Body mass index and diabetes risk in fifty-seven low- and middle-income countries

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Table 1. Characteristics of population-based surveys conducted in 57 LMICs between 2008 and 2016, by geographic classification

Country	Survey type	Survey year	Response rate, %	Sample size	Mean age, years (SD)	Age range, years	Female, %	Mean BMI, kg/m^2 (SD)	Diabetes prevalence, %
Latin America and the Caribbean									
Chile	Non-STEPS	2009-10	85	4,049	47.7 (14.8)	25-100	51.8	28.0 (5.1)	9.7
Costa Rica	STEPS	2010	87.8	2,234	47.1 (15.5)	25-104	50.4	27.6 (6.0)	11.6
Ecuador	STEPS	2018	69.5	3,337	44.6 (12.4)	25-69	51.7	27.9 (4.8)	9.1
Guyana	STEPS	2016	66.7	784	42.2 (11.9)	25-69	53.0	27.6 (6.8)	20.1
Mexico	Non-STEPS	2009-12	90	7,002	54.3 (14.0)	25-99	66.6	28.8 (5.5)	34.4
SVG	STEPS	2013	67.8	886	42.8 (12.2)	25-69	56.9	28.0 (6.3)	11.2
Europe and Central Asia									
Azerbaijan	STEPS	2017	..	2,325	43.0 (12.1)	25-69	50.6	27.2 (5.1)	8.3
Belarus	STEPS	2016	87.1	4,418	45.9 (12.5)	25-69	52.4	27.5 (5.3)	5.2
Georgia	STEPS	2016	75.7	2,907	46.3 (12.7)	25-70	53.0	29.0 (6.3)	6.4
Kyrgyzstan	STEPS	2013	100	2,475	40.8 (11.5)	25-64	48.3	26.6 (5.3)	5.4
Moldova	STEPS	2013	83.5	3,231	43.8 (12.3)	25-69	50.6	27.5 (5.5)	7.0
Mongolia	STEPS	2013	97.4	1,855	42.6 (9.1)	25-64	51.4	27.2 (5.3)	4.7
Romania	Non-STEPS	2015-16	69.1	1,775	51.6 (15.7)	25-80	52.5	28.7 (5.7)	11.3
Tajikistan	STEPS	2016	94	2,155	36.4 (11.6)	25-70	43.2	25.9 (4.7)	1.9
East and Southeast Asia									
Bangladesh	STEPS	2018	84.6	6,155	41.9 (11.3)	25-69	52.6	23.0 (4.3)	9.6
Bhutan	STEPS	2014	96.9	2,400	40.1 (11.2)	25-69	41.7	24.2 (3.7)	2.5
Cambodia	STEPS	2010	92	5,097	40.4 (10.8)	25-64	51.1	21.8 (3.3)	2.4

Country	Survey Type	Year								
China	Non-STEPS	2009	88	8,001	52.5 (13.8)	25-99	53.4	23.5 (3.5)	8.5
India	Non-STEPS	2015-16	96	490,532	37.0 (7.9)	25-54	46.6	22.8 (4.3)	4.9
Indonesia	Non-STEPS	2014	83	5,345	44.4 (13.6)	25-101	51.9	23.6 (4.4)	8.1
Laos	STEPS	2013	99.2	2,099	42.4 (10.8)	25-65	58.4	23.1 (4.1)	5.6
Myanmar	STEPS	2014	90	7,725	41.8 (11.0)	25-64	49.2	22.7 (4.5)	6.4
Nepal	STEPS	2019	86.4	4,488	40.7 (12.4)	25-69	53.1	23.3 (4.1)	7.1
Timor Leste	STEPS	2014	96.3	1,993	44.4 (12.7)	25-69	56.2	21.3 (3.9)	3.0
Vietnam	STEPS	2015	79.8	2,763	42.8 (12.0)	25-69	50.6	22.3 (3.2)	3.1
Sub-Saharan Africa									
Benin	STEPS	2015	98.6	4,032	39.0 (11.1)	25-69	53.7	23.4 (4.6)	6.6
Botswana	STEPS	2014	63	2,559	39.2 (11.7)	25-69	48.7	24.2 (5.8)	3.8
Burkina Faso	STEPS	2013	97.8	3,935	39.3 (10.9)	25-64	53.1	22.4 (4.0)	2.8
Comoros	STEPS	2011	96.5	2,359	41.5 (11.4)	25-64	73.9	26.0 (5.9)	4.2
Eritrea	STEPS	2010	97	5,518	43.5 (12.7)	25-74	80.8	20.4 (4.0)	3.6
Eswatini	STEPS	2014	81.8	1,812	40.5 (12.1)	25-70	56.0	27.3 (6.6)	6.6
Kenya	STEPS	2015	95	3,287	39.1 (11.6)	25-69	50.5	23.6 (5.1)	2.4
Lesotho	STEPS	2012	80	1,958	38.0 (11.0)	25-64	50.1	25.8 (7.2)	2.8
Liberia	STEPS	2011	87.1	1,566	37.6 (10.0)	25-64	54.0	26.9 (7.4)	13.2
Malawi	STEPS	2009	95.5	2,903	38.6 (11.0)	25-64	50.1	23.1 (3.9)	0.9
Namibia	Non-STEPS	2013	96.9	3,250	46.8 (8.3)	25-64	60.3	24.8 (6.2)	6.1
Rwanda	STEPS	2012	99	5,214	38.6 (10.5)	25-64	53.2	22.6 (3.5)	1.6
Sao Tome and Principe	STEPS	2009	95	1,990	39.8 (11.3)	25-64	52.4	24.7 (5.6)	2.9
Seychelles	STEPS	2013	73	1,239	42.6 (10.5)	25-64	49.9	27.8 (6.0)	19.1
South Africa	Non-STEPS	2012	92.6	3,201	43.8 (14.2)	25-97	52.9	27.7 (7.2)	13.2
Sudan	STEPS	2015	88	5,273	40.0 (11.5)	25-70	46.1	23.7 (5.3)	8.4
Tanzania	STEPS	2012	94.7	4,696	38.9 (10.8)	25-65	50.4	22.9 (4.7)	2.8
Togo	STEPS	2010	91	2,567	38.9 (11.0)	25-64	51.6	23.5 (4.6)	3.3

Uganda	STEPS	2014	99	2,562	40.2 (11.4)	25-69	56.9	22.9 (4.5)	1.7
Zambia	STEPS	2017	74	2,534	39.2 (11.1)	25-69	50.1	23.6 (5.0)	8.3
Zanzibar	STEPS	2011	97.6	2,252	38.8 (10.1)	25-64	51.1	24.3 (5.4)	3.5
Middle East and North Africa									
Algeria	STEPS	2016	..	5,140	41.9 (11.6)	25-69	48.7	27.1 (5.4)	11.5
Iran	STEPS	2016	99	18,885	47.6 (14.7)	25-100	54.1	27.1 (5.0)	11.3
Iraq	STEPS	2015	93	3,166	42.6 (14.1)	25-102	48.2	29.5 (6.4)	18.9
Lebanon	STEPS	2017	65.9	1,032	43.3 (11.4)	25-69	51.9	28.0 (5.4)	12.7
Morocco	STEPS	2017	89	4,180	46.1 (14.9)	25-100	50.8	26.6 (5.3)	13.7
Oceania									
Fiji	Non-STEPS	2009	80	1,324	55.5 (10.5)	25-90	57.2	29.0 (5.9)	42.8
Kiribati	STEPS	2015	55	956	43.1 (11.6)	25-69	57.5	30.7 (6.3)	20.9
Marshall Islands	STEPS	2017	92.3	2,269	42.5 (12.1)	25-86	52.5	30.5 (6.8)	31.2
Samoa	STEPS	2013	64	1,187	41.2 (10.9)	25-64	49.9	33.4 (7.4)	24.6
Solomon Islands	STEPS	2015	58.4	1,467	41.5 (11.2)	25-71	51.8	27.3 (5.4)	5.4
Timor Leste	STEPS	2014	96.3	1,993	44.4 (12.7)	25-69	56.2	21.3 (3.9)	3.0
Tuvalu	STEPS	2015	76	832	43.6 (12.4)	25-69	45.9	33.4 (6.7)	11.9
World (all data)	..	2009-2019	76.9	685,616	42.6 (12.6)	25-104	52.8	25.8 (6.1)	9.3

Notes: Survey year and response rate shown for the complete study population of each survey. Other characteristics calculated among individuals that met our inclusion criteria. Mean age, % female, % per education category (no formal schooling; completed primary school; secondary school or above), mean BMI, and diabetes prevalence calculated using re-scaled sampling weights. Abbreviations: SVG: Saint Vincent and the Grenadines. Details on non-STEPS surveys included in the study are provided in Appendix 2.

Table 2. BMI cut-offs for diabetes risk in 57 LMICs, according to geographic region and sex

	Women					**Men**				
	AUC	BMI cut-off	Sensitivity (%)	Specificity (%)	Youden Index	AUC	BMI cut-off	Sensitivity (%)	Specificity (%)	Youden Index
Latin America and the Caribbean	0.59					0.63				
Optimal cut-off		28.3	62.8	52.1	15.0		25.3	76.3	43.2	19.5
		23.0	91.5	15.2	6.7		23.0	87.5	22.6	10.0
		25.0	80.7	28.0	8.6		25.0	78.0	40.6	18.6
		30.0	49.4	63.6	13.1		30.0	34.0	81.2	15.2
Europe and Central Asia	0.68					0.67				
Optimal cut-off		28.0	73.0	54.0	27.0		27.6	67.7	59.1	26.7
		23.0	93.4	19.7	13.1		23.0	90.6	20.1	10.6
		25.0	87.1	33.3	20.4		25.0	81.8	36.5	18.3
		30.0	59.3	66.0	25.2		30.0	48.7	76.4	25.1
East and Southeast Asia	0.65					0.66				
Optimal cut-off		23.9	61.0	63.0	24.1		23.8	57.1	69.6	26.6
		23.0	68.1	54.2	22.3		23.0	63.9	62.1	26.0
		25.0	50.5	71.3	21.8		25.0	42.3	79.9	22.2
		30.0	15.8	93.8	9.6		30.0	8.5	97.0	5.5
Sub-Saharan Africa	0.68					0.68				
Optimal cut-off		27.3	58.9	70.4	29.3		25.4	50.9	78.4	29.3
		23.0	80.1	42.7	22.8		23.0	67.2	59.4	26.6
		25.0	70.1	57.5	27.7		25.0	52.3	76.4	28.8
		30.0	43.8	81.0	24.8		30.0	22.2	94.0	16.2

Middle East and North Africa	0.61					0.60				
Optimal cut-off		28.3	63.8	53.0	16.9		24.2	81.7	33.8	15.5
		23.0	92.4	16.6	9.0		23.0	88.7	24.1	12.9
		25.0	83.2	29.5	12.6		25.0	72.9	40.2	13.1
		30.0	50.3	64.4	14.7		30.0	30.7	79.4	10.2
Oceania	0.55					0.56				
Optimal cut-off		25.2	85.5	23.8	9.3		28.1	57.1	53.7	10.8
		23.0	93.3	13.2	6.5		23.0	87.6	17.0	4.7
		25.0	86.0	22.8	8.8		25.0	76.4	31.2	7.5
		30.0	58.0	48.2	6.3		30.0	43.6	65.7	9.3

Notes: Table shows area under the receiver operating characteristic curve as displayed in Figure 3. Additionally, it includes diabetes screening characteristics (sensitivity, specificity, Youden index) of several binary body mass index (BMI) cut-offs for each world region, separately by sex. Optimal BMI cut-offs were defined as the respective BMI value which maximizes the Youden index. Each country was weighed equally. Abbreviations: AUC: area under the curve; BMI: body mass index.