0.16	0.02	129.3 (118.0, 140.7)	131.3 (122.3, 140.0)	0.71
Mali	0.18	0.34	0.06	699	1026	117	0.27	0.27	0.00	122.7 (111.5, 134.2)	128.0 (120.6, 135.2)	1.91
Mauritania	0.27	0.41	0.05	1559	1783	80	0.53	0.54	0.00	126.0 (114.5, 137.3)	130.0 (120.8, 139.1)	1.42
Niger	0.13	0.17	0.01	865	651	-76	0.15	0.04	-0.04	128.0 (117.0, 139.0)	135.1 (129.4, 140.9)	2.52
Nigeria	0.29	0.48	0.07	1504	1965	165	0.23	0.12	-0.04	131.0 (120.5, 141.6)	135.5 (129.3, 142.0)	1.61
São Tomé and Príncipe	0.33	0.61	0.10	1609	1608	0	0.11	0.20	0.03	131.5 (120.3, 142.0)	136.3 (130.7, 141.9)	1.70
Senegal	0.36	0.42	0.02	1333	1593	93	0.20	0.24	0.02	127.7 (116.6, 138.8)	130.3 (121.4, 138.7)	0.93
Sierra Leone	0.29	0.38	0.03	973	762	-75	0.15	0.10	-0.02	130.1 (119.9, 140.1)	134.7 (130.1, 139.2)	1.66
Togo	0.25	0.42	0.06	1256	753	-180	0.04	0.05	0.01	127.5 (116.4, 138.5)	131.0 (122.2, 139.7)	1.27
North Africa and Middle East												
Algeria	0.44	0.65	0.08	5522	6588	381	0.33	0.38	0.02	130.8 (120.4, 141.0)	129.9 (122.8, 136.9)	-0.31
Bahrain	0.86	0.89	0.01	23853	29774	2115	0.45	0.40	-0.02	138.6 (128.2, 148.8)	129.9 (122.0, 137.6)	-3.09
Egypt	0.44	0.43	0.00	2301	5088	995	0.26	0.27	0.00	124.6 (115.3, 133.6)	125.1 (119.8, 130.4)	0.19
Iran (Islamic Republic of)	0.50	0.69	0.07	6314	10379	1452	0.33	0.40	0.03	128.0 (118.8, 137.3)	125.2 (121.2, 129.2)	-1.02
Iraq	0.66	0.66	0.00	8878	3500	-1921	0.45	0.49	0.01	130.4 (119.6, 141.1)	126.0 (116.9, 135.0)	-1.59
Jordan	0.60	0.78	0.07	4279	4923	230	0.39	0.52	0.05	126.0 (116.5, 136.1)	121.4 (116.6, 126.3)	-1.64
Kuwait	0.95	0.98	0.01	45297	44733	-201	0.80	0.71	-0.03	136.1 (125.7, 146.7)	123.4 (117.9, 128.9)	-4.54
Lebanon	0.74	0.87	0.05	11079	11733	234	0.57	0.63	0.02	131.8 (120.8, 142.4)	127.5 (118.6, 136.7)	-1.53
Libyan Arab Jamahiriya	0.70	0.78	0.03	31276	15869	-5502	0.67	0.51	-0.06	138.4 (127.3, 148.9)	133.6 (128.6, 138.4)	-1.70
Morocco	0.41	0.57	0.06	2272	3823	554	0.27	0.32	0.02	126.5 (115.7, 137.8)	126.5 (117.7, 135.3)	0.02
Occupied Palestinian Territory	0.62	0.74	0.04	2114	2217	37	0.36	0.36	0.00	127.1 (116.2, 138.0)	127.3 (120.0, 134.5)	0.07
Oman	0.48	0.73	0.09	9785	23216	4797	0.42	0.47	0.02	130.3 (120.9, 140.5)	126.9 (120.1, 133.6)	-1.22
Qatar	0.89	0.96	0.02	98083	84944	-4692	0.46	0.46	0.00	139.5 (128.4, 150.6)	126.3 (120.8, 131.7)	-4.69
Saudi Arabia	0.66	0.82	0.06	31506	21774	-3476	0.55	0.55	0.00	135.2 (124.9, 145.5)	126.8 (121.3, 132.3)	-2.98
Syrian Arab Republic	0.47	0.55	0.03	3342	4197	305	0.55	0.59	0.01	129.0 (118.6, 140.1)	127.0 (118.2, 135.9)	-0.72
Tunisia	0.51	0.67	0.06	3607	7242	1298	0.30	0.40	0.04	130.0 (120.6, 139.2)	128.6 (121.6, 135.5)	-0.48
Turkey	0.44	0.69	0.09	6042	11479	1942	0.40	0.48	0.03	127.1 (118.0, 137.0)	124.1 (120.1, 128.0)	-1.09
United Arab Emirates	0.81	0.83	0.01	74010	48685	-9045	0.87	0.62	-0.09	134.5 (124.3, 145.0)	121.7 (114.7, 128.8)	-4.57
Yemen	0.17	0.31	0.05	1468	2242	276	0.23	0.27	0.01	123.5 (112.5, 134.9)	126.4 (117.3, 135.3)	1.02
Asia, South												
Afghanistan	0.16	0.22	0.02	680	866	66	0.15	0.18	0.01	122.1 (110.6, 133.5)	125.1 (115.4, 134.8)	1.07
Bangladesh	0.15	0.27	0.04	650	1297	231	0.02	0.04	0.01	120.3 (108.8, 132.3)	125.0 (115.4, 134.3)	1.67
Bhutan	0.10	0.33	0.08	900	4316	1220	0.15	0.19	0.01	119.1 (107.9, 130.1)	125.1 (117.7, 132.4)	2.17
India	0.23	0.29	0.02	927	2839	683	0.09	0.18	0.03	120.9 (111.7, 129.8)	123.1 (119.2, 127.1)	0.80
Nepal	0.06	0.18	0.04	608	1077	167	0.11	0.05	-0.02	119.5 (107.9, 131.2)	125.6 (116.1, 135.3)	2.15
Pakistan	0.28	0.35	0.03	1284	2355	383	0.31	0.47	0.06	123.3 (113.7, 132.7)	126.5 (119.6, 134.0)	1.16
Asia, East												
China (Hong Kong SAR)	0.91	1.00	0.03	13919	39565	9159	0.27	0.29	0.01	131.1 (122.7, 140.0)	119.3 (111.3, 127.3)	-4.21
China (Macao SAR)	0.99	1.00	0.01	14233	53943	14182	0.25	0.28	0.01	133.3 (121.7, 144.9)	121.8 (111.3, 132.0)	-4.10
China	0.19	0.45	0.09	561	5941	1922	0.15	0.62	0.17	125.7 (119.9, 132.1)	124.3 (121.3, 127.4)	-0.51
Democratic People's Republic of Korea	0.57	0.60	0.01	2284	1185	-392	0.19	0.19	0.00	126.1 (115.1, 137.0)	122.1 (112.2, 132.2)	-1.42
Taiwan	0.63	0.69	0.02	7685	29241	7698	0.25	0.28	0.01	124.1 (116.3, 132.3)	117.6 (112.9, 122.5)	-2.31
Asia, Southeast												
Cambodia	0.09	0.20	0.04	567	1840	455	0.03	0.21	0.06	112.6 (101.0, 124.3)	117.6 (112.7, 122.6)	1.77
Indonesia	0.22	0.44	0.08	1489	3742	805	0.07	0.23	0.06	122.5 (112.0, 132.7)	126.4 (120.7, 132.0)	1.41
Lao People's Democratic Republic	0.12	0.31	0.07	753	2136	494	0.08	0.23	0.05	116.8 (105.2, 128.1)	123.0 (115.9, 130.2)	2.22
Malaysia	0.42	0.70	0.10	4669	12695	2866	0.50	0.58	0.03	124.6 (114.7, 134.4)	123.9 (118.0, 129.7)	-0.27
Maldives	0.22	0.38	0.05	1225	5018	1355	0.14	0.68	0.19	119.6 (107.9, 131.3)	123.3 (113.1, 133.1)	1.33
Myanmar	0.24	0.32	0.03	312	1037	259	0.04	0.24	0.07	116.3 (104.4, 128.7)	123.1 (114.1, 132.2)	2.45
Philippines	0.37	0.49	0.04	2462	3146	244	0.31	0.41	0.04	122.2 (112.1, 132.4)	122.3 (116.3, 128.3)	0.04
Sri Lanka	0.22	0.14	-0.03	1516	4128	933	0.04	0.15	0.04	121.6 (111.0, 132.4)	124.9 (119.0, 130.9)	1.16
Thailand	0.27	0.33	0.02	2313	7638	1902	0.24	0.52	0.10	118.3 (108.8, 127.8)	120.5 (114.8, 126.4)	0.78
Timor-Leste	0.16	0.27	0.04	1148	1274	45	0.13	0.21	0.03	116.6 (104.7, 129.0)	122.7 (113.4, 132.3)	2.19

Country	Proportion urban			Per capita GDP (2005 Int $)			Percentage of Western Diet			SBP (mmHg)					
	1980	2008	Change per decade	1980	2008	Change per decade	1980	2008	Change per decade	1980 (Female)	2008 (Female)	Change per decade (Female)	1980 (Male)	2008 (Male)	Change per decade (Male)
Viet Nam	0.19	0.29	0.04	581	2622	729	0.08	0.40	0.11	117.1 (106.6, 128.1)	121.9 (115.9, 128.0)	1.72	123.2 (112.8, 133.6)	126.6 (120.6, 132.6)	1.22
Oceania															
Cook Islands	0.54	0.74	0.07	4225	17882	4878	0.45	0.47	0.01	124.7 (114.3, 135.2)	126.5 (119.3, 133.4)	0.65	130.9 (120.3, 140.8)	134.2 (127.1, 141.2)	1.17
Fiji	0.38	0.51	0.05	3319	4267	338	0.52	0.58	0.02	124.4 (113.9, 134.7)	127.5 (120.1, 134.3)	1.11	128.9 (118.5, 138.9)	129.6 (122.5, 136.8)	0.26
French Polynesia	0.57	0.52	-0.02	17781	25602	2793	0.71	0.84	0.04	128.7 (116.9, 140.5)	123.9 (113.9, 133.8)	-1.71	133.9 (122.5, 145.0)	131.5 (122.7, 140.6)	-0.86
Kiribati	0.32	0.44	0.04	2935	3258	115	0.29	0.38	0.03	120.4 (109.9, 130.9)	122.0 (115.1, 128.6)	0.57	127.5 (117.4, 137.3)	128.7 (121.9, 135.4)	0.46
Marshall Islands	0.58	0.71	0.05	5133	5970	299	0.43	0.47	0.01	122.4 (111.7, 133.4)	121.5 (114.0, 128.7)	-0.34	127.4 (117.3, 137.3)	127.6 (120.3, 134.8)	0.06
Micronesia (Federated States of)	0.26	0.23	-0.01	2699	3262	201	0.45	0.49	0.02	121.5 (110.9, 132.1)	125.4 (118.2, 132.8)	1.41	130.0 (119.8, 140.0)	132.1 (125.0, 139.0)	0.75
Nauru	1.00	1.00	0.00	30996	6516	-8743	0.52	0.49	-0.01	133.4 (123.4, 143.2)	127.4 (120.7, 134.5)	-2.12	135.5 (125.9, 144.8)	133.9 (127.2, 140.3)	-0.59
Palau	0.63	0.81	0.07	14794	13603	-425	0.44	0.48	0.02	129.5 (117.4, 141.2)	124.5 (114.9, 133.8)	-1.79	134.4 (122.8, 145.2)	130.8 (122.1, 139.4)	-1.29
Papua New Guinea	0.13	0.13	0.00	1905	2234	118	0.43	0.48	0.02	110.3 (103.4, 117.2)	120.1 (114.1, 126.1)	3.47	118.7 (111.1, 126.0)	122.6 (117.1, 128.1)	1.39
Samoa	0.21	0.21	0.00	3586	5501	684	0.34	0.66	0.11	122.9 (112.1, 133.7)	126.4 (119.2, 133.7)	1.23	130.3 (119.7, 140.6)	132.4 (125.1, 139.6)	0.75
Solomon Islands	0.11	0.18	0.03	2466	2433	-12	0.19	0.13	-0.02	118.3 (107.5, 129.3)	124.0 (117.0, 130.8)	2.06	123.9 (113.6, 134.2)	125.7 (119.0, 132.3)	0.65
Tonga	0.21	0.23	0.01	2701	5771	1096	0.48	0.47	-0.01	119.5 (109.1, 130.0)	125.8 (119.4, 132.3)	2.23	126.3 (116.3, 136.2)	130.6 (124.0, 136.9)	1.53
Vanuatu	0.15	0.25	0.04	3476	4872	499	0.47	0.34	-0.04	124.8 (114.0, 135.1)	132.1 (125.3, 138.8)	2.60	131.9 (121.6, 141.9)	134.2 (127.7, 140.6)	0.80
Caribbean															
Antigua and Barbuda	0.35	0.30	-0.01	6385	17863	4099	0.64	0.75	0.04	125.7 (113.5, 137.6)	125.3 (115.8, 134.5)	-0.13	132.6 (121.2, 144.1)	133.5 (125.1, 141.8)	0.32
Bahamas	0.73	0.84	0.04	21957	28590	2369	0.82	0.79	-0.01	131.9 (120.3, 143.8)	124.4 (115.0, 133.5)	-2.68	136.6 (125.4, 147.6)	132.8 (124.3, 140.9)	-1.36
Barbados	0.40	0.43	0.01	17630	22090	1593	0.82	0.77	-0.02	129.1 (118.3, 140.5)	126.4 (118.9, 133.9)	-0.98	134.1 (123.1, 145.2)	131.2 (124.0, 138.8)	-1.03
Belize	0.49	0.51	0.01	3972	7608	1299	0.72	0.62	-0.03	121.8 (110.8, 133.0)	120.9 (114.8, 127.2)	-0.30	127.9 (117.0, 138.4)	127.9 (121.6, 134.5)	0.01
Bermuda	1.00	1.00	0.00	50770	77779	9646	0.96	0.85	-0.04	136.1 (123.3, 148.0)	124.0 (114.4, 133.6)	-4.30	139.9 (128.0, 151.3)	133.5 (125.0, 142.3)	-2.28
British Virgin Islands	0.23	0.41	0.06	7916	73167	23304	0.64	0.67	0.01	127.1 (116.0, 138.7)	127.7 (122.4, 132.9)	0.22	133.2 (122.2, 143.8)	135.2 (130.4, 140.2)	0.72
Cuba	0.68	0.75	0.03	5728	8862	1119	0.72	0.44	-0.10	126.5 (114.7, 138.5)	126.1 (116.8, 135.6)	-0.16	130.4 (118.9, 141.8)	129.6 (120.8, 138.4)	-0.28
Dominica	0.63	0.67	0.01	3426	7745	1542	0.64	0.77	0.05	130.8 (119.3, 141.9)	131.1 (125.5, 136.7)	0.09	134.1 (123.7, 143.9)	135.0 (129.5, 140.2)	0.33
Dominican Republic	0.51	0.68	0.06	3860	8236	1563	0.37	0.57	0.07	128.0 (117.2, 138.7)	126.4 (118.4, 134.2)	-0.59	130.0 (119.5, 140.9)	130.8 (123.2, 138.6)	0.28
Grenada	0.33	0.39	0.02	3986	10542	2342	0.54	0.64	0.04	125.1 (113.4, 136.7)	125.6 (116.5, 134.4)	0.19	130.3 (119.0, 141.8)	131.6 (123.3, 139.9)	0.45
Guyana	0.30	0.28	-0.01	2966	3896	332	0.47	0.37	-0.04	122.5 (110.8, 134.4)	125.2 (115.5, 134.5)	0.96	127.1 (115.4, 138.8)	129.1 (120.6, 137.7)	0.72
Haiti	0.21	0.49	0.10	1924	1174	-268	0.20	0.27	0.03	123.5 (111.4, 135.5)	125.3 (115.7, 135.0)	0.65	128.3 (117.0, 140.2)	130.0 (121.2, 138.9)	0.62
Jamaica	0.47	0.52	0.02	5950	8005	734	0.57	0.63	0.02	127.0 (115.5, 138.5)	125.4 (116.2, 134.6)	-0.58	131.3 (119.8, 142.5)	130.8 (122.4, 139.3)	-0.15
Netherlands Antilles	0.81	0.93	0.04	26948	31276	1546	0.86	0.84	-0.01	132.5 (120.8, 144.6)	123.3 (113.6, 132.6)	-3.28	137.2 (125.7, 148.5)	132.2 (123.5, 140.8)	-1.80
Puerto Rico	0.67	0.98	0.11	12977	23553	3777	0.65	0.64	0.00	127.8 (116.5, 138.9)	121.1 (113.3, 128.7)	-2.37	132.1 (121.4, 142.4)	130.2 (123.1, 137.3)	-0.67
Saint Kitts and Nevis	0.36	0.32	-0.01	4360	13821	3379	0.64	0.69	0.02	128.2 (117.3, 139.5)	129.3 (122.7, 136.0)	0.42	134.2 (123.6, 144.8)	135.9 (129.7, 142.2)	0.59
Saint Lucia	0.27	0.28	0.00	5231	10702	1954	0.54	0.80	0.09	125.4 (114.0, 137.4)	125.2 (115.9, 134.4)	-0.07	131.1 (119.5, 142.3)	132.2 (123.7, 140.6)	0.41
Saint Vincent and the Grenadines	0.36	0.48	0.04	2586	8413	2081	0.39	0.68	0.10	124.4 (112.6, 136.3)	125.4 (116.4, 134.4)	0.34	129.2 (117.8, 140.5)	131.3 (123.0, 139.7)	0.75
Suriname	0.55	0.68	0.05	7281	8365	387	0.53	0.56	0.01	127.1 (115.9, 138.9)	124.6 (115.4, 134.0)	-0.88	131.1 (120.0, 142.3)	130.4 (121.9, 138.5)	-0.26
Trinidad and Tobago	0.11	0.13	0.01	14040	26886	4588	0.64	0.65	0.01	126.1 (115.1, 137.2)	125.0 (116.8, 133.6)	-0.38	131.6 (120.6, 142.2)	131.0 (123.2, 138.7)	-0.22
Latin America, Andean															
Bolivia	0.45	0.66	0.07	3391	3901	182	0.60	0.51	-0.03	125.1 (113.4, 137.0)	122.4 (112.7, 132.3)	-0.95	130.2 (119.1, 141.7)	128.2 (118.9, 137.1)	-0.73
Ecuador	0.47	0.66	0.07	5620	7007	495	0.53	0.63	0.04	127.1 (115.1, 139.2)	123.0 (113.3, 132.5)	-1.47	131.9 (120.7, 143.2)	129.4 (120.3, 138.2)	-0.89
Peru	0.65	0.76	0.04	5775	7719	694	0.37	0.34	-0.01	126.5 (115.7, 137.4)	119.6 (113.5, 125.6)	-2.44	129.7 (120.0, 139.7)	125.6 (119.7, 131.4)	-1.44
Latin America, Central															
Colombia	0.62	0.74	0.04	4853	8037	1137	0.55	0.64	0.03	127.6 (118.5, 137.1)	124.0 (119.1, 128.8)	-1.28	132.3 (123.1, 141.7)	130.3 (125.3, 135.4)	-0.71
Costa Rica	0.43	0.63	0.07	7037	10571	1262	0.64	0.70	0.02	125.3 (114.4, 136.6)	121.3 (113.6, 129.1)	-1.41	131.1 (120.7, 141.7)	129.1 (121.9, 136.4)	-0.72
El Salvador	0.44	0.63	0.07	4418	6643	795	0.36	0.52	0.06	122.9 (112.1, 134.3)	119.9 (112.5, 127.6)	-1.07	127.8 (117.4, 138.3)	126.5 (119.0, 133.7)	-0.47
Guatemala	0.37	0.49	0.04	4475	4995	186	0.30	0.33	0.01	123.0 (113.0, 134.2)	121.0 (114.3, 127.7)	-0.73	127.8 (117.7, 138.3)	127.0 (120.3, 133.7)	-0.32
Honduras	0.35	0.50	0.06	3088	3813	259	0.32	0.51	0.07	123.2 (112.1, 134.3)	123.0 (115.4, 130.7)	-0.07	128.5 (118.1, 139.1)	128.4 (121.0, 135.8)	-0.02
Mexico	0.66	0.77	0.04	9963	13193	1153	0.57	0.73	0.06	128.2 (118.8, 138.1)	122.1 (117.1, 127.2)	-2.15	129.7 (120.5, 139.5)	126.7 (121.6, 132.0)	-1.08
Nicaragua	0.50	0.57	0.02	2876	2482	-140	0.36	0.35	0.00	126.4 (115.7, 137.2)	123.5 (115.7, 131.1)	-1.06	131.6 (121.3, 142.5)	129.0 (121.7, 136.4)	-0.95
Panama	0.50	0.73	0.08	5845	10835	1782	0.60	0.65	0.02	126.8 (115.6, 138.7)	122.7 (113.3, 131.9)	-1.48	131.9 (120.9, 143.2)	130.0 (121.7, 138.2)	-0.68
Venezuela (Bolivarian Republic of)	0.79	0.93	0.05	10937	11081	51	0.66	0.65	-0.01	132.2 (121.3, 143.0)	123.7 (116.3, 131.3)	-3.05	136.5 (125.9, 147.2)	132.1 (124.8, 139.7)	-1.55
Latin America, Southern															
Argentina	0.83	0.92	0.03	9201	12780	1278	0.92	0.85	-0.02	124.5 (114.3, 134.4)	118.9 (110.8, 127.7)	-2.01	131.5 (121.2, 142.0)	128.5 (120.4, 136.7)	-1.08
Chile	0.81	0.88	0.03	5440	13141	2750	0.58	0.73	0.05	130.1 (118.6, 141.2)	125.5 (119.0, 132.3)	-1.62	133.4 (122.2, 144.0)	133.5 (126.8, 140.4)	0.03
Uruguay	0.85	0.92	0.02	7016	11412	1570	0.82	0.70	-0.04	129.0 (117.2, 140.4)	124.3 (118.1, 130.4)	-1.70	134.8 (124.0, 145.3)	132.3 (126.0, 138.7)	-0.90
Latin America, Tropical															
Brazil	0.65	0.86	0.07	7581	9523	694	0.53	0.70	0.06	133.6 (124.5, 143.5)	124.9 (120.4, 129.7)	-3.12	136.6 (127.7, 146.5)	133.4 (129.0, 137.9)	-1.15
Paraguay	0.42	0.60	0.07	3951	4218	95	0.59	0.72	0.05	128.1 (116.5, 140.4)	123.6 (114.2, 133.6)	-1.59	132.8 (122.0, 144.5)	130.7 (122.1, 139.8)	-0.75

Country	TC (mmol/L)						BMI (kg/m^2)					
	1980 (Female)	2008 (Female)	Change per decade (Female)	1980 (Male)	2008 (Male)	Change per decade (Male)	1980 (Female)	2008 (Female)	Change per decade (Female)	1980 (Male)	2008 (Male)	Change per decade (Male)
Viet Nam	4.5 (3.5, 5.5)	4.7 (4.0, 5.4)	0.07	4.4 (3.6, 5.3)	4.5 (3.9, 5.2)	0.03	18.6 (17.4, 19.8)	21.1 (20.1, 22.0)	0.88	19.0 (18.1, 20.0)	20.9 (20.1, 21.7)	0.68
Oceania												
Cook Islands	5.0 (4.5, 5.5)	5.3 (4.6, 6.0)	0.11	5.0 (4.6, 5.5)	5.2 (4.6, 5.9)	0.07	26.3 (23.0, 29.4)	33.9 (32.5, 35.5)	2.72	26.2 (23.6, 28.6)	32.7 (31.5, 33.8)	2.31
Fiji	4.9 (3.9, 5.7)	5.0 (4.4, 5.7)	0.06	5.1 (4.2, 5.8)	5.2 (4.6, 5.7)	0.03	23.5 (20.5, 26.6)	29.3 (27.8, 30.8)	2.07	22.3 (19.9, 24.8)	26.5 (25.4, 27.7)	1.52
French Polynesia	5.3 (4.4, 6.3)	5.4 (4.7, 6.2)	0.03	5.5 (4.7, 6.4)	5.5 (4.8, 6.2)	-0.02	26.3 (22.5, 30.1)	32.1 (28.8, 35.3)	2.06	25.4 (22.2, 28.6)	30.9 (28.4, 33.2)	1.95
Kiribati	4.8 (3.8, 5.6)	4.7 (4.2, 5.3)	-0.01	4.8 (3.9, 5.6)	4.5 (4.1, 5.0)	-0.08	25.9 (22.7, 29.1)	31.3 (30.0, 32.7)	1.92	25.5 (23.1, 27.8)	29.2 (28.2, 30.2)	1.34
Marshall Islands	4.9 (4.1, 5.8)	5.0 (4.4, 5.6)	0.03	5.0 (4.2, 5.8)	4.8 (4.3, 5.3)	-0.08	25.4 (22.2, 28.6)	31.4 (29.8, 33.0)	2.14	24.7 (22.2, 27.0)	29.4 (28.2, 30.6)	1.68
Micronesia (Federated States of)	4.8 (3.8, 5.7)	5.0 (4.4, 5.6)	0.07	4.9 (4.0, 5.7)	5.0 (4.4, 5.5)	0.03	25.8 (22.7, 29.0)	31.3 (29.7, 32.8)	1.96	24.4 (22.0, 26.8)	28.1 (26.9, 29.3)	1.32
Nauru	5.2 (4.2, 6.0)	5.1 (4.5, 5.6)	-0.03	5.3 (4.5, 6.1)	4.8 (4.3, 5.2)	-0.17	28.3 (24.5, 31.8)	35.0 (33.6, 36.3)	2.41	28.1 (25.0, 30.9)	33.9 (32.8, 35.0)	2.06
Palau	5.2 (4.3, 6.2)	5.2 (4.5, 5.9)	-0.02	5.4 (4.6, 6.2)	5.1 (4.4, 5.7)	-0.09	26.3 (22.5, 30.2)	31.8 (28.8, 34.9)	1.98	25.4 (22.3, 28.4)	30.4 (28.0, 32.8)	1.77
Papua New Guinea	4.5 (3.7, 5.3)	4.8 (4.1, 5.5)	0.08	4.7 (4.1, 5.4)	4.6 (4.0, 5.3)	-0.04	20.8 (18.4, 23.2)	25.8 (24.6, 26.9)	1.77	21.8 (19.8, 23.8)	25.0 (24.3, 25.8)	1.16
Samoa	4.8 (3.8, 5.7)	4.7 (4.0, 5.4)	-0.03	4.7 (3.9, 5.5)	4.5 (4.0, 5.0)	-0.08	26.8 (25.1, 28.6)	33.7 (32.1, 35.2)	2.44	25.8 (24.4, 27.3)	30.4 (29.2, 31.7)	1.64
Solomon Islands	4.7 (3.8, 5.6)	4.7 (4.1, 5.2)	-0.01	4.6 (3.9, 5.4)	4.4 (4.0, 4.9)	-0.07	23.8 (20.6, 27.0)	28.9 (27.5, 30.3)	1.82	24.0 (21.6, 26.5)	27.2 (26.1, 28.2)	1.13
Tonga	4.6 (3.7, 5.6)	4.9 (4.3, 5.5)	0.09	4.7 (3.9, 5.5)	5.1 (4.6, 5.5)	0.12	27.2 (23.7, 30.4)	34.3 (32.8, 35.7)	2.53	26.4 (23.9, 28.7)	31.0 (30.0, 32.0)	1.65
Vanuatu	4.8 (3.8, 5.7)	4.7 (4.1, 5.4)	-0.01	4.8 (4.0, 5.6)	4.6 (4.0, 5.3)	-0.08	22.9 (20.3, 25.6)	28.5 (27.1, 29.8)	1.97	23.2 (21.1, 25.4)	26.8 (25.7, 27.8)	1.28
Caribbean												
Antigua and Barbuda	5.0 (4.0, 6.0)	4.9 (4.1, 5.7)	-0.03	4.9 (4.0, 5.8)	4.8 (4.0, 5.5)	-0.04	24.2 (20.8, 27.5)	27.5 (24.3, 30.6)	1.17	23.3 (20.8, 25.9)	25.8 (23.4, 28.1)	0.88
Bahamas	5.4 (4.4, 6.4)	5.2 (4.4, 5.9)	-0.09	5.3 (4.4, 6.2)	5.0 (4.3, 5.7)	-0.11	25.7 (22.3, 29.1)	29.1 (26.1, 32.2)	1.22	24.2 (21.6, 26.9)	27.2 (24.9, 29.7)	1.08
Barbados	5.3 (4.3, 6.3)	4.9 (4.2, 5.7)	-0.13	5.1 (4.2, 6.0)	4.7 (4.0, 5.4)	-0.15	26.6 (24.7, 28.5)	29.2 (26.8, 31.6)	0.94	24.4 (22.8, 25.9)	26.4 (24.7, 28.1)	0.72
Belize	5.0 (4.0, 6.0)	4.7 (4.0, 5.4)	-0.11	4.9 (4.0, 5.8)	4.5 (3.8, 5.1)	-0.15	25.7 (22.9, 28.5)	29.8 (28.7, 30.9)	1.45	24.5 (22.4, 26.5)	27.0 (26.1, 27.9)	0.89
Bermuda	5.8 (4.8, 6.8)	5.4 (4.7, 6.2)	-0.13	5.7 (4.7, 6.6)	5.3 (4.6, 6.0)	-0.14	27.4 (23.8, 31.0)	30.3 (27.3, 33.5)	1.03	25.1 (22.4, 27.8)	28.4 (26.0, 30.9)	1.19
British Virgin Islands	5.0 (4.0, 6.0)	5.2 (4.3, 6.0)	0.06	4.8 (3.9, 5.7)	5.0 (4.2, 5.8)	0.08	24.8 (21.6, 28.1)	28.9 (27.9, 30.0)	1.49	23.7 (21.4, 26.2)	27.3 (26.6, 28.0)	1.27
Cuba	5.0 (4.1, 6.1)	4.7 (3.9, 5.4)	-0.14	4.9 (4.0, 5.8)	4.4 (3.7, 5.1)	-0.18	23.8 (22.4, 25.2)	26.6 (25.0, 28.2)	0.99	22.7 (21.7, 23.8)	25.1 (23.8, 26.3)	0.83
Dominica	4.9 (4.0, 5.9)	4.9 (4.4, 5.3)	-0.03	4.7 (3.9, 5.7)	4.5 (4.1, 4.9)	-0.08	25.0 (22.1, 27.9)	28.8 (27.7, 29.9)	1.36	22.3 (20.3, 24.4)	24.6 (23.8, 25.4)	0.80
Dominican Republic	4.8 (3.9, 5.8)	4.7 (4.0, 5.4)	-0.06	4.5 (3.7, 5.5)	4.4 (3.8, 5.0)	-0.06	22.6 (20.7, 24.5)	26.9 (25.2, 28.6)	1.51	22.9 (21.2, 24.6)	25.2 (23.8, 26.6)	0.81
Grenada	4.9 (3.9, 5.9)	4.7 (4.0, 5.4)	-0.05	4.6 (3.7, 5.5)	4.5 (3.8, 5.1)	-0.07	24.0 (20.8, 27.4)	27.3 (24.3, 30.3)	1.17	23.3 (20.6, 26.0)	25.2 (22.9, 27.5)	0.68
Guyana	4.7 (3.7, 5.7)	4.4 (3.7, 5.1)	-0.12	4.5 (3.6, 5.4)	4.1 (3.4, 4.8)	-0.15	23.7 (20.3, 27.0)	26.5 (23.3, 29.6)	1.01	22.7 (20.0, 25.3)	23.7 (21.2, 26.1)	0.35
Haiti	4.6 (3.6, 5.7)	4.4 (3.6, 5.1)	-0.10	4.4 (3.5, 5.3)	4.1 (3.4, 4.7)	-0.12	20.8 (18.6, 23.1)	23.3 (22.4, 24.2)	0.89	22.9 (20.3, 25.6)	23.7 (21.2, 26.1)	0.27
Jamaica	5.0 (4.0, 6.0)	4.7 (4.0, 5.4)	-0.10	4.8 (3.9, 5.7)	4.4 (3.8, 5.1)	-0.13	24.7 (22.4, 26.9)	27.2 (25.5, 29.0)	0.90	22.3 (20.6, 24.1)	24.0 (22.6, 25.4)	0.60
Netherlands Antilles	5.5 (4.5, 6.5)	5.3 (4.5, 6.0)	-0.09	5.4 (4.5, 6.3)	5.1 (4.4, 5.8)	-0.10	26.5 (24.1, 28.9)	29.6 (27.8, 31.4)	1.09	24.6 (22.8, 26.5)	27.7 (26.1, 29.3)	1.10
Puerto Rico	5.2 (4.2, 6.1)	4.9 (4.5, 5.4)	-0.08	5.0 (4.2, 5.9)	4.9 (4.4, 5.3)	-0.05	26.0 (23.0, 29.1)	30.2 (27.8, 32.6)	1.50	24.8 (22.4, 27.2)	28.4 (26.4, 30.3)	1.28
Saint Kitts and Nevis	5.0 (4.0, 6.0)	4.9 (4.1, 5.7)	-0.03	4.8 (3.9, 5.7)	4.7 (4.0, 5.4)	-0.03	26.4 (23.3, 29.4)	30.5 (29.2, 31.9)	1.46	25.3 (22.9, 27.6)	28.2 (27.2, 29.3)	1.06
Saint Lucia	4.9 (3.9, 5.9)	4.8 (4.1, 5.6)	-0.03	4.7 (3.7, 5.6)	4.6 (3.9, 5.3)	-0.03	24.0 (21.4, 26.6)	27.2 (24.9, 29.7)	1.16	22.8 (20.7, 24.9)	24.7 (22.7, 26.6)	0.65
Saint Vincent and the Grenadines	4.8 (3.8, 5.8)	4.8 (4.0, 5.5)	-0.01	4.6 (3.7, 5.5)	4.5 (3.8, 5.2)	-0.02	24.0 (20.6, 27.3)	27.5 (24.6, 30.6)	1.27	23.1 (20.4, 25.7)	25.4 (23.1, 27.7)	0.85
Suriname	5.0 (4.0, 6.0)	4.7 (4.0, 5.5)	-0.10	4.9 (4.0, 5.7)	4.5 (3.8, 5.2)	-0.12	24.7 (21.4, 28.1)	27.7 (24.8, 30.6)	1.10	23.3 (20.7, 25.9)	25.5 (23.1, 27.9)	0.79
Trinidad and Tobago	5.0 (4.0, 6.1)	4.8 (4.0, 5.6)	-0.08	4.9 (4.0, 5.8)	4.6 (3.8, 5.4)	-0.10	26.1 (23.8, 28.5)	28.3 (25.8, 30.7)	0.77	24.8 (23.0, 26.7)	26.4 (24.5, 28.3)	0.57
Latin America, Andean												
Bolivia	4.9 (3.9, 6.0)	4.7 (4.0, 5.4)	-0.08	4.8 (3.9, 5.8)	4.6 (3.9, 5.3)	-0.10	23.6 (21.2, 25.9)	26.9 (26.0, 27.7)	1.18	23.0 (20.1, 25.9)	24.4 (22.9, 26.0)	0.51
Ecuador	5.0 (4.0, 6.0)	4.8 (4.1, 5.5)	-0.06	4.9 (4.0, 5.8)	4.7 (4.0, 5.3)	-0.08	24.7 (21.5, 27.8)	27.1 (25.7, 28.4)	0.84	23.8 (20.9, 26.7)	25.6 (23.9, 27.2)	0.64
Peru	5.0 (4.0, 5.9)	4.8 (4.4, 5.1)	-0.07	4.9 (4.0, 5.8)	4.7 (4.3, 5.0)	-0.09	25.1 (22.8, 27.1)	26.0 (25.3, 26.6)	0.33	23.0 (20.3, 25.8)	24.8 (24.1, 25.4)	0.62
Latin America, Central												
Colombia	4.9 (3.9, 5.8)	4.9 (4.5, 5.3)	-0.01	4.9 (4.0, 5.7)	4.8 (4.4, 5.1)	-0.04	23.4 (21.3, 25.4)	26.2 (25.5, 26.9)	1.00	22.1 (20.3, 23.8)	24.9 (24.3, 25.6)	1.03
Costa Rica	5.0 (4.2, 5.9)	4.9 (4.2, 5.6)	-0.03	4.8 (4.1, 5.5)	4.7 (4.0, 5.3)	-0.05	23.4 (20.5, 26.3)	27.0 (25.8, 28.3)	1.31	23.7 (21.4, 25.9)	26.5 (25.5, 27.5)	0.99
El Salvador	4.9 (3.9, 5.9)	4.7 (4.0, 5.4)	-0.05	4.7 (3.9, 5.6)	4.5 (3.8, 5.1)	-0.10	23.7 (20.9, 26.4)	27.8 (26.9, 28.8)	1.49	23.8 (21.4, 26.1)	26.4 (24.9, 28.0)	0.93
Guatemala	4.8 (3.9, 5.8)	4.5 (3.9, 5.1)	-0.11	4.7 (3.9, 5.5)	4.2 (3.7, 4.7)	-0.17	22.9 (20.5, 25.1)	26.8 (25.7, 28.0)	1.41	23.2 (20.8, 25.5)	25.3 (24.1, 26.5)	0.75
Honduras	4.8 (3.8, 5.8)	4.6 (3.9, 5.3)	-0.06	4.6 (3.8, 5.4)	4.3 (3.6, 4.9)	-0.10	23.0 (20.0, 26.0)	26.7 (25.8, 27.6)	1.32	23.1 (20.7, 25.6)	25.1 (23.6, 26.7)	0.71
Mexico	5.0 (4.1, 6.0)	5.2 (4.7, 5.6)	0.05	4.9 (4.1, 5.7)	4.9 (4.6, 5.3)	0.01	24.6 (22.6, 26.4)	28.7 (27.9, 29.6)	1.49	24.5 (22.5, 26.3)	27.4 (26.8, 28.1)	1.06
Nicaragua	5.0 (4.0, 5.9)	4.6 (3.9, 5.2)	-0.14	4.8 (4.0, 5.7)	4.3 (3.6, 5.0)	-0.18	24.4 (21.9, 26.7)	27.6 (26.7, 28.4)	1.14	24.0 (21.6, 26.3)	25.8 (24.2, 27.3)	0.62
Panama	5.0 (4.1, 6.0)	4.9 (4.2, 5.6)	-0.03	4.9 (4.1, 5.7)	4.7 (4.1, 5.4)	-0.05	23.9 (21.0, 26.8)	27.7 (26.2, 29.2)	1.34	23.5 (21.3, 25.7)	26.3 (25.1, 27.4)	0.98
Venezuela (Bolivarian Republic of)	5.3 (4.3, 6.2)	4.8 (4.2, 5.5)	-0.15	5.1 (4.2, 5.9)	4.5 (3.9, 5.1)	-0.19	24.7 (21.9, 27.4)	28.1 (26.5, 29.8)	1.24	24.6 (22.4, 26.7)	27.4 (26.1, 28.8)	1.02
Latin America, Southern												
Argentina	5.4 (4.4, 6.4)	5.1 (4.3, 5.8)	-0.12	5.4 (4.5, 6.3)	5.0 (4.4, 5.7)	-0.12	23.8 (22.0, 25.6)	27.5 (25.9, 29.0)	1.29	25.4 (24.0, 26.8)	27.5 (26.3, 28.7)	0.76
Chile	5.1 (4.1, 6.1)	5.0 (4.4, 5.6)	-0.04	5.0 (4.2, 5.8)	5.0 (4.5, 5.4)	-0.02	24.0 (20.8, 27.0)	27.9 (26.7, 29.1)	1.41	24.5 (22.6, 26.4)	27.0 (26.0, 28.0)	0.90
Uruguay	5.3 (4.3, 6.3)	4.8 (4.3, 5.3)	-0.17	5.3 (4.4, 6.2)	4.8 (4.4, 5.2)	-0.17	23.3 (19.9, 26.6)	26.6 (25.4, 27.9)	1.19	24.2 (22.0, 26.5)	26.4 (25.5, 27.3)	0.77
Latin America, Tropical												
Brazil	4.9 (4.0, 5.9)	4.9 (4.2, 5.5)	-0.01	4.9 (4.1, 5.6)	4.8 (4.3, 5.4)	-0.01	24.1 (22.5, 25.6)	26.0 (25.3, 26.7)	0.69	22.6 (21.2, 24.0)	25.8 (25.2, 26.4)	1.12
Paraguay	4.9 (3.9, 5.9)	4.8 (4.0, 5.5)	-0.04	4.7 (3.9, 5.6)	4.6 (3.9, 5.3)	-0.04	23.5 (19.7, 27.2)	25.9 (22.5, 29.4)	0.87	23.4 (20.4, 26.4)	25.5 (22.9, 28.2)	0.76

Country	FPG (mmol/L)					
	1980 (Female)	2008 (Female)	Change per decade (Female)	1980 (Male)	2008 (Male)	Change per decade (Male)
Viet Nam	5.3 (4.4, 6.2)	5.2 (4.5, 5.90)	-0.03	5.0 (4.1, 5.9)	5.2 (4.5, 5.9)	0.07
Oceania						
Cook Islands	5.4 (4.8, 6.0)	6.5 (5.6, 7.40)	0.39	5.6 (5.1, 6.2)	6.5 (5.6, 7.4)	0.31
Fiji	5.3 (4.9, 5.7)	6.1 (5.5, 6.70)	0.28	5.6 (5.1, 6.0)	5.9 (5.2, 6.5)	0.10
French Polynesia	5.5 (5.0, 5.9)	6.3 (5.4, 7.10)	0.28	5.7 (5.2, 6.1)	6.3 (5.4, 7.2)	0.23
Kiribati	5.5 (5.1, 5.9)	6.8 (6.2, 7.40)	0.48	5.6 (5.2, 6.0)	6.8 (6.1, 7.4)	0.40
Marshall Islands	5.5 (3.9, 6.7)	7.3 (6.5, 8.20)	0.66	5.5 (4.3, 6.6)	6.9 (6.1, 7.7)	0.50
Micronesia (Federated States of)	5.4 (4.4, 6.3)	6.4 (5.7, 7.10)	0.37	5.5 (4.6, 6.5)	6.0 (5.3, 6.6)	0.16
Nauru	5.3 (4.8, 5.9)	6.0 (5.4, 6.60)	0.22	5.7 (5.1, 6.2)	5.8 (5.1, 6.4)	0.03
Palau	5.4 (4.4, 6.3)	6.3 (5.5, 7.20)	0.34	5.6 (4.6, 6.6)	6.3 (5.4, 7.1)	0.23
Papua New Guinea	5.2 (4.4, 6.0)	6.0 (5.6, 6.50)	0.31	5.5 (4.6, 6.3)	6.1 (5.6, 6.6)	0.23
Samoa	5.2 (4.2, 6.1)	6.7 (6.0, 7.40)	0.55	5.4 (4.5, 6.3)	6.6 (5.9, 7.3)	0.42
Solomon Islands	5.2 (4.1, 6.1)	6.3 (5.7, 6.90)	0.40	5.4 (4.4, 6.3)	6.2 (5.6, 6.8)	0.30
Tonga	5.3 (4.4, 6.3)	6.4 (5.8, 7.00)	0.37	5.6 (4.7, 6.6)	6.2 (5.6, 6.8)	0.22
Vanuatu	4.8 (3.7, 6.0)	5.4 (4.5, 6.30)	0.21	5.3 (4.2, 6.4)	5.4 (4.6, 6.3)	0.04
Caribbean						
Antigua and Barbuda	5.1 (4.1, 6.2)	5.7 (4.8, 6.60)	0.19	5.3 (4.3, 6.4)	5.6 (4.7, 6.5)	0.11
Bahamas	5.2 (4.1, 6.2)	5.8 (5.0, 6.70)	0.23	5.4 (4.3, 6.4)	5.8 (4.9, 6.6)	0.14
Barbados	5.5 (4.6, 6.4)	6.0 (5.1, 6.90)	0.17	5.7 (4.7, 6.6)	5.8 (4.9, 6.6)	0.05
Belize	5.1 (4.1, 6.2)	5.7 (5.2, 6.30)	0.22	5.4 (4.4, 6.4)	5.3 (4.8, 5.9)	-0.02
Bermuda	5.3 (4.3, 6.4)	6.0 (5.1, 6.90)	0.22	5.5 (4.4, 6.6)	5.9 (5.0, 6.8)	0.16
British Virgin Islands	5.1 (4.1, 6.3)	5.8 (4.8, 6.70)	0.22	5.4 (4.3, 6.4)	5.8 (4.8, 6.7)	0.16
Cuba	5.1 (4.1, 6.2)	5.7 (4.9, 6.50)	0.19	5.3 (4.3, 6.3)	5.7 (4.8, 6.5)	0.11
Dominica	5.3 (4.0, 6.5)	6.5 (5.9, 7.10)	0.42	5.2 (4.0, 6.3)	6.1 (5.5, 6.7)	0.34
Dominican Republic	4.7 (3.6, 5.9)	5.3 (4.5, 6.10)	0.21	5.0 (3.9, 6.0)	5.2 (4.4, 6.0)	0.08
Grenada	5.1 (4.0, 6.2)	5.7 (4.9, 6.60)	0.20	5.3 (4.3, 6.4)	5.6 (4.8, 6.5)	0.11
Guyana	5.2 (4.1, 6.3)	5.8 (4.9, 6.70)	0.20	5.4 (4.3, 6.3)	5.6 (4.7, 6.4)	0.08
Haiti	4.8 (3.7, 5.9)	5.4 (4.5, 6.30)	0.21	5.2 (4.1, 6.3)	5.4 (4.6, 6.3)	0.08
Jamaica	5.2 (4.2, 6.1)	5.8 (5.3, 6.30)	0.22	5.3 (4.4, 6.2)	5.6 (5.0, 6.1)	0.10
Netherlands Antilles	5.3 (4.2, 6.4)	5.9 (5.1, 6.80)	0.22	5.4 (4.4, 6.5)	5.9 (5.1, 6.8)	0.17
Puerto Rico	5.2 (4.1, 6.2)	6.0 (5.5, 6.60)	0.28	5.4 (4.4, 6.5)	6.2 (5.6, 6.8)	0.26
Saint Kitts and Nevis	5.4 (4.3, 6.5)	5.9 (5.0, 6.90)	0.19	5.6 (4.6, 6.6)	5.9 (5.0, 6.8)	0.11
Saint Lucia	5.1 (4.0, 6.1)	5.6 (4.8, 6.50)	0.20	5.2 (4.2, 6.3)	5.5 (4.7, 6.4)	0.11
Saint Vincent and the Grenadines	5.2 (4.1, 6.2)	5.7 (4.9, 6.60)	0.19	5.3 (4.3, 6.4)	5.6 (4.8, 6.5)	0.10
Suriname	5.3 (4.2, 6.3)	5.8 (4.9, 6.70)	0.21	5.4 (4.4, 6.4)	5.7 (4.8, 6.5)	0.10
Trinidad and Tobago	5.3 (4.2, 6.4)	5.8 (4.8, 6.80)	0.17	5.5 (4.4, 6.5)	5.7 (4.8, 6.7)	0.09
Latin America, Andean						
Bolivia	5.2 (4.1, 6.3)	5.5 (4.5, 6.30)	0.11	5.2 (4.1, 6.3)	5.3 (4.4, 6.2)	0.05
Ecuador	5.2 (4.1, 6.3)	5.4 (4.5, 6.30)	0.07	5.2 (4.2, 6.3)	5.4 (4.5, 6.3)	0.05
Peru	5.2 (4.1, 6.4)	4.9 (4.5, 5.30)	-0.10	5.2 (4.1, 6.3)	4.9 (4.5, 5.3)	-0.10
Latin America, Central						
Colombia	5.1 (4.2, 6.1)	4.9 (4.5, 5.40)	-0.06	5.3 (4.4, 6.3)	5.1 (4.6, 5.5)	-0.09
Costa Rica	4.9 (4.1, 5.7)	5.5 (5.0, 6.00)	0.21	5.1 (4.3, 5.9)	5.5 (5.0, 6.0)	0.16
El Salvador	5.2 (4.2, 6.2)	5.5 (4.9, 6.10)	0.13	5.4 (4.4, 6.4)	5.7 (5.0, 6.3)	0.09
Guatemala	5.2 (4.0, 6.2)	5.9 (5.3, 6.50)	0.27	5.4 (4.3, 6.4)	5.7 (5.2, 6.3)	0.13
Honduras	5.1 (4.1, 6.2)	5.3 (4.7, 5.90)	0.07	5.3 (4.3, 6.3)	5.3 (4.7, 6.0)	0.02
Mexico	5.3 (4.3, 6.2)	5.9 (5.4, 6.40)	0.24	5.3 (4.4, 6.2)	5.9 (5.3, 6.3)	0.19
Nicaragua	5.1 (4.1, 6.2)	5.3 (4.7, 5.90)	0.08	5.2 (4.2, 6.2)	5.3 (4.7, 5.9)	0.04
Panama	5.2 (4.1, 6.2)	5.6 (4.8, 6.50)	0.15	5.3 (4.3, 6.3)	5.6 (4.8, 6.4)	0.10
Venezuela (Bolivarian Republic of)	5.1 (4.1, 6.1)	5.5 (4.8, 6.20)	0.14	5.2 (4.3, 6.2)	5.6 (4.9, 6.3)	0.12
Latin America, Southern						
Argentina	5.1 (4.0, 6.2)	5.5 (4.7, 6.20)	0.15	5.4 (4.3, 6.5)	5.6 (4.9, 6.4)	0.08
Chile	5.1 (4.1, 6.2)	5.4 (4.8, 6.00)	0.08	5.4 (4.3, 6.4)	5.6 (5.0, 6.2)	0.10
Uruguay	5.0 (4.0, 6.1)	5.4 (4.5, 6.30)	0.15	5.2 (4.2, 6.3)	5.6 (4.7, 6.5)	0.13
Latin America, Tropical						
Brazil	5.1 (4.2, 6.0)	5.5 (4.9, 6.00)	0.13	5.0 (4.0, 5.9)	5.6 (5.0, 6.2)	0.21
Paraguay	5.1 (4.0, 6.1)	5.5 (4.6, 6.30)	0.14	5.2 (4.2, 6.2)	5.6 (4.7, 6.5)	0.14

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Epidemiology

Maternal and perinatal outcomes among nulliparous adolescents in low- and middle-income countries: a multi-country study

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Objective To investigate the risk of adverse pregnancy outcomes and caesarean section among adolescents in low- and middle-income countries.

Design Secondary analysis using facility-based cross-sectional data from the World Health Organization (WHO) Global Survey on Maternal and Perinatal Health.

Setting Twenty-three countries in Africa, Latin America, and Asia.

Population Women admitted for delivery in 363 health facilities during 2–3 months between 2004 and 2008.

Methods We constructed multilevel logistic regression models to estimate the effect of young maternal age on risks of adverse pregnancy outcomes.

Main outcome measures Risk of adverse pregnancy outcomes among young mothers.

Results A total of 78 646 nulliparous mothers aged ≤24 years and their singleton infants were included in the analysis. Compared with mothers aged 20–24 years, adolescents aged 16–19 years had a significantly lower risk of caesarean section (adjusted OR 0.75, 95% CI 0.71–0.79). When the analysis was restricted to caesarean section indicated for presumed cephalopelvic disproportion, the risk of caesarean section was significantly higher among mothers aged ≤15 years (aOR 1.27, 95% CI 1.07–1.49) than among those aged 20–24 years. Higher risks of low birthweight and preterm birth were found among adolescents aged 16–19 years (aOR 1.10, 95% CI 1.03–1.17; aOR 1.16, 95% CI 1.09–1.23, respectively) and ≤15 years (aOR 1.33, 95% CI 1.14–1.54; aOR 1.56, 95% CI 1.35–1.80, respectively).

Conclusions Adolescent girls experiencing pregnancy at a very young age (i.e. <16 years) have an increased risk of adverse pregnancy outcomes.

Keywords Adolescent pregnancy, caesarean section, low- and middle-income countries, low birthweight, perinatal mortality, preterm birth.

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Introduction

Pregnancy and childbirth are the leading causes of death in adolescent girls in low- and middle-income countries,[1] and obstetric risk is highest by far in sub-Saharan Africa.[2] It is estimated that about 15 million adolescents aged 15–19 years give birth each year, and more than 90% of these births occur in low- and middle-income countries.[1] In 2007, the number of births per 1000 women aged 15–19 years was as high as 121 in sub-Saharan Africa, and 74 in Latin America and the Caribbean, and in many parts of the world the decline in adolescent birth rates has stagnated since 2000.[3]

Pregnancy during adolescence has been associated with higher risks of adverse pregnancy outcomes such as low birthweight, preterm delivery, and perinatal and maternal death.[4,5] However, pregnant adolescents are more likely to be socially deprived: they are more likely to be poorer, less educated, and single, and to have fewer antenatal care visits than older mothers.[4–6] Hence, the contribution of young age itself to the risk of adverse pregnancy outcomes among adolescents is difficult to estimate, as the risk may be at least partly attributable to the unfavourable sociodemographic characteristics of adolescent mothers.[7]

Despite the fact that most adolescent pregnancies occur in low- and middle-income countries, large studies from such countries are scarce, and most of these studies have not taken into account the confounding effect of sociodemographic factors.[8–10] We therefore conducted an analysis of data from the Global Survey on Maternal and Perinatal Health, which was a large multi-country study carried out in 24 mainly low- and middle-income countries in Africa, Latin America, and Asia, to assess the effect of young maternal age on pregnancy outcomes after adjustment for sociodemographic characteristics.

Methods

Study design

A secondary analysis of data from the World Health Organization (WHO) Global Survey on Maternal and Perinatal Health was conducted. Methodological details of this survey have been published elsewhere.[11,12] Briefly, the survey was a multi-country, facility-based, cross-sectional study. A stratified multistage cluster sampling design was used to obtain a sample of countries and health facilities worldwide. The survey was implemented in 24 countries and 373 health facilities. In each country, the capital city was included in the sample. In addition, two provinces were randomly selected from other administrative areas. The countries included in the survey were from three continents: Africa (Algeria, Angola, Democratic Republic of Congo, Niger, Nigeria, Kenya, and Uganda), Latin America (Argentina, Brazil, Cuba, Ecuador, Mexico, Nicaragua, Paraguay, and Peru), and Asia (Cambodia, China, India, Japan, Nepal, the Philippines, Sri Lanka, Thailand, and Vietnam). Only health institutions that reported at least 1000 deliveries per year and were capable of performing caesarean sections were eligible to participate. A random sample of up to seven institutions from each country was selected. All women admitted for delivery during a fixed recruitment period were included in the survey. The period of recruitment (data collection) was arbitrary, defined as 3 months for institutions with up to 6000 deliveries per year, and 2 months for those with more than 6000 deliveries. The survey was conducted between 2004 and 2005 in Africa and Latin America, and between 2007 and 2008 in Asia.

Data collection

Data were collected for institutions and individuals. Data for individuals were directly extracted from the patient records by trained medical staff before maternal hospital discharge or within 7 days of delivery. Maternal age referred to age in completed years at the time of delivery. Maternal weight in Africa and Latin America was measured at the last antenatal care visit, whereas in Asia it was measured upon maternal admission for delivery. Gestational age at birth was defined as the number of completed weeks of gestation based on the estimated delivery date in the clinical records. Consistent with previous studies,[13,14] the operational definition of caesarean section indicated for cephalopelvic disproportion (CPD) in our study was based on presumed CPD, and included caesarean sections indicated for dystocia, failure to progress, and failed vacuum extraction or forceps delivery, but excluded those indicated for fetal distress, breech and other types of malpresentation, and failed induction. Maternal and early neonatal deaths were defined as intra-hospital deaths that occurred on or before the eighth day postpartum and seventh day after delivery, respectively. Stillbirths included both macerated and fresh stillbirths.

Institutional data were collected on a standard form by the hospital coordinators, in consultation with the director or head of obstetrics. Data on the provision of maternal and perinatal care were obtained, including: laboratory tests; anaesthesiology resources; services provided for intrapartum care, delivery, and care of the newborn baby; and the presence or absence of basic emergency medical and obstetric care facilities, intensive care units, and human training resources.

Statistical analysis

The study population was restricted to nulliparous women because of the small number of multiparous younger mothers and the strong correlation between parity and maternal age. Only mothers who had a singleton neonate of birthweight $\geq$500 g or gestational age $\geq$22 weeks – if the birthweight was missing – were included in the analysis, as a birthweight or gestational age outside this range is considered a miscarriage.[15] Age was categorised as $\leq$15, 16–19, and 20–24 years, and, similar to previous studies,[4,8,16,17] those over 25 years of age were excluded from the analysis. Japan was excluded from the analysis as our aim was to focus on low- and middle-income countries.

Region-wise descriptive analyses were conducted to account for the heterogeneity between regions, as the quality of medical services and the social and cultural backgrounds of adolescent mothers were expected to differ by region. The region-wise characteristics of mothers in the three age groups were compared using chi-square tests.

To estimate the effect of young maternal age on the risks of caesarean section, caesarean section indicated for CPD, low birthweight (<2500 g), preterm delivery (<37 completed weeks of gestation), and perinatal death (early intra-hospital death or stillbirth), we constructed multilevel logistic regression models with random effects for facilities and countries. The significance of the random effects was determined using a likelihood ratio test by comparing models nested within models with additional levels.[18] The variability of outcomes was assessed, and caterpillar plots of the random-effect estimates for each country are shown for low birthweight only (Figure 1). For the analyses, four models are presented. In order to understand the independent roles of biological versus environmental factors in the association between adolescent pregnancy and adverse birth outcomes, adjustment was made for country and facility variables in the first model, and individual variables such as maternal education, marital status, and antenatal care visits in the second. For analyses on caesarean section, caesarean section indicated for CPD, low birthweight, and perinatal mortality, further adjustment was made for maternal height (short maternal height being defined as <1.50 m) and gestational age at birth in the third and fourth models. Individual- and facility-level variables were available in the survey data, whereas country-level variables were obtained from the World Bank Development Indicators and *Lancet* series on maternal and child mortality.[19] Country variables included in the model were gross national income (GNI) *per capita*, classified according to the World Bank categorisation as low ($935 or less), lower–middle ($936–3705) and upper–middle ($3706–11 455), maternal mortality ratio (MMR) per 100 000 live births, and early neonatal mortality (ENM) per 1000 live births. The facility capacity index score was considered as a facility-level variable, and was used to reflect the level of services available in each of the facilities and to summarise the capacity of an institution to provide obstetric care.[20] The analyses were not adjusted for maternal body mass index (BMI) because of variation in the timing of maternal weight measurements among countries. Data on maternal morbidities such as eclampsia, diabetes, severe anaemia (defined as haemoglobin, HB < 7 g/dl), sexually transmitted infections, and HIV infection were available, and the multiple regression analyses were only adjusted for those associated with maternal age in the univariate analysis, in order to restrict the number of confounding factors included in the final models. For multilevel logistic regression analyses on caesarean section and caesarean section indicated for CPD, facilities with no provision for caesarean section delivery, and countries with > 40% missing data on maternal height (Angola, 42.3%; Kenya, 87.5%; Brazil, 68.1%), were excluded. Statistical analysis was performed in STATA/MP 12.0 (Stata Corp. LP, College Station, TX, USA), and $P < 0.05$ was considered to be statistically significant.

Results

The WHO Global Survey on Maternal and Perinatal Health collected data on a total of 290 610 deliveries. A total of 119 551 mothers and their infants were retained in the analysis after exclusion of data from Japan, multiparous births, multiple births, and infants with birthweight <500 g or gestational age <22 weeks, if birthweight was missing. Table 1 presents the distribution of women by age group.

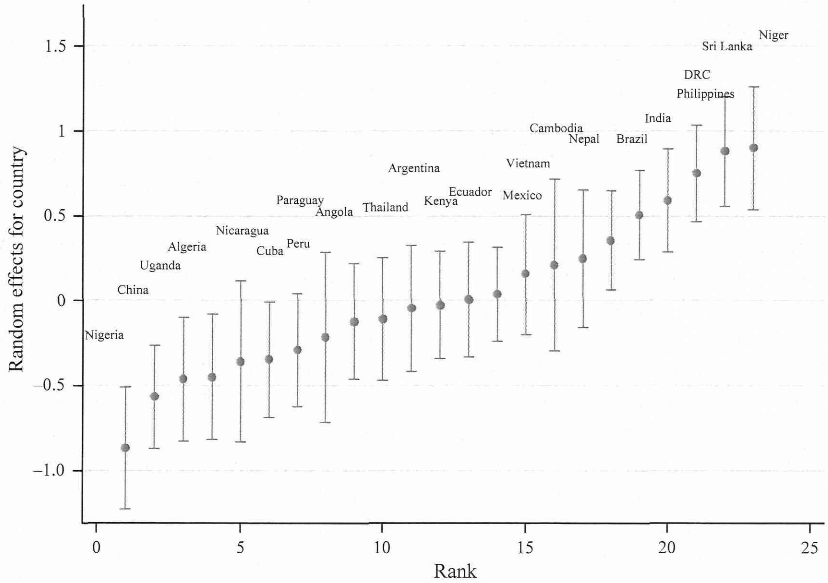

Figure 1. Random-effect estimations for low birthweight: country-level effects in rank order, with approximate 95% confidence intervals. DRC, Democratic Republic of Congo.