

## 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

| <i>Country</i>                         | <b>Survey type</b> | <b>Survey year</b> | <b>Response rate, %</b> | <b>Sample size</b> | <b>Mean age, years (SD)</b> | <b>Age range, years</b> | <b>Female, %</b> | <b>Mean BMI, kg/m<sup>2</sup> (SD)</b> | <b>Diabetes prevalence, %</b> |
|--|--------------------|--------------------|-------------------------|--------------------|-----------------------------|-------------------------|------------------|--|-------------------------------|
| <i>Latin America and the Caribbean</i> |                    |                    |                         |                    |                             |                         |                  |  |                               |
| Chile                                  | Non-<br>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-<br>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                          |
| <i>Europe and Central Asia</i>         |                    |                    |                         |                    |                             |                         |                  |  |                               |
| 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-<br>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                           |
| <i>East and Southeast Asia</i>         |                    |                    |                         |                    |                             |                         |                  |  |                               |
| 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                           |

|                                  |               |         |      |         |             |        |      |            |      |
|----------------------------------|---------------|---------|------|---------|-------------|--------|------|------------|------|
| China                            | Non-<br>STEPS | 2009    | 88   | 8,001   | 52.5 (13.8) | 25-99  | 53.4 | 23.5 (3.5) | 8.5  |
| India                            | Non-<br>STEPS | 2015-16 | 96   | 490,532 | 37.0 (7.9)  | 25-54  | 46.6 | 22.8 (4.3) | 4.9  |
| Indonesia                        | Non-<br>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  |
| <b><i>Sub-Saharan Africa</i></b> |               |         |      |         |             |        |      |            |      |
| 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-<br>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-<br>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  |
| <b><i>Middle East and North Africa</i></b> |               |           |      |         |             |        |      |            |      |
| 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 |
| <b><i>Oceania</i></b>                      |               |           |      |         |             |        |      |            |      |
| Fiji                                       | Non-<br>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 |
| <b><i>World (all data)</i></b>             | ..            | 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

|   | <b>Women</b> |             |                 |                 |              | <b>Men</b> |             |                 |                 |              |
|---|--------------|-------------|-----------------|-----------------|--------------|------------|-------------|-----------------|-----------------|--------------|
|   | AUC          | BMI cut-off | Sensitivity (%) | Specificity (%) | Youden Index | AUC        | BMI cut-off | Sensitivity (%) | Specificity (%) | Youden Index |
| <b><i>Latin America and the Caribbean</i></b> | 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         |
| <b><i>Europe and Central Asia</i></b>         | 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         |
| <b><i>East and Southeast Asia</i></b>         | 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          |
| <b><i>Sub-Saharan Africa</i></b>              | 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         |

|  |      |      |      |      |      |      |      |      |      |      |
|--|------|------|------|------|------|------|------|------|------|------|
| <b><i>Middle East and North Africa</i></b> | 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 |
| <b><i>Oceania</i></b>                      | 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.