

Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19·2 million participants



NCD Risk Factor Collaboration (NCD-RisC)*



Summary

Background Underweight and severe and morbid obesity are associated with highly elevated risks of adverse health outcomes. We estimated trends in mean body-mass index (BMI), which characterises its population distribution, and in the prevalences of a complete set of BMI categories for adults in all countries.

Methods We analysed, with use of a consistent protocol, population-based studies that had measured height and weight in adults aged 18 years and older. We applied a Bayesian hierarchical model to these data to estimate trends from 1975 to 2014 in mean BMI and in the prevalences of BMI categories (<18·5 kg/m² [underweight], 18·5 kg/m² to <20 kg/m², 20 kg/m² to <25 kg/m², 25 kg/m² to <30 kg/m², 30 kg/m² to <35 kg/m², 35 kg/m² to <40 kg/m², ≥40 kg/m² [morbid obesity]), by sex in 200 countries and territories, organised in 21 regions. We calculated the posterior probability of meeting the target of halting by 2025 the rise in obesity at its 2010 levels, if post-2000 trends continue.

Findings We used 1698 population-based data sources, with more than 19·2 million adult participants (9·9 million men and 9·3 million women) in 186 of 200 countries for which estimates were made. Global age-standardised mean BMI increased from 21·7 kg/m² (95% credible interval 21·3–22·1) in 1975 to 24·2 kg/m² (24·0–24·4) in 2014 in men, and from 22·1 kg/m² (21·7–22·5) in 1975 to 24·4 kg/m² (24·2–24·6) in 2014 in women. Regional mean BMIs in 2014 for men ranged from 21·4 kg/m² in central Africa and south Asia to 29·2 kg/m² (28·6–29·8) in Polynesia and Micronesia; for women the range was from 21·8 kg/m² (21·4–22·3) in south Asia to 32·2 kg/m² (31·5–32·8) in Polynesia and Micronesia. Over these four decades, age-standardised global prevalence of underweight decreased from 13·8% (10·5–17·4) to 8·8% (7·4–10·3) in men and from 14·6% (11·6–17·9) to 9·7% (8·3–11·1) in women. South Asia had the highest prevalence of underweight in 2014, 23·4% (17·8–29·2) in men and 24·0% (18·9–29·3) in women. Age-standardised prevalence of obesity increased from 3·2% (2·4–4·1) in 1975 to 10·8% (9·7–12·0) in 2014 in men, and from 6·4% (5·1–7·8) to 14·9% (13·6–16·1) in women. 2·3% (2·0–2·7) of the world's men and 5·0% (4·4–5·6) of women were severely obese (ie, have BMI ≥35 kg/m²). Globally, prevalence of morbid obesity was 0·64% (0·46–0·86) in men and 1·6% (1·3–1·9) in women.

Interpretation If post-2000 trends continue, the probability of meeting the global obesity target is virtually zero. Rather, if these trends continue, by 2025, global obesity prevalence will reach 18% in men and surpass 21% in women; severe obesity will surpass 6% in men and 9% in women. Nonetheless, underweight remains prevalent in the world's poorest regions, especially in south Asia.

Funding Wellcome Trust, Grand Challenges Canada.

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Introduction

High body-mass index (BMI) is an important risk factor for cardiovascular and kidney diseases, diabetes, some cancers, and musculoskeletal disorders.^{1–7} Concerns about the health and economic burden of increasing BMI have led to adiposity being included among the global non-communicable disease (NCD) targets, with a target of halting, by 2025, the rise in the prevalence of obesity at its 2010 level.^{8,9} Information on whether countries are on track to achieve this target is needed to support accountability towards the global NCD commitments.¹⁰

Two previous studies^{11–13} estimated global trends in the prevalence of overweight and obesity. However, the largest health benefits of weight management are achieved by shifting the population distribution of BMI. The only global

report on mean BMI, which characterises distributional shifts, estimated trends to 2008,¹¹ before the global target was agreed. Epidemiological studies have shown substantial risks in people with very high BMI—eg, severe (≥35 kg/m²) or morbid (≥40 kg/m²) obesity.¹⁴ Being underweight is also associated with increased risk of morbidity and mortality (ie, a so-called J-shaped association) and with adverse pregnancy outcomes.^{4,6,15,16} Very few analyses of trends in underweight,¹⁷ especially for men, and in severe and morbid obesity have been done. Finally, no information is available on the likelihood of individual countries or the world as a whole achieving the global obesity target.

We pooled population-based data to estimate trends from 1975 to 2014 in both mean BMI and in prevalence of

Lancet 2016; 387: 1377–96

This online publication has been corrected. The corrected version first appeared at thelancet.com on May 12, 2016

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*NCD Risk Factor Collaboration members are listed at the end of the paper

Correspondence to: Prof Majid Ezzati, School of Public Health, Imperial College London, London W2 1PG, UK majid.ezzati@imperial.ac.uk

Research in context

Evidence before this study

We searched MEDLINE (via PubMed) for manuscripts published in any language between Jan 1, 1950, and March 12, 2013, using the search terms “body size”[mh:noexp] OR “body height”[mh:noexp] OR “body weight”[mh:noexp] OR “birth weight”[mh:noexp] OR “overweight”[mh:noexp] OR “obesity”[mh] OR “thinness”[mh:noexp] OR “Waist-Hip Ratio”[mh:noexp] or “Waist Circumference”[mh:noexp] or “body mass index” [mh:noexp]) AND (“Humans”[mh]) AND (“1950”[PDAT] : “2013”[PDAT]) AND (“Health Surveys”[mh] OR “Epidemiological Monitoring”[mh] OR “Prevalence”[mh]) NOT Comment[ptyp] NOT Case Reports[ptyp]. Articles were screened according to the inclusion and exclusion criteria described in the appendix (pp 2–5).

The only global study on trends in mean body-mass index (BMI), which characterises shifts in the population distribution of BMI, reported trends to 2008 (before the global target on obesity was agreed) and no recent data are available. Two previous studies estimated global trends in the prevalence of overweight and obesity. Neither study reported trends in underweight, which is associated with increased risk of morbidity, mortality, and adverse pregnancy outcomes, or in

high levels of BMI (eg, ≥ 35 or ≥ 40 kg/m²), which are associated with substantial risks of many non-communicable diseases.

Added value of this study

This study provides the longest and most complete picture of trends in adult BMI, including, for the first time, in underweight and severe and morbid obesity, which are of enormous clinical and public health interest. We were able to robustly depict this rich picture by reanalysing and pooling hundreds of population-based sources with measurements of height and weight according to a common protocol. We also systematically projected recent trends into the future, and assessed the probability of the global obesity target being achieved.

Implications of all the available evidence

The world has transitioned from an era when underweight prevalence was more than double that of obesity, to one in which more people are obese than underweight. However, underweight remains a public health problem in the world's poorest regions—namely south Asia and central and east Africa. If present trends continue, not only will the world not meet the global obesity target, but severe obesity will also surpass underweight in women by 2025.

BMI categories ranging from underweight to morbid obesity. We also estimated the probability of achieving the global obesity target.

Methods

Study design

We analysed population-based studies that had measured height and weight in adults aged 18 years and older with use of a consistent protocol. We estimated trends in mean BMI and prevalence of BMI categories (<18.5 kg/m² [underweight], 18.5 kg/m² to <20 kg/m², 20 kg/m² to <25 kg/m², 25 kg/m² to <30 kg/m², 30 kg/m² to <35 kg/m², 35 kg/m² to <40 kg/m², and ≥ 40 kg/m² [morbid obesity]) from 1975 to 2014, in 200 countries and territories. We report results for these categories, and for total obesity (BMI ≥ 30 kg/m²) and severe obesity (BMI ≥ 35 kg/m²). Countries and territories were organised into 21 regions, mostly on the basis of geography and national income (appendix pp 10, 11). The exception was a region consisting of high-income English-speaking countries because BMI and other cardiometabolic risk factors have similar trends in these countries, which can be distinct from other countries in their geographical region. Our analysis covered men and women aged 18 years and older, consistent with the Global Monitoring Framework for NCDs.⁸

Our study had two steps: first, we identified, accessed, and reanalysed population-based studies that had measured height and weight; then, we used a statistical model to estimate mean BMI and prevalences of BMI categories for all countries and years.

Data sources

We used multiple routes for identifying and accessing data, including from publicly available sources and through requests to various national and international organisations, as described in the appendix (pp 2–5). We used data sources that were representative of a national, subnational, or community population and had measured height and weight. We did not use self-reported height and weight because they are subject to biases that vary by geography, time, age, sex, and socioeconomic characteristics.^{18–20} Because of these variations, present approaches to correcting self-reported data leave residual bias and error. Our data inclusion and exclusion criteria were designed to ensure population representativeness (appendix pp 2–5).

Statistical analysis

The statistical method is described in a statistical paper²¹ and in the appendix of a previous paper.²² In summary, the model had a hierarchical structure in which estimates for each country and year were informed by the country and year's own data, if available, and by data from other years in the same country and in other countries, especially those in the same region with data for similar time periods. The hierarchical structure shares information to a greater degree when data are non-existent or weakly informative (eg, have a small sample size or are not national), and to a lesser extent in data-rich countries and regions.

The model incorporated non-linear time trends and age patterns; national versus subnational and community

See [Online](#) for appendix

representativeness; and whether data covered both rural and urban areas versus only one of them. The model also included covariates that help predict BMI, including national income (natural logarithm of per-person gross domestic product adjusted for inflation and purchasing power), proportion of population living in urban areas, mean number of years of education, and summary measures of availability of different food types for human consumption as described elsewhere.^{23,24} We also did an analysis without the use of covariates and compared the estimates with and without covariates. Estimates with and without covariates were virtually identical in most countries (appendix pp 147,148) with the exception of a few countries that had no data and whose covariates (eg, national income) differed from those of their region (eg, Brunei, Bermuda, and North Korea). We report estimates for the model with covariates because it had better fit to data, as measured by the deviance information criterion.

We analysed mean BMI and each prevalence of a BMI category separately. We rescaled the estimated prevalence of different categories so that their sum was 1.0 in each age, sex, country, and year. The mean scaling factor across draws was 1.05 for men and 1.07 for women—ie, the sum of each separately estimated prevalence was close to 1.0. Estimates for regions and the world were calculated as population-weighted means of the constituent country estimates by age group and sex. For presentation, we age-standardised each estimated mean and prevalence to the WHO standard population,²⁵ by taking weighted means of age–sex-specific estimates, with use of age weights from the standard population. We tested how well our statistical model predicted mean BMI and the prevalence of each BMI category when a country-year did not have data as described in the appendix (pp 8,9), which showed that it performed very well in terms of its prediction validity.

We estimated mean change in BMI (absolute change for mean BMI and relative change for prevalence of BMI categories) over the 40 years of analysis, which we report as change per decade. We also report the posterior probability that an estimated increase or decrease in mean BMI or prevalence of a BMI category represented a truly increasing or decreasing trend. Additionally, we made separate estimates of change for pre-2000 and post-2000 years to assess whether the increasing recognition of adiposity as an “epidemic” in the 1990s,²⁶ and the subsequent public health attention and response,^{27,28} might have slowed down its rise. Finally, we calculated the posterior probability of meeting the global obesity target if post-2000 trends continue.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. MDC, JB, and Country and Regional Data Group members had full access to the data in the study and the corresponding author had final responsibility for the decision to submit for publication.

Results

We accessed and used 1698 population-based data sources, with more than 19.2 million participants (9.9 million men and 9.3 million women) aged 18 years or older whose height and weight had been measured, in 186 of 200 countries for which estimates were made (appendix pp 143, 144); these 186 countries covered 99% of the world’s population. 159 countries had at least two data sources, which allowed more reliable trend estimates. 827 sources (49%) were national, 236 (14%) were subnational, and the remaining 635 (37%) were community-based (appendix pp 145, 146). The mean number of data sources per country varied between regions from 2.8 data sources in Polynesia and Micronesia to 34.7 data sources in high-income Asia Pacific. 525 data sources (31%) were from years before 1995 and another 1173 (69%) data sources from 1995 and later. 1314 (77%) sources had data on men and women, 144 (8%) only on men, and 240 (14%) only on women.

Global age-standardised mean BMI in men increased from 21.7 kg/m² (95% CrI 21.3–22.1) in 1975 to 24.2 kg/m² (24.0–24.4) in 2014, and in women from 22.1 kg/m² (21.7–22.5) in 1975 to 24.4 kg/m² (24.2–24.6) in 2014 (figure 1); the posterior probability that the observed trends were true increases was greater than 0.9999 for both sexes. The mean increases of 0.63 kg/m² per decade (0.53–0.73) for men and 0.59 kg/m² per decade (0.49–0.70) for women are equivalent to the world’s population having become on average more than 1.5 kg heavier each decade.

Regional mean BMI in 2014 in men ranged from 21.4 kg/m² in central Africa and south Asia to 29.2 kg/m² (95% CrI 28.6–29.8) in Polynesia and Micronesia (figure 1). In women, the range was from 21.8 kg/m² (21.4–22.3) in south Asia to 32.2 kg/m² (31.5–32.8) in Polynesia and Micronesia. Mean BMI was also high in men and women in high-income English-speaking countries, and in women in southern Africa and in the Middle East and north Africa.

The largest increase in men’s mean BMI occurred in high-income English-speaking countries (1.00 kg/m² per decade; posterior probability >0.9999) and in women in central Latin America (1.27 kg/m² per decade; posterior probability >0.9999). The increase in women’s mean BMI was also more than 1.00 kg/m² per decade in Melanesia, Polynesia and Micronesia, high-income English-speaking countries, southeast Asia, Andean Latin America, and the Caribbean. Because of these trends, men and women in high-income English-speaking countries in 2014 had substantially higher BMIs than those in continental Europe, whereas in 1975 their BMI had been similar or lower, especially for women (figure 1). By contrast with these large increases, the rise in women’s mean BMI was less than 0.2 kg/m² per decade in central Europe, southwestern Europe, and high-income Asia Pacific.

In 1975, age-standardised mean BMI was less than 19 kg/m² in men in Timor-Leste, Burundi, India,

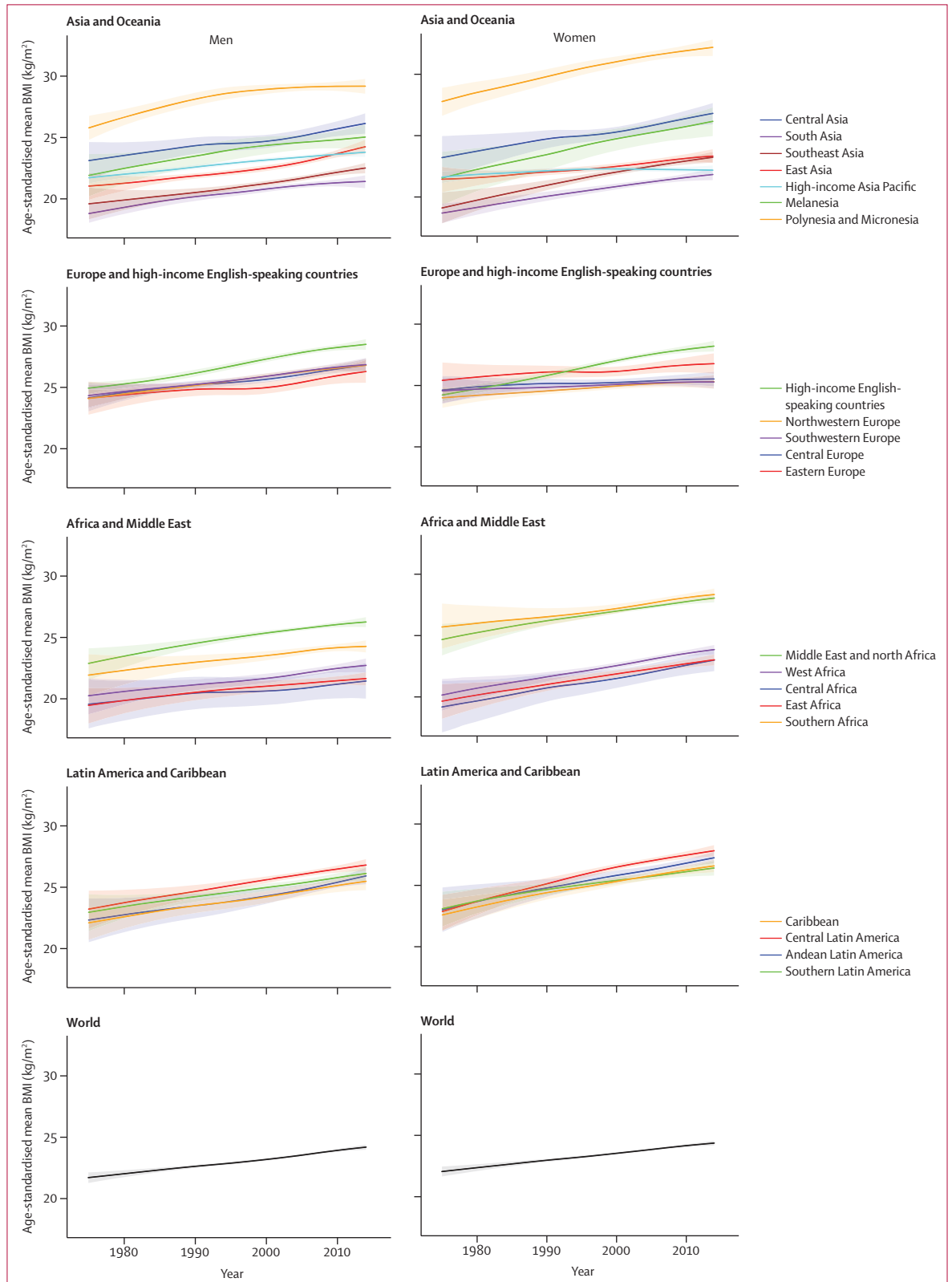


Figure 1: Trends in age-standardised mean BMI by sex and region
 Lighter colours are 95% credible intervals. See appendix (pp 155–355) for results by sex and country. BMI=body-mass index.

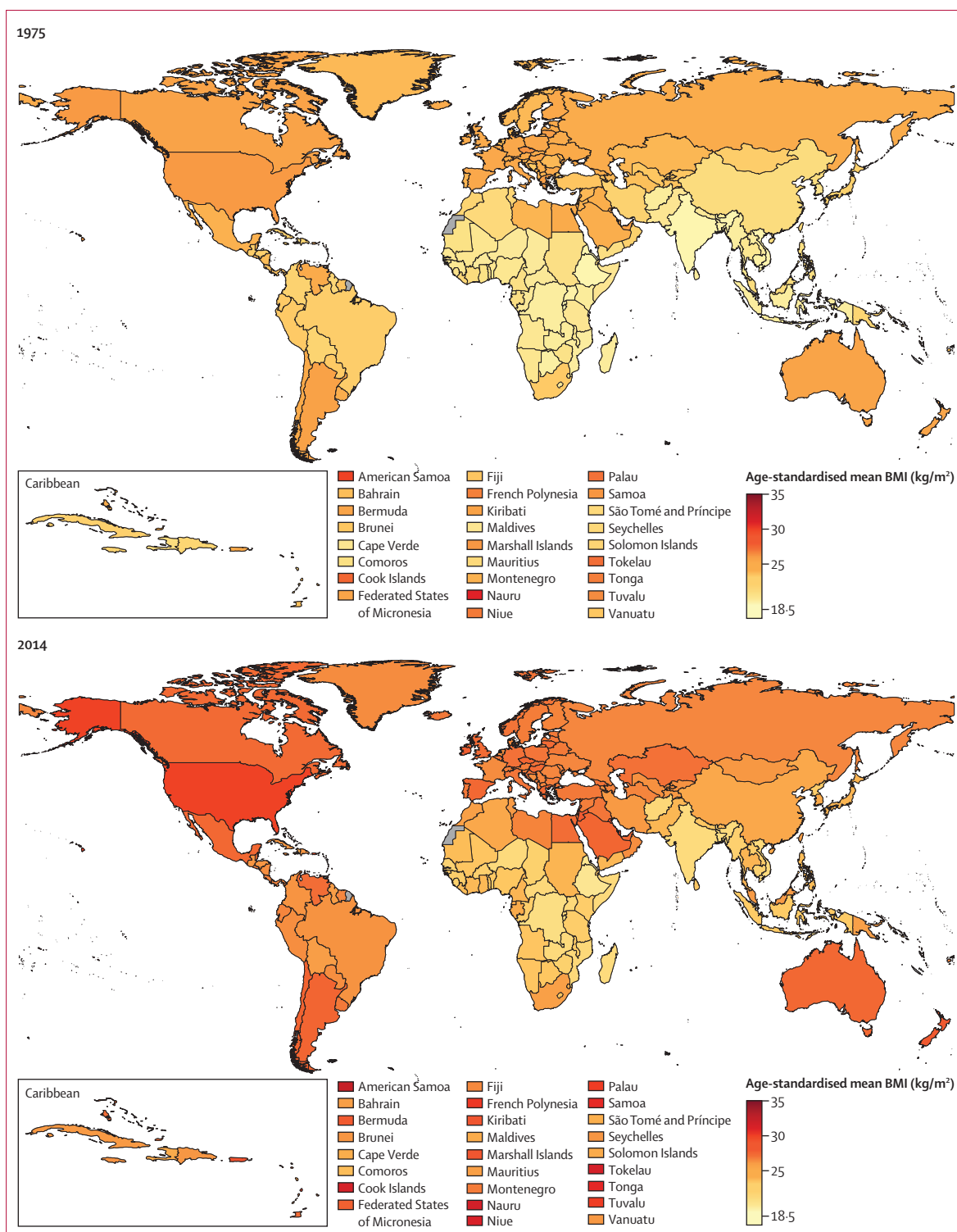


Figure 2: Age-standardised mean BMI in men by country in 1975 and 2014
See appendix (pp 56–64) for numerical results. BMI=body-mass index.

Ethiopia, Vietnam, Rwanda, Eritrea, and Bangladesh (figure 2), and 17–18 kg/m² in women in Bangladesh, Nepal, Timor-Leste, Burundi, Cambodia, and Vietnam

(figure 3). In the same year, men and women in Nauru and women in American Samoa already had mean BMIs of more than 30 kg/m².^{29,30} By 2014, age-standardised

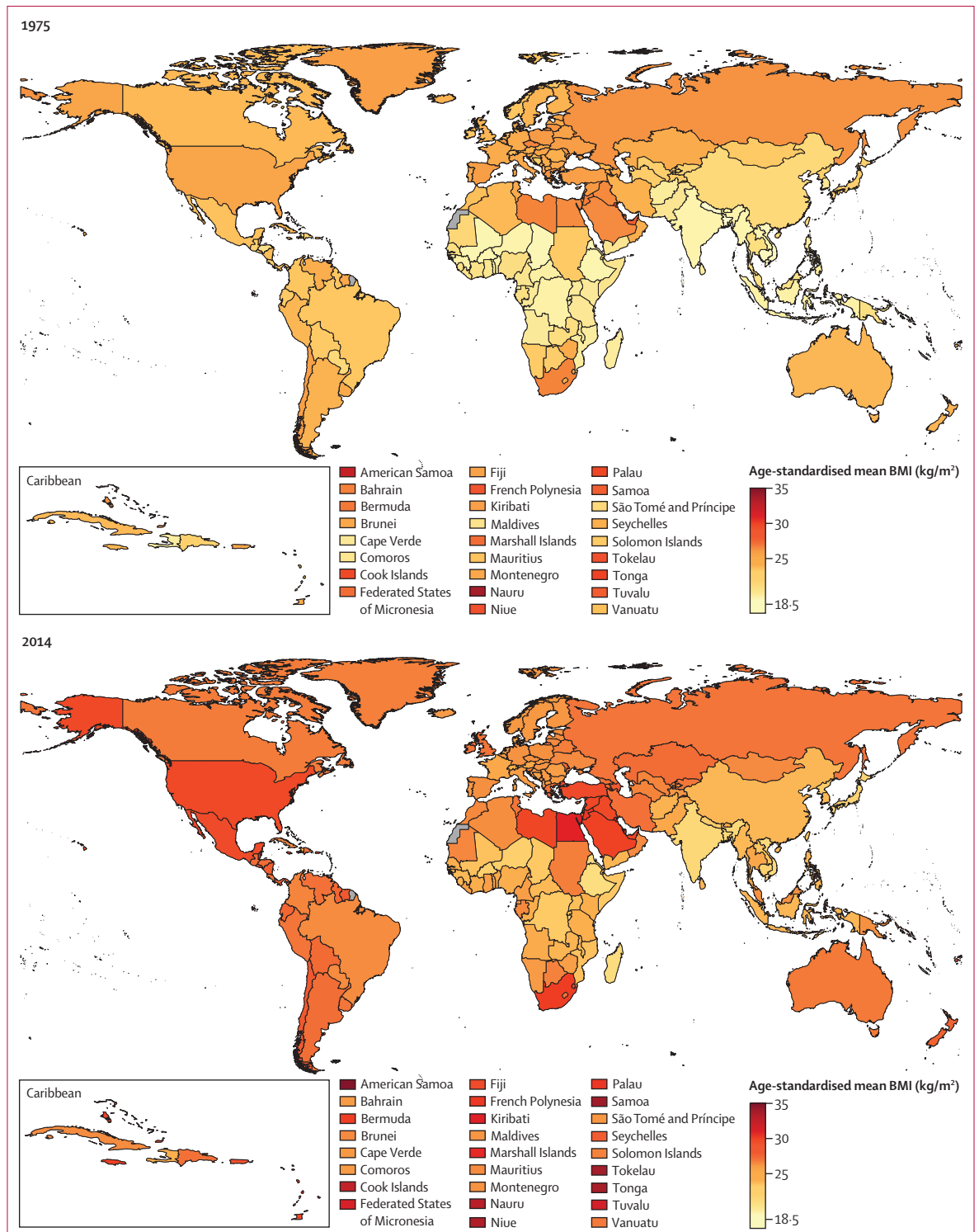


Figure 3: Age-standardised mean BMI in women by country in 1975 and 2014
See appendix (pp 56–64) for numerical results. BMI=body-mass index.

mean BMI was more than 20.0 kg/m² in men and more than 20.7 kg/m² in women in every country, with Ethiopia, Eritrea, and Timor-Leste having the lowest

BMI for both sexes. At the same time, in American Samoa, the age-standardised mean BMIs were 32.2 kg/m² (95% CrI 30.5–33.7) for men and

34.8 kg/m² (33.2–36.3) for women, with mean BMI also more than 30 kg/m² in both sexes in some other islands in Polynesia and Micronesia, and in women in some countries in the Middle East and north Africa (eg, Egypt and Kuwait) and the Caribbean.

From 1975 to 2014, trends in men's BMI ranged from virtually flat in Nauru (albeit at a very high level), North Korea, and several countries in sub-Saharan Africa, to an increase of more than 1.5 kg/m² per decade. Similarly, women's BMI did not change in Bahrain and Nauru (both starting at high BMIs), Singapore, Japan, North Korea, and several European countries, but increased by more than 1.5 kg/m² per decade in some countries. BMI increased more slowly after the year 2000 than in the preceding 25 years in Oceania and in most high-income countries for both sexes, and for women in most countries in Latin America and the Caribbean (figure 4). By contrast, the post-2000 increase was steeper than pre-2000 in men in central and eastern Europe, east and southeast Asia, and most countries in Latin America and the Caribbean. In other regions, increases in BMI before and after 2000 were similar or they had a mixture of slow-down and acceleration. The standard deviation of BMI also increased from 1975 to 2014 (appendix pp 149, 150), which contributed to an increase in the prevalence of people at either or both extremes of BMI.

Mean BMI in 2014 varied more across countries in women than it did in men. For example, the difference in women's mean BMI between American Samoa (the country with the highest mean BMI) and Timor-Leste (the country with the lowest mean BMI) was 14.1 kg/m² in 2014, which is equivalent to about a 35 kg difference in the mean weight per person, whereas in men, the difference in mean BMI was 12.1 kg/m², which is also equivalent to about a 35 kg difference in the mean weight per person (because men tend to be taller). Although male and female BMIs were correlated across countries, women on average had higher BMI than did men in 141 countries in 2014 (appendix pp 151, 152). The main exceptions from this sex pattern were countries in Europe and in high-income Asia Pacific and English-speaking countries. Changes in male and female BMI were weakly correlated across countries.

From 1975 to 2014, global age-standardised prevalence of underweight (BMI <18.5 kg/m²) decreased from 13.8% (95% CrI 10.5–17.4) to 8.8% (7.4–10.3) in men (figure 5) and from 14.6% (11.6–17.9) to 9.7% (8.3–11.1) in women (figure 6). Compared with the fall in underweight, prevalence of obesity (BMI ≥30 kg/m²) increased by a larger amount—from 3.2% (2.4–4.1) in 1975 to 10.8% (9.7–12.0) in 2014 in men, and from 6.4%

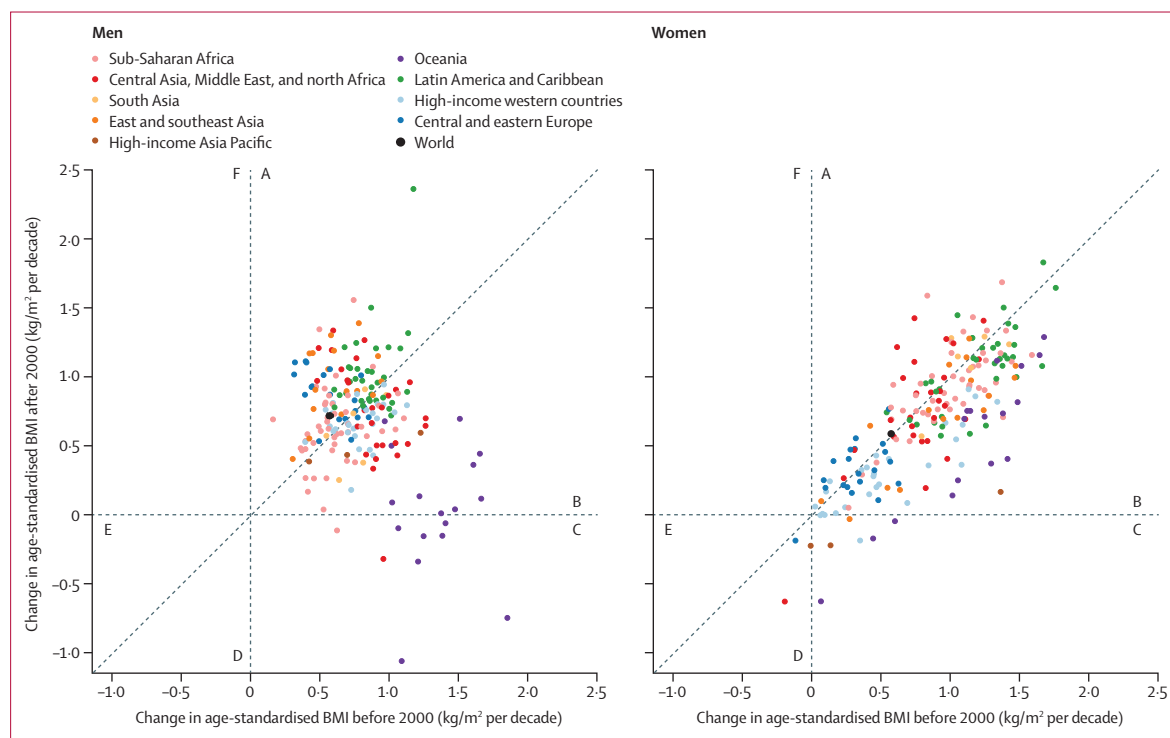


Figure 4: Comparison of mean change in age-standardised mean BMI before and after the year 2000

Each point represents one country. (A) countries in which mean BMI increased more rapidly after 2000 than it had before 2000. (B) countries in which mean BMI increased more slowly after 2000 than it had before 2000. (C) countries in which mean BMI increased before 2000 but decreased after 2000. (D) countries in which mean BMI decreased more rapidly after 2000 than it had before 2000. (E) countries in which mean BMI decreased more slowly after 2000 than it had before 2000. (F) countries in which BMI decreased before 2000 but increased after 2000. BMI=body-mass index.

(5.1–7.8) to 14.9% (13.6–16.1) in women. Prevalence of obesity surpassed that of underweight in 2004 in women and in 2011 in men. 2.3% (2.0–2.7) of the world's men and 5.0% (4.4–5.6) of women were severely obese in 2014. The global prevalence of morbid obesity

(BMI ≥ 40 kg/m²) was 0.64% (0.46–0.86) in men and 1.6% (1.3–1.9) in women in 2014.

Age-standardised underweight prevalence in south Asia, where it is most common, decreased from more than 35% in both sexes in 1975 to 23.4% (95% CrI

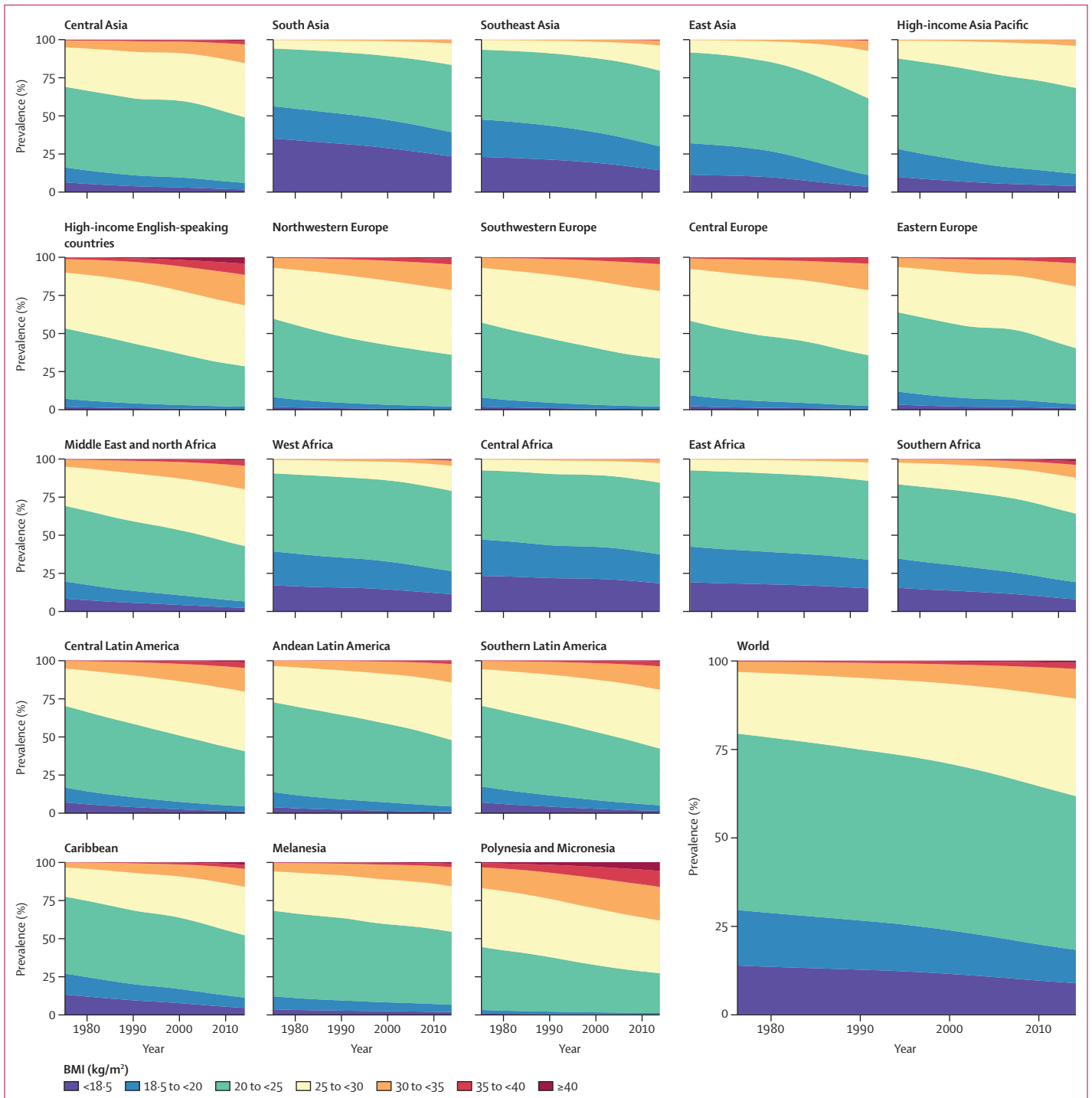


Figure 5: Trends in age-standardised prevalence of BMI categories in men by region. See appendix (pp 155–355) for results by country. BMI=body-mass index.

17.8–29.2) in men and 24.0% (18.9–29.3) in women in 2014 (figures 5, 6). Underweight prevalence also remained higher than 12% in women and higher than 15% in men in central and east Africa in 2014, despite some reductions. At the other extreme, more than 38% of

men and more than 50% of women in Polynesia and Micronesia were obese in 2014. Obesity prevalence also surpassed 30% in men and women in high-income English-speaking countries, and in women in southern Africa and in the Middle East and north Africa.

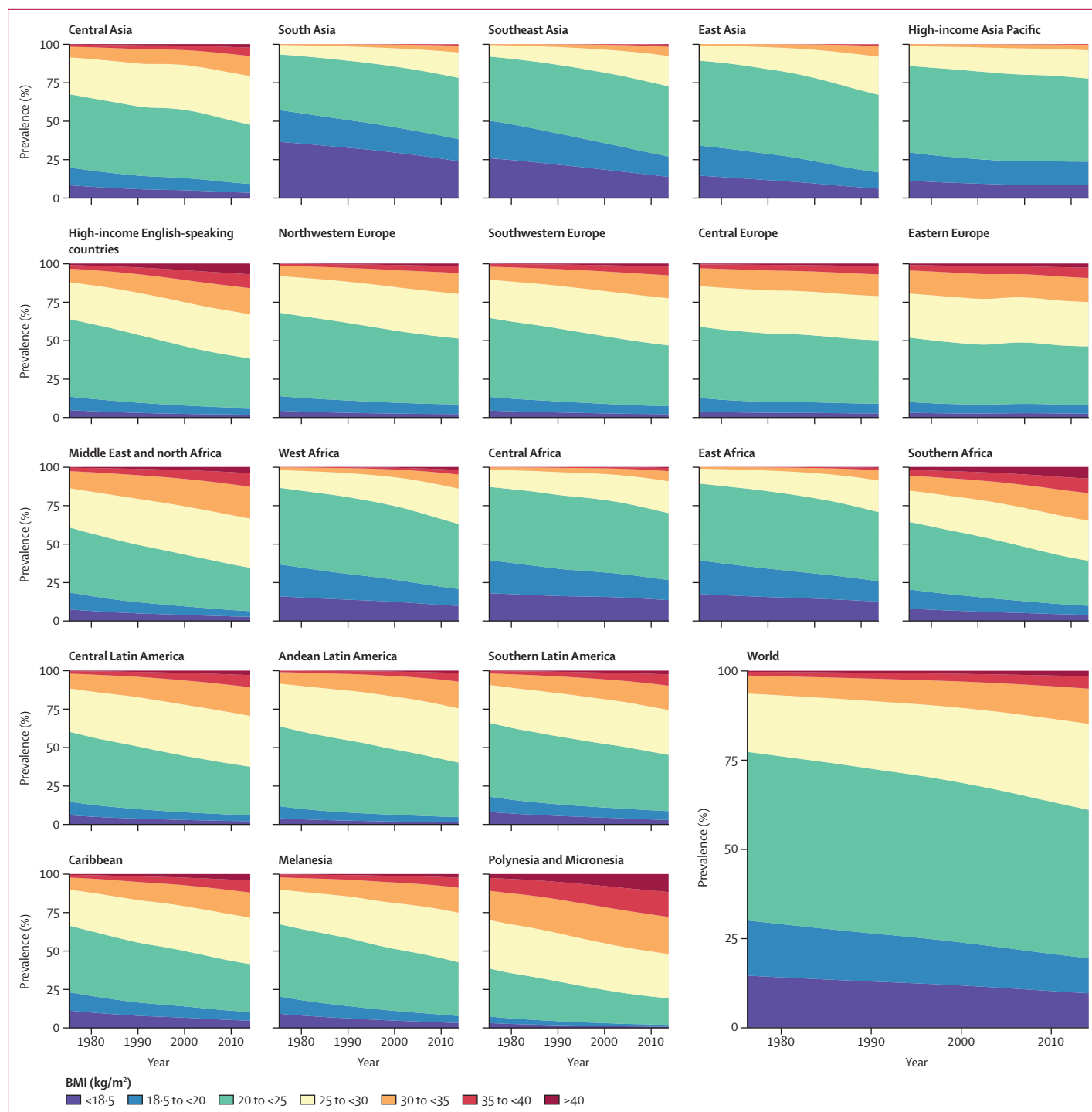
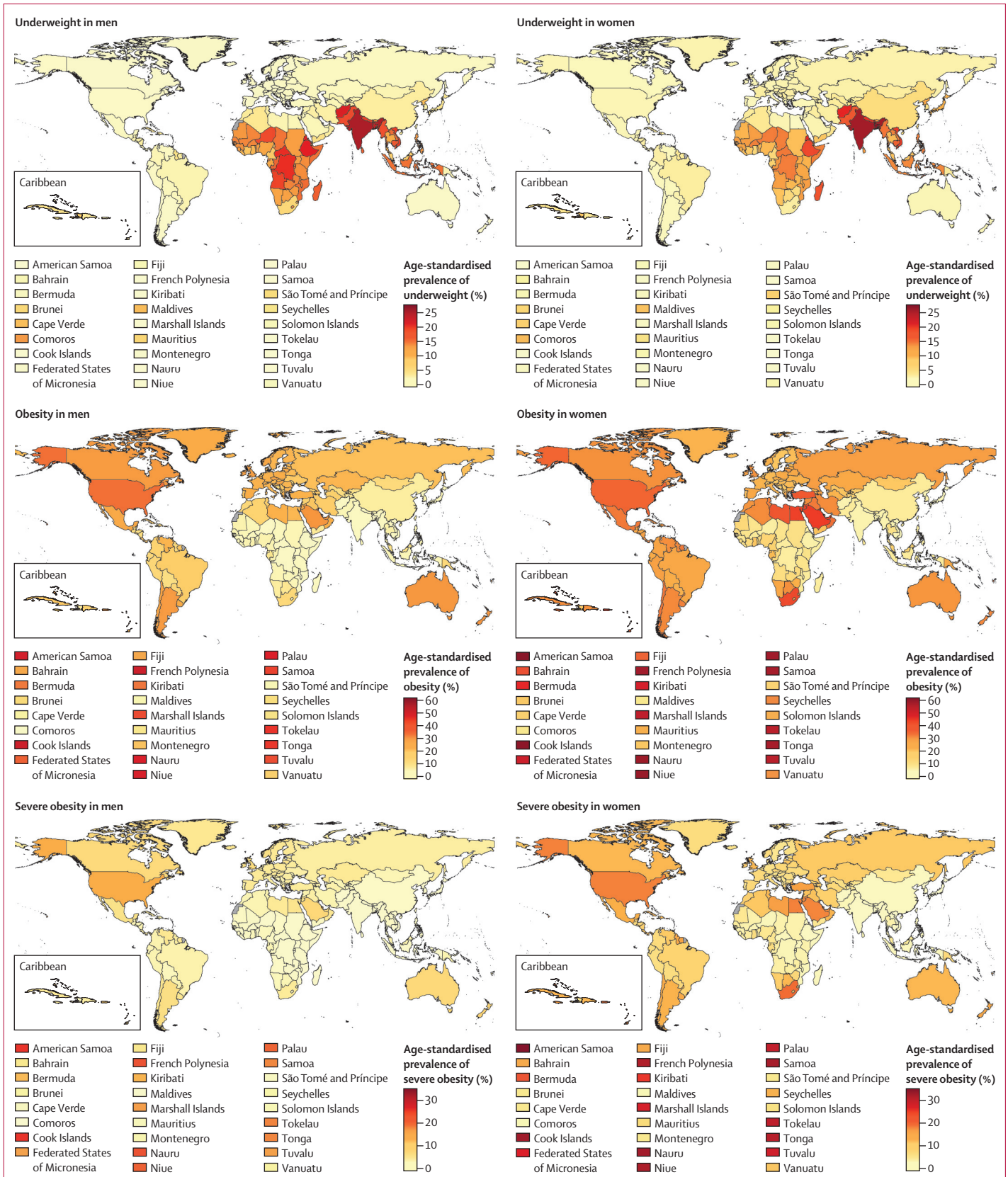


Figure 6: Trends in age-standardised prevalence of BMI categories in women by region
See appendix (pp 155–355) for results by country. BMI=body-mass index.



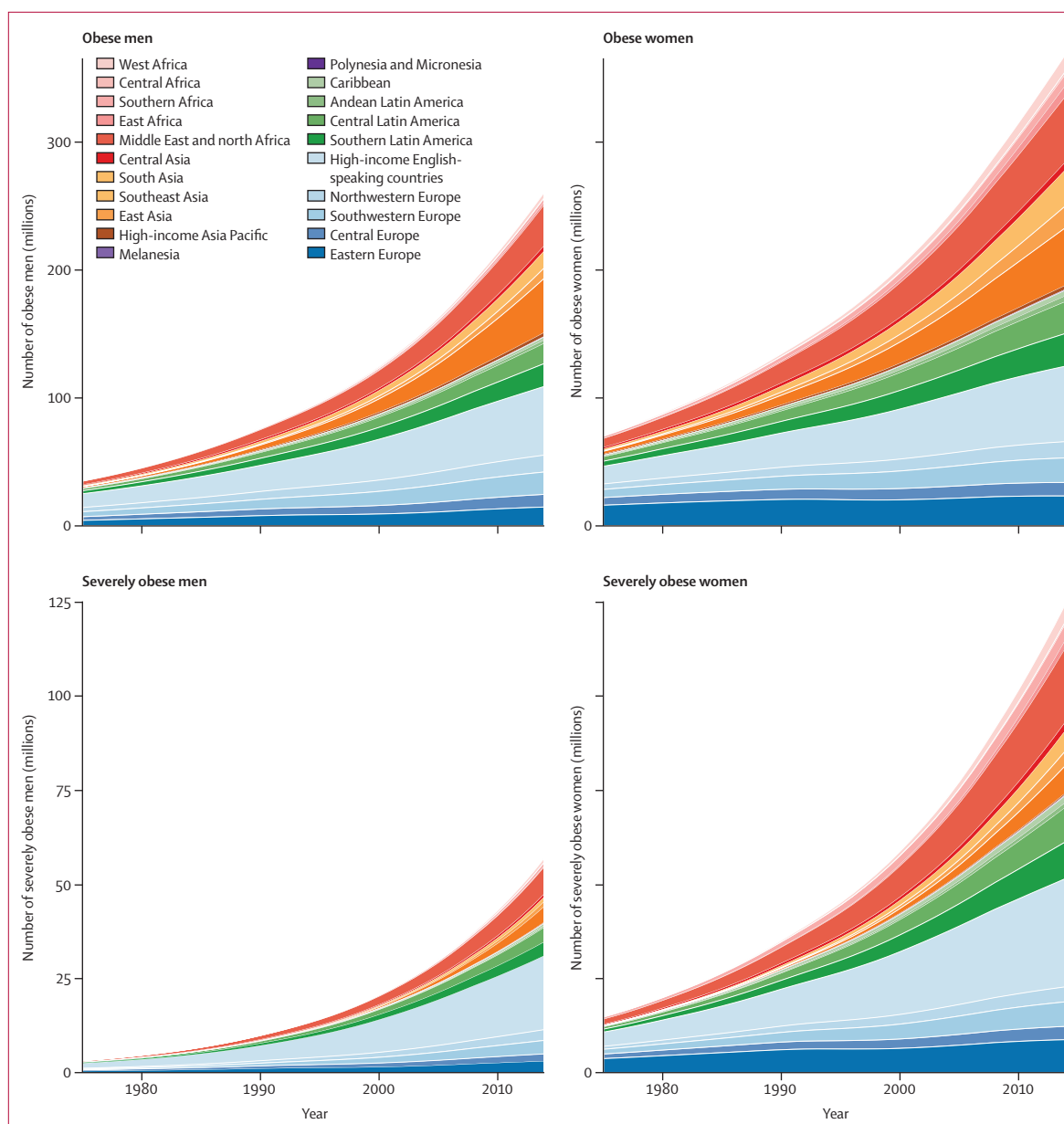


Figure 8: Trends in the number of obese and severely obese people by region

A person is obese if they have a body-mass index (BMI) of 30 kg/m^2 or higher, or is severely obese if they have a BMI of 35 kg/m^2 or higher.

Age-standardised prevalence of underweight in 2014 was less than 1% in men in 68 countries and in women in 11 countries (figure 7). At the other extreme, more than 20% of men in India, Bangladesh, Timor-Leste, Afghanistan, Eritrea, and Ethiopia, and a quarter or more of women in Bangladesh and India are still underweight.

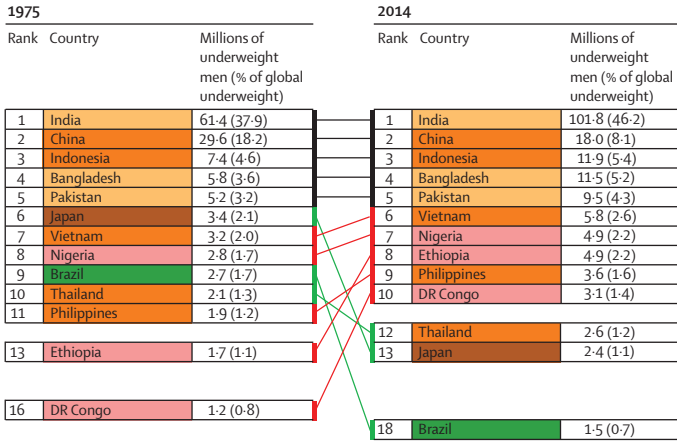
Figure 7: Age-standardised prevalence of underweight, obesity, and severe obesity by sex and country in 2014

Underweight (BMI $<18.5 \text{ kg/m}^2$); obesity (BMI $\geq 30 \text{ kg/m}^2$); and severe obesity (BMI $\geq 35 \text{ kg/m}^2$). See appendix (pp 65–107) for numerical results for all BMI ranges. BMI=body-mass index.

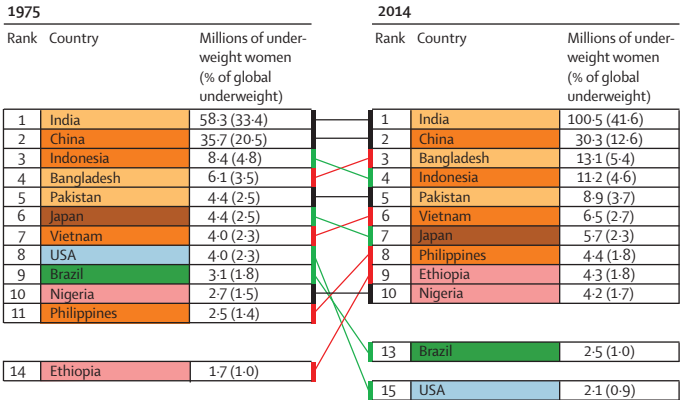
In 1975, the proportion had been as high as 37% in Indian and Bangladeshi women.

In 2014, more men were obese than underweight in 136 (68%) of 200 countries; in 113 of these countries, more men were severely obese than underweight. For women, obesity surpassed underweight in 165 (83%) countries and severe obesity surpassed underweight in 135 countries. Obesity prevalence was less than 1% in men in Burundi and Timor-Leste and 1–2% in another 15 countries in central, east, and west Africa and in south and southeast Asia. The lowest prevalences in women were in Timor-Leste, Japan,

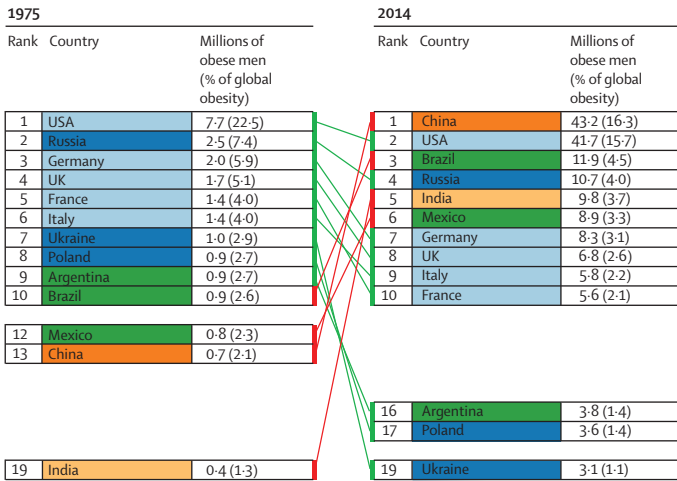
Underweight in men



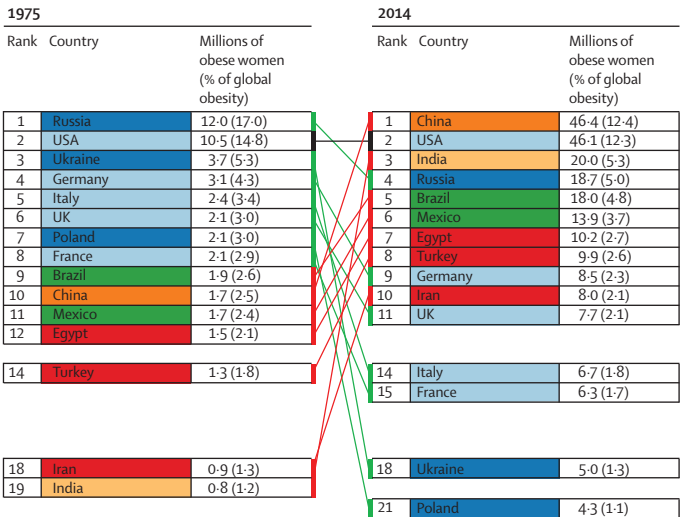
Underweight in women



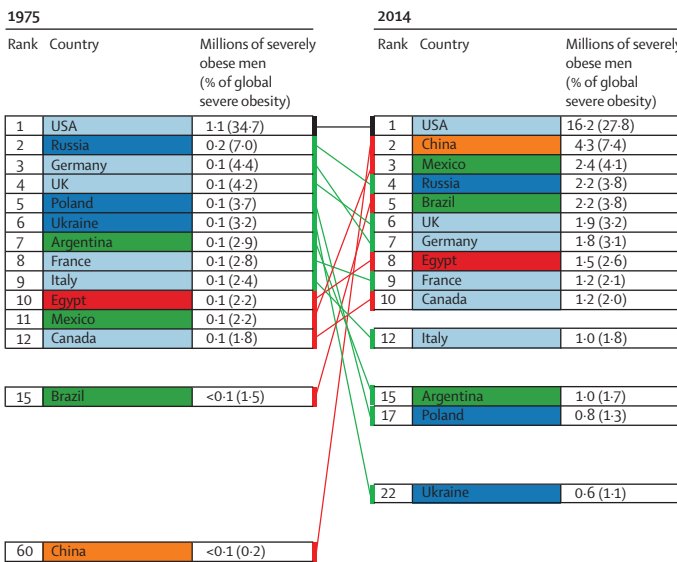
Obesity in men



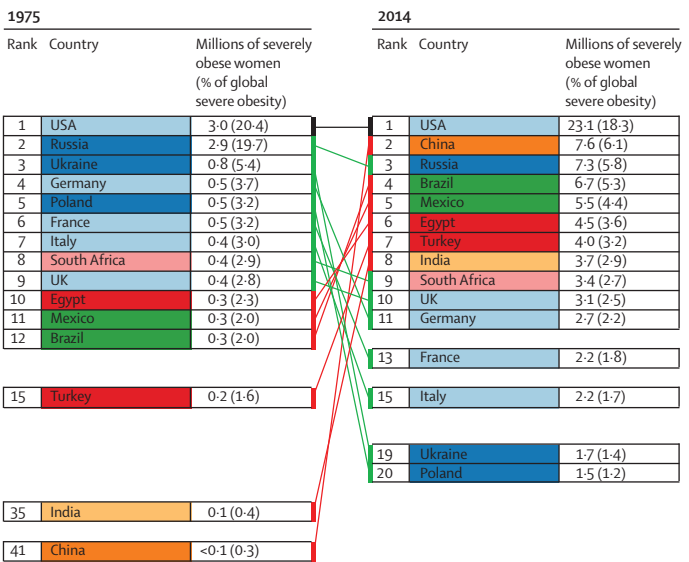
Obesity in women



Severe obesity in men



Severe obesity in women



Vietnam, North Korea, Cambodia, Laos, and Bangladesh, all less than 5%. At the other extreme, more than 45% of men in six island nations in Polynesia and Micronesia, and more than 50% of women in 11 such island nations were obese. The prevalence of obesity in women in several Caribbean and Middle Eastern countries was 40–50%. Severe obesity surpassed 20% in men and 30% in women in some Polynesian and Micronesian islands, reaching 33·4% (95% CrI 23·6–43·5) in American Samoa in 2014. More than 15% of women in Nauru and American Samoa were morbidly obese.

In 2014, about 266 million men (95% CrI 240–295 million) and 375 million women (344–407 million) were obese in the world, compared with 34 million men (26–44 million) and 71 million women (57–87 million) in 1975 (figure 8). 58 million (49–68 million) of these men and 126 million (112–141 million) of these women were severely obese in 2014. 18·4% of the world's obese adults (118 million) lived in high-income English-speaking countries and these countries contained an even larger share of the world's severely obese people (27·1%; 50 million), followed by 13·9% (26 million) in the Middle East and north Africa.

Countries where large numbers of underweight people lived in 1975 and in 2014 were mostly large countries in Asia and sub-Saharan Africa, with an increasing share of underweight people living in south Asia over time (figure 9). By contrast with this stability of underweight geography, countries with the largest number of obese and severely obese people changed over these four decades, with more middle-income countries joining the USA, especially for women. In 2014, slightly more obese men and women lived in China than in the USA, and even for severe obesity, China moved from 60th place for men and 41st place for women in 1975, to 2nd rank for both men and women in 2014. Nonetheless, more than one in four severely obese men and almost one in five severely obese women in the world still live in the USA.

If post-2000 trends continue, every country has a less than 50% probability of meeting the global obesity target, with Nauru having the highest probability of about 45% (appendix pp 153, 154). The probability of achieving the target is less than 10% for men in 194 countries, and for women in 174 countries. At the global level, the probability of meeting the target is virtually zero. Rather, if present trends continue, by 2025, global obesity prevalence will reach 18% in men and surpass 21% in women; severe obesity will surpass 9% in women and 6% in men, and will be larger than the projected prevalence of underweight in women.

Figure 9: Ten countries with the largest number of underweight, obese, and severely obese men and women in 1975 and 2014

Colours for each country indicate its region, using the same colour scheme as in figure 4. Underweight (BMI <18·5 kg/m²); obesity (BMI ≥30 kg/m²); and severe obesity (BMI ≥35 kg/m²). BMI=body-mass index.

Discussion

Over the past four decades, we have transitioned from a world in which underweight prevalence was more than double that of obesity, to one in which more people are obese than underweight, both globally and in all regions except parts of sub-Saharan Africa and Asia. The rate of increase in BMI since 2000 has been slower than in the preceding decades in high-income countries, where adiposity became an explicit public health concern around this time,^{27,28} and in some middle-income countries. However, because the rate of BMI increase has accelerated in some other regions, the global increase in BMI has not slowed down. If post-2000 trends continue, not only will the world not meet the global target for halting the increase in obesity, but also severe obesity will surpass underweight in women by 2025. Nonetheless, underweight remains a public health problem in south Asia and central and east Africa.

We estimated a slightly larger increase in mean BMI since 1980 than Finucane and colleagues did,¹¹ especially in men, because our estimates for 1980 were lower, globally and in most regions; this difference might be because our study included substantially more data, from a larger number of countries. Our global estimates of overweight prevalence are similar to those reported by Stevens and colleagues¹³ for 2008, and by Ng and colleagues for 2013.¹² Our estimates for obesity for the same years are slightly lower than those of Stevens and colleagues and slightly higher than those of Ng and colleagues. Furthermore, we estimated a lower prevalence of obesity for 1980 than Ng and colleagues had, which means we have attributed a larger role to the rise over the past few decades for the present extent of obesity. Differences between our study and that of Ng and colleagues were greater at the regional level; for example, our estimates for obesity prevalence in men in south Asia and central, east, and west Africa were less than half of those by Ng and colleagues. None of these previous works had estimated underweight or severe and morbid obesity, which are important clinical and public health outcomes.

The strengths of our study include its unique scope of making consistent estimates of mean BMI and the prevalence of all BMI categories with clinical and public health relevance, including the first-ever estimates of underweight and severe and morbid obesity. These estimates helped reveal the details of the transition from underweight to overweight and obesity throughout the world. We also reported on the probability of each country meeting the global obesity target. We put great emphasis on data quality and used only population-based data sources that had measured height and weight to avoid the bias in self-reported data. Characteristics and quality of data sources were verified by Collaborating Group members (appendix pp 2–5). Data were analysed according to a common protocol to obtain the required mean and prevalence by age and sex, which in turn minimised reliance on

models for filling such gaps, as done in previous studies.^{11–13} Finally, we pooled data using a statistical model designed to take into account the epidemiological features of outcomes such as BMI, and one that used all available data while giving more weight to national data than subnational and community studies.

Despite our efforts in identifying and accessing country-level data, some countries had few data sources, especially those in Polynesia and Micronesia, the Caribbean, and central Asia. Additionally, only 42% of sources included people older than 70 years. In view of ageing trends throughout the world, older people should be included in health and nutrition surveys, which have traditionally focused on childbearing ages. Even measured height and weight data can have error depending on how closely measurement protocols are followed. Although data held by Collaborating Group members were analysed to provide all needed details by sex and age group and BMI level, individual participant data could not be accessed for 19.4% of data used in our analysis, hence conversions across categories were still needed; nonetheless, the conversion regressions had high predictive accuracy (appendix pp 41–55). A novel component of our study is that we estimated the prevalences of a complete set of BMI categories, but the uncertainty intervals for BMIs of 30 kg/m² or more and 35 kg/m² or more, prevalences that span more than one of the analysed categories, could be affected by the fact that we combined posterior distributions across Bayesian models. We did not estimate trends in measures of adiposity other than BMI, such as waist circumference and waist-to-hip ratio, because these were measured in less than half of all the data sources and their measurement became more common after the 1980s. A systematic review³¹ of epidemiological studies reported that, taken together, studies that had measured BMI and either waist circumference or waist-to-hip ratio do not show that any of the measures of adiposity have “superior discriminatory capability” of adverse cardiometabolic outcomes; any reported difference was “too small to be of any clinical relevance”. We did not analyse children and adolescents for two reasons. First, because childhood and adolescence is a period of rapid growth, BMI cutoffs used to define underweight, overweight, and obesity for children and adolescents are different from those for adults, and vary by age and sex.³² Second, time trends in children’s and adolescents’ obesity are different from those of adults.³³

Our results have several implications. First, the global focus on the obesity epidemic has largely overshadowed the persistence of underweight in some countries. Our results show the need to address the remaining underweight problem and by doing so reduce risks to pregnant women and their newborn infants,¹⁵ mortality from tuberculosis and other respiratory diseases,³⁴ and possibly all-cause mortality, which has a J-shaped association.^{2,3} To address this problem will require social and food policies that enhance food security in poor

households, but also avoid overconsumption of processed carbohydrates and other unhealthy foods. Second, although adiposity has been consistently shown to be an independent risk factor for several NCDs in individual-level epidemiological studies, at the population level, the effect of rising BMI on the course of mortality reduction has so far been somewhat small in high-income countries,^{35,36} possibly because pharmacological treatment has helped reduce blood pressure and serum cholesterol and manage diabetes complications, which are mediators of the effects of BMI on cardiovascular diseases. In low-income countries, where health systems might not have the capacity to identify and treat hypertension, dyslipidaemia, and diabetes, adiposity might have a larger effect on population health. Furthermore, we have shown that some high-income and middle-income regions are now facing an epidemic of severe obesity. Even anti-hypertensive drugs, statins, and glucose lowering drugs will not be able to fully address the hazards of such high BMI levels,⁷ and bariatric surgery might be the most effective intervention for weight loss and disease prevention and remission.³⁷ However, long-term health outcomes of bariatric surgery are largely unknown and it is not accessible to most people in low-income and middle-income countries because of financial and health system barriers.

Present interventions and policies have not been able to stop the rise in BMI in most countries.^{38–40} The global NCD target on obesity, although ambitious in view of past trends, has engendered a new look at policies that could slow down and stop the worldwide increase in BMI.^{40–42} To avoid an epidemic of severe obesity, the next step must be to implement these policies, and to systematically assess their effect.⁴³

Contributors

ME designed the study and oversaw research. Members of the Country and Regional Data Group collected and reanalysed data, and checked pooled data for accuracy of information about their study and other studies in their country. MDC and GAS led data collection and JB led the statistical analysis and prepared results. Members of the Pooled Analysis and Writing Group collated data, checked all data sources in consultation with the Country and Regional Data Group, analysed pooled data, and prepared results. ME wrote the first draft of the report with input from other members of Pooled Analysis and Writing Group. Members of Country and Regional Data Group commented on draft report.

NCD Risk Factor Collaboration

Pooled Analysis and Writing (≈equal contribution)—Mariachiara Di Cesare (Imperial College London, London, UK; Middlesex University, London, UK)²; James Bentham (Imperial College London, London, UK)²; Gretchen A Stevens (World Health Organization, Geneva, Switzerland)⁶; Bin Zhou (Imperial College London, London, UK); Goodarz Danaei (Harvard T H Chan School of Public Health, Boston, MA, USA); Yuan Lu (Harvard T H Chan School of Public Health, Boston, MA, USA); Honor Bixby (Imperial College London, London, UK); Melanie J Cowan (World Health Organization, Geneva, Switzerland); Leanne M Riley (World Health Organization, Geneva, Switzerland); Kaveh Hajifathalian (Harvard T H Chan School of Public Health, Boston, MA, USA); Léa Fortunato (Imperial College London, London, UK); Cristina Taddei (University of Florence, Florence, Italy); James E Bennett (Imperial College London, London, UK); Nayu Ikeda (National Institute of Health and Nutrition, Tokyo, Japan); Prof Young-Ho Khang

(Seoul National University, Seoul, South Korea); Catherine Kyobutungi (African Population and Health Research Center, Nairobi, Kenya); Avula Laxmaiah (Indian Council of Medical Research, New Delhi, India); Yanping Li (Harvard T H Chan School of Public Health, Boston, MA, USA); Hsien-Ho Lin (National Taiwan University, Taipei, Taiwan); J Jaime Miranda (Universidad Peruana Cayetano Heredia, Lima, Peru); Aya Mostafa (Ain Shams University, Cairo, Egypt); Maria L Turley (Ministry of Health, Wellington, New Zealand); Christopher J Paciorek (University of California, Berkeley, CA, USA); Marc Gunter (Imperial College London, London, UK); Prof Majid Ezzati (Imperial College London, London, UK).

*Country and Regional Data (*equal contribution; listed alphabetically)*—Ziad A Abdeen (Al-Quds University, Palestine)*; Zargar Abdul Hamid (Center for Diabetes and Endocrine Care, India)*; Niveen M Abu-Rmeileh (Birzeit University, Palestine)*; Benjamin Acosta-Cazares (Instituto Mexicano del Seguro Social, Mexico)*; Robert Adams (The University of Adelaide, Australia)*; Wichai Aekplakorn (Mahidol University, Thailand)*; Carlos A Aguilar-Salinas (Instituto Nacional de Ciencias Médicas y Nutrición, Mexico)*; Alireza Ahmadvand (Non-Communicable Diseases Research Center, Iran)*; Wolfgang Ahrens (Leibniz Institute for Prevention Research and Epidemiology—BIPS, Germany)*; Mohamed M Ali (World Health Organization Regional Office for the Eastern Mediterranean, Egypt)*; Ala'a Alkerwi (Luxembourg Institute of Health, Luxembourg)*; Mar Alvarez-Pedrerol (Centre for Research in Environmental Epidemiology, Spain)*; Eman Aly (World Health Organization Regional Office for the Eastern Mediterranean, Egypt)*; Philippe Amouyel (Lille University and Hospital, France)*; Antoinette Amuzu (London School of Hygiene & Tropical Medicine, UK)*; Lars Bo Andersen (University of Southern Denmark, Denmark)*; Sigmund A Anderssen (Norwegian School of Sport Sciences, Norway)*; Dolores S Andrade (Universidad de Cuenca, Ecuador)*; Ranjit Mohan Anjana (Madras Diabetes Research Foundation, India)*; Hajer Aounallah-Skhiri (National Institute of Public Health, Tunisia)*; Inger Ariansen (Norwegian Institute of Public Health, Norway)*; Tahir Aris (Ministry of Health, Malaysia)*; Nimmathota Arlappa (Indian Council of Medical Research, India)*; Dominique Arveiler (Strasbourg University and Hospital, France)*; Felix K Assah (University of Yaoundé 1, Cameroon)*; Mária Avdicová (Regional Authority of Public Health, Banská Bystrica, Slovakia)*; Fereidoun Azizi (Shahid Beheshti University of Medical Sciences, Iran)*; Bontha V Babu (Indian Council of Medical Research, India)*; Nagalla Balakrishna (Indian Council of Medical Research, India)*; Piotr Bandosz (Medical University of Gdansk, Poland)*; José R Banegas (Universidad Autónoma de Madrid, Spain)*; Carlo M Barboglio (University of Palermo, Italy)*; Alberto Barceló (Pan American Health Organization, USA)*; Amina Barkat (Université Mohammed V de Rabat, Morocco)*; Mauro V Barros (University of Pernambuco, Brazil)*; Iqbal Bata (Dalhousie University, Canada)*; Anwar M Batieha (Jordan University of Science and Technology, Jordan)*; Rosângela L Batista (Federal University of Maranhão, Brazil)*; Louise A Baur (University of Sydney, Australia)*; Robert Beaglehole (University of Auckland, New Zealand)*; Habiba Ben Romdhane (University Tunis El Manar, Tunisia)*; Mikhail Benet (University Medical Science, Cuba)*; Antonio Bernabe-Ortiz (Universidad Peruana Cayetano Heredia, Peru)*; Gailute Bernotiene (Lithuanian University of Health Sciences, Lithuania)*; Heloisa Bettiol (University of São Paulo, Brazil)*; Aroor Bhargyalaxmi (B J Medical College, India)*; Sumit Bharadwaj (Chirayu Medical College, India)*; Santosh K Bhargava (Sunder Lal Jain Hospital, India)*; Zaid Bhatti (The Aga Khan University, Pakistan)*; Zulfiqar A Bhatta (The Aga Khan University, Pakistan)*; HongSheng Bi (Shandong University of Traditional Chinese Medicine, China)*; Yufang Bi (Shanghai Jiao-Tong University School of Medicine, China)*; Peter Bjerregaard (University of Southern Denmark, Denmark; University of Greenland, Greenland)*; Espen Bjertness (University of Oslo, Norway)*; Marius B Bjertness (University of Oslo, Norway)*; Cecilia Björkelund (University of Gothenburg, Sweden)*; Margaret Blake (NatCen Social Research, UK)*; Anneke Blokstra (National Institute for Public Health and the Environment, Netherlands)*; Simona Bo (University of Turin, Italy)*; Martin Bobak (University College London, UK)*; Lynne M Boddy (Liverpool John Moores University, UK)*; Bernhard O Boehm (Nanyang Technological University, Singapore)*; Heiner Boeing (German Institute of Human Nutrition, Germany)*; Carlos P Boissonnet (CEMIC, Argentina)*; Vanina Bongard (Toulouse University School of Medicine, France)*; Pascal Bovet (Ministry of Health, Seychelles; University of Lausanne, Switzerland)*; Lutgart Braeckman (Ghent University, Belgium)*; Marjolijn C E Bragt (FrieslandCampina, Singapore)*; Imperia Brajkovich (Universidad Central de Venezuela, Venezuela)*; Francesco Branca (World Health Organization, Switzerland)*; Juergen Breckenkamp (Bielefeld University, Germany)*; Hermann Brenner (German Cancer Research Center, Germany)*; Lizzy M Brewster (University of Amsterdam, Netherlands)*; Garry R Brian (The Fred Hollows Foundation New Zealand, New Zealand)*; Graziella Bruno (University of Turin, Italy)*; H B(as) Bueno-de-Mesquita (National Institute for Public Health and the Environment, Netherlands)*; Anna Bugge (University of Southern Denmark, Denmark)*; Con Burns (Cork Institute of Technology, Ireland)*; Antonio Cabrera de León (University La Laguna, Spain)*; Joseph Cacciottolo (University of Malta, Malta)*; Tilema Cama (Ministry of Health, Tonga)*; Christine Cameron (Canadian Fitness and Lifestyle Research Institute, Canada)*; José Camolas (Hospital Santa Maria, CHLN, Portugal)*; Günay Can (Istanbul University, Turkey)*; Ana Paula C Cândido (Universidade Federal de Juiz de Fora, Brazil)*; Vincenzo Capuano (Cardiologia di Mercato S. Severino, Italy)*; Viviane C Cardoso (University of São Paulo, Brazil)*; Maria J Carvalho (University of Porto, Portugal)*; Felipe F Casanueva (Santiago de Compostela University, Spain)*; Juan-Pablo Casas (University College London, UK)*; Carmelo A Caserta (Associazione Calabrese di Epatologia, Italy)*; Katia Castetbon (French Institute for Health Surveillance, France)*; Snehalatha Chamukuttan (India Diabetes Research Foundation, India)*; Angelique W Chan (Duke-NUS Graduate Medical School, Singapore)*; Queenie Chan (Imperial College London, UK)*; Himanshu K Chaturvedi (National Institute of Medical Statistics, India)*; Nishi Chaturvedi (University College London, UK)*; Chien-Jen Chen (Academia Sinica, Taiwan)*; Fangfang Chen (Capital Institute of Pediatrics, China)*; Huashuai Chen (Duke University, USA)*; Shuohua Chen (Kailuan General Hospital, China)*; Zhengming Chen (University of Oxford, UK)*; Ching-Yu Cheng (Duke-NUS Graduate Medical School, Singapore)*; Angela Chetrit (The Gertner Institute for Epidemiology and Health Policy Research, Israel)*; Arnaud Chiolero (Lausanne University Hospital, Switzerland)*; Shu-Ti Chiou (Ministry of Health and Welfare, Taiwan)*; Adela Chirita-Emandi (Victor Babeş University of Medicine and Pharmacy, Romania)*; Yumi Cho (Korea Centers for Disease Control and Prevention, South Korea)*; Kaare Christensen (University of Southern Denmark, Denmark)*; Jerzy Chudek (Medical University of Silesia, Poland)*; Renata Cifkova (Charles University in Prague, Czech Republic)*; Frank Claessens (Katholieke Universiteit Leuven, Belgium)*; Els Clays (Ghent University, Belgium)*; Hans Concini (Agency for Preventive and Social Medicine, Austria)*; Cyrus Cooper (University of Southampton, UK)*; Rachel Cooper (University College London, UK)*; Tara C Coppinger (Cork Institute of Technology, Ireland)*; Simona Costanzo (IRCCS Istituto Neurologico Mediterraneo Neuromed, Italy)*; Dominique Cottel (Institut Pasteur de Lille, France)*; Chris Cowell (Westmead University of Sydney, Australia)*; Cora L Craig (Canadian Fitness and Lifestyle Research Institute, Canada)*; Ana B Crujeiras (CIBEROBN, Spain)*; Graziella D'Arrigo (National Council of Research, Italy)*; Eleonora d'Orsi (Federal University of Santa Catarina, Brazil)*; Jean Dallongeville (Institut Pasteur de Lille, France)*; Albertino Damasceno (Eduardo Mondlane University, Mozambique)*; Camilla T Damsgaard (University of Copenhagen, Denmark)*; Goodarz Danaei (Harvard T H Chan School of Public Health, USA)*; Rachel Dankner (The Gertner Institute for Epidemiology and Health Policy Research, Israel)*; Luc Dauchet (Lille University Hospital, France)*; Guy De Backer (Ghent University, Belgium)*; Dirk De Bacquer (Ghent University, Belgium)*; Giovanni de Gaetano (IRCCS Istituto Neurologico Mediterraneo Neuromed, Italy)*; Stefaan De Henauw (Ghent University, Belgium)*; Delphine De Smedt (Ghent University, Belgium)*; Mohan Deepa (Madras Diabetes Research Foundation, India)*; Alexander D Deev (National Research Centre for Preventive Medicine, Russia)*; Abbas Dehghan (Erasmus Medical Center Rotterdam, Netherlands)*; Hélène Delisle (University of Montreal, Canada)*; Francis Delpuech (Institut de Recherche pour le

Développement, France)*; Klodian Dhana (Erasmus Medical Center Rotterdam, Netherlands)*; Augusto F Di Castelnuovo (IRCCS Istituto Neurologico Mediterraneo Neuromed, Italy)*; Juvenal Soares Dias-da-Costa (Universidade do Vale do Rio dos Sinos, Brazil)*; Alejandro Diaz (National Council of Scientific and Technical Research, Argentina)*; Shirin Djalalinia (Non-Communicable Diseases Research Center, Iran)*; Ha T P Do (National Institute of Nutrition, Vietnam)*; Annette J Dobson (University of Queensland, Australia)*; Chiara Donfrancesco (Istituto Superiore di Sanità, Italy)*; Angela Döring (Helmholtz Zentrum München, Germany)*; Kouamelan Doua (Ministère de la Santé et de la Lutte Contre le Sida, Côte d'Ivoire)*; Wojciech Drygas (The Cardinal Wyszyński Institute of Cardiology, Poland)*; Eruke E Egbagbe (University of Benin College of Medical Sciences, Nigeria)*; Robert Eggertsen (University of Gothenburg, Sweden)*; Ulf Ekelund (Norwegian School of Sport Sciences, Norway)*; Jalila El Ati (National Institute of Nutrition and Food Technology, Tunisia)*; Paul Elliott (Imperial College London, UK)*; Reina Engle-Stone (University of California Davis, USA)*; Rajiv T Erasmus (University of Stellenbosch, South Africa)*; Cihangir Erem (Karadeniz Technical University, Turkey)*; Louise Eriksen (University of Southern Denmark, Denmark)*; Jorge Escobedo-de la Peña (Instituto Mexicano del Seguro Social, Mexico)*; Alun Evans (The Queen's University of Belfast, UK)*; David Faeh (University of Zurich, Switzerland)*; Caroline H Fall (University of Southampton, UK)*; Farshad Farzadfar (Tehran University of Medical Sciences, Iran)*; Francisco J Felix-Redondo (Centro de Salud Villanueva Norte, Spain)*; Trevor S Ferguson (The University of the West Indies, Jamaica)*; Daniel Fernández-Bergés (Hospital Don Benito-Villanueva de la Serena, Spain)*; Daniel Ferrante (Ministry of Health, Argentina)*; Marika Ferrari (Council for Agriculture Research and Economics, Italy)*; Catterina Ferreccio (Pontificia Universidad Católica de Chile, Chile)*; Jean Ferrieres (Toulouse University School of Medicine, France)*; Joseph D Finn (University of Manchester, UK)*; Krista Fischer (University of Tartu, Estonia)*; Eric Monterubio Flores (Instituto Nacional de Salud Pública, Mexico)*; Bernhard Föger (Agency for Preventive and Social Medicine, Austria)*; Leng Huat Foo (Universiti Sains Malaysia, Malaysia)*; Ann-Sofie Forslund (Luleå University, Sweden)*; Stephen P Fortmann (Stanford University, USA)*; Heba M Fouad (WHO Regional Office for the Eastern Mediterranean, Egypt)*; Damian K Francis (The University of the West Indies, Jamaica)*; Maria do Carmo Franco (Federal University of São Paulo, Brazil)*; Oscar H Franco (Erasmus Medical Center Rotterdam, Netherlands)*; Guillermo Frontera (Hospital Universitario Son Espases, Spain)*; Flavio D Fuchs (Hospital de Clinicas de Porto Alegre, Brazil)*; Sandra C Fuchs (Universidade Federal do Rio Grande do Sul, Brazil)*; Yuki Fujita (Kinki University Faculty of Medicine, Japan)*; Takuro Furusawa (Kyoto University, Japan)*; Zbigniew Gaciong (Medical University of Warsaw, Poland)*; Mihai Gafencu (Victor Babeş University of Medicine and Pharmacy, Romania)*; Dickman Garetá (University of KwaZulu-Natal, South Africa)*; Sarah P Garnett (University of Sydney, Australia)*; Jean-Michel Gaspoz (Geneva University Hospitals, Switzerland)*; Magda Gasull (CIBER en Epidemiología y Salud Pública, Spain)*; Louise Gates (Australian Bureau of Statistics, Australia)*; Johanna M Geleijnse (Wageningen University, Netherlands)*; Anoosheh Ghasemian (Non-Communicable Diseases Research Center, Iran)*; Simona Giampaoli (Istituto Superiore di Sanità, Italy)*; Francesco Gianfagna (University of Insubria, Italy)*; Jonathan Giovannelli (Lille University Hospital, France)*; Aleksander Giwercman (Lund University, Sweden)*; Rebecca A Goldsmith (Nutrition Department, Ministry of Health, Israel)*; Marcela Gonzalez Gross (Universidad Politécnica de Madrid, Spain)*; Juan P González Rivas (The Andes Clinic of Cardio-Metabolic Studies, Venezuela)*; Mariano Bonet Gorbea (National Institute of Hygiene, Epidemiology and Microbiology, Cuba)*; Frederic Gottrand (Université de Lille 2, France)*; Sidsel Graff-Iversen (Norwegian Institute of Public Health, Norway)*; Dušan Grafnetter (Institute for Clinical and Experimental Medicine, Czech Republic)*; Aneta Grajda (The Children's Memorial Health Institute, Poland)*; Maria G Grammatikopoulou (Alexander Technological Educational Institute, Greece)*; Ronald D Gregor (Dalhousie University, Canada)*; Tomasz Grodzicki (Jagiellonian University Medical College, Poland)*; Anders Grøntved (University of Southern Denmark, Denmark)*; Gabriella Gruden (University of Turin, Italy)*; Vera Grujic (Institute of Public Health of Vojvodina, Serbia)*; Dongfeng Gu (National Center of Cardiovascular Diseases, China)*; Ong Peng Guan (Singapore Eye Research Institute, Singapore)*; Vilmundur Gudnason (Icelandic Heart Association, Iceland)*; Ramiro Guerrero (Universidad Icesi, Colombia)*; Idris Guessous (Geneva University Hospitals, Switzerland)*; Andre L Guimaraes (State University of Montes Claros, Brazil)*; Martin C Gulliford (King's College London, UK)*; Johanna Gunnlaugsdottir (Icelandic Heart Association, Iceland)*; Marc Gunter (Imperial College London, UK)*; Xiu H Guo (Capital Medical University, China)*; Yin Guo (Capital Medical University, China)*; Prakash C Gupta (Healis-Sekhsaria Institute for Public Health, India)*; Oye Gureje (University of Ibadan, Nigeria)*; Beata Gurzkowska (The Children's Memorial Health Institute, Poland)*; Laura Gutierrez (Institute for Clinical Effectiveness and Health Policy, Argentina)*; Felix Gutzwiller (University of Zurich, Switzerland)*; Jytte Halkjær (Danish Cancer Society Research Centre, Denmark)*; Rebecca Hardy (University College London, UK)*; Rachakulla Hari Kumar (Indian Council of Medical Research, India)*; Alison J Hayes (University of Sydney, Australia)*; Jiang He (Tulane University, USA)*; Marleen Elisabeth Hendriks (University of Amsterdam Academic Medical Center, Netherlands)*; Leticia Hernandez Cadena (National Institute of Public Health, Mexico)*; Ramin Heshmat (Tehran University of Medical Sciences, Iran)*; Ilpo Tapani Hihtaniemi (Imperial College London, UK)*; Sai Yin Ho (University of Hong Kong, China)*; Suzanne C Ho (The Chinese University of Hong Kong, China)*; Michael Hobbs (University of Western Australia, Australia)*; Albert Hofman (Erasmus Medical Center Rotterdam, Netherlands)*; Claudia M Hormiga (Fundación Oftalmológica de Santander, Colombia)*; Bernardo L Horta (Universidade Federal de Pelotas, Brazil)*; Leila Houti (University of Oran 1, Algeria)*; Thein Thein Htay (Ministry of Health, Myanmar)*; Aung Soe Htet (University of Oslo, Norway)*; Maung Maung Than Htike (Ministry of Health, Myanmar)*; Yonghua Hu (Peking University Health Science Center, China)*; Abdullatif S Hussieni (Birzeit University, Palestine)*; Chinh Nguyen Huu (National Institute of Nutrition, Vietnam)*; Inge Huybrechts (International Agency for Research on Cancer, France)*; Nahla Hwalla (American University of Beirut, Lebanon)*; Licia Iacoviello (IRCCS Istituto Neurologico Mediterraneo Neuromed, Italy)*; Anna G Iannone (Cardiologia di Mercato S. Severino, Italy)*; M Mohsen Ibrahim (Cairo University, Egypt)*; Nayu Ikeda (National Institute of Health and Nutrition, Japan)*; M Arfan Ikram (Erasmus Medical Center Rotterdam, Netherlands)*; Vilma E Irazola (Institute for Clinical Effectiveness and Health Policy, Argentina)*; Muhammad Islam (Aga Khan University, Pakistan)*; Masanori Iwasaki (Niigata University, Japan)*; Rod T Jackson (University of Auckland, New Zealand)*; Jeremy M Jacobs (Hadassah University Medical Center, Israel)*; Tazeen Jafar (Duke-NUS Graduate Medical School, Singapore)*; Kazi M Jamil (Kuwait Institute for Scientific Research, Kuwait)*; Konrad Jamrozik (University of Adelaide, Australia; deceased)*; Grazyna Jasienska (Jagiellonian University Medical College, Poland)*; Chao Qiang Jiang (Guangzhou 12th Hospital, China)*; Michel Joffres (Simon Fraser University, Canada)*; Mattias Johansson (International Agency for Research on Cancer, France)*; Jost B Jonas (Ruprecht-Karls-University of Heidelberg, Germany)*; Torben Jørgensen (Research Centre for Prevention and Health, Denmark)*; Pradeep Joshi (World Health Organization Country Office, India)*; Anne Juolevi (National Institute for Health and Welfare, Finland)*; Gregor Jurak (University of Ljubljana, Slovenia)*; Vesna Jureša (University of Zagreb, Croatia)*; Rudolf Kaaks (German Cancer Research Center, Germany)*; Anthony Kafatos (University of Crete, Greece)*; Ofra Kalter-Leibovici (The Gertner Institute for Epidemiology and Health Policy Research, Israel)*; Efthymios Kapantais (Hellenic Medical Association for Obesity, Greece)*; Amir Kasaeian (Non-Communicable Diseases Research Center, Iran)*; Joanne Katz (Johns Hopkins Bloomberg School of Public Health, USA)*; Prabhdeep Kaur (National Institute of Epidemiology, India)*; Maryam Kavousi (Erasmus Medical Center Rotterdam, Netherlands)*; Ulrich Keil (University of Münster, Germany)*; Lital Keinan Boker (University of Haifa, Israel)*; Roya Kelishadi

(Research Institute for Primordial Prevention of Non-Communicable Disease, Iran)*; Han H C G Kemper (VU University Medical Center, Netherlands)*; Andre P Kengne (South African Medical Research Council, South Africa)*; Mathilde Kersting (Research Institute of Child Nutrition (FKE), Germany)*; Timothy Key (University of Oxford, UK)*; Yousef Saleh Khader (Jordan University of Science and Technology, Jordan)*; Davoud Khalili (Shahid Beheshti University of Medical Sciences, Iran)*; Young-Ho Khang (Seoul National University, South Korea)*; Kay-Tee H Khaw (University of Cambridge, UK)*; Ilse M S L Khouw (FrieslandCampina, Singapore)*; Stefan Kiechl (Medical University Innsbruck, Austria)*; Japhet Killewo (Muhimbili University of Health and Allied Sciences, Tanzania)*; Jeongseon Kim (National Cancer Center, South Korea)*; Yutaka Kiyohara (Kyushu University, Japan)*; Jeannette Klimont (Statistics Austria, Austria)*; Elin Kolle (Norwegian School of Sport Sciences, Norway)*; Patrick Kolsteren (Institute of Tropical Medicine, Belgium)*; Paul Korrovits (Tartu University Clinics, Estonia)*; Seppo Koskinen (National Institute for Health and Welfare, Finland)*; Katsuyasu Kouda (Kinki University Faculty of Medicine, Japan)*; Slawomir Koziel (Polish Academy of Sciences Anthropology Unit in Wrocław, Poland)*; Wolfgang Kratzer (University Hospital Ulm, Germany)*; Steinar Krokstad (Norwegian University of Science and Technology, Norway)*; Daan Kromhout (Wageningen University, Netherlands)*; Herculina S Kruger (North-West University, South Africa)*; Krzysztof Kula (Medical University of Lodz, Poland)*; Zbigniew Kulaga (The Children's Memorial Health Institute, Poland)*; R Krishna Kumar (Amrita Institute of Medical Sciences, India)*; Yadlapalli S Kusuma (All India Institute of Medical Sciences, India)*; Kari Kuulasmaa (National Institute for Health and Welfare, Finland)*; Catherine Kyobutungi (African Population and Health Research Center, Kenya)*; Fatima Zahra Laamiri (Université Mohammed V de Rabat, Morocco)*; Tiina Laatikainen (National Institute for Health and Welfare, Finland)*; Carl Lachat (Ghent University, Belgium)*; Youcef Laid (National Institute of Public Health of Algeria, Algeria)*; Tai Hing Lam (University of Hong Kong, China)*; Orlando Landrove (Ministerio de Salud Pública, Cuba)*; Vera Lanska (Institute for Clinical and Experimental Medicine, Czech Republic)*; Georg Lappas (Sahlgrenska Academy, Sweden)*; Lars E Laugsand (Norwegian University of Science and Technology, Norway)*; Avula Laxmaiah (Indian Council of Medical Research, India)*; Khanh Le Nguyen Bao (National Institute of Nutrition, Vietnam)*; Tuyen D Le (National Institute of Nutrition, Vietnam)*; Catherine Leclercq (Food and Agriculture Organization, Italy)*; Jeannette Lee (National University of Singapore, Singapore)*; Jeonghee Lee (National Cancer Center, South Korea)*; Terho Lehtimäki (Tampere University Hospital, Finland)*; Rampal Lekhray (Universiti Putra Malaysia, Malaysia)*; Luz M León-Muñoz (Universidad Autónoma de Madrid, Spain)*; Yanping Li (Harvard T H Chan School of Public Health, USA)*; Wei-Yen Lim (National University of Singapore, Singapore)*; M Fernanda Lima-Costa (Oswaldo Cruz Foundation Rene Rachou Research Institute, Brazil)*; Hsien-Ho Lin (National Taiwan University, Taiwan)*; Xu Lin (University of Chinese Academy of Sciences, China)*; Allan Linneberg (Research Centre for Prevention and Health, Denmark)*; Lauren Lissner (University of Gothenburg, Sweden)*; Mieczyslaw Litwin (The Children's Memorial Health Institute, Poland)*; Jing Liu (Capital Medical University, Beijing Anzhen Hospital, China)*; Roberto Lorbeer (University Medicine Greifswald, Germany)*; Paulo A Lotufo (University of São Paulo, Brazil)*; José Eugenio Lozano (Consejería de Sanidad Junta de Castilla y León, Spain)*; Dalia Luksiene (Lithuanian University of Health Sciences, Lithuania)*; Annamari Lundqvist (National Institute for Health and Welfare, Finland)*; Nuno Lunet (University of Porto Medical School, Portugal)*; Per Lytsy (University of Uppsala, Sweden)*; Guansheng Ma (Peking University, China)*; Suka Machi (The Jikei University School of Medicine, Japan)*; Stefania Maggi (National Research Council, Italy)*; Dianna J Magliano (Baker IDI Heart and Diabetes Institute, Australia)*; Marcia Makdisse (Hospital Israelita Albert Einstein, Brazil)*; Reza Malekzadeh (Tehran University of Medical Sciences, Iran)*; Rahul Malhotra (Duke-NUS Graduate Medical School, Singapore)*; Kodavanti Mallikharjuna Rao (Indian Council of Medical Research, India)*; Yannis Manios (Harokopio University of Athens, Greece)*; Jim I Mann (University of Otago, New Zealand)*; Enzo Manzato (University of Padova, Italy)*; Paula Margozzini (Pontificia Universidad Católica de Chile, Chile)*; Oonagh Markey (University of Reading, UK)*; Pedro Marques-Vidal (Lausanne University Hospital, Switzerland)*; Jaume Marrugat (Institut Hospital del Mar d'Investigacions Mèdiques, Spain)*; Yves Martin-Prevel (Institut de Recherche pour le Développement, France)*; Reynaldo Martorell (Emory University, USA)*; Shariq R Masoodi (Sher-i-Kashmir Institute of Medical Sciences, India)*; 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Kamarul Imran Musa (Universiti Sains Malaysia, Kota Bharu, Malaysia)*; Vera Musil (University of Zagreb, Croatia)*; Gabriele Nagel (Ulm University, Germany)*; Harunobu Nakamura (Kobe University, Japan)*; Jana Námesná (Regional Authority of Public Health, Banská Bystrica, Slovakia)*; Ei Ei K Nang (National University of Singapore, Singapore)*; Vinay B Nangia (Suraj Eye Institute, India)*; Martin Nankap (Helen Keller International, Cameroon)*; Sameer Narake (Healis-Sekhsaria Institute for Public Health, India)*; Eva Maria Navarrete-Muñoz (CIBER en Epidemiología y Salud Pública, Spain)*; Ilona Nenko (Jagiellonian University Medical College, Poland)*; Martin Neovius (Karolinska Institutet, Sweden)*; Flavio Nervi (Pontificia Universidad Católica de Chile, Chile)*; Hannelore K Neuhauser (Robert Koch Institute, Germany)*; Nguyen D Nguyen (University of Pharmacy and Medicine of Ho Chi Minh City, Vietnam)*; Quang Ngoc Nguyen (Hanoi Medical University, Vietnam)*; Ramfis E Nieto-Martínez (Universidad Centro-Occidental Lisandro

Alvarado, Venezuela)*; Guang Ning (Shanghai Jiao-Tong University School of Medicine, China)*; Toshiharu Ninomiya (Kyushu University, Japan)*; Sania Nishtar (Heartfile, Pakistan)*; Marianna Noale (National Research Council, Italy)*; Teresa Norat (Imperial College London, UK)*; Davide Noto (University of Palermo, Italy)*; Mohannad Al Nsour (Eastern Mediterranean Public Health Network, Jordan)*; Dermot O'Reilly (The Queen's University of Belfast, UK)*; Angélica M Ochoa-Avilés (Universidad de Cuenca, Ecuador)*; Kyungwon Oh (Korea Centers for Disease Control and Prevention, South Korea)*; Iman H Olayan (Kuwait Institute for Scientific Research, Kuwait)*; Maria Teresa Anselmo Olinto (University of Vale do Rio dos Sinos, Brazil)*; Maciej Oltarzewski (National Food and Nutrition Institute, Poland)*; Mohd A Omar (Ministry of Health, Malaysia)*; Altan Onat (Istanbul University, Turkey)*; Pedro Ordunez (Pan American Health Organization, USA)*; Ana P Ortiz (University of Puerto Rico, Puerto Rico)*; Merete Osler (Research Center for Prevention and Health, Denmark)*; Clive Osmond (MRC Lifecourse Epidemiology Unit, UK)*; Sergej M Ostojic (University of Novi Sad, Serbia)*; Johanna A Otero (Fundación Oftalmológica de Santander, Colombia)*; Kim Overvad (Aarhus University, Denmark)*; Fred Michel Paccaud (Institute for Social and Preventive Medicine, Switzerland)*; Cristina Padez (University of Coimbra, Portugal)*; Andrzej Pajak (Jagiellonian University Medical College, Poland)*; Domenico Palli (Cancer Prevention and Research Institute, Italy)*; Alberto Palloni (University of Madison-Wisconsin, USA)*; Luigi Palmieri (Istituto Superiore di Sanità, Italy)*; Songhomitra Panda-Jonas (Ruprecht-Karls-University of Heidelberg, Germany)*; Francesco Panza (University of Bari, Italy)*; Winsome R Parnell (University of Otago, New Zealand)*; Mahboubeh Parsaeian (Non-Communicable Diseases Research Center, Iran)*; Mangesh S Pednekar (Healis-Sekhsaria Institute for Public Health, India)*; Petra H Peeters (University Medical Center Utrecht, Netherlands)*; Sergio Viana Peixoto (Oswaldo Cruz Foundation Rene Rachou Research Institute, Brazil)*; Alexandre C Pereira (Heart Institute (InCor), Brazil)*; Cynthia M Pérez (University of Puerto Rico Medical Sciences Campus, Puerto Rico)*; Annette Peters (Helmholtz Zentrum München, Germany)*; Niloofar Peykari (Non-Communicable Diseases Research Center, Iran)*; Son Thai Pham (Vietnam National Heart Institute, Vietnam)*; Iris Pigeot (Leibniz Institute for Prevention Research and Epidemiology—BIPS, Germany)*; Hynek Pikhart (University College London, UK)*; Aida Pilav (Federal Ministry of Health, Bosnia and Herzegovina)*; Lorenza Pilotto (Cardiovascular Prevention Centre Udine, Italy)*; Francesco Pistelli (University Hospital of Pisa, Italy)*; Freda Pitakaka (University of New South Wales, Australia)*; Aleksandra Piwonska (The Cardinal Wyszyński Institute of Cardiology, Poland)*; Jerzy Piwonski (The Cardinal Wyszyński Institute of Cardiology, Poland)*; Pedro Plans-Rubió (Public Health Agency of Catalonia, Spain)*; Bee Koon Poh (Universiti Kebangsaan Malaysia, Malaysia)*; Miquel Porta (Institut Hospital del Mar d'Investigacions Mèdiques, Spain)*; Marileen L P Portegies (Erasmus Medical Center Rotterdam, Netherlands)*; Dimitrios Poulimeneas (Alexander Technological Educational Institute, Greece)*; Rajendra Pradeepa (Madras Diabetes Research Foundation, India)*; Mathur Prashant (Indian Council of Medical Research, India)*; Jacqueline F Price (University of Edinburgh, UK)*; Maria Puiu (Victor Babeş University of Medicine and Pharmacy, Romania)*; Margus Punab (Tartu University Clinics, Estonia)*; Radwan F Qasrawi (Al-Quds University, Palestine)*; Mostafa Qorbani (Alborz University of Medical Sciences, Iran)*; Tran Quoc Bao (Ministry of Health, Vietnam)*; Ivana Radic (Institute of Public Health of Vojvodina, Serbia)*; Ricardas Radisauskas (Lithuanian University of Health Sciences, Lithuania)*; Mahmudur Rahman (Institute of Epidemiology Disease Control and Research, Bangladesh)*; Olli Raitakari (Turku University Hospital, Finland)*; Manu Raj (Amrita Institute of Medical Sciences, India)*; Sudha Ramachandra Rao (National Institute of Epidemiology, India)*; Ambady Ramchandran (India Diabetes Research Foundation, India)*; Jacqueline Ramke (University of New South Wales, Australia)*; Rafel Ramos (Institut Universitari d'Investigació en Atenció Primària Jordi Gol, Spain)*; Sanjay Rampal (University of Malaya, Malaysia)*; Finn Rasmussen (Karolinska Institutet, Sweden)*; Josep Redon (University of Valencia, Spain)*; Paul Ferdinand M Reganit (University of the Philippines, Philippines)*; Robespierre Ribeiro (Department of Health, Brazil)*; Elio Riboli (Imperial College London, UK)*; Fernando Rigo (Health Center San Agustín, Spain)*; Tobias Floris Rinke de Wit (PharmAccess Foundation, Netherlands)*; Raphael M Ritti-Dias (Hospital Israelita Albert Einstein, Brazil)*; Juan A Rivera (Instituto Nacional de Salud Pública, Mexico)*; Sian M Robinson (University of Southampton, UK)*; Cynthia Robitaille (Public Health Agency of Canada, Canada)*; Fernando Rodríguez-Artalejo (Universidad Autónoma de Madrid, Spain)*; María del Cristo Rodríguez-Perez (Canarian Health Service, Spain)*; Laura A Rodríguez-Villamizar (Universidad Industrial de Santander, Colombia)*; Rosalba Rojas-Martinez (Instituto Nacional de Salud Pública, Mexico)*; Nipa Rojroongwasinkul (Mahidol University, Thailand)*; Dora Romaguera (CIBEROBN, Spain)*; Kimmo Ronkainen (University of Eastern Finland, Finland)*; Annika Rosengren (University of Gothenburg, Sweden)*; Ian Rouse (Fiji National University, Fiji)*; Adolfo Rubinstein (Institute for Clinical Effectiveness and Health Policy, Argentina)*; Frank J Rühli (University of Zurich, Switzerland)*; Ornelas Rui (University of Madeira, Portugal)*; Blanca Sandra Ruiz-Betancourt (Instituto Mexicano del Seguro Social, Mexico)*; Andrea R V Russo Horimoto (Heart Institute (InCor), Brazil)*; Marcin Rutkowski (Medical University of Gdansk, Poland)*; Charumathi Sabanayagam (Singapore Eye Research Institute, Singapore)*; Harshpal S Sachdev (Sitaram Bharta Institute of Science and Research, India)*; Olfa Saidi (Faculty of Medicine of Tunis, Tunisia)*; Benoit Salanave (French Institute for Health Surveillance, France)*; Eduardo Salazar Martinez (National Institute of Public Health, Mexico)*; Veikko Salomaa (National Institute for Health and Welfare, Finland)*; Jukka T Salonen (University of Helsinki, Finland)*; Massimo Salvetti (University of Brescia, Italy)*; Jose Sánchez-Abanto (National Institute of Health, Peru)*; Sandjaja (Ministry of Health, Indonesia)*; Susana Sans (Catalan Department of Health, Spain)*; Diana A Santos (University of Lisbon, Portugal)*; Osvaldo Santos (Institute of Preventive Medicine, Portugal)*; Renata Nunes dos Santos (University of São Paulo, Brazil)*; Rute Santos (University of Porto, Portugal)*; Luis B Sardinha (University of Lisbon, Portugal)*; Nizal Sarrafzadegan (Isfahan Cardiovascular Research Center, Iran)*; Kai-Uwe Saum (German Cancer Research Center, Germany)*; Savvas C Savva (Research and Education Institute of Child Health, Cyprus)*; Marcia Sczufca (University of São Paulo, Brazil)*; Angelika Schaffrath Rosario (Robert Koch Institute, Germany)*; Herman Schargrodsy (Hospital Italiano de Buenos Aires, Argentina)*; Anja Schienkiewitz (Robert Koch Institute, Germany)*; Ida Maria Schmidt (Rigshospitalet, Denmark)*; Ione J Schneider (Federal University of Santa Catarina, Brazil)*; Constance Schultz (University of Amsterdam Academic Medical Center, Netherlands)*; Aletta E Schutte (MRC North-West University, South Africa)*; Aye Aye Sein (Ministry of Health, Thailand)*; Abhijit Sen (Norwegian University of Science and Technology, Norway)*; Idowu O Senbanjo (Lagos State University College of Medicine, Nigeria)*; Sadaf G Sepanlou (Digestive Diseases Research Institute, Iran)*; Svetlana A Shalnova (National Research Centre for Preventive Medicine, Russia)*; Jonathan E Shaw (Baker IDI Heart and Diabetes Institute, Australia)*; Kenji Shibuya (The University of Tokyo, Japan)*; Youchan Shin (Singapore Eye Research Institute, Singapore)*; Rahman Shiri (Finnish Institute of Occupational Health, Finland)*; Rosalynn Siantar (Singapore Eye Research Institute, Singapore)*; Abba M Sibai (American University of Beirut, Lebanon)*; Antonio M Silva (Federal University of Maranhão, Brazil)*; Diego Augusto Santos Silva (Federal University of Santa Catarina, Brazil)*; Mary Simon (India Diabetes Research Foundation, India)*; Judith Simons (St Vincent's Hospital, Australia)*; Leon A Simons (University of New South Wales, Australia)*; Michael Sjöström (Karolinska Institutet, Sweden)*; Jolanta Slowikowska-Hilczler (Medical University of Lodz, Poland)*; Przemyslaw Slusarczyk (International Institute of Molecular and Cell Biology, Poland)*; Liam Smeeth (London School of Hygiene & Tropical Medicine, UK)*; Margaret C Smith (University of Oxford, UK)*; Marieke B Snijder (University of Amsterdam Academic Medical Center, Netherlands)*; Hung-Kwan So (The Chinese University of Hong Kong, China)*; Eugène Sobngwi (University of Yaoundé 1, Cameroon)*; Stefan Söderberg (Umeå University, Sweden)*; Moesijanti Y E Soekatri (Health Polytechnics Institute, Indonesia)*; Vincenzo Solfrizzi

- (University of Bari, Italy)*; Emily Sonestedt (Lund University, Sweden)*; Thorkild I A Sørensen (University of Copenhagen, Denmark)*; Maroje Sorić (University of Zagreb, Croatia)*; Charles Sossa Jérôme (Institut Régional de Santé Publique, West Africa)*; Aicha Soumare (University of Bordeaux, France)*; Jan A Staessen (University of Leuven, Belgium)*; Gregor Starc (University of Ljubljana, Slovenia)*; Maria G Stathopoulou (INSERM, France)*; Kaspar Staub (University of Zurich, Switzerland)*; Bill Stavreski (Heart Foundation, Australia)*; Jostein Steene-Johannessen (Norwegian School of Sport Sciences, Norway)*; Peter Stehle (Bonn University, Germany)*; Aryeh D Stein (Emory University, USA)*; George S Stergiou (Sotiria Hospital, Greece)*; Jochanan Stessman (Hadassah University Medical Center, Israel)*; Jutta Stieber (Helmholtz Zentrum München, Germany)*; Doris Stöckl (Helmholtz Zentrum München, Germany)*; Tanja Stocks (Lund University, Sweden)*; Jakub Stokwizewski (National Institute of Public Health-National Institute of Hygiene, Poland)*; Gareth Stratton (Swansea University, UK)*; Maria Wany Strufaldi (Federal University of São Paulo, Brazil)*; Chien-An Sun (Fu Jen Catholic University, Taiwan)*; Johan Sundström (Uppsala University, Sweden)*; Yn-Tz Sung (The Chinese University of Hong Kong, China)*; Jordi Sunyer (Centre for Research in Environmental Epidemiology, Spain)*; Paibul Suriyawongpaisal (Mahidol University, Thailand)*; Boyd A Swinburn (The University of Auckland, New Zealand)*; Rody G Sy (University of the Philippines, Philippines)*; Lucjan Szponar (National Food and Nutrition Institute, Poland)*; E Shyong Tai (National University of Singapore, Singapore)*; Mari-Liis Tammesoo (University of Tartu, Estonia)*; Abdonas Tamosiunas (Lithuanian University of Health Sciences, Lithuania)*; Line Tang (Research Centre for Prevention and Health, Denmark)*; Xun Tang (Peking University Health Science Center, China)*; Frank Tanser (University of KwaZulu-Natal, South Africa)*; Yong Tao (Peking University, China)*; Mohammed Tarawneh (Ministry of Health, Jordan)*; 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Atul Trivedi (Government Medical College, India)*; Lechaba Tshepo (Sefako Makgatho Health Science University, South Africa)*; Marshall K Tulloch-Reid (The University of the West Indies, Jamaica)*; Tomi-Pekka Tuomainen (University of Eastern Finland, Finland)*; Jaakko Tuomilehto (Dasman Diabetes Institute, Kuwait)*; Maria L Turley (Ministry of Health, New Zealand)*; Per Tynelius (Karolinska Institutet, Sweden)*; Themistoklis Tzotzas (Hellenic Medical Association for Obesity, Greece)*; Christophe Tzourio (University of Bordeaux, France)*; Peter Ueda (Harvard T H Chan School of Public Health, USA)*; Flora AM Ukoli (Meharry Medical College, USA)*; Hanno Ulmer (Medical University of Innsbruck, Austria)*; Belgün Unal (Dokuz Eylül University, Turkey)*; Gonzalo Valdivia (Pontificia Universidad Católica de Chile, Chile)*; Susana Vale (University of Porto, Portugal)*; Damaskini Valvi (Harvard T H Chan School of Public Health, USA)*; Yvonne T van der Schouw (University Medical Center Utrecht, Netherlands)*; 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Jyrki K Virtanen (University of Eastern Finland, Finland)*; Sophie Visvikis-Siest (INSERM, France)*; Bharathi Viswanathan (Ministry of Health, Seychelles)*; Peter Vollenweider (Lausanne University Hospital, Switzerland)*; Sari Voutilainen (University of Eastern Finland, Finland)*; Martine Vrijheid (Centre for Research in Environmental Epidemiology, Spain)*; Alisha N Wade (University of the Witwatersrand, South Africa)*; Aline Wagner (University of Strasbourg, France)*; Janette Walton (University College Cork, Ireland)*; Wan Nazaimoon Wan Mohamad (Institute for Medical Research, Malaysia)*; Ming-Dong Wang (Public Health Agency of Canada, Canada)*; Qian Wang (Xinjiang Medical University, China)*; Ya Xing Wang (Beijing Tongren Hospital, China)*; S Goya Wannamethee (University College London, UK)*; Nicholas Wareham (University of Cambridge, UK)*; Deepa Weerasekera (Ministry of Health, New Zealand)*; Peter H Whincup (St George's, University of London, UK)*; Kurt Widhalm (Medical University of Vienna, Austria)*; Indah S Widyahening (Universitas Indonesia, Indonesia)*; Andrzej Wiecek (Medical University of Silesia, Poland)*; Rainford J Wilks (The University of the West Indies, Jamaica)*; Johann Willeit (Medical University Innsbruck, Austria)*; Bogdan Wojtyniak (National Institute of Public Health-National Institute of Hygiene, Poland)*; Jyh Eiin Wong (Universiti Kebangsaan Malaysia, Malaysia)*; Tien Yin Wong (Duke-NUS Graduate Medical School, Singapore)*; Jean Woo (The Chinese University of Hong Kong, China)*; Mark Woodward (University of Sydney, Australia; University of Oxford, UK)*; Frederick C Wu (University of Manchester, UK)*; JianFeng Wu (Shandong University of Traditional Chinese Medicine, China)*; Shou Ling Wu (Kailuan General Hospital, China)*; Haiquan Xu (Institute of Food and Nutrition Development of Ministry of Agriculture, China)*; Liang Xu (Capital Medical University, China)*; Uruwan Yamborisut (Mahidol University, Thailand)*; Weili Yan (Fudan University, China)*; Xiaoguang Yang (Chinese Center for Disease Control and Prevention, China)*; Nazan Yardim (Ministry of Health, Turkey)*; Xingwang Ye (University of Chinese Academy of Sciences, China)*; Panayiotis K Yiallourou (Cyprus University of Technology, Cyprus)*; Akihiro Yoshihara (Niigata University, Japan)*; Qi Sheng You (Capital Medical University, China)*; Novie O Younger-Coleman (The University of the West Indies, Jamaica)*; Ahmad F Yusoff (Ministry of Health, Malaysia)*; Ahmad A Zainuddin (Universiti Teknologi MARA, Malaysia)*; Sabina Zambon (University of Padova, Italy)*; Tomasz Zdrojewski (Medical University of Gdansk, Poland)*; Yi Zeng (Duke University, USA; Peking University, China)*; Dong Zhao (Capital Medical University Beijing Anzhen Hospital, China)*; Wenhua Zhao (Chinese Center for Disease Control and Prevention, China)*; Yingfeng Zheng (Singapore Eye Research Institute, Singapore)*; Maigeng Zhou (Chinese Center for Disease Control and Prevention, China)*; Dan Zhu (Inner Mongolia Medical University, China)*; Esther Zimmermann (Bispebjerg and Frederiksberg Hospitals, Denmark)*; Julio Zuñiga Cisneros (Gorgas Memorial Institute of Public Health, Panama)
- Declaration of interests**
JJM reports funding from Medtronic Foundation, outside the submitted work. All other authors declare no competing interests.
- Acknowledgments**
We thank Christina Banks, Quentin Hennocq, Dheeya Rizmie, and Yasaman Vali for assistance with data extraction. We thank WHO country and regional offices and the World Heart Federation for support in data identification and access.
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