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NN, Nieto-Martinez, RE, Ning, G, Ninomiya, T, Nishtar, S, Noale, M, Norat, T, Noto, D, Al Nsour, M, O'Reilly, D, Ochoa-Aviles, AM, Oh, K, Olayan, IH, Anselmo Olinto, MT, Oltarzewski, M, Omar, MA, Ordunez, P, Ortiz, AP, Osler, M, Osmond, C, Ostojic, SM, Otero, JA, Overvad, K, Paccaud, FM, Padez, C, Pajak, A, Palli, D, Palloni, A, Palmieri, L, Panda-Jonas, S, Panza, F, Parnell, WR, Parsaeian, M, Pednekar, MS, Peeters, PH, Peixoto, SV, Pereira, AC, Perez, CM, Peters, A, Peykari, N, Son, TP, Pigeot, I, Pikhart, H, Pilav, A, Pilotto, L, Pistelli, F, Pitakaka, F, Piwonska, A, Piwonski, J, Plans-Rubio, P, Poh, BK, Porta, M, Portegies, MLP, Poulimeneas, D, Pradeepa, R, Prashant, M, Price, JF, Puiu, M, Punab, M, Qasrawi, RF, Qorbani, M, Tran, QB, Radic, I, Radisauskas, R, Rahman, M, Raitakari, O, Raj, M, Rao, SR, Ramachandran, A, Ramke, J, Ramos, R, Rampal, S, Rasmussen, F, Redon, J, Reganit, PFM, Ribeiro, R, Riboli, E, Rigo, F, de Wit, TFR, Ritti-Dias, RM, Rivera, JA, Robinson, SM, Robitaille, C, Rodriguez-Artalejo, F, del Cristo Rodriguez-Perez, M, Rodriguez-Villamizar, LA, Rojas-Martinez, R, Rojroongwasinkul, N, Romaguera, D, Ronkainen, K, Rosengren, A, Rouse, I, Rubinstein, A, Ruehli, FJ, Rui, O, Sandra Ruiz-Betancourt, B, Russo Horimoto, ARV, Rutkowski, M, Sabanayagam, C, Sachdev, HS, Saidi, O, Salanave, B, Salazar Martinez, E, Salomaa, V, Salonen, JT, Salvetti, M, Sanchez-Abanto, J, Sandjaja, , Sans, S, Santos, DA, Santos, O, dos Santos, RN, Santos, R, Sardinha, LB, Sarrafzadegan, N, Saum, K-U, Savva, SC, Scazufca, M, Rosario, AS, Schargrodsky, H, Schienkiewitz, A, Schmidt, IM, Schneider, IJ, Schultsz, C, Schutte, AE, Sein, AA, Senbanjo, IO, Sepanlou, SG, Shalnova, SA, Shaw, JE, Shibuya, K, Shin, Y, Shiri, R, Siantar, R, Sibai, AM, Silva, AM, Santos Silva, DA, Simon, M, Simons, J, Simons, LA, Sjostrom, M, Slowikowska-Hilczer, J, Slusarczyk, P, Smeeth, L, Smith, MC, Snijder, MB, So, H-K, Sobngwi, E, Soderberg, S, Soekatri, MYE, Solfrizzi, V, Sonestedt, E, Sorensen, TIA, Soric, M, Jerome, CS, Soumare, A, Staessen, JA, Starc, G, Stathopoulou, MG, Staub, K, Stavreski, B, Steene-Johannessen, J, Stehle, P, Stein, AD, Stergiou, GS, Stessman, J, Stieber, J, Stoeckl, D, Stocks, T, Stokwiszewski, J, Stratton, G, Strufaldi, MW, Sun, C-A, Sundstrom, J, Sung, Y-T, Sunyer, J, Suriyawongpaisal, P, Swinburn, BA, Sy, RG, Szponar, L, Tai, ES, Tammesoo, M-L, Tamosiunas, A, Tang, L, Tang, X, Tanser, F, Tao, Y, Tarp, J, Tarqui-Mamani, CB, Taylor, A, Tchibindat, F, Thijs, L, Thuesen, BH, Tjonneland, A, Tolonen, HK, Tolstrup, JS, Topbas, M, Topor-Madry, R, Torrent, M, Traissac, P, Trichopoulou, A, Trichopoulos, D, Trinh, OTH, Trivedi, A, Tshepo, L, Tulloch-Reid, MK, Tuomainen, T-P, Tuomilehto, J, Turley, ML, Tynelius, P, Tzotzas, T, Tzourio, C, Ueda, P, Ukoli, FAM, Ulmer, H, Unal, B, Valdivia, G, Vale, S, Valvi, D, van der Schouw, YT, Van Herck, K, Hoang, VM, van Valkengoed, IGM, Vanderschueren, D, Vanuzzo, D, Vatten, L, Vega, T, Velasquez-Melendez, G, Veronesi, G, Verschuren, WMM, Viegi, G, Viet, L, Viikari-Juntura, E, Vineis, P, Vioque, J, Virtanen, JK, Visvikis-Siest, S, Viswanathan, B, Vollenweider, P, Voutilainen, S, Vrijheid, M, Wade, AN, Wagner, A, Walton, J, Mohamud, WNW, Wang, M-D, Wang, Q, Wang, YX,

The weight of the world – trends in adult body mass index in 200 countries since 1975: pooled analysis of 1,698 population-based measurement studies with 19.2 million participants

NCD Risk Factor Collaboration (NCD-RisC)

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Summary

Background: Trends in mean body mass index (BMI) characterise shifts in the population distribution of BMI, and prevalences of underweight, and severe and morbid obesity (BMI ≥ 35 and 40 kg/m^2, respectively) show what proportion of the population are at high risks of adverse health outcomes. Our aim was to estimate trends in mean BMI and in prevalences of various BMI categories for adults in all countries.

Methods: We reanalysed population-based studies with measured height and weight data in adults aged 18 years and older using a consistent protocol. 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 < 18.5 kg/m^2 (underweight), 18.5 to <20 kg/m^2, 20 to <25 kg/m^2, 25 to <30 kg/m^2, 30 to <35 kg/m^2, 35 to <40 kg/m^2, ≥40 kg/m^2 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 compared to its 2010 levels, if post-2000 trends continue.

Findings: Global age-standardised mean BMI increased from 21.7 kg/m^2 (95% credible interval 21.3-22.1) in 1975 to 24.2 kg/m^2 (24.0-24.4) in 2014 in men, and from 22.1 (21.7-22.5) kg/m^2 in 1975 to 24.4 (24.2-24.6) kg/m^2 in 2014 in women. Regional mean BMIs in 2014 for men ranged from 21.4 kg/m^2 in Central Africa and South Asia to 29.2 (28.6-29.8) kg/m^2 in Polynesia and Micronesia; for women the range was from 21.8 (21.4-22.3) kg/m^2 in South Asia to 32.2 (31.5-32.8) kg/m^2 in Polynesia and Micronesia. Over these four decades, global prevalence of underweight (BMI <18.5 kg/m^2) declined 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. 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 adult men and 5.0% (4.4-5.6) of adult women are severely obese. Morbid obesity is 0.64% (0.46-0.86) among men and 1.6% (1.3-1.9) among women. 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 surpass 17% in men and 21% in women; severe obesity will surpass 6% in men and 9% in women.

Interpretation: If current trends continue, the world will not meet the global obesity target, and will face an epidemic of severe obesity. Underweight nonetheless 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 conditions.[1-7] Concerns about the health and economic burden of increasing BMI have led to adiposity being included among the global non-communicable diseases (NCD) targets, with a target of halting, by 2025, the rise in the prevalence of obesity compared to 2010 (i.e., age-standardised prevalence in 2025 is no more than 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 estimated global trends in the prevalences of overweight and obesity.[11-13] 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 upon. Epidemiological studies have also demonstrated substantial risks among people with very high BMI, e.g., ≥35 or ≥40kg/m^2 (referred to as severe and morbid obesity, respectively).[14] Being underweight is also associated with increased risk of morbidity and mortality (i.e., a so-called J-shaped association) and with adverse pregnancy outcomes.[4, 6, 15, 16] There are no consistent global estimates of trends in underweight, especially for men,[17] and in severe and morbid obesity. Finally, there is no information on how likely it is for countries to achieve the global obesity target.

We pooled population-based data to estimate trends from 1975 to 2014 in both mean BMI and in prevalences of BMI categories, ranging from underweight to morbid obesity. We also estimated the probability of achieving the global obesity target.

Methods

Overview

We estimated trends in mean BMI and prevalences of BMI categories <18.5 kg/m^2 (underweight), 18.5 to <20 kg/m^2, 20 to <25 kg/m^2, 25 to <30 kg/m^2, 30 to <35 kg/m^2, 35 to <40 kg/m^2, ≥40 kg/m^2 (morbid obesity) from 1975 to 2014 in 200 countries and territories. We report results for these categories, as well as for total obesity (BMI ≥30 kg/m^2) and severe obesity (BMI ≥35 kg/m^2). Countries and territories were organised into 21 regions, mostly based on geography and national income (Appendix Table 1). 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 18 years of age and older, consistent with the Global Monitoring Framework for NCDs.[8]

Our study had two steps, described below. First, we identified, accessed, and reanalysed population-based measurement studies of human anthropometry. We then used a statistical model to estimate trends for all countries and years.

Data sources

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] Due to these variations, current approaches to correcting self-reported data leave residual bias and error. Our data inclusion and exclusion criteria, listed in Appendix, were designed to ensure population representativeness. Our methods for identifying and accessing data are described in Appendix.

Statistical methods

We performed all analyses by sex, because there are differences in BMI levels and trends in relation to sex. The statistical method is described in a statistical paper, and in the Appendix of a previous empirical paper.[21, 22] In summary, the model had a hierarchical structure in which estimates for each country and year were informed by its 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 (e.g., have a small sample size or, as described below, 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 included covariates that help predict BMI, including national income (natural logarithm of per-person GDP adjusted for inflation and purchasing power), proportion of population living in urban areas, and a summary measure of availability of different food types for human consumption.[23, 24] We also conducted 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 Figure 4) with the exception of a few countries that had no data and whose covariates (e.g., national income) differed from those of their region, e.g., Brunei Darussalam, Bermuda, and North Korea. We report estimates for the model with covariates because it had significantly better fit to data, as measured by deviance information criterion.

We analysed mean BMI and each of the above prevalences separately. We re-scaled the estimated prevalences of different categories so that their sum was 1.0 in each age, sex, country, and year. The average scaling factor across draws was 1.05 for men and 1.07 for women, i.e., the sum of the separately estimated prevalences was close to 1.0. Estimates for regions and the world were calculated as population-weighted averages of the constituent country estimates by age group and sex. For presentation, we age-standardised the estimated means and prevalences to the WHO reference population,[25] by taking weighted averages of age-sex-specific estimates with use of age weights from the reference population. We tested how well our statistical model predicts missing data as described in the Appendix, which showed that it performed extremely well in estimating mean BMI as well as prevalences of BMI categories when data were missing.

We estimated average change in mean and prevalence (absolute change for mean and relative change for prevalence) over the 40 years of analysis and report as change per decade. We also report the posterior probability (PP) that an estimated increase or decrease represents a truly increasing or decreasing trend. In addition, we made separate trend estimates for pre-2000 and post-2000 years to assess whether the increasing recognition of adiposity as an "epidemic" in the 1990s,[26] and subsequent public health attention and response,[27, 28] may have slowed down its rise. We calculated the PP of meeting the global obesity target if post-2000 trends continue.

Role of funding source

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

Results

Data availability

We used 1,698 population-based data sources, with ~19.2 million participants (9.9 million men; 9.3 million women) aged ≥18 years whose height and weight had been measured, in 186 of 200 countries for which estimates were made (Appendix Figure 2); 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 (48.7%) were national, 236 (13.9%) were subnational, and the remaining 635 (37.4%) were community-based (Appendix Figure 3). Across regions, there were between an average of 2.8 data sources per country in Polynesia and Micronesia to 35 per country in high-income Asia Pacific. 525 data sources (30.9%) were from years before 1995 and another 1173 (69.1%) for 1995 and later. 1314 sources had data on men as well as women, 144 only on men, and 240 only on women.

Mean BMI (global and regional)

Global age-standardised mean BMI in men increased from 21.7 kg/m^2 (95% CrI 21.3-22.1) in 1975 to 24.2 kg/m^2 (24.0-24.4) in 2014, and in women from 22.1 (21.7-22.5) kg/m^2 in 1975 to 24.4 (24.2-24.6) kg/m^2 in 2014 (Figure 1) (PP of being a true rise >0.9999 for both sexes). The average rises of 0.63 kg/m^2 per decade (0.53-0.73) for men and 0.59 kg/m^2 per decade (0.49-0.70) for women are equivalent to the world's population having become on average >1.5 kg heavier each decade.

Regional mean BMI in 2014 for men ranged from 21.4 kg/m^2 in Central Africa and South Asia to 29.2 (28.6-29.8) kg/m^2 in Polynesia and Micronesia (Figure 1). For women the range was from 21.8 (21.4-22.3) kg/m^2 in South Asia to 32.2 (31.5-32.8) kg/m^2 in Polynesia and Micronesia. Mean BMI was also high among men and women in the region comprising of high-income English-speaking countries, and in women in Southern Africa and in Middle East and North Africa.

The largest rise in men's BMI occurred in high-income English-speaking countries (1.00 kg/m^2 per decade; PP >0.9999) and for women in Central Latin America (1.27 kg/m^2 per decade; PP >0.9999). The increase in female BMI was also >1.00 kg/m^2 per decade in Melanesia, Polynesia and Micronesia, high-income English-speaking countries, South East Asia, Andean Latin America and the Caribbean. Due to these trends, in 2014 men and women in high-income English-speaking countries had substantially higher BMIs than those in continental Europe, whereas in 1975 their BMI had been similar or lower, especially for women (Figure 1). In contrast to these large increases, the rise in women's BMI was <0.2 kg/m^2 per decade in Central and South Western Europe and high-income Asia-Pacific.

Mean BMI (country level)

In 1975, age-standardised mean BMI was <19 kg/m^2 among men in Timor-Leste, Burundi, India, Ethiopia, Viet Nam, Rwanda, Eritrea and Bangladesh, and 17-18 kg/m^2 among women in Bangladesh, Nepal, Timor-Leste, Burundi, Cambodia and Viet Nam (Figure 2). In the same year, men and women in Nauru and women in American Samoa already had mean BMIs >30 kg/m^2.[29, 30] By 2014, age-standardised mean BMI had reached >20.0 kg/m^2 in men and >20.7 kg/m^2 in women in every country, with Ethiopia, Eritrea and Timor-Leste having the lowest BMIs for both sexes. At the same time, men and women in American Samoa had age-standardised mean BMIs of 32.2 (30.5-33.7) and 34.8 (33.2-36.3) kg/m^2, respectively, with mean BMI also >30 kg/m^2 in both sexes in some other islands in Polynesia and Micronesia, and in women in some countries in Middle East and North Africa (e.g., Egypt and Kuwait) and the Caribbean.

Trends in men's BMI over these four decades ranged from virtually flat in Nauru (albeit at a very high level), North Korea and a number of countries in sub-Saharan Africa, to an increase of >1.5 kg/m^2 per decade. Similarly, women's BMI did not change in Bahrain and Nauru (both starting at high BMIs), Singapore, Japan, North Korea and a number of European countries, but increased by >1.5 kg/m^2 per decade in some countries. BMI rose more slowly after the year 2000 than it had in the preceding 2.5 decades in Oceania and in most high-income countries for both sexes, and for women in most countries in Latin America and the Caribbean (Figure 3). In contrast, the post-2000 rise was steeper than pre-2000 among men in Central and Eastern Europe, East and Southeast Asia, and most countries in Latin America and the Caribbean. In other regions, pre- and post-2000 increases in BMI were similar or there was a mix of slow-down and acceleration. The standard deviation of BMI also increased from 1975 to 2014 (Appendix Figure 5), which contributed to increasing the prevalences of people at low and/or high BMI levels, as presented below.

BMI varied more across countries in women (e.g., 14.1 kg/m^2, equivalent to ~35 kg heavier in American Samoa compared to Timor-Leste) than it did among men (12.1 kg/m^2). Although male and female BMIs were correlated across countries, women had higher BMI than men in 141 countries in 2014 (Appendix Figure 6). There was weak correlation between changes in male and female BMI across countries.

Prevalences of BMI categories (global and regional)

Over these four decades, global age-standardised prevalence of underweight declined 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 (Figure 4). Compared to the fall in underweight, prevalence of obesity 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% (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 adult men and 5.0% (4.4-5.6) of adult women are severely obese. Morbid obesity is 0.64% (0.46-0.86) among men and 1.6% (1.3-1.9) among women.

Age-standardised underweight prevalence in South Asia, where it is most common, declined from >35% in 1975 to ~24% in 2014 in both sexes (Figure 4). Underweight prevalence also remains >12% in women and >15% in men in Central and East Africa, despite some declines. At the other extreme, >38% of men and >50% of women in Polynesia and Micronesia are obese. Obesity prevalence also surpasses 30% among men and women in English-speaking high-income countries, and women in Southern Africa and in Middle East and North Africa.

Prevalences of BMI categories (country level)

Age-standardised prevalence of underweight in 2014 was less than 1% among men in 68 countries and among women in 11 countries (Figure 5). At the other extreme, >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. In 1975, the proportion had been as high as 37% in Indian and Bangladeshi women.

In 136 of 200 countries, more men are now obese than underweight; in 113 of these, more are severely obese than underweight. For women, obesity surpasses underweight in 165 countries and severe obesity surpasses underweight in 135. Obesity prevalence was <1% among men in Burundi and Timor-Leste and between 1% and 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, Viet Nam, North Korea, Cambodia, Lao PDR and Bangladesh all <5%. At the other extreme, >45% of men in 6 islands in Polynesia and Micronesia, and >50% of women in 11 such island nations were obese. Women in a number of Caribbean and Middle Eastern countries had obesity prevalences of 40% to 50%. Severe obesity surpassed 20% in men and 30% in women in some Polynesian and Micronesian islands, reaching 33.4% (23.6-43.5) in American Samoa in 2014. Over 15% of women in Nauru and American Samoa were morbidly obese.

Number of underweight, obese and severely obese people

The above prevalences translate to 266 (240-295) million obese men and 375 (344-407) million obese women in the world in 2014, compared to 34 (26-44) million and 71 (57-87) million in 1975 (Figure 6). 58 (49-68) million of these men and 126 (112-141) million of these women are severely obese. 18.4% of the world’s obese adults (118 million) live in English-speaking high-income countries, followed by 14.5% (93 million) in East Asia and 12.4% (79 million) in Middle East and North Africa. English-speaking high-income countries house an even larger share of the world's severely obese people (27.1%; 50 million), followed by 13.9% (26 million) in Middle East and North Africa.

Countries where large numbers of underweight people lived in 1975 as well as 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 7). In contrast to 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. More obese men and women now live 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 are still from the USA.

Progress towards the global target

If post-2000 trends continue, the probability of meeting the global obesity target is less than 50% in every country, with Nauru having the highest probability of ~45% (Appendix Figure 7). With an obesity prevalence at >45% for men and >55% for women in Nauru, this is not a public health achievement. The probability of achieving the target is <10% among men in 194 countries and women in 174 countries. At the global level, the probability of meeting the target is virtually zero. Rather, if current trends continue, by 2025, global obesity prevalence will surpass 17% in men and

21% in women; and severe obesity will surpass 9% in women, and will be larger than the projected prevalence of underweight.

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 – globally as well as in all regions except parts of sub-Saharan Africa and Asia. The rate of increase in BMI since 2000 has been slower than 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; BMI, however, rose faster in some other regions such that the global rise in BMI has not slowed. If recent trends continue, not only will the world not meet the global target for halting the rise in obesity, but also severe obesity will surpass underweight among women by 2025. Underweight nonetheless remains a public health problem in South Asia and Central and East Africa.

We estimated a slightly larger rise in mean BMI since 1980 than Finucane et al,[11] especially for men, because our estimates for 1980 were lower, globally and in most regions. This may 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 et al[13] for 2008 and by Ng et al for 2013;[12] our estimates for obesity for the same years are slightly lower than those of Stevens et al and slightly higher than those of Ng et al. Further, we estimated a lower prevalence of obesity for 1980 than Ng et al had, which means we attribute a larger role to the rise over the past few decades for the current extent of obesity. Differences between our study and Ng et al were greater at the regional level, e.g., for obesity among men in South Asia and Central, East and West Africa, where our estimates of obesity prevalence are less than half of those by Ng et al. 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 as well as the prevalences of all BMI categories with clinical and public health relevance – including the first-ever estimates of underweight and severe and morbid obesity. This helped reveal the details of underweight to overweight/obesity transition throughout the world. We also reported the probability that each country will meet the global obesity target. We put great emphasis on data quality and used only population-based data that had measured height and weight, to avoid the bias in self-reported data. Characteristics and quality of data sources were verified through repeated checks by Collaborating Group members. Data were analysed according to a common protocol to obtain the required mean and prevalences 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 fewer data sources, especially those in Polynesia and Micronesia, the Caribbean and Central Asia. In addition, only 42% of sources included people older than 70 years. Given 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 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 – the conversion regressions nonetheless had high predictive accuracy (Appendix Table 3). Estimating prevalences for a complete set of BMI categories is a novel component of our work, but the uncertainty intervals for BMI ≥30 kg/m^2 and BMI ≥35 kg/m^2, which span more than one of the analysed categories, may 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, as these are only measured in recent surveys. A systematic review of epidemiological studies found that, taken together, these studies do not show that any of the measures of adiposity had "superior discriminatory capability" in terms of risk of adverse cardiometabolic outcomes; any observed difference was "too small to be of any clinical relevance".[31] We did not analyse children and adolescents for two reasons. First, because childhood and adolescence is a period of rapid growth, BMI cut-offs used to define under/over-weight 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] Finally, the global obesity target does not penalise a situation in which high prevalence of obesity persists in a country, as is the case in Nauru for example.

There are a number of implications to our results. First, the global focus on the obesity epidemic has largely overshadowed the persistence of underweight in some countries. Our results demonstrate the need to address the remaining underweight problem, which will reduce risks to pregnant women and their newborn infants,[15] mortality from tuberculosis and other respiratory diseases,[34] and possibly all-cause mortality for which there is a J-shaped association.[2, 3] Achieving this requires social and food policies that enhance food security in poor households, but avoid overconsumption of processed carbohydrates and other unhealthy foods. Second, although adiposity has been consistently shown to be an independent risk factor for a number of NCDs in individual-level epidemiological studies, at the population level, the effect of rising BMI on the course of mortality decline has so far been modest in high-income countries,[35, 36] possibly because pharmacological treatment has helped lower 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 larger impact on population health. Further, we have shown that some high-income and middle-income regions are now facing an epidemic of severe obesity. Even antihypertensive medicines, statins and glucose lowering drugs will not be able to fully address the hazards of such high BMI levels,[7] and bariatric surgery may 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- and middle-income countries due to financial and health systems barriers.

Current 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 the light of past trends, has engendered a new look at policies that may slow down and stop the worldwide rise in BMI.[40-42] To avoid an epidemic of severe obesity, the next step must be to implement these policies, and to systematically evaluate their impact.[43]

Research in Context

Evidence before this study

We searched Medline (via PubMed) 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.

The only study on trends in mean BMI,[11] which characterises shifts in the population distribution of BMI, reported trends to 2008 before the global target on obesity was agreed upon, and there are no recent data. Two previous studies estimated global trends in the prevalences of overweight and obesity.[11-13] Neither study reported trends in underweight, which is associated with increased risk of morbidity, mortality and adverse pregnancy outcomes, and in high levels of BMI, e.g., ≥35 or ≥40kg/m^2, which are associated with substantial risks of many NCDs.

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 that are of enormous clinical and public health interest. We were able to robustly depict this rich picture by re-analysing and pooling hundreds of population-based sources with actual measurements of height and weight according to a common protocol. We also systematically projected recent trends into the future, and assessed the probability of achieving the global obesity target.

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. Underweight however remains a public health problem in the world's poorest regions, namely South Asia and Central and East Africa. If current trends continue, the world not only will not meet the global obesity target, but also severe obesity will surpass underweight among women by 2025.

NCD Risk Factor Collaboration (NCD-RisC)

Pooled Analysis and Writing (* equal contribution)

Mariachiara Di Cesare (Imperial College London, UK)*; James Bentham (Imperial College London, UK)*; Gretchen A Stevens (World Health Organization, Switzerland)*; Bin Zhou (Imperial College London, UK); Goodarz Danaei (Harvard T.H. Chan School of Public Health, USA); Yuan Lu (Harvard T.H. Chan School of Public Health, USA); Honor Bixby (Imperial College London, UK); Melanie J Cowan (World Health Organization, Switzerland); Leanne M Riley (World Health Organization, Switzerland); Kaveh Hajifathalian (Harvard T.H. Chan School of Public Health, USA); Léa Fortunato (Imperial College London, UK); Cristina Taddei (University of Florence, Italy); James E Bennett (Imperial College London, UK); Nayu Ikeda (National Institute of Health and Nutrition, Japan); Prof Young-Ho Khang (Seoul National University, Republic of Korea); Catherine Kyobutungi (African Population and Health Research Center, Kenya); Avula Laxmaiah (Indian Council of Medical Research, India); Yanping Li (Harvard T.H. Chan School of Public Health, USA); Hsien-Ho Lin (National Taiwan University, Taiwan); J Jaime Miranda (Universidad Peruana Cayetano Heredia, Peru); Aya Mostafa (Ain Shams University, Egypt); Maria L Turley (Ministry of Health, New Zealand); Christopher J Paciorek (University of California, Berkeley, USA); Marc Gunter (Imperial College London, UK); Prof Majid Ezzati (Imperial College 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 Nutricion, 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 Health Institute, 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, Banska 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 Barbagallo (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)*; Rosangela L Batista (Federal University of Maranhao, Brazil)*; Louise A Baur (University of Sydney, Australia)*; Robert Beaglehole (University of Auckland, New Zealand)*; Habiba Ben Romdhane (Faculty of Medicine of Tunis, 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 Bhagyalaxmi (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 Bhutta (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, The 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 CE 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, The 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, The Netherlands)*; Anna Bugge (University of Southern Denmark, Denmark)*; Con Burns (Cork Institute of Technology, Ireland)*; Antonio Cabrera de León (Canarian Health Service, 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 (University of Medicine and Pharmacy "Victor Babes", 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 Concin (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 (Moscow Lomonosov State University, Russia)*; Abbas Dehghan (Erasmus Medical Center Rotterdam, The Netherlands)*; Hélène Delisle (University of Montreal, Canada)*; Francis Delpeuch (Institut de Recherche pour le Développement, France)*;

Klodian Dhana (Erasmus Medical Center Rotterdam, The Netherlands)*; Wan Mohamud Dhana (Institute for Medical Research, Malaysia)*; 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 TP 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 Wyszynski 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 (Non-Communicable Diseases Research Center, 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 Agricultural 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 (Department of Health Science, 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, The 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 (University of Medicine and Pharmacy "Victor Babes", Romania)*; Andrzej Galbarczyk (Jagiellonian University Medical College, Poland)*; Dickman Gareta (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, The 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)*; 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)*; Grabriella 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 (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, The 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, Hong Kong)*; Michael Hobbs (University of Western Australia, Australia)*; Albert Hofman (Erasmus Medical Center Rotterdam, The 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)*; Mohsen M Ibrahim (Cairo University, Egypt)*; Nayu Ikeda (National Institute of Health and Nutrition, Japan)*; M Arfan Ikram (Erasmus Medical Center Rotterdam, The 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 (Aga Khan University, 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 (University of Hong Kong, China)*; Michel Joffres (Simon Fraser University, Canada)*; 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, The Netherlands)*; Ulrich Keil (University of Münster, Germany)*; Lital Keinan Boker (University of Haifa, Israel)*; Roya Kelishadi (Isfahan University of Medical Sciences, Iran)*; Han HCG Kemper (Vu Medical University, The 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)*; Davood 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 MSL 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 Wroclaw, Poland)*; Wolfgang Kratzer (University Hospital Ulm, Germany)*; Steinar Krokstad (Norwegian University of Science and Technology, Norway)*; Daan Kromhout (Wageningen University, The 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 Lekhraj (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 (Beijing Anzhen Hospital, Capital Medical University, 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)*; Tandi E Matsha (Cape Peninsula University of Technology, South Africa)*; Johansson Mattias (International Agency for Research on Cancer, France)*; Artur Mazur (University of Rzeszow, Poland)*; Jean Claude N Mbanya (University of Yaoundé 1, Cameroon)*; Shelly R McFarlane (The University of the West Indies, Jamaica)*; Stephen T McGarvey (Brown University, USA)*; Martin McKee (London School of Hygiene & Tropical Medicine, UK)*; Stela McLachlan (University of Edinburgh, UK)*; Rachael M McLean (University of Otago, New Zealand)*; Breige A McNulty (University College Dublin, Ireland)*; Safiah Md Yusof (Universiti Teknologi MARA, Malaysia)*; Sounnia Mediene-Benchekor (University of Oran 1, Algeria)*; Aline Meirhaeghe (Institut National de la Santé et de la Recherche Médicale, France)*; Christa Meisinger (Helmholtz Zentrum München, Germany)*; Larissa L Mendes (Universidade Federal de Juiz de Fora, Brazil)*; Ana Maria B Menezes (Universidade Federal de Pelotas, Brazil)*; Gert BM Mensink (Robert Koch Institute, Germany)*; Indrapal I Meshram (Indian Council of Medical Research, India)*; Andres Metspalu (University of Tartu, Estonia)*; Jie Mi (Capital Institute of Pediatrics, China)*; Kim F Michaelsen (University of Copenhagen, Denmark)*; Kairit Mikkel (University of Tartu, Estonia)*; Jody C Miller (University of Otago, New Zealand)*; Juan Francisco Miquel (Pontificia Universidad Católica de Chile, Chile)*; J Jaime Miranda (Universidad Peruana Cayetano Heredia, Peru)*; Marjeta Mišigoj-Durakovic (University of Zagreb, Croatia)*; Mostafa K Mohamed (Ain Shams University, Egypt)*; Kazem Mohammad (Tehran University of Medical Sciences, Iran)*; Noushin Mohammadifard (Isfahan University of Medical Sciences, Iran)*; Viswanathan Mohan (Madras Diabetes Research Foundation, India)*; Muhammad Fadhli Mohd Yusoff (Ministry of Health, Malaysia)*; Drude Molbo (University of Copenhagen, Denmark)*; Niels C Møller (University of Southern Denmark, Denmark)*; Dénes Molnár (University of Pécs, Hungary)*; Charles K Mondo (Mulago Hospital, Uganda)*; Eric A Monterrubio (Instituto Nacional de Salud Pública, Mexico)*; Kotsedi Daniel K Monyeki (University of Limpopo, South Africa)*; Leila B Moreira (Universidade Federal do Rio Grande do Sul, Brazil)*; Alain Morejon (University Medical Science, Cuba)*; Luis A Moreno (Universidad de Zaragoza, Spain)*; Karen

Morgan (RCSI Dublin, Ireland)*; Erik Lykke Mortensen (University of Copenhagen, Denmark)*; George Moschonis (Harokopio University of Athens, Greece)*; Malgorzata Mossakowska (International Institute of Molecular and Cell Biology, Poland)*; Aya Mostafa (Ain Shams University, Egypt)*; Jorge Mota (University of Porto, Portugal)*; Mohammad Esmaeel Motlagh (Ahvaz Jundishapur University of Medical Sciences, Iran)*; Jorge Motta (Gorgas Memorial Institute of Public Health, Panama)*; Thet Thet Mu (Ministry of Health, Myanmar)*; Maria L Muiesan (University of Brescia, Italy)*; Martina Müller-Nurasyid (Helmholtz Zentrum München, Germany)*; Neil Murphy (Imperial College London, UK)*; Jaakko Mursu (University of Eastern Finland, Finland)*; Elaine M Murtagh (Mary Immaculate College, Ireland)*; 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 Námešná (Regional Authority of Public Health, Banska 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)*; 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 (Sekhsaria Institute for Public Health, India)*; Petra H Peeters (University Medical Center Utrecht, The 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, Italy)*; Francesco Pistelli (University Hospital of Pisa, Italy)*; Freda Pitakaka (University of New South Wales, Australia)*; Aleksandra Piwonska (The Cardinal Wyszynski Institute of Cardiology, Poland)*; Jerzy Piwonski (The Cardinal Wyszynski 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 LP Portegies (Erasmus Medical Center Rotterdam, The 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 (University of Medicine and Pharmacy "Victor Babes", 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 Ramachandran (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 (University of Amsterdam, The 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 Rodriguez-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 Bhartia 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 (Department of Health, Spain)*; Diana 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 University of Medical Sciences, Iran)*; Kai-Uwe Saum (German Cancer Research Center, Germany)*; Savvas C Savva (Research and Education Institute of Child Health, Cyprus)*; Marcia Scazufca (University of São Paulo, Brazil)*; Angelika Schaffrath Rosario (Robert Koch Institute, Germany)*; Herman Schargrodsky (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 Schultsz (University of Amsterdam, The Netherlands)*; Aletta E Schutte (MRC North-West University, South Africa)*; Aye Aye Sein (Ministry of Health, Thailand)*; Idowu O Senbanjo (Lagos State University College of Medicine, Nigeria)*; Sadaf G Sepanlou (Digestive Diseases Research Institute, Iran)*; Svetlana A Shalnova (Moscow State Pirigov Medical University, 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)*; Abla M Sibai (American University of Beirut, Lebanon)*; Antonio M Silva (Federal University of Maranhao, 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 Sjostrom (Karolinska Institutet, Sweden)*; Jolanta Slowikowska-Hilczer (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 (Academic Medical Center of University of Amsterdam, The Netherlands)*; Hung-kwan So (The Chinese University of Hong Kong, China)*; Eugène Sobngwi (University of Yaoundé 1, Cameroon)*; Stefan Söderberg (Umeå University, Sweden)*; Moesijanti YE Soekatri (Health Polytechnics Institute, Indonesia)*; Vincenzo Solfrizzi (University of Bari, Italy)*; Emily Sonestedt (Lund University, Sweden)*; Thorkild IA Sørensen (University of Copenhagen, Denmark)*; Maroje Soric (University of Zagreb, Croatia)*; Charles Sossa Jérome (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 Stokwiszewski (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 Cente, China)*; Frank Tanser (University of KwaZulu-Natal, South Africa)*; Yong Tao (Peking University, China)*; Mohammed Tarawneh (Ministry of Health, Jordan)*; Jakob Tarp (University of Southern Denmark, Denmark)*; Carolina B Tarqui-Mamani (National Institute of Health, Peru)*; Anne Taylor (The University of Adelaide, Australia)*; Félicité Tchibindat (UNICEF, Cameroon)*; Lutgarde Thijs (University of Leuven, Belgium)*; Anne Tjonneland (Danish Cancer Society Research Centre, Denmark)*; Hanna K Tolonen (National Institute for Health and Welfare, Finland)*; Janne S Tolstrup (University of Southern Denmark, Denmark)*; Murat Topbas (Karadeniz Technical University, Turkey)*; Roman Topór-Madry (Jagiellonian University Medical College, Poland)*; Maties Torrent (IB-SALUT Area de Salut de Menorca, Spain)*; Pierre Traissac (Institut de Recherche pour le Développement, France)*; Antonia Trichopoulou (Hellenic Health Foundation, Greece)*; Dimitrios Trichopoulou (Harvard T.H. Chan School of Public Health, USA)*; Oanh TH Trinh (University of Pharmacy and Medicine of Ho Chi Minh City, Vietnam)*; 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 (National Institute for Health and Welfare, Finland)*; Maria L Turley (Ministry of Health, New Zealand)*; Per Tynelius (Karolinska Institutet, Sweden)*; Themistoklis Tzotzas (Hellenic Medical Association for Obesity, Greece)*; Betina Thuesen H (Research Centre for Prevention and Health, Denmark)*; 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)*; Belgin Unal (Dokuz Eylul 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, The Netherlands)*; Koen van Herck (Ghent University, Belgium)*; Hoang Van Minh (Hanoi Medical University, Vietnam)*; Irene GM van Valkengoed (Academic Medical Center of University of Amsterdam, The Netherlands)*; Dirk Vanderschueren (Katholieke Universiteit Leuven, Belgium)*; Diego Vanuzzo (Centro di Prevenzione Cardiovascolare Udine, Italy)*; Lars Vatten (Norwegian University of Science and Technology, Norway)*; Tomas Vega (Consejería de Sanidad Junta de Castilla y León, Spain)*; Gustavo Velasquez-Melendez (Universidade Federal de Minas Gerais, Brazil)*; Giovanni Veronesi (University of Insubria, Italy)*; WM Monique Verschuren (National Institute for Public Health and the Environment, The Netherlands)*; Giovanni Viegi (Italian National Research Council, Italy)*; Lucie Viet (National Institute for Public Health and the Environment, The Netherlands)*; Eira Viikari-Juntura (Finnish Institute of Occupational Health, Finland)*; Paolo Vineis (Imperial College London, UK)*; Jesus Vioque (Universidad Miguel Hernandez, Spain)*; 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)*; 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)*; Aleksander Giwercman Wu (Lund University, Sweden)*; 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 Yiallouros (Cyprus University of Technology, Cyprus)*; Akihiro Yoshihara (Niigata University, Japan)*; Qi S 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)*; Dong Zhao (Beijing Anzhen

Hospital, Capital Medical University, 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)

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Contributions

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.

Conflict of interest

Dr. Miranda reports funding from Medtronics Foundation, outside the submitted work.

Figure 1: Trends in age-standardised mean BMI by sex and region. See Appendix Figure 8 for trends by country.

Figure 2: Age-standardised mean BMI by sex and country in 1975 and 2014. See Appendix Table 4 for numerical results.

Figure 3: Comparison of average change in age-standardised mean BMI before and after the year 2000. Each point shows 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.

Figure 4: Trends in age-standardised prevalences of BMI categories by sex and region. See Appendix Figure 8 for results by country.

Figure 5: Age-standardised prevalence by sex and country in 2014 for underweight (BMI < 18.5 kg/m^2); obesity (BMI ≥ 30 kg/m^2); and severe obesity (BMI ≥ 35 kg/m^2). See Appendix Table 5 for numerical results for all BMI ranges.

Figure 6: Trends in the number of obese (BMI ≥ 30 kg/m^2) and severely obese (BMI ≥ 35 kg/m^2) people, by region.

Figure 7: Ten countries with the largest number of underweight (BMI < 18.5 kg/m^2), obese (BMI ≥ 30 kg/m^2), and severely obese (BMI ≥ 35 kg/m^2) people in 1975 and 2014. Colours for each country indicate its region, using the same colour scheme as in Figure 3.

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