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

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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.

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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

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/m^2), 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]

See Online for appendix

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 paper[21] 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

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,

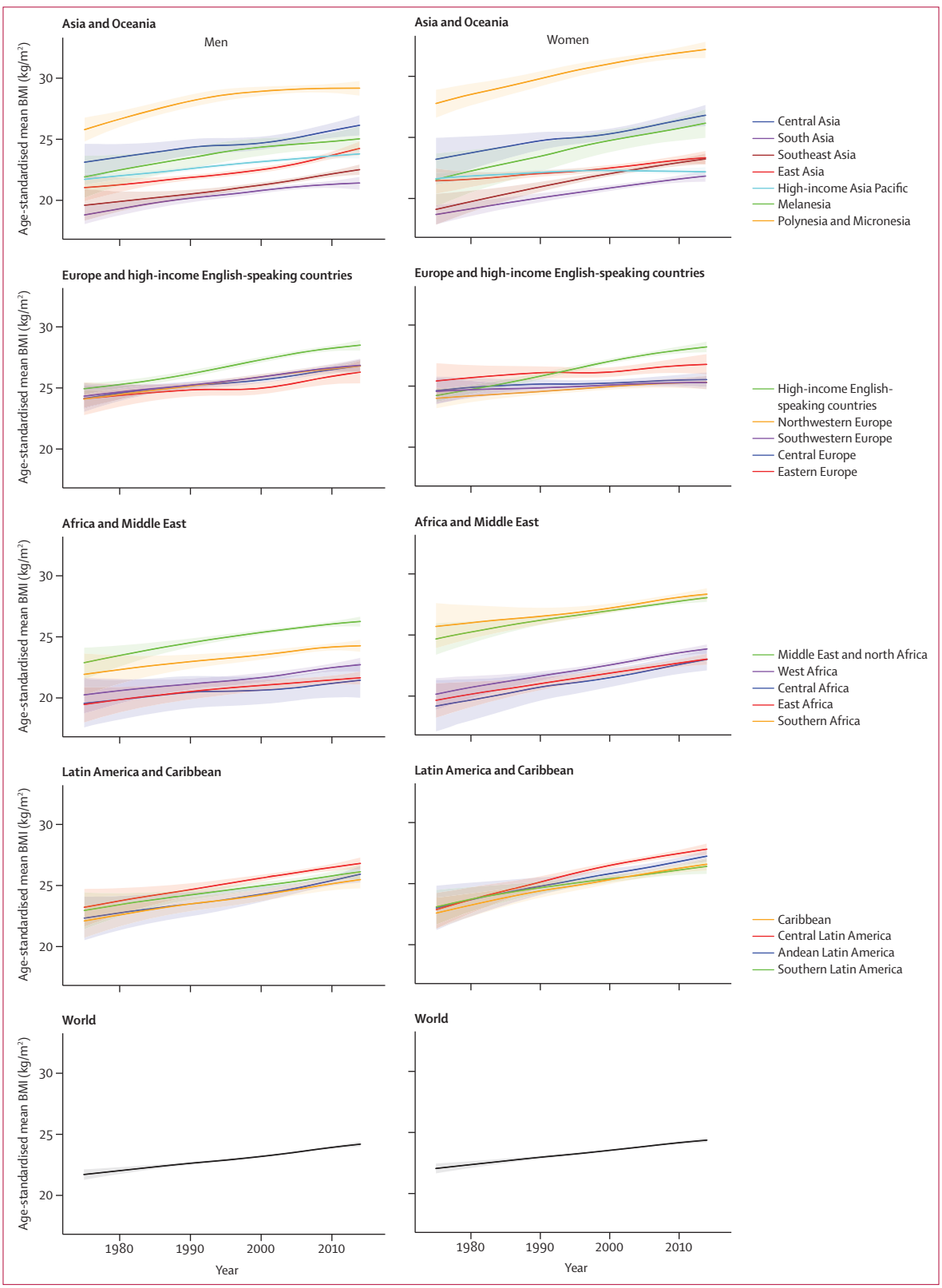

Figure 1: **Trends in age-standardised mean BMI by sex and region**
Lighter colours are 95% credible intervals. See appendix (pp 155–355) for results by sex and country. BMI=body-mass index.